THE RENEWED INTEREST IN NEW NUCLEAR CONSTRUCTION

IN THE UNITED STATES:

LESSONS FROM HISTORY, THE MEDIA, AND INTERVIEWS

by

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A Thesis
Submitted in partial fulfillment
of the requirements for the degree
Master of Environmental Studies
The Evergreen State College
December 2009

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ABSTRACT

The Renewed Interest in New Nuclear Construction in the United States: Lessons from History, the Media, and Interviews

Kathleen M. Saul

In 2007, after a three-decade hiatus, companies in the United States started applying to the Nuclear Regulatory Commission (NRC) for licenses to build and operate new commercial nuclear power facilities. This thesis explores the factors underlying the decisions to submit those applications and proposes a model that encapsulates those factors. It begins with a review of the history of commercial nuclear power in the United States to better understand the changing environmental, regulatory, and economic contexts facing utilities in the 1960s and '70s and today. That historical review serves as the basis for interviews with representatives of seven of the applicant companies (AmerenUE, Dominion, Duke Energy, Entergy, PPL, Progress Energy Florida, and the Tennessee Valley Authority (TVA)) as well as professionals in the nuclear industry. Those interview results are combined with information gleaned from books, articles in technical journals (such as *Energy Policy*, *Power Engineering*, and *Nuclear News*), news articles (from *The New York Times*, the *Wall Street Journal*, *Fortune* magazine as well on-line publications), company annual reports, and transcripts of hearings before the Committee on Energy and Natural Resources of the U.S. Senate. This research reveals that increased demand for electricity can lead companies to consider building new capacity, and concern over carbon dioxide emissions can prompt interest in renewable sources and nuclear power. However, utilities will not build new nuclear power plants without (a) the changes in the nuclear reactor licensing process instituted in the 1990s, and (b) either the federal financial incentives provided by the Energy Policy Act of 2005 or rate increases through the cost recovery mechanism of Construction Work in Progress (CWIP).

This thesis then proposes a theoretical model for new nuclear reactor construction. It draws on work in Political Ecology, a field that examines conflicts between people, their productive activities, and nature, and the influence of cultural and political activity on all three. More specifically, utilities choose to build new facilities to satisfy the need/want for readily available electricity. Awareness of the potential for decreasing supplies of oil and natural gas as well as pending legislation regulating carbon dioxide emissions cause the utilities to look toward sources other than traditional coal- or gas-fired plants. Companies will chose the nuclear option only if capital becomes available, whether in the form of federal loan guarantees, production tax credits, or "construction work in progress" (CWIP) financing. The model may be extended to other energy investment decisions facing utility companies in the United States.

The Political Ecology Model of Energy Investments

Natural Resources/Environment ⟷ Technology ⟷ Human Wants/Needs

↑

Capital Investment/Financing

Table of Contents

List of Figures

List of Tables

Acknowledgements

I wish to thank the following people for their contributions to this work:

My thesis committee
Dr. John H. Perkins, The Evergreen State College
Dr. Ralph Murphy, The Evergreen State College
Mr. Dana Kelly, Idaho National Laboratory

Interview participants
Dr. John Bickel, Evergreen Safety & Reliability Technologies, LLC
Danny Blanton, Entergy
Mike Cleary, AmerenUE
C.J. Fong, NRC Region II Construction Inspection Organization
Rick Grantom, South Texas Project
Hossein Hamzehee, NRC
Terry Johnson, Tennessee Valley Authority
Rick Kimble, Progress Energy Florida
David Lochbaum, Union of Concerned Scientists
Rita Sipe, Duke Energy
Richard Zuercher, Dominion
Anonymous, PPL

My friends and family, including
Greg Saul
Dr. David J. and Kae Hentges
Natalie Kopytko

And the people of Chernobyl and Kiev, Ukraine, who inspired my interest in nuclear power.

Preface

During the summer of 2007 I traveled to Chernobyl, Ukraine. The trip was part of a course that delved into the basics of nuclear power and the details of the catastrophe of April, 1986, when a fire and core melt-down at Unit 4 sent plumes of radioactive materials high into the sky. That facility stood eerily idle, with makeshift scaffolding holding up the hastily erected “sarcophagus” that covered the destroyed unit. A hand-held dosimeter indicated that the area around the unit remained radioactive, despite the best efforts of legions of Soviet men to bury and contain any debris from the accident, any equipment being used on site at the time, and any trees or shrubs in the immediate vicinity. In the nearby town of Pripyat, trees had grown up through cracks in the sidewalks and children’s playground, where an unused ferris wheel watched quietly over rusted bumper cars. Vines and trees also had begun to reclaim the old wooden houses within the “exclusion zone” around the plant. Decaying signs pointed to abandoned towns.

Many people remember the Chernobyl accident for dramatic efforts expended to cap the reactor and relocate nearby residents; or for the amounts of radioactive strontium, cesium, iodine, and other materials it spewed into the atmosphere, quantities detected world-wide. Others recall it as the event that, on the heels of the melt-down at Three Mile Island in Pennsylvania, finally brought an end to the first nuclear era in the United States. For me, the visit to Chernobyl and discussions with people who had been there that fateful day renewed my interest in commercial nuclear power.

Soon after returning, I was intrigued to see stories in *The New York Times* about plans to construct two new nuclear units at the South Texas Project near Houston, TX. I wondered why, so many years after construction of nuclear power plants came to a halt in the U.S., a utility was again considering that option.

My Master's thesis began to take shape.

1.0 Introduction

On September 20, 2007, NRG Energy became the first company in over three decades to submit a complete application to the Nuclear Regulatory Commission (NRC) for the construction and operation of a new nuclear power plant.[1] The company press release of September 24 announced a "new day for the environment," a way of generating electricity without the carbon dioxide and greenhouse gas emissions associated with coal-fired plants, a means of meeting the growing demand for power without increased dependence on foreign sources of oil.[2]

An application from the Tennessee Valley Authority (TVA), and its partners at NuStart Energy Development, followed. Earlier, Craven Crowell, former Chairman of the TVA, had expressed his view that new nuclear power was the only means of meeting the nations' appetite for electricity while protecting the environment.[3] According to Craven, neither renewable sources nor conservation could supply enough power, and the volatility of the price of natural gas made it impractical for baseload power.

By the beginning of 2009, the NRC had received applications to build 26 new reactor units at 17 separate sites. The application for Florida Power and Light's new Turkey Point units followed in June of 2009. Were all applications driven by an interest

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[1] Vicki Vaughn, "Application is First in Decades for New Nuclear Reactor," *San Antonio Express-News*, September 24, 2007, www.chron.com/disp/story.mpl/business/energy/516`662.html, (accessed October 8, 2007).

[2] "NRG Energy Submits Application for New 2,700 Megawatt Nuclear Plant in South Texas," Company News Release, September 24, 2007, http://phx.corporate-ir.net/phoenix.zhtml?c=121544&p=irol-newsArticle_Print&ID=1054822&highlight=, (accessed February 14, 2008).

[3] "U.S. Power Industry Sees Nuclear Renaissance Near," February 16, 2007, www.reuters.com/article/bondsNews, (accessed March 19, 2009).

to reduce carbon dioxide and greenhouse gas emissions, and turn to sources of electricity that were more environmentally friendly? After all, the belching smokestacks of coal-fired electric plants were nothing new, having been the target of air quality regulation enforcement of the 1970s. The discussion about climate change had been occurring for decades, and debates over ratification of the Kyoto Protocol and its mandatory limits on greenhouse gas production had occurred ten years earlier, in the mid-1990s. Those events did not spur any new reactor construction applications.

Likewise, foreign oil imports have been increasing since the 1950s, save for a brief period in the early 1980s.[4] Natural gas prices also have been fluctuating throughout the late 1990s and the 2000s. But again, no reactor applications followed directly from changes in either oil import level or gas prices.

What factor or combination of factors really motivated the interest in building new nuclear power units, as demonstrated by construction and operation applications submitted during 2007 and 2008? Was it truly due to concerns about the environment? Was it caused by a surge in demand for electricity fueled by an American lifestyle that relies on computers, computer games, electric coffee makers and can openers, large screen televisions, cell phones and digital cameras whose batteries need frequent recharging? Did increased reliance on computers in business and industry trigger the interest, or was it based on declining domestic oil production and related fears over national security (such as those that spurred interest in drilling in the Alaska National

[4]Energy Information Administration's Energy in Brief, "How Dependent Are We on Foreign Oil?" April 23, 2009, http://tonto.eia.doe.gov/energy_in_brief/foreign_oil_dependence.cfm, (accessed August 26, 2009).

Wildlife Refuge under President Bush)?[5] Or did something else generate the interest in commercial reactor construction in the U.S.?

It was the goal of this research to explore the answers to those questions and to develop a better understanding of why some utility companies and nuclear power plant operators in the United States chose to submit applications to build and operate new nuclear power plants. While the popular press and individual company annual reports could offer some insights, there have been no systematic investigations that posed one set of questions to the various companies about their rationale for submitting applications to the NRC. Nor has there been an attempt to appreciate the decisions in a broader context that includes the changes that have occurred in the nuclear industry since the accidents at Three Mile Island, PA and Chernobyl, Ukraine. This study has attempted to do just that.

[5] Bumiller, Elisabeth, and Jeff Gerth, "The Blackout: Legislation; Ambitious Bush Plan is Undone by Energy Politics," *The New York Times*, August 20, 2003, www.nytimes.com/2003/08/20/, (accessed August 26, 2009).

2.0 Methods

The research for this thesis consisted of four main parts: (1) A review of the history of the commercial nuclear power industry in the United States, with an eye toward the factors that have changed over time and could have spurred new interest in reactor construction, (2) Interviews with representatives of companies that had filed a completed combined construction and operating license (COL) application with the NRC, (3) A synthesis of the responses to the interview questions, and (4) Development of a theoretical framework that could be used to understand the decision-making process for building a new nuclear power facility in the United States.

The history of the nuclear power industry (Chapter 3) emerged from extensive reading of books written on the subject, including Fermi's *Atoms in the Family*; *Shouldering Risks* by Constance Perin; *Hostages of Each Other: The Transformation of Nuclear Safety Since Three Mile Island* by Joseph Rees; Cohn's well-known book, *Too Cheap to Meter*, and Nutall's recent volume *Nuclear Renaissance: Technologies and Policies for the Future of Nuclear Power*. Archived articles from *The New York Times*, *The Wall Street Journal*, *The Dallas Morning News*, *Newsweek*, and other print and on-line newspapers and magazines provided snapshots of particular incidents and events at the time of their occurrence. From technical journals, such as *Power Engineering*, *Nuclear News*, and *The Electricity Journal*, came industry analyses of the overall structure of the electrical generating industry as well as the prospects for a "nuclear renaissance." Transcripts of hearings before the Committee on Energy and Natural Resources of the U.S. Senate and the Subcommittee on Energy Conservation and Power of the U.S. House of Representatives furnished valuable insight into the arguments for and against changing the licensing process for new nuclear reactors, standardizing new reactor designs, and offering federal programs and providing federal funding to spur interest in new reactor construction. Technical data and historical information came from the internet sites of the American Nuclear Society, the Nuclear Regulatory Commission, the Department of Energy, the Energy Information Association, and other industry organizations.

Windows' Excel program was used to analyze and graph construction data. Least squares regression lines were added to Figures 1 and 2 to emphasize the upward inclination of the points with year or order of construction start. The regression line in Figure 3 shows the positive relationship between the reactor capacity (MW(e)) and construction time.

The historical context framed the questions written for the telephone interviews that followed. The questions were vetted through the Evergreen Human Subjects Review Process before being asked of members of the nuclear power industry. (See Appendix 8 for the list of questions.) Although the questions served as the foundation of each interview, some were omitted and others were added as each interview progressed. For example, if a company had not yet chosen a final design for their reactor, questions about the design were bypassed. In addition, time constraints limited the number of questions that could be asked in some cases. Most interviews lasted between 45 minutes and one hour.

The NRC's list of COL applicants served as the basis for finding interview candidates. Attempts to reach executives within the companies failed (phone calls were not returned); calls to the media/press departments did result in interviews with representatives from seven of the applicant companies: AmerenUE, Dominion, Duke Energy, Entergy, PPL, Progress Energy Florida, and the Tennessee Valley Authority (TVA).

Additional interviews related to specific areas of interest followed. Rick Grantom of the South Texas Project and David Lochbaum (then with the Union of Concerned Scientists) provided information about the Probabilistic Risk Analysis (PRA) now used in the industry; C.J. Fong of the NRC answered questions about how PRA is being incorporated into new reactor designs and licensing (see Chapter 3, Section 2, and Appendix VI). Hossein Hamzehee, also of the NRC, added to the historical review with his recollections of his days working at the Comanche Peak facility in Texas (Appendix 3), and Dr. John Bickel, who had worked at Millstone Unit 1 (Connecticut) and the NRC, did likewise with descriptions of the early years of the U.S. nuclear power industry (Chapter 3, Section 1).

Data from the discussions with company representatives were combined with information gleaned from annual reports, press releases, and other media reports to create a detailed picture of the many factors behind decisions to submit reactor construction applications to the NRC. First, a list of the most important factors was generated based on the interviews and readings. Next, those factors were grouped into broader categories, as described below.

1. Environmental (including concerns over climate change, carbon dioxide emissions, or the potential for regulation or taxing of those emissions);

2. Issues related to National Energy Security and the need to find domestic sources of energy;

3. Financial matters, divided into three subcategories—the potential to secure Federal Loan Guarantees or Production Tax Credits, and the Ability to Recoup Costs During Construction;

4. Other regulatory factors related to new nuclear power plants: Risk Insurance, Price Anderson Insurance Backing, and the new One-Step Licensing Process;

5. Meeting Demand, in terms of either the need for more baseload generation or renewable sources not being capable of supplying enough electrical power;

6. Fuel-related factors—the Need for Fuel Diversity (not relying solely on coal or natural gas or hydroelectric power), the Cost of Alternative Fuels;

7. Past Experience with Nuclear Reactors; and

8. Other.

In the third step of this process, the interview transcripts and printed documents were coded according to the factors mentioned. If the transcript or document discussed material under one of the above categories one or more times, it received a checkmark for that category. Because of the exploratory nature of this research, the focus was not on the precise number of times each reason was mentioned, but rather on the variety of reasons cited for each applicant company. Thus, each interview or document might receive check marks for several categories but only once for any given category. For example, if an article revealed a company's concerns over emissions from their coal-fired electric plants as a factor in the choice of nuclear power, and later discussed the CEO's anxiety over potential cap and trade legislation, that article would receive only one check for the Environmental category. Finally, the results for all companies were summarized in a table (see Table 3).

An attempt to provide a cohesive framework for the results let to an examination of theories from the Business Strategy and the Economics literature (briefly reviewed in Chapter 5), but neither could explain the many different reasons behind a decision to seek a COL from the NRC. Further research revealed the ideas of Political Ecology as encompassing the breadth of factors uncovered in this research.[6] In particular, the model advanced by Dr. J. H. Perkins in *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War* demonstrated how the choice of technology mediates between human wants and needs and the natural environment and natural resources.[7] That model was adapted to the nuclear power industry, an industry that must respond to people's demand for electricity while searching for ways of generating electricity that have less of an impact on the natural environment.

In the sections that follow in this thesis, the first part of Chapter 3 discusses in more detail the historical context of the first round of nuclear reactor construction in the United States (that is, reactors planned and ordered before 1980). The second section of that chapter reviews the changes that have occurred since that time. Chapter 3, Section 3 gives details about the Federal Loan Guarantee program as set forth in the Energy Policy Act of 2005. Chapter 4 recounts the results of the interviews with company representatives and the final chapter of this thesis explains the theoretical framework developed to better understand the complexity of factors considered by utilities and nuclear power companies when deciding to build a new nuclear plant.

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[6] Political Ecology adopts a multi-disciplinary approach to explore the conflicts between people, their productive activities, and nature, and the influence of cultural and political activity on all three. It stresses the interconnections of the historical, political, economic, social, and biophysical contexts of environmentally-based problems.

[7] John H. Perkins, *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War*, New York, NY: Oxford University Press, 1997.

3.0 Nuclear Power Then and Now

Ren·ais·sance: n. A rebirth, revival; a renewal of life, vigor, interest.

Since the early 1990s, the popular press has been hinting at a renaissance in nuclear power plant construction to meet the growing demand for electricity in the United States.[8] With over 60 % of the U.S. population under the age of 44 and thus too young to remember the first wave of nuclear reactor construction building ("Census 2000 Summary File (SF 1) 100-Percent Data: QT-P1. Age Groups and Sex: 2002,"), it behooves us to revisit the context in which those original decisions were made and to understand what has changed since then—to appreciate the "nuclear renaissance."[9] Words from President Dwight D. Eisenhower's 1953 speech to the United Nations resonate even today: "The atomic age has moved forward at such a pace that every citizen of the world should have some comprehension, at least in comparative terms, of the extent of this development, of the utmost significance to every one of us."[10]

The first section that follows will highlight some of the important elements that supported the decisions to construct nuclear power plants in the U.S. in the 1960s and 1970s. The second section will review how that situation has changed and why the time may be ripe for another round of nuclear power plant construction in the 2010s.

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[8] Barrie McKenna, "Nuclear 'Renaissance' Seen Following Latest AECL Deal," *The Globe and Mail*, September 19, 1992, p. B2; "Nuclear Option Cannot Be Denied," *San Antonio Express-News*, May 30, 1991, p. 1; "Go Slow on More Nuclear Power Plants," *U.S.A. Today*, April 16, 1990, p. 08A.

[9] "Census 2000 Summary File (SF 1) 100-Percent Data: QT-P1 Age Groups and Sex: 2000," http://factfinder.census.gov, (accessed 9/28/08).

[10] "Atoms for Peace, Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly," www.iaea.org/About/history_speech.html, (accessed September 29, 2008).

3.1 That Was Then: Understanding the Early Years of the U.S. Commercial Nuclear Industry[11]

> 'The Italian Navigator has reached the New World.'
> 'And how did he find the Natives?'
> 'Very friendly.'

With those simple yet powerful words, Professor Arthur Compton communicated to his colleagues that the unthinkable had been accomplished.[12] On December 2, 1942, Enrico Fermi, an Italian émigré, and his team had succeeded in creating a self-sustained nuclear reaction at a makeshift reactor (or "pile") in a squash court under the stadium at the University of Chicago.[13] Twenty-five feet wide and 20 feet high, moderated by graphite and controlled using cadmium rods, the reactor only produced a half-watt of power.[14] But it ushered in a new age, an age in which the tiny nucleus of a uranium atom could be harnessed to provide the energy for modern life.

3.1.1 The Atomic Energy Commission (AEC)

During the balance of World War II, focus shifted to the construction of nuclear weapons. Then, in 1946, Congress passed the Atomic Energy Act, establishing the Atomic Energy Commission (AEC) to oversee the peacetime uses of nuclear power in the

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[11] Note: In its early years, nuclear energy was widely referred to as "atomic" energy. However, to be consistent throughout this document, I will use terms such as nuclear power, nuclear energy, and nuclear technology except in the case of direct quotes.

[12] Laura Fermi, *Atoms in the Family: My Life with Enrico Fermi*, Chicago, IL: The University of Chicago Press, 1954. p. 198.

[13] Ibid, p. 197; Enrico Fermi, "The Development of the First Chain Reacting Pile," Symposium on Atomic Energy and its Implications, November 17, 1945, Freeport, NY: Books for Libraries Press, 1969, pp. 20 – 24.

[14] "Chicago Pile One (CP-1)," http://www.atomicarchive.com/Photos/CP1/index.shtml, (accessed February 3, 2009).

United States. The AEC was charged with formulating policies for nuclear energy, conducting research and development, encouraging the commercial use of nuclear energy for electrical generation, regulating its safety, and ensuring the safety of the American public.[15] Although established as a civilian group and not an arm of the military, the AEC could not escape its military roots: The initial post war plans centered on developing dual-purpose military-civilian reactors and reactor powered U.S. Navy submarines (under Captain Hyman G. Rickover) and Air Force jets.[16]

The AEC realized that achieving a competitive nuclear power industry was of national importance, to maintain U.S. technological superiority, to give the U.S. advantage in bargaining with other nations, and to assure a supply of uranium ores from foreign countries who looked to the United States for nuclear power technology.[17] But how could the AEC involve industry in the development of nuclear power without divulging military secrets? To what degree should the government finance the projects, if at all? Who would own the reactors and the fissionable material they contained? And was industry willing and able to take the lead in reactor development?

In the summer of 1953 the AEC decided that using a variation of the pressurized water reactor of the naval propulsion systems would be its quickest path to designing a

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[15] Steven L. Del Sesto, *Science, Politics, and Controversy: Civilian Nuclear Power in the United States, 1946 – 1974*, Boulder, CO: Westview Press, 1979; Steve Cohn, *Too Cheap to Meter: An Economic and Philosophical Analysis of the Nuclear Dream*, Albany, NY: State University of New York Press, 1997.

[16] Richard G. Hewlett, and Jack M. Holl, *Atoms for Peace and War, 1953 – 1961: Eisenhower and the Atomic Energy Commission*, Berkeley, CA: University of California Press, 1989, p. 188.

[17] Ibid, pp. 23 and 194.

full-scale commercial power reactor.[18] That winter, the Commission invited industry members to submit proposals to participate in a project to create and operate that reactor as part of a five-year program.

3.1.2 Peaceful Power from Atomic Energy

Representatives of world powers gathered at the United Nations in December of 1953 to discuss the spread of nuclear weapons and the threat that they posed to human lives. In the speech now known as "Atoms for Peace", Dwight D. Eisenhower proposed that the build-up of nuclear weapons be reversed, that uranium and fissionable material be controlled by a central, international agency, and that efforts be devoted to peaceful uses of nuclear power. "[P]eaceful power from atomic energy is no dream of the future. The capability, already proven, is here today." He suggested that nuclear energy be applied "to the needs of agriculture, medicine and other peaceful activities. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world."[19] These words signaled two significant post-war features of the use of nuclear technology. First, nuclear power would be directed toward generation of electricity not weapons, and second, an international body would be created to oversee the exchange of information, technology, and materials. That body would be a clearinghouse, with membership open to all nations, but would not have the authority to conduct or support nuclear projects of its own.[20]

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[18] Ibid, p. 192.
[19] "Atoms for Peace, Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly."

[20] Hewlett and Holl, p. 217.

After "Atoms for Peace", the AEC shifted its focus from dual-use military/civilian nuclear reactors to the development of full-scale reactors for electricity production. Pressure mounted to find reactors that could be deployed quickly as reliable power sources. Economics were not of paramount concern.[21] With electricity production foremost in its mind, the AEC supported development of a number of different reactor designs and technologies, believing that the diversity would result in important comparative data that could be used for decision-making when it came time for actual construction.[22] Unfortunately, most of the data was gathered on small-scale laboratory prototypes. Extrapolations from that data proved overly optimistic.

The year 1953 also saw the shift to private ownership of nuclear reactors.[23] The AEC maintained ownership of the nuclear fuels, leasing them out to reactor owners. The lease arrangement lasted until the passage of the Private Ownership of Special Nuclear Fuels Act in 1964.[24]

3.1.3 Insurance Coverage Through the Price-Anderson Act

Although the government, after much debate, backed the fledgling nuclear industry financially, few insurers were willing to underwrite the construction and operation of nuclear power plants. The risk was too great. Congress intervened with the passage of the Price-Anderson Indemnity Act of 1957. The Act required that all nuclear licensees carry the maximum level of primary insurance available to them (determined to

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[21] Steve Cohn, *Too Cheap to Meter: An Economic and Philosophical Analysis of the Nuclear Dream*, Albany, NY: State University of New York Press, 1997.

[22] Steven L. Del Sesto, *Science, Politics, and Controversy: Civilian Nuclear Power in the United States, 1946 – 1974*, Boulder, CO: Westview Press, 1979.

[23] Ibid, p. 54.

[24] Ibid, p. 84.

be about $60 million). The government committed to contribute $500 million to cover any claims in excess of that insurance amount. The 1975 extension of the Act replaced the government funding with a pool of funds to which each licensee was required to contribute. Those funds then would be available to provide "prompt and orderly compensation" if members of the public or their property were to be harmed by a nuclear incident (whether due to an accident at a power plant or a test or research reactor, or during the transport of fuel to or from those facilities). The Act provided essential protection for the suppliers to and operators of nuclear facilities, limiting the extent of their liability in the event of a nuclear incident to the $60 million in required insurance plus their contribution to the industry pool. It also safeguarded the public by forcing those suppliers and operators/utilities to carry insurance rather than allowing them to resort to filing bankruptcy in the face of accident claims (which would, in essence, have forced taxpayers to pay for any damages). Based on assessments of the time, the known risks were covered.[25]

3.1.4 Problems in Licensing and Construction

The AEC was unprepared for the complexity of the task it faced when commercial reactor license applications began arriving in the early 1960s. The AEC had yet to establish general construction and safety guidelines for nuclear power plant construction. As a result, each application required careful attention since architects and

[25] "The Price-Anderson Act: Background Information," American Nuclear Society, November 2005, www.ans.org, (accessed July 2, 2008); "Price-Anderson Act of 1957, United States," http://www.eoearth.org/article/Price-Anderson_Act_of_1957,_United_States, (accessed September 29, 2008); "Price-Anderson Nuclear Indemnity Act," http://www.absoluteastronomy.com/topics/Price-Anderson_Nuclear_Industries_Indemnity_Act, (accessed May 16, 2009).

engineers tailored each reactor design to specific electrical power needs and site characteristics. All elements of the proposals were new and untested.

Following a safety evaluation, environmental impact review, antitrust inquiries, and public hearings, the AEC issued a construction permit.[26] Later, when a plant had been almost entirely completed, and after another public hearing, the AEC could issue an operating license. For the first 10 to 12 commercial reactors (including Dresden 2, Millstone 1, Oyster Creek, Palisades, and Pilgrim 1 (various AEC documents)), the AEC chose to distribute "provisional" operating licenses. The AEC realized it did not yet have the experience or technical information to know which designs were "good" or safe enough, nor did they have a set of regulations to ensure the facilities would pose no undue risk to the public.[27] By issuing a provisional license, the AEC allowed a plant to start commercial operation but maintained the right to return and request changes and upgrades to meet evolving criteria. Even plants that did receive a full-power operating license from the AEC found themselves faced with amendments to those licenses for the redesign or rebuilding of systems to meet new criteria. This licensing process (often called the "two-step" licensing process) resulted in schedule delays and cost overruns as requirements continued to change and disrupt construction.[28] For example, the 1975

[26] "Our History: Atomic Energy Commission," www.nrc.gov/about-nrc/history.html, (accessed July 2, 2008).

[27] John H. Bickel, Evergreen Safety and Reliability Technologies, LLC, Evergreen, CO, Telephone Interview of March 16, 2009.

[28] Richard Meserve and Ernest Moniz, "The Changing Climate for Nuclear Power in the United States," *Bulletin of the American Academy of Arts and Sciences*, Vol. 55, No. 2, Winter 2002, pp. 57 – 72: Rebecca Smith, "Politics and Economics: New Hurdle for Nuclear Plants; Licensing System Seen by Utilities as Too Slow Amid Rush for Supply," *The Wall Street Journal*, October 15, 2007, p. A.8.

Browns Ferry Al fire, spurred new regulations for fire protection (10 CFR 50, App. R), and a critical accident at Three Mile Island, PA in 1979 both led to revised safety requirements and rework for all plants not yet completed. In addition, the 1986 fire and explosion at the Chernobyl Nuclear Station in Ukraine led to increased scrutiny of safety and emergency response plans.[29]

Unfortunately, each additional *month* of construction cost the utilities between $23 million and $35 million (1980 dollars) in interest costs alone for plants whose total costs had been estimated back in 1974 at about $775 million.[30] The two-step licensing process also allowed nuclear opponents ample opportunity to delay work on a reactor through litigation and even block the operation of a completed plant that had not yet received an operating license, as in the case of the Shoreham plant on Long Island, NY.[31] As time progressed, the backlog at the AEC grew, and construction costs and durations continued to climb.

Figures 1 and 2 show the trend of increasing construction time the later in the queue the start of the reactor construction. (Note: Data are for units still in service as of this writing.) Figure 1 displays a positive association between the year the construction license was granted (between 1964 and 1979) and the time from issuance of that license

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[29] Diamond Stuart, "Chernobyl Causing Big Revisions in Global Nuclear Power," *The New York Times*, October 27, 1986; Diamond Stuart, "How Chernobyl Alters the Nuclear Equation," *The New York Times*, May 25, 1986, p. A1.

[30] David Real, "Hearings Crucial to N-Plant, At Stake: Licenses for Comanche Peak," *The Dallas Morning News*, September 23, 1984, p. 37a; David Real, "Cost Estimate Raised for Comanche Peak," *The Dallas Morning News*, November 19, 1985, p. 1A; Matthew L. Wald, "Building Reactors the New Way," *The New York Times*, July 17, 1989, p. D.1.

[31] Matthew L. Wald, "Shift Seen on Reactor Licensing," *The New York Times*, March 25, 1989, p. 1.33.

and the reactor operation: the later the NRC issued the license, the longer it took to begin generating electricity at the reactor.

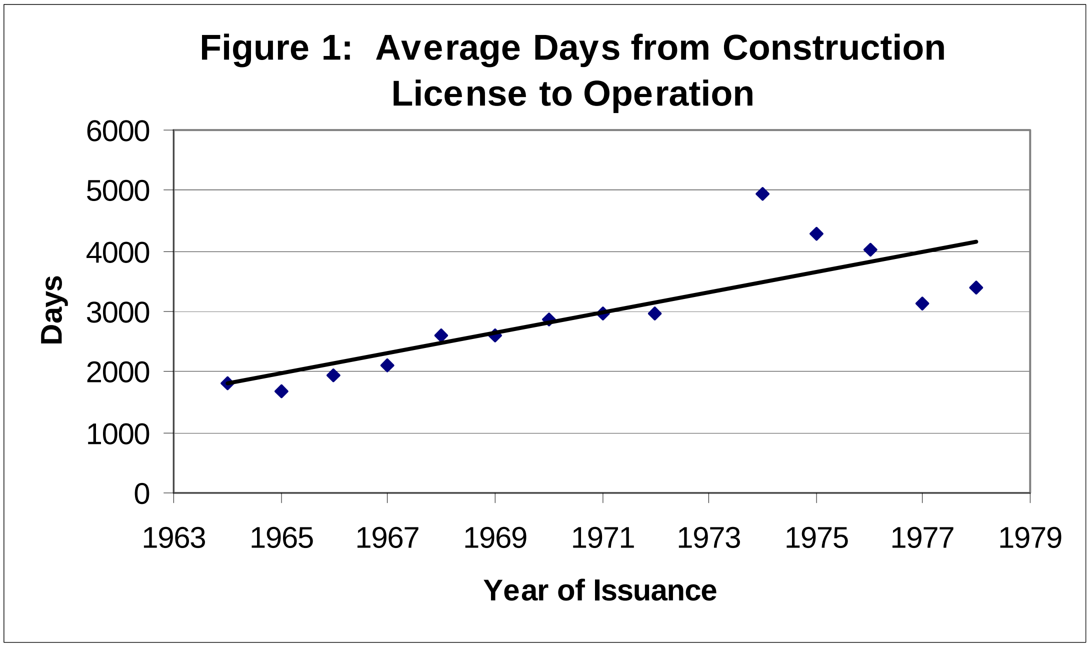

Figure 1: The Average Days from Construction License Issuance to Reactor Operation
Based on Data from the U.S. NRC *Information Digest, 2007 – 2008*
(Least squares regression line added.)

Figure 2 shows a similar relationship between the days between license issuance and operation, and the order in which the license was issued. The later the NRC issued the reactor construction license, the longer it took to achieve operating status.

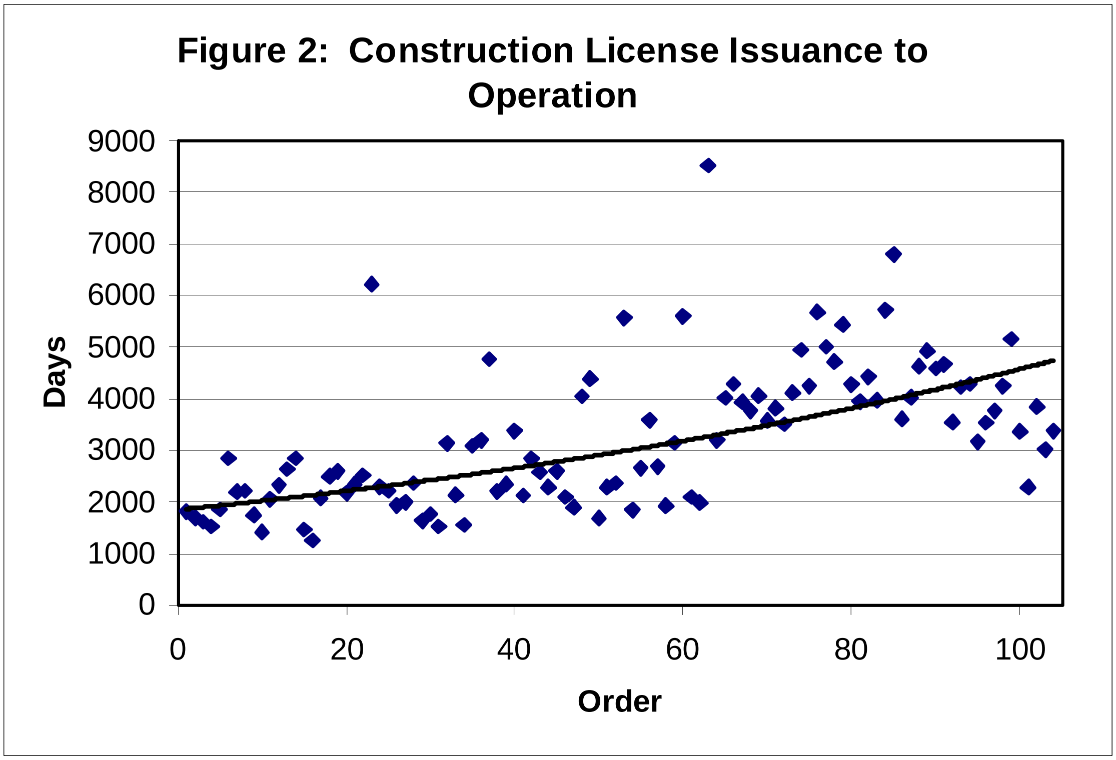

Figure 2: Construction Start Order versus Days from Construction License Issuance to Reactor Operation
Based on Data from the U.S. NRC *Information Digest, 2007 – 2008*
(Least squares regression line added.)

In addition, Figure 3 below indicates the positive relationship between the size of the reactor unit (its capacity in MW(e)) and the construction time.

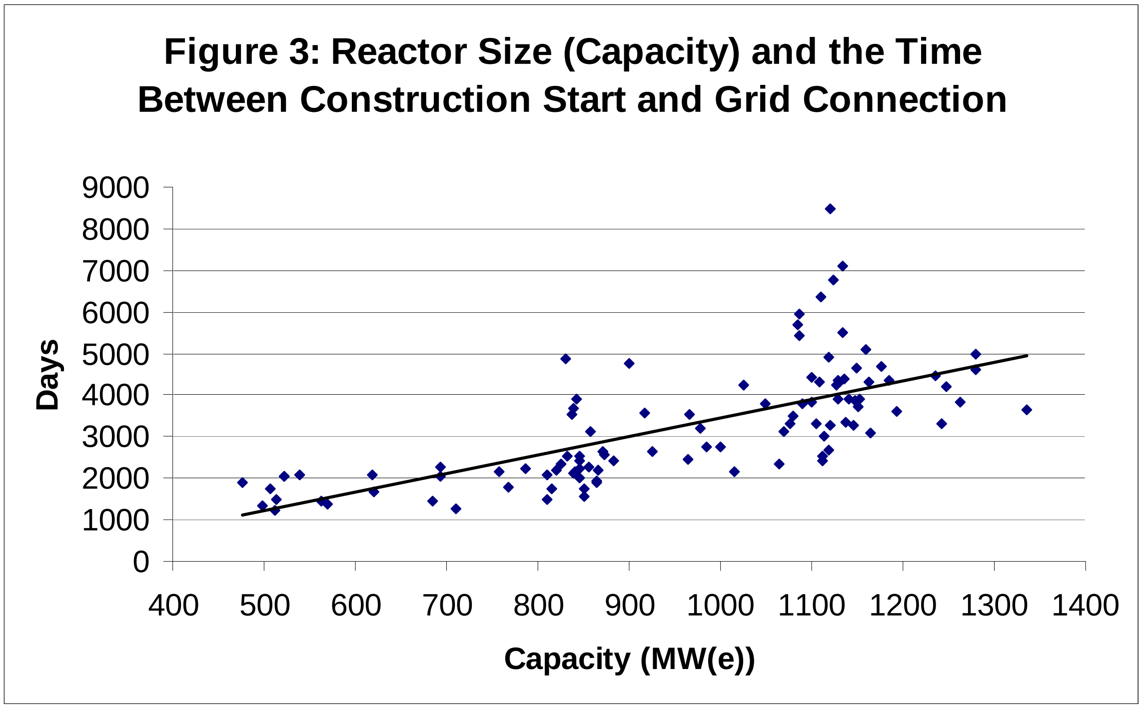

Figure 3: Reactor Size (Capacity) and the Time Between Construction Licensing and Reactor Operation
Based on Data from the U.S. NRC *Information Digest, 2007 – 2008*
(Least squares regression line added.)

A series of multiple regression analyses conducted specifically for this thesis demonstrated that three variables accounted for 65% of the variation in the time between issuance of a construction license and beginning operations (adjusted $R^2 = 0.651$, p value < 0.0001): (1) Reactor capacity, (2) If operations began after the Three Mile Island (TMI) accident in 1979, and (3) If the utility built a Westinghouse designed nuclear reactor system. See Table 1.

	Regression Coefficient
Reactor Capacity (MW(e))	2.22
Pre (1) / Post (0) TMI	-1317.98
Westinghouse Design (Y = 1 / N = 0)	391.6
Adjusted R2	0.65
p - value	< 0.0001

Dependent Variable = Time between issuance of a construction license and beginning operations

Table 1: Least Squares Linear Regression

Adding a variable for the region of the country in which the reactor was located (corresponding to the NRC regional divisions) did not change the explanatory value of the regression model. Dividing the sample into two smaller ones, the first containing reactors that began operations before TMI and the second only those that began operations afterward, yielded somewhat different regression results. In both cases, the variable for reactor capacity is statistically significantly related to the time between the construction license and operations. Before TMI, a utility's choice of Bechtel as architect/engineer is negatively and somewhat significantly related to construction time (p-value = 0.075), whereas after TMI, having a Westinghouse reactor design resulted in a longer construction time (p-value = 0.078). What might be lurking behind these results?

Bechtel took an early lead in the commercial nuclear power industry in the late 1950s with its role in the construction of General Electric's Boiling Water Reactor, Dresden 1, in Illinois.[32] However, by the early 1960s, companies like Westinghouse and General Electric (GE) began offing their clients something Bechtel could not--turnkey contracts. Westinghouse and GE could perform the engineering, manufacture the

[32] "1945 – 1959: Bringing Energy to the World," http://www.bechtel.com/BAC-Chapter-3.html, (accessed May 4, 2009).

turbines and generators, and build the facilities. Bechtel often became a subcontractor. About half of Bechtel's nuclear reactor jobs came from utilities hoping to build Westinghouse or GE designs; the other half used Babcock and Wilcox or Combustion Engineering designs. (In contrast, over 85% of the jobs for other architect/engineering firms called for Westinghouse or GE reactors.) The Bechtel reactor projects tended to be slightly smaller than the average (797 MW(e) versus 818 MW(e)) and took less time to construct (2032 days versus an average of 2263 days). Those factors could lead to the negative relationship observed in the regression analysis.

Over half of the reactors constructed after Three Mile Island used a Westinghouse designed nuclear system. That alone could explain the positive relationship between Westinghouse and the time between issuance of the construction license and reactor operation. In addition, Westinghouse was associated with several very problematic projects of that period: Comanche Peak 1 and 2 (TX), Diablo Canyon 1 and 2 (CA), Seabrook Station (NH), and Watts Bar 1 (TN). Discovery of an earthquake fault near the Diablo Canyon site slowed construction there as the facility design had to be modified to meet new seismic standards. Quality assurance issues during construction led to a shutdown at the Watts Bar site. Concerns over construction practices and lawsuits from local citizens and environmental groups plagued Comanche Peak. (See Appendix 3 for more details on these and two other projects with extremely long construction times.) Thus, factors outside of direct Westinghouse control and not the Westinghouse design itself often delayed bringing reactors on line.

In the end, the one factor that stands out as affecting the time it took to construct nuclear power plants is the size (capacity) of the reactor. Whether examining the entire sample of facilities or for smaller sub-samples of them, the larger the nuclear reactor, the longer it took to build.

3.1.5 Challenges in Operations

Once the new nuclear powered electric generating plants came on line, they were manned by operators who lacked experience. Most came from coal or natural gas plants. According to a former CEO of Detroit Edison (owner/operator of the Enrico Fermi facility), "No one foresaw the complexity of the modern-day nuclear power operations . . . The feeling was that this new technology would just replace the boiler in a coal-fired plant. The immense difference between running a nuclear plant and a conventional plant was never dreamed of."[33] Operators often treated the new facilities just as they had the old fossil fuel plants, running them until they broke, waiting to do maintenance until things "just didn't work any more."[34] That approach contributed to long periods of shutdown for repairs, low levels of reactor availability (measured by capacity factors), and high costs for the electricity that did get produced.

In addition, for 65 sites still existing today from that first round of construction, there were 53 original ownership groups (utilities or power consortia). (See Appendix 1.) The multi-site owners included companies like Commonwealth Edison, with reactors at five locations, and Duke Energy with three different sites. However, most reactor construction was undertaken by local utilities with their own particular needs, requirements, and preferences. Consider the reactors constructed in New York in the

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[33] Perin, Constance, *Shouldering Risks: The Culture of Control in the Nuclear Power Industry*, Princeton, NJ: Princeton University Press, 2006, p. 1.

[34] Rees, Joseph, *Hostages of Each Other: The Transformation of Nuclear Safety Since Three Mile Island*, Chicago, IL: University of Chicago Press, 1996. pp. 21-24; Perin, p. 3.

1960s. Niagara Mohawk Power chose a 825 MW(e) General Electric (GE) Boiling Water Reactor for their Fitzpatrick site while Mohawk Power built a 621 MW(e) GE Boiling Water Reactor. Rochester Gas and Electric selected a 498 MW(e) Westinghouse Pressurized Water Reactors for R.E. Ginna, Consolidated Edison constructed a 965 MW(e) Westinghouse reactor for Indian Point, and the New York Power Authority built a 985 MW(e) Westinghouse Pressurized Water Reactor at that same site. The wide diversity of ownership and goals deterred sharing of knowledge gained during construction or information about best practices once the reactors became operational.

The results of inexperience in building and operating reactors can be seen below in Figure 4, Capacity Factors for Operating Reactors in the U.S. (Note: The Nuclear Regulatory Commission defines the capacity factor for a nuclear reactor as the ratio of the energy a reactor has actually produced to the energy that could have been generated at continuous full-power operation during the same period. The lower the capacity factor, the lower the electrical output of a reactor.[35]) The average capacity factor hovered around 60% for the first few decades of reactor operations. It was not until the early 1990s that reactor capacity factors began to increase, a full twenty years after the first reactors came on line. And, a part of that increase can be attributed to factors other than increased experience with reactor operations. For example, as a result of Probabilistic Risk Assessments of the early 1990s, the NRC began allowing reactors to continue operating rather than shutting down during routine maintenance activities.[36] Keeping a reactor on line increases its energy output and thus the capacity factor.

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[35] "Capacity Factor-Net," http://www.nrc.gov/reading-rm/basic-ref/glossary/capacity-factor-net.html, (accessed January 29, 2009).

[36] Dana Kelly, Idaho National Laboratory, Conversation of January 30, 2009.

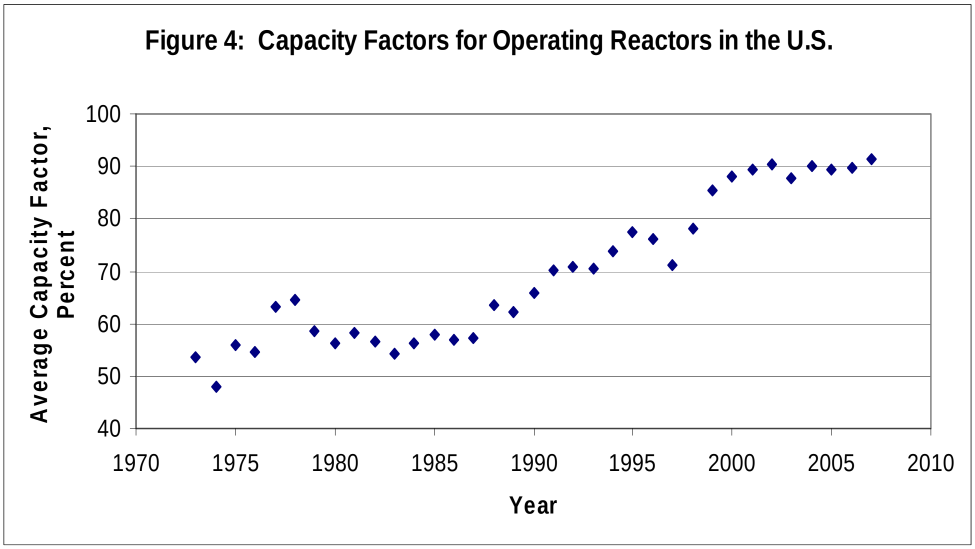

Figure 4: Capacity Factors for Operating Reactors in the U.S., 1970s to the Present Data Source: "Nuclear Power Plant Operations, 1957 - -2006," from the Energy Information Administration

Figure 5 contains the numbers of unplanned reactor shutdowns of six months or more, by year, per plant. Such shutdowns reflect time the reactor was out of service for issues not related to planned maintenance, modifications, or refueling. Dividing by the number of plants in operation at year-end eliminates variations due to the number of plant openings and closures. According to Nils J. Diaz, former Chairman of the NRC, unplanned shutdowns of the early 1980s resulted from material degradation problems and post-Three Mile Island regulatory actions.[37] In the mid-80s, a push to increase reactor capacity and the need to amend reactor operating licenses led to an increase in shutdowns. By the late 1980s and early 1990s, design issues and material degradation were the primary issues. In addition, of the unplanned shutdowns since 1979 that lasted

[37] Nils J. Diaz, "Excellence in Safety Management (Ensuring the Assurance of Adequate Protection and Enhancing Public Confidence)," Speech Before the Institute of Nuclear Power Operations, Atlanta, GA, November 3 – 4, 2004, *NRC News*, No. S-04-018, U.S. Nuclear Regulatory Commission, Washington D.C.

more than one year, about 50% resulted from design or licensing related issues. Thus, particularly in the early years of the industry, inexperience with reactor designs and with the potential range of problems that could result from increased reactor usage led to lost power production.

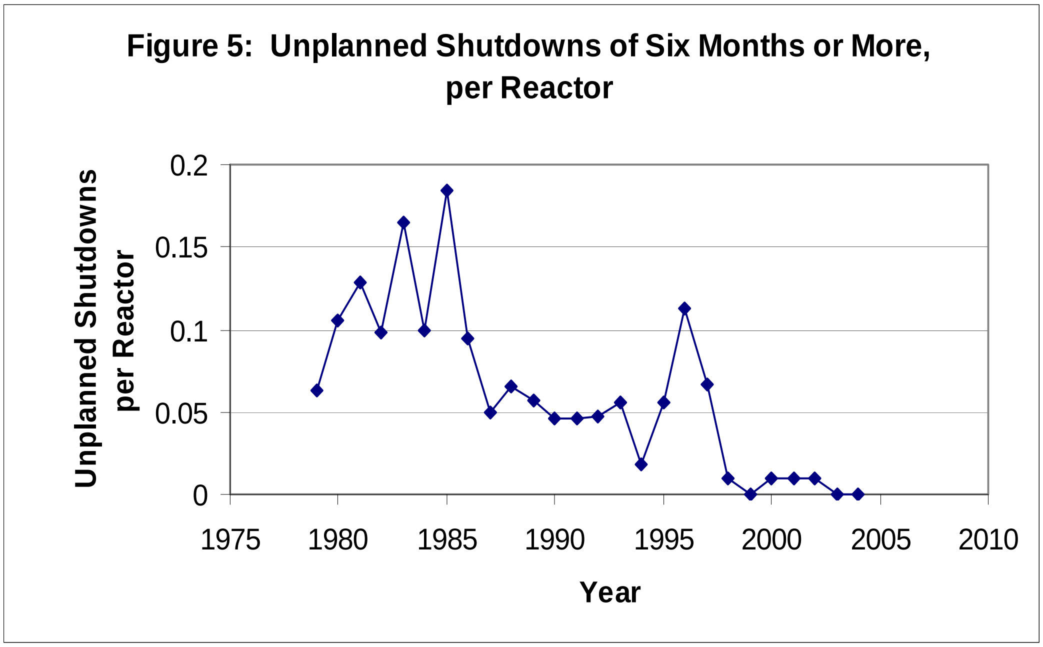

Figure 5: Unplanned Reactor Shutdowns Lasting More than Six Months
A Look Back
Based on Data from Diaz, PowerPoint of November 3, 2004

3.1.6 Changes in the Environmental and Energy Contexts

Two additional factors shaped the first wave of nuclear power plant construction in the United States. First, in 1963 the initial version of the Clean Air Act was enacted under the auspices of the U.S. Public Health Service. Under this Act, the federal government began to implement and enforce regulations setting limits on certain air pollutants known to affect human and environmental health.[38] Initially, the act focused on sulfur dioxide and nitrous oxide, chemicals known to react with water to form particles know as "acid rain."[39] In later years it expanded its purview to include particulates (soot, smoke), ground level ozone (smog), carbon monoxide, sulfur and nitrogen oxides, and lead.[40] These subsequent versions of the Act gave the Environmental Protection Agency (EPA), established in 1970, the authority to police the emissions coming from chemical plants, steel mills, utilities, and manufacturing facilities, and to levy fines and require equipment modifications to bring operations into compliance with EPA emissions standards. Electric utilities felt increasing pressure to clean up their operations, either by retrofitting their plants with often-costly pollution control equipment or by investing in electrical generating technology that utilized fuels with lower levels of pollution, such as nuclear power.

The energy crisis of the early 1970s and resultant prices of fossil fuels also spurred the nuclear reactor construction boom. At the time, electric producers were switching away from coal, to oil and natural gas, due to increased costs of mining, transportation problems, and waste, environmental and emissions issues associated with mining and processing coal.[41] That put a drain on domestic oil reserves. The Middle

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[38] "Understanding the Clean Air Act," www.epa.gov/air/caa/peg/understand.html, (accessed June 23, 2008).

[39] W. J. Nutall, *Nuclear Renaissance: Technologies and Policies for the Future of Nuclear Power*, London, England: Taylor and Francis, 2004.

[40] "Cleaning Up Commonly Found Air Pollutants," http://www.epa.gov/air/caa/peg/cleanup.html, (accessed June 23, 2008).

[41] Paul W. McCracken, "The Energy Crisis," American Enterprise Institute Roundtable of September 25-27, 1973, Washington D.C.: American Enterprise Institute for Public Policy Research, 1974. p. 7.

East Oil Embargo of 1973-74 compounded those shortages.[42] The world price of oil shot up from almost $14 (all fuel cost figures given in 2008 dollars) per barrel in 1970 to over $42 per barrel by January of 1974—an over 200% increase.[43] (See Figure 6.) Oil prices peaked again in the late 1970s and early 1980s, mainly as a result of the Iranian Revolution (resulting in the ouster of the Shah, who had had close ties to American Oil Companies, and the loss of two to 2.5 million barrels of oil per day).[44]

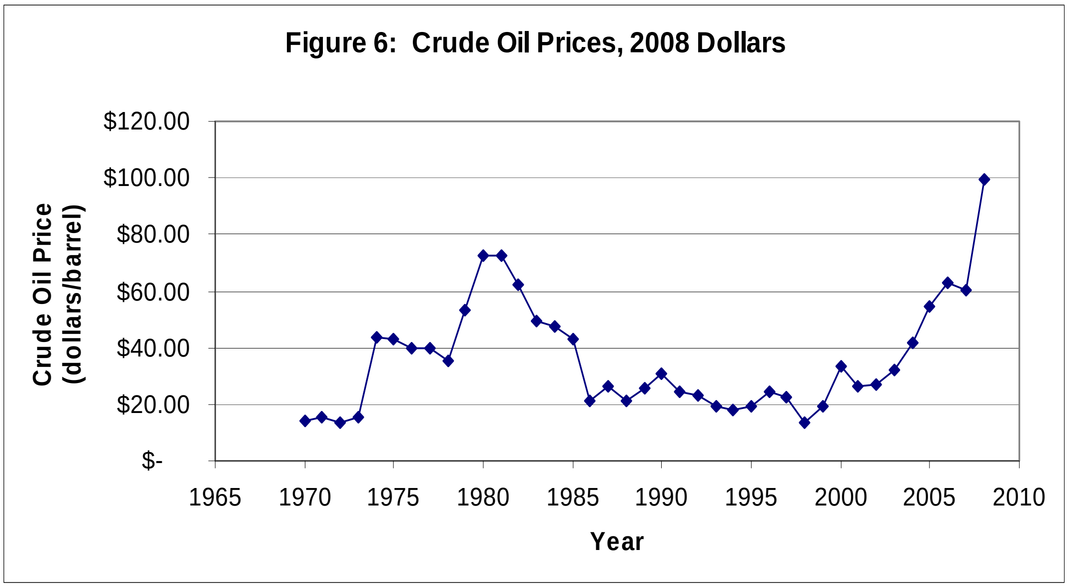

Figure 6: U.S. Crude Oil Prices, 1970 to 2008
Based on Data From "Crude Oil Prices, 2006 Dollars"

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[42] During the embargo, Arab members of the Organization of the Petroleum Exporting Countries (OPEC) stopped shipping oil to the United States and the Netherlands due to their support of Israel during the "Yom Kippur" War with Egypt in October of 1973. (Greg Burt, "The Arab Oil Embargo: What Happened and Could it Happen Again?' August 9, 2009, http://www.heatingoil.com/wp-content/uploads/2009/09/the_arab_oil_embargo.pdf, (accessed December 20, 2009).

[43] "Crude Oil Prices, 2006 Dollars," www.wtrg.com/oil_graphs/oilprice1970.gif, (accessed May 3, 2009).

[44] "The Iranian Revolution," http://www.wsu.edu/~dee/SHIA/REV.HTM, (accessed December 20, 2009); "The Iranian Revolution: King Pahlavi (the Shah) against Dissent," http://www.fsmitha.com/h2/ch29ir.html, (accessed December 20, 2009); "Oil Price History and Analysis," http://www.wtrg.com/prices.htm, (accessed December 20, 2009).

Prices for natural gas also increased in the 1970s and 1980s as a result of the energy crisis and of utilities changing their fuel source from oil to gas (Figure 7). In January of 1976, 1000 cubic feet of natural gas cost $0.54; by 1983, that price was up almost 400% to $2.66.[45] Even the real U.S. coal prices rose just over 75%, from $29 per short ton in 1973 to almost $53 by 1978.[46]

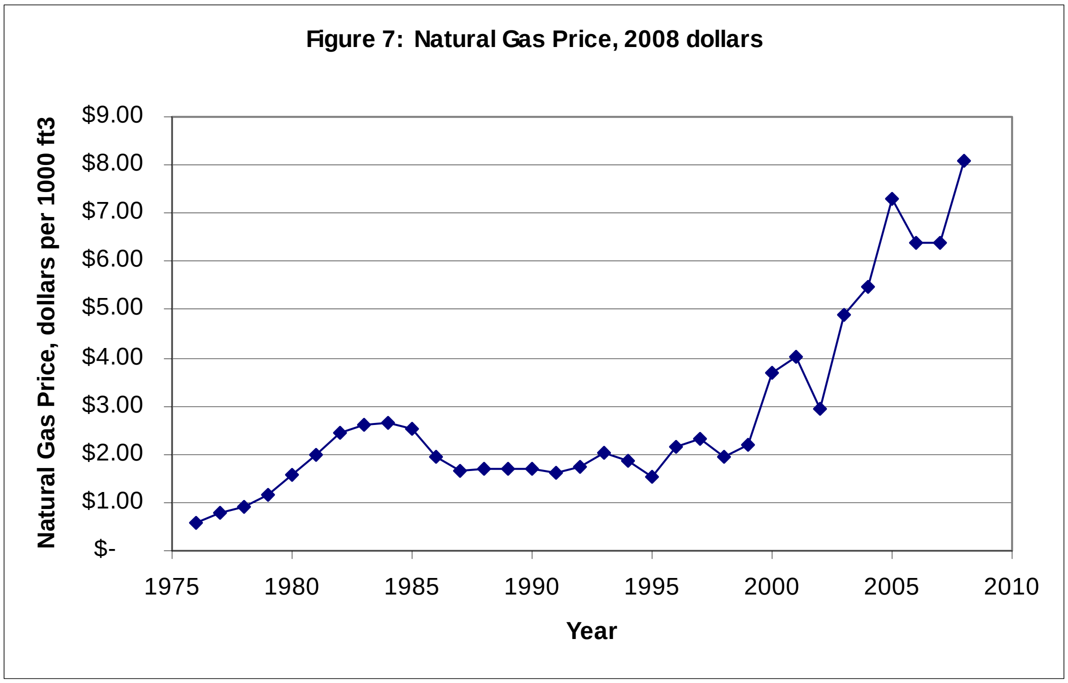

Figure 7: U.S. Natural Gas Prices, 1970s to the Present
Based on Data From "Natural Gas Navigator: U.S. Natural Gas Wellhead Price (Dollars per Thousand Cubic Feet)"

[45] "Natural Gas Navigator: U.S. Natural Gas Wellhead Price (Dollars per Thousand Cubic Feet)," http://tonto.eia.doe.gov/dnav/ng/hist/n9190us3m.htm, (accessed October 10, 2008).

[46] "Table 7.8: Coal Prices, 1949 – 2008," Annual Coal Report of the Energy Information Administration, http://www.eia.doe.gov/emeu/aer/txt/stb0708.xls, (accessed May 14, 2009).

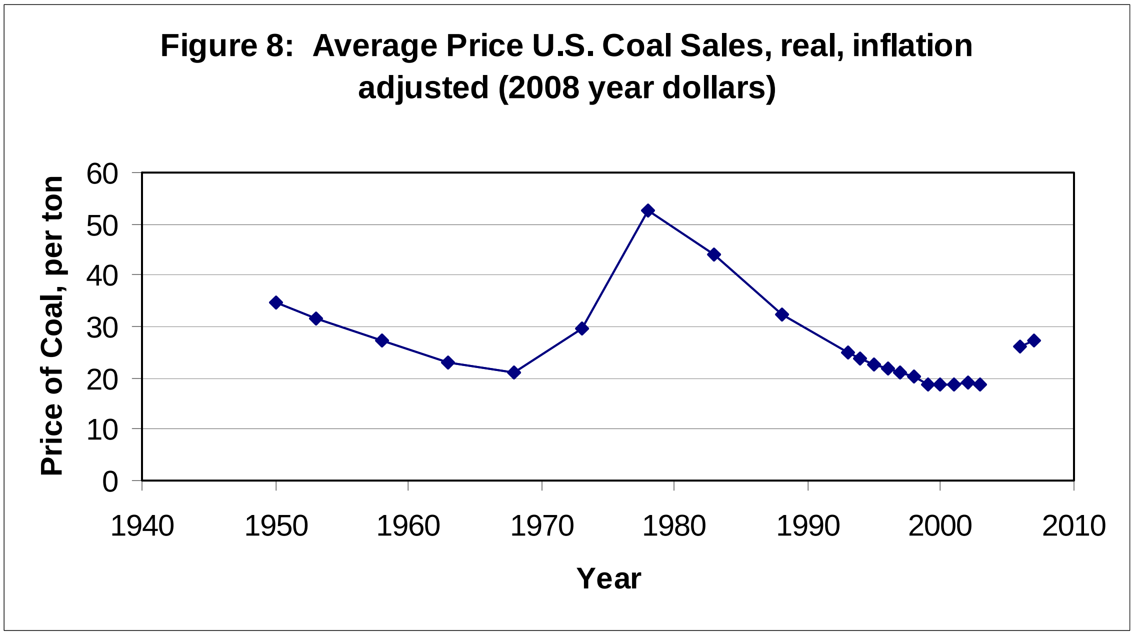

Figure 8: Historic U.S. Coal Prices
Based on Data From the Annual Coal Report of the Energy Information Administration

It is difficult to directly compare the cost per kilowatt-hour of electricity generated by coal, natural gas, oil, and nuclear power due to a myriad of factors including the distance the fuel must be transported, the quality of the fuel, and whether or not the power plant is operated to supply base load capacity, and whether nuclear power costs include future decommissioning costs.[47] Still, a potential shortage of oil, the need to add scrubbers to clean up the emissions from coal fired plants, and the rising costs of all fuels made nuclear an increasingly economical alternative.

The unrest in the Middle East in the 1970s not only raised fuel costs and the cost of petroleum-derived goods, but also elevated concerns about the security of American fuel supplies. The newly enacted environmental regulations made some oil producers

[47] Charles Komanoff, *Power Plant Performance: Nuclear and Coal Capacity Factors and Economics*, New York: Council on Economic Priorities, 1976. pp. 7-8.

reluctant to invest in new facilities—the funds might be needed to upgrade older facilities to reduce emissions and to produce the new type of fuel required by those regulations.[48] Growth in refining capacity lagged growth in demand. Thus, more and more oil (and, by association, the gasoline refined from it) came from outside the U.S. In fact, by the early 1970s, the U.S. imported about one third of the oil it used.[49] With tensions in the Middle East threatening a major source of American energy, utilities began to look to domestic sources of fuel, such as the Alaskan North Slope fields, with an increased sense of urgency.[50]

Tensions also mounted at the Atomic Energy Commission. The AEC had been charged not only with advancing the commercial uses of nuclear energy but also with regulating those uses. Concern over those conflicting missions led to the Energy Reorganization Act of 1974 and the formation of two separate bodies: (1) The Nuclear Regulatory Commission (NRC), to promote human health and safety, to oversee the licensing of nuclear facilities and their safe operation, and to manage nuclear wastes; and (2) The Energy Research and Development Administration, whose mission of advancing and expanding the industry was taken over by the Department of Energy in 1977.[51]

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[48] McCracken, p. 6.

[49] Ibid, p. 27.

[50] Production from the North Slopes fields in Alaska began in 1977. ("Supply," U.S. Energy Information Administration, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/oil_market_basics/supply_text.htm, (accessed December 20, 2009).)

[51] "Federal Government, Atomic Energy Commission, 1946-1977," http://www.u-s-history.com/pages/h1813.html, (accessed October 25, 2008); "Our History: Atomic Energy Commission," www.nrc.gov/about-nrc/history.html, (accessed July 2, 2008).

As the first decades of commercial nuclear power in the United States drew to a close, the industry, which had devoted itself to the peaceful use of the atom that had been so proudly extolled by President Eisenhower, was saddled with cost overruns, low levels of productivity, and canceled plans for expansion. It faced a public very concerned about the safety of nuclear power (primarily resulting from the accidents at Three Mile Island and Chernobyl). Prices for the competing fossil fuels--oil, coal, and natural gas--had peaked in the late 1970s and early 1980s, but quickly dropped off. Would the industry survive?

3.2 This is Now: The Nuclear Power Industry of the 2000s

The first part of this chapter reviewed the contextual elements supporting the decision to construct nuclear reactors in the 1960s, 1970s, and 1980s. The interest in building nuclear power plants waned as costs mounted and it became apparent that the plants were neither as easy to operate nor did they produce as much electricity as had been expected. No new reactor construction was begun after 1977.[52] Even so, the regulatory framework supporting the existing reactors continued to change and develop. This section will focus on the post-Three Mile Island regulatory and government policy changes, industry reorganization, establishment of industry-specific organizations, and updates of processes and procedures within the NRC and reactor management.

The accident at Three Mile Island brought issues of nuclear power plant safety to the forefront. Under President Jimmy Carter, the Kemeny Commission investigated the accident. That Commission concluded that the AEC/NRC's approach failed to adequately ensure the safety of the public or the power plants. It recommended the creation of a program that would (1) Establish appropriate safety objectives for the nuclear industry and standards of excellence against which operating performance could be compared; (2) Gather, review, and analyze performance data from all the nuclear power plants; and (3) Build an industry-wide communications network to share that and other information.[53] Those recommendations gave rise to the Institute of Nuclear Power Operations (INPO) in 1979.

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[52] *Information Digest, 2007 – 2008*, U.S. NRC, NUREG – 1350, Vol. 19, August 2007, Washington D.C.: Office of the Chief Financial Officer, U.S. Nuclear Regulatory Commission.

[53] "About Us," www.inpo.info/AboutUs.htm, (accessed May 21, 2008); "Nuclear Industry Organizations," www.nucleartourist.com/basics/inpo.htm, (accessed May 21, 2008).

3.2.1 The Institute of Nuclear Power Operations (INPO)

Unlike the AEC or the NRC, INPO is neither a government agency nor is it located in the Washington D.C. area. Instead, it is a not-for-profit organization headquartered in Atlanta, GA. Although INPO employs nuclear professionals, many with past experience working at commercial power plants or with the NRC, and although it counts all operating nuclear power plants in the United States among its members, INPO strives to maintain independence from those constituencies it serves. The NRC continues to license and regulate the industry, and attend to legal issues, and the Department of Energy (DOE) promotes the use of nuclear power, allowing INPO to focus its efforts on continual improvement in plant safety and reliability.

Self-regulation by peer review lies at the heart of the INPO philosophy.[54] Each member plant undergoes inspection by a panel of INPO and industry personnel every 18 to 24 months.[55] Each plant gets evaluated on the caliber of its workers, the quality of its programs and procedures, and the effectiveness of its management. Plant managers then receive suggestions for improvements, suggestions they are expected to follow.[56] INPO also requires plant managers to provide qualitative performance data on a quarterly basis and then makes all of that information available to all INPO members.[57] The managers and industry executives can compare their plants' performances with those of their competitors and with the INPO standards of excellence and can readily understand where

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[54] Perin, p. i.

[55] "Nuclear Industry Organizations," www.nucleartourist.com/basics/inpo.htm, (accessed May 21, 2008).

[56] "About Us," www.inpo.info/AboutUs.htm, (accessed May 21, 2008); Perin, p. 10.

[57] Perin, p. A-8.

changes need to be made. Peer pressure compels them to adopt the "best practices" of the better performers.

INPO does have a formal memorandum of understanding with the NRC for exchange of information, reactor reviews, and summary level or trend data.[58] INPO also shares information with international agencies through its international equivalent, the World Association of Nuclear Operators (WANO). WANO members exchange experiences and analyses to help improve the safety of nuclear reactor facilities worldwide.

INPO also took on some of the responsibility for the on-site training of nuclear plant personnel. The National Academy for Nuclear Training was established in 1985 to integrate training programs for all U.S. nuclear plant workers and supervisors.[59] Although plants can develop training programs tailored to their site and particular equipment, INPO provides the accreditation.[60] For example, at the Duke Power Co., trainees spend four years in training before taking their reactor operator licensing exam: three years of apprenticeship and one year of classroom, simulator, and on-the-job training. Those individuals must then take a refresher exam each year to renew their license. Exelon Nuclear favors reinforcement of classroom teaching with "dynamic learning activities"—putting people in situations similar to those they would find on the

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[58] Ibid, p. 12.

[59] "Nuclear Plant Personnel Training Facts," www.nukeworker.com/study/radiation_faqs/Training_Facts.shtml, (accessed July 2, 2008).

[60] Matthew L. Wald, "Can Nuclear Power be Rehabilitated?" *The New York Times*, March 31, 1991, p. 3.6.

job, whether in a real plant setting or using simulators.[61] Those experiences help trainees practice correct behaviors and appropriate responses in any situation they might face.

3.2.2 Deregulation of Electrical Markets

Nuclear power plant performance did improve through the 1980s and 1990s (Figures 4 and 5), in part due to INPO oversight, in part due to improved operator training, but also due in part to pressures put on many of the utilities by deregulation of the electricity markets, made possible by the Energy Act of 1992 and Federal Energy Regulatory Commission (FERC) Orders.[62] Under regulation, state Public Utility Commissions determined the gross revenue, and thus rate of return, that each utility would be permitted to receive from customers.[63] The rate of return would cover the operating expenses and cost of services plus an operating income and profit for the utility.[64] The rate of return might also cover expenses being incurred during construction of new facilities or equipment upgrades.[65] Unfortunately, because utilities could pass costs on to their customers, there was little incentive to reduce costs or increase

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[61] Rick Michal, "Coovert: Human Performance Training at Exelon Nuclear," *Nuclear News*, January 2003, pp. 23 – 25.

[62] Energy Policy Act of 1992, H.R. 776, http://thomas.loc.gov/cgi-bin/query/F?c102:1:./temp/~mdbs0MIIy3::, (accessed November 12, 2008).

[63] Arturo Gandara, *Electric Utility Decision-making and the Nuclear Option*, Santa Monica, CA: Rand, 1977; "A Primer on Electric Utilities, Deregulation, and Restructuring of U.S. Utilities Markets," U.S. Department of Energy, May 2002, Version 2.0, http://www/eren.doe.gov/femp, (accessed July 23, 2008). pp. 5.2 – 5.9.

[64] Saunders Miller, *The Economics of Nuclear and Coal Power*, New York, NY: Praeger, 1976. pp. 61-63; "A Primer on Electric Utilities, Deregulation, and Restructuring of U.S. Utilities Markets," U.S. Department of Energy, May 2002, Version 2.0, http://www/eren.doe.gov/femp, (accessed July 23, 2008). pp. 5.2 – 5.9.

[65] Gandara, p. 73.

operational efficiencies.[66] In contrast, under deregulation, the workings of the wholesale market for electricity, and not utility commissions, would determine utility revenues.[67]

Deregulation promised lower retail prices for electricity through competition in the industry, improved operations and plant management, and consumer choice of electric suppliers.[68] That did not occur. Some smaller utilities merged in order to survive competition. Other utilities sold their electric generation facilities and concentrated on the transmission and distribution of power instead.[69] Consumers did not get the promised choice of suppliers. In areas like Houston, TX, regulators required utilities to sell their power plants. Investment firms snatched up the power plants and later sold them for a profit.[70] Some utilities, unable to generate a profit in the competitive environment, once again fell under government regulation. According to [then] CEO of Duke Energy, "The dream of an integrated gas and power generation industry serving free and open markets

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[66] David Cay Johnston, "In Deregulation, Plants Turn into Blue Chips," *The New York Times*, October 23, 2006; Lester B. Lave, Jay Apt, and Seth Blumsack, "Deregulation/Restructuring Part I: Reregulation Will Not Fix the Problems," *The Electricity Journal*, Vol. 20, No. 8, October 2007, pp. 10 – 12.

[67] Seth A. Blumsack, Jay Apt, and Lester B. Lave, "Lessons from the Failure of the U.S. Electricity Restructuring," *The Electricity Journal*, Vol. 19, No. 2, March 2006, pp. 15 – 32; Severin Borentstein, "The Trouble with Electricity Markets: Understanding California's Restructuring Disaster," *The Journal of Economic Perspectives*, Vol. 16, No. 1, Winter 2002, pp. 191 – 211.

[68] Rebecca Smith, "States Face Fights as Caps Expire on Electric Rates; Deregulation Deadlines Highlight Disparities Between Customers, Utilities," *The Wall Street Journal* (Eastern Edition), August 17, 2004, p. A.1.

[69] Matthew Brown, "Transforming the Electricity Business," State Legislatures Magazine, April 1999, http://www.ncsl.org/programs/pubs/499elec.htm, accessed July 22, 2008; "A Primer on Electric Utilities, Deregulation, and Restructuring of U.S. Utilities Markets," U.S. Department of Energy, May 2002, Version 2.0, http://www/eren.doe.gov/femp, (accessed July 23, 2008).

[70] David Cay Johnston, "In Deregulation, Plants Turn into Blue Chips," *The New York Times*, October 23, 2006.

with a balance of hard assets and trading has turned into a nightmare."[71] Dreams of a competitive electrical market had faded.

Although nuclear power plants improved their efficiency during the period (as reflected in increased capacity factors, Figure 4), other issues negated their impact on electricity prices. For example, not all deregulated states obtained electrical power from nuclear facilities—Delaware and Maine among them.[72] In most of the other deregulated states, nuclear power contributed less than half of the total electric demand. Without similar efficiency improvements in their coal or natural gas-fired power plants, suppliers overall costs did not decrease and consumer prices did not come down. In fact, in the end, many consumers paid the price of deregulation through higher, monopolistic, prices for electricity. (Texans, for example, saw their electric bills rise 56 to 80%.[73])

Many states enacted price caps to shield customers from high prices during the transition from regulated to deregulated electric markets, but those caps began to expire in the mid-2000s. When caps lifted in 2001 in Montana, retail customers went from paying some of the lowest prices in the nation to having among the highest electric rates

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[71] "Duke Energy 2003 Summary Annual Report," http://www.duke-energy.com/pdfs/Duke_Energy_2003_Annual_Report.pdf, (accessed March 13, 2009).

[72] Nuclear Energy Fact Sheets, http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/factsheet/, (accessed January 27, 2010).

[73] Tom Fowler, and Janet Elliott, "Deregulation Debate: Many Texas Consumers Feel Competition in the State's Energy Markets has Been a Costly Failure," *Houston Chronicle*, October 8, 2001, www.chron.com, (accessed 10/29/08); Rebecca Smith, "States Seek Ways to Curb Surging Electricity Bills; Many Consumers Face Jolt Arising from '90s Changes; Connecticut's 22 % Increase," *The Wall Street Journal* (Eastern Edition), February 28, 2006, p. A.1.

in the region, a 40 % increase.[74] Rates in Illinois rose 30 to 50 % in January of 2008 and Maryland customers faced increases of over 70 % until the legislature intervened.[75] Although some argue that the increases reflect the change in energy prices during the period the price caps were in effect, an Associated Press (AP) analysis indicates that the retail rate gap between regulated and unregulated states did indeed increase during that time. Energy prices alone did not explain the difference. Even the large industrial customers saw no price advantages under deregulation.[76]

Giving customers the option to choose their own power supplier also proved easier in theory than in practice. Many found little financial benefit to switching providers and others just did not want to do the research and make the arrangements to switch.[77] In addition, some of the new power providers left the market when the volume of residential customers could not sustain their businesses. Those customers ended up back with their original electric providers.

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[74] Matt Gouras, "Deregulation Has Stung Montanans; The State Went From Having Some of the Lowest Electricity Rates to Among the Highest in the Region. Efforts to Undo the Effects Face Hurdles," *Los Angeles Times*, March 7, 2006, p. C.5; Ryan Keith, "Energy Deregulation Hits Consumers Hard; As States Halt Caps on Electricity Prices, Anticipated Decreases Don't Materialize," *The Washington Post*, May 6, 2007, p. A. 16.

[75] Keith, p. A. 16.

[76] Jay Apt, "Competition Has Not Lowered U.S. Industrial Electricity Prices," *Electricity Journal*, Vol. 18, No. 2, March 2005, pp. 52 – 61.

[77] Brooks Barnes, "What Happened?—Nothing Personal: Many Individual Consumers Have Come to a Simple Conclusion About Electricity Deregulation: Big pain, little gain," *The Wall Street Journal* (Eastern Edition), September 17, 2001, p. R12.

Under regulation, utilities could obtain low cost capital for investments and expansion and could pass the costs on to customers through their rate of return.[78] Deregulation has made it more difficult to recoup those costs, increasing the risk associated with investments and thus the interest rates utilities must pay. One would expect that construction of new nuclear power plants would occur mainly in regulated environments. However, of the twelve applications received by the NRC by the end of November 2008, half were in regulated states (North and South Carolina, Florida, Georgia, Louisiana, Mississippi, and Missouri) and half in deregulated states (Texas, New York, Michigan, and Pennsylvania). Other factors, such as the proximity to centers of population growth and to the transmission grid, must be at work.

3.2.3 Utility Industry Consolidation

Industry consolidation and reorganization spurred by deregulation and the 2006 repeal of the Public Utility Holding Act of 1935 also affected the nuclear power generators.[79] Under the Public Utility Holding Act, generating plants and distribution facilities owned by a utility had to be physically interconnected or capable of being interconnected, and had to be confined to a single area or region. With that regulation no longer in force, utilities could branch out geographically. A company like NRG Energy can now own natural gas, coal, wind, oil, and nuclear facilities in states as far-flung as Texas, Louisiana, Illinois, California, Nevada, New York, Pennsylvania, Connecticut,

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[78] William J. Hausman, and John L. Neufeld, "The Market for Capital and the Origins of State Regulation of Electric Utilities in the United States," *The Journal of Economic History*, Vol. 62, No. 4, December 2002, pp. 1050 – 1073.

[79] Adam Vann, "The Repeal of the Public Utility Holding Company Act of 1935 (PUHCA) and its Impact on Electric and Gas Utilities," CRS Report for Congress, Congressional Research Service, The Library of Congress, Washington, D.C., November 20, 2006.

Delaware, Maryland, and Massachusetts. This type of industry upheaval has meant that only 31 different groups/organizations owned the U.S. nuclear power plants by the summer of 2008, down from the original 53. For example, PECO Energy and Unicom merged in 2000 to form Exelon Corporation, with a fleet of 14 reactors.[80] In 2008, Exelon tendered an offer for NRG Energy Inc., part owner of two Texas plants, in a bid to become the nation's largest power company.[81] The NRG Board of Directors and its stockholders rejected that bid during the 2009 annual meeting.[82]

In addition, smaller utilities have ceded operation of their nuclear power plants to firms specializing in plant management. First Energy Nuclear Operating Company, incorporated in 1988, now oversees the two reactors at Beaver Valley, PA (on behalf of Pennsylvania Power and Ohio Edison), and reactors at David Besse and Perry, both in Ohio (for Cleveland Electric). Southern Nuclear Operating Company (established in 1990) manages Alabama Power's Farley reactors, as well as Georgia Power's Hatch and Vogtle facilities. Theoretically, shared management should increase the exchange of technical information and sharing of experiences regarding equipment repairs and refueling, and should result in improved plant performance.[83] Figure 9 indicates that shared management did not necessarily benefit all reactors in the First Energy Nuclear fleet—the average capacity factor for the Perry and Beaver Valley units fell below the

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[80] Mark Holt, "CRS Issue Brief for Congress: Nuclear Energy Policy," Washington D.C.: Congressional Research Service, Library of Congress, March 15, 2001. p. CSR-2.

[81] Mark Williams, "Utilities Consolidation Goes On: Exelon for NRG," http://www.biz.yahoo.com/ap/081020/exelon_nrg_energy.html, (accessed October 21, 2008).

[82] "Exelon Drops its Bid for NRG Energy," The New York Times, July 21, 2009.

[83] Robert Peltier, "Nuclear Renaissance Continues," *Power*, Vol. 148, Issue 5, June 1, 2004, p. 32.

national average throughout most of the 1990s. In contrast, shared management may have contributed to the consistently good capacity factor performance of Southern Nuclear reactors in the 1990s (Figure 10).

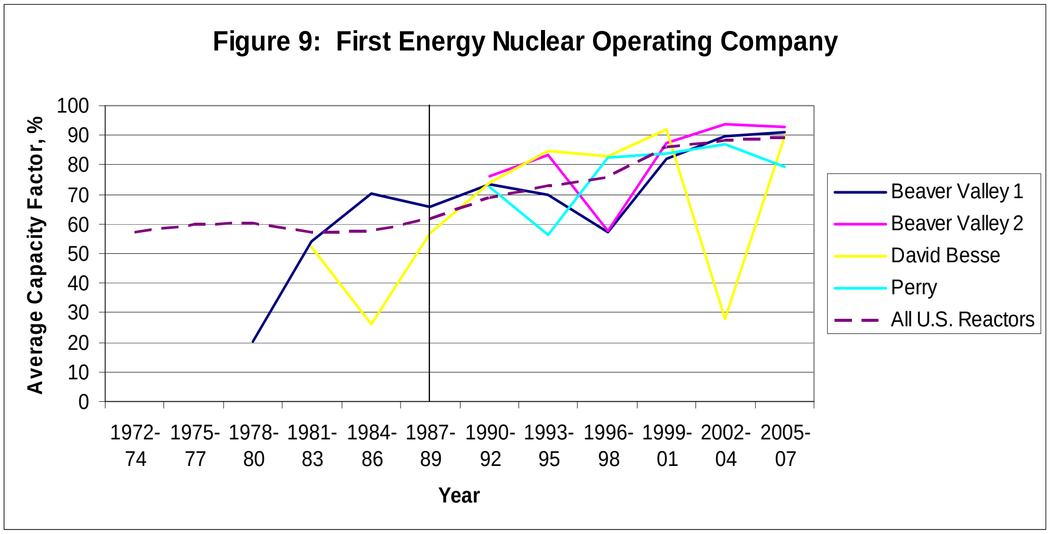

Figure 9: First Energy Nuclear Operating Company Performance Results
Source: Blake

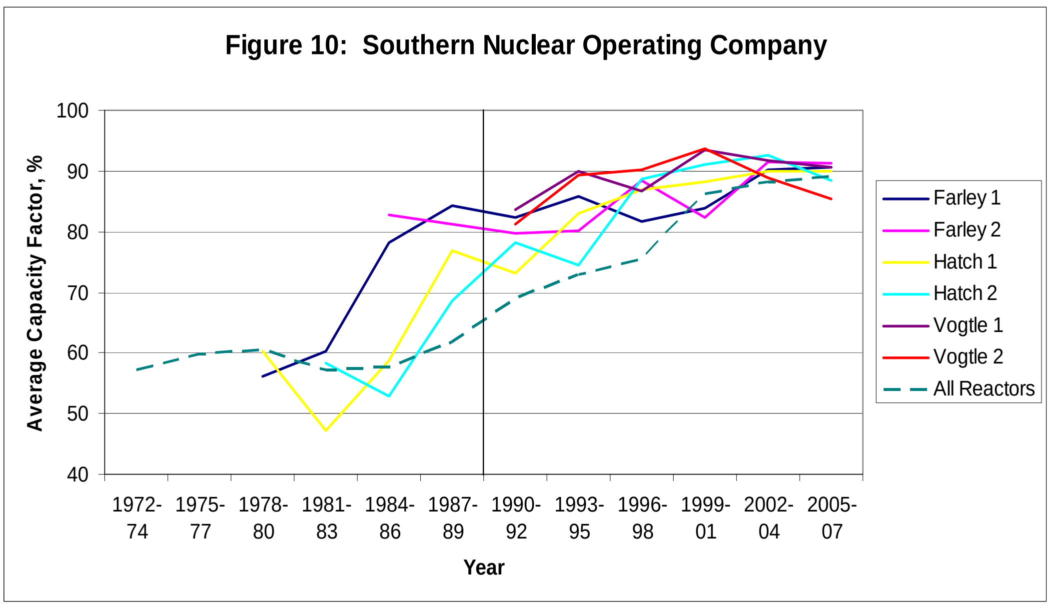

Figure 10: Southern Nuclear Operating Company Performance Results
Source: Blake

3.2.4 Reactor Design Standardization

Why has reactor performance not always improved under specialized management teams? One reason may be the plethora of reactor designs built and operating in the United States. First Energy Nuclear Operating Company supervises work at two Westinghouse pressurized water reactors, one Babcock and Wilcox pressurized water reactor, and a General Electric boiling water reactor. Thus, learning from one site does not translate well to another. Even within sites, experience with one reactor may not apply to another. Dominion's Millstone, CT plant has one Westinghouse pressurized water reactor and one Combustion Engineering pressurized water reactor. The two designs have different processes and protection systems and are susceptible to different types of stresses, cracks, or failures, necessitating some specialization among operation and maintenance personnel.[84]

Beginning as early as 1985, the U.S. House of Representatives introduced legislation to standardize the designs available to utilities planning to build new nuclear power plants. The Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce heard testimony on three bills aiming to amend the Atomic Energy Act of 1954. (See Appendix 4 for partial text of H.R 1029.) Among the main goals: "To facilitate the development and use of standardized designs and pre-approved sites for nuclear powerplants (sic)."[85] Utility executives, engineers from industry and

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[84] Rick Michal, "Sarver and Jordan: Maintenance at Millstone," *Nuclear News*, October 2003, pp. 40 – 48.

[85] "Nuclear Powerplant (sic) Design Standardization," Hearings before the Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, House of Representatives, July 25 and December 10, 1985, Washington D.C.: U.S. Government Printing Office, 1986, p. 40.

academia, and representatives of the Union of Concerned Scientists all agreed that design standardization would be essential to the future of the nuclear power industry. Mr. Bertram Wolfe, Vice President and General Manager of the General Electric Nuclear Technology and Fuel Division, enumerated the benefits:[86]

> I believe that standardization offers the single most important contribution to a more effective licensing and regulatory process and to the assurance of a high level of safety for future nuclear power plants. There are five important reasons why this is so . . .
>
> First, standardization will provide the predictability which is essential to making the multi-billion dollar decision to invest in a nuclear plant;
>
> Second, standardization necessarily leads to a better allocation of industry [engineering] resources and regulatory safety resources;
>
> Third, standardization will improve the quality of NRC licensing and regulatory decisions;
>
> Fourth, standardization will substantially reduce the costs of constructing and licensing new nuclear units; and
>
> Fifth, the preapproval process, which is an integral aspect of standardization, will enhance both the timeliness and effectiveness of public participation in the licensing process.

Although the 1985 House bills did not get enacted, in 1989 the NRC did implement reactor design standardization processes similar to those outlined in those bills.[87] The NRC hoped manufacturers and designers of nuclear power plants would submit a handful of designs for advanced certification. The designs would be for essentially complete nuclear power plants, except for necessarily site-specific elements, such as water intake structures. Designs would be subject to thorough safety reviews and public hearings before receiving certification. Utilities seeking to build plants would then choose among the certified designs and bypass design reviews during the licensing process. That would shorten the time from application to the start of construction and

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[86] Ibid, pp. 143 – 144.

[87] "Backgrounder: Nuclear Power Plant Licensing Process," http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/licensing-process-bg.html, (accessed 11/1/08).

would give the utilities an added degree of certainty that, once begun, their nuclear power plant would not need modification to meet changing NRC criteria. (Many of the reactors built during the first wave of nuclear power plant construction were begun with designs that were only 15 – 20 percent complete, a "design as you go" approach that added to the duration and costs building.[88] It also resulted in custom plants at almost every site.

Unfortunately, as the United States moves toward a second wave of nuclear plant construction, power companies and utilities have already begun selecting designs not yet approved by the NRC or are requesting changes to the pre-certified designs.[89] Originally, the South Texas Project Nuclear Operating Company had selected the pre-certified General Electric/Hitachi Advanced Boiling Water Reactor (certified in 1997), but now has chosen to partner with Toshiba to construct that type of reactor. Six construction permit applicants aim to build a version of the Westinghouse AP1000, an advanced passive pressurized water reactor for which the NRC just completed preliminary safety reviews in September of 2008. Although five applicants initially favored the General Electric/Hitachi Economic Simplified Boiling Water Reactor (design certification application received August of 2005), Exelon and Dominion Virginia Power are revisiting their choice. (Dominion cites an inability to reach an agreement with GE/Hitachi over terms of the contract as the fundamental reason for the reconsideration.[90]) Four applicants want to build the Evolutionary Power Reactor (EPR)

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[88] "Nuclear Powerplant (sic) Design Standardization," pp. 57 and 124.

[89] Matthew L. Wald, "Plan to Build Reactors is Running into Hurdles," *The New York Times*, December 5, 2007, Section C, p. 1.

[90] Rick Zuercher, Manager, Public Affairs, Dominion Virginia Power, Telephone Interview of March 12, 2009.

now under construction in France, Finland, and China; the NRC received that design application in December 2007. Finally, one application references the Mitsubishi Heavy Industries U.S. Advanced Pressurized Water Reactor, whose design certification also was submitted in December of 2007. (See Appendix 5 for a brief overview of reactor design features. All design application dates have been taken from the NRC website http://www.nrc.gov/reactors/new-reactors/col.html.) Despite the push for standardization in the U.S., utilities and power companies have chosen both boiling water and pressurized water reactor designs from five different manufacturers.

The manufacturers of the second wave of plants for the U.S. advertise three to four years of construction for new plants 1154 to 1700 MW in capacity (Appendix 5). Historical data presented earlier in this thesis indicate that larger nuclear power plants take longer to build and that any plants with a capacity over about 1150 MW have taken at least 3000 days from construction licensing to commencing operations (See Figure 3). Even if construction continued for 365 days per year, past experience would suggest plants over 1150 MW will take eight years to build, not three or four. The new EPR in Finland was originally scheduled to begin operations in 2009 but likely will not produce power until 2012 or later—not a very propitious sign for those awaiting ground breaking in the U.S.[91]

[91] "Delayed Finland EPR Project Spurs Contractual Disputes," October 22, 2008, *Power: Business and Technology for the Global Generation Industry*, http://www.powermag.com/POWERnews/1476.html, (accessed November 27, 2009).

3.2.5 New Construction Issues

In addition, as pointed out during the nuclear plant design hearings of 1985, standardized designs do not guarantee standardized construction.[92] Each site will have its unique topographical and geological features, weather conditions, and water supply issues. Each construction team will have different concrete pourers, pipe fitters, welders, electricians, and managers. Those factors will affect both how well the plant conforms to the original design and how quickly it can be erected.

As construction ramps up worldwide, competition for building supplies will increase. Whereas during the first round of U.S. nuclear plant construction most suppliers were domestic, today they span the globe and outfit plants in the United States, Asia, and Europe. [93] Areva (of France) and Northrup Grumman, Westinghouse/Toshiba and the Shaw Group have begun building factories in Louisiana, Indiana, and Virginia, but it will be some time before those facilities are certified by the NRC to manufacture reactor components.[94] By some estimates, existing suppliers can fabricate enough parts for only three or four reactors per year.[95] The demand for ultra-heavy forgings will be especially tight--only Japan Steel works and France's Creusot Forge (Areva) can make

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[92] "Nuclear Powerplant (sic) Design Standardization," p. 251.

[93] Teresa Hansen, "Nuclear Renaissance Faces Formidable Challenges," *Power Engineering*, Vol. 111, Issue 8, August 2007, pp. 12 – 13; Teresa Hansen, "The Nuclear Renaissance's Future," *Power Engineering*, Vol. 111, Issue 9, September 2007, pp. 46 – 48.

[94] Matthew L. Wald, Matthew L., "After 35-Year Lull, Nuclear Power May be in the Early Stages of a Revival," *The New York Times*, October 24, 2008, p. B.3; Rebecca Smith, "Areva Will Build Reactors in U.S.: Joint Venture with Northrop Grumman to Establish Nuclear-Components Facility," *The Wall Street Journal*, October 24, 2008, p. B.2.

[95] Matthew L. Wald, "Plan to Build Reactors is Running into Hurdles," *The New York Times*, December 5, 2007, Section C, p. 1.

those elements for the new reactor designs.[96] In addition, NRC inspectors will need to visit those foreign manufacturers to ensure component parts they make meet U.S. regulatory requirements, adding yet another layer of complexity to parts procurement.[97]

To cope with potential supply issues, some power companies and utilities have already begun to order reactor parts, well in advance of design certifications or license approvals. For example, Entergy Nuclear submitted an order for its forgings and turbine components.[98] Unistar Nuclear Energy has placed orders amounting to tens of millions of dollars on heavy steel parts for its reactor vessels and other critical components. According to Unistar Co-CEO Michael J. Wallace, "We're creating the certainty that the most critical early-on hardware is in hand . . ."[99] In the end, the availability of parts may be the determining factor in the time it takes to complete new nuclear power plants.

3.2.6 A One-Step Licensing Process

The three House bills introduced in 1985 also proposed to further decrease the time involved and to increase the predictability of new nuclear plant construction by allowing utilities and power companies to get early approval for potential nuclear reactor

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[96] Teresa Hansen, "Nuclear Renaissance Faces Formidable Challenges," *Power Engineering*, Vol. 111, Issue 8, August 2007, pp. 12 – 13; John Carey, "Nuclear's Tangled Economics," *Business Week*, Issue 4091, July 7, 2008, pp. 24 – 26.

[97] Jeffrey S. Merrifield, "Not Your Father's Nuclear Regulator: The Role of the Licensing Process in the Future of Nuclear Energy," Address to the Nuclear Energy Conference, Washington D.C., February 16, 2005.

[98] Teresa Hansen, "The Nuclear Renaissance's Future," *Power Engineering*, Vol. 111, Issue 9, September 2007, pp. 46 – 48.

[99] Wald, Matthew L., "Nuclear Power Venture Orders Crucial Parts for Reactor," *The New York Times*, August 4, 2006, Section C, p. 2.

sites and by replacing the two-step licensing process with a streamlined one-step approach.

> A utility seeking to build a nuclear plant today will not do so unless it knows in advance and with certainty that it can proceed with diligent construction and lifetime operations on a reasonable schedule . . . Three bills currently pending in the House . . . would provide authority for the NRC to issue combined construction and operating licenses. We believe this is the cornerstone of a predictable licensing system." (Mr. Sol Burnstein, Vice Chairman, Wisconsin Electric Power Co.)[100]

In 1992, Congress amended the Atomic Energy Act of 1954 to allow combined construction and operating licenses.[101] Not surprisingly, the primary sponsors of the earlier nuclear plant licensing bills that eventually became part of the 1992 Energy Policy Act represented states already enjoying the benefits of electricity generated by nuclear power and the states that are now seeking to build new nuclear power plants. (See Appendix 6 for relevant text of the 1992 Energy Policy Act.)

Early site permitting addresses the hydrological, geological, seismic, and meteorological features of a proposed site and how the construction of a nuclear power plant would impact the surrounding area (especially in the event of an accident leading to release of radiation).[102] It examines the general location of the power plant and potential

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[100] "Nuclear Powerplant (sic) Design Standardization," pp. 95-96.

[101] Cliffird Krauss, "Senate Votes to Simplify Nuclear-Plant Licensing," *The New York Times*, February 7, 1992, p. D2; "House Votes to Speed Licensing of Nuclear Plants," *The New York Times*, May 21, 1992, p. D2.

[102] "Part 52 – Licenses, Certifications, and Approvals for Nuclear Power Plants," U.S. NRC, http://www.nrc.gov/reading-rm/doc-collections/cfr/part052/full-text.html, (accessed November 5, 2008). pp. 11 and 12.

alternative sites. A mandatory public hearing precedes issuance of an early site permit by the NRC. The permit is valid for no less than 10 years and no more than 20 years.[103]

An application for a combined construction and operating license (COL) must include the technical site data plus detailed information about the complete reactor design; safety analyses of the structures, systems, and components; emergency evacuation plans; site security plans; quality assurance, equipment testing, and maintenance programs. The application must also reveal particulars about the companies contracted to build the facility, the plant organization structure, and training and requalification programs for reactor operators.[104] Up front review of all of these aspects should minimize the likelihood of delays such as those that plagued Texas Utility Company's Comanche Peak and others.[105] In addition, a mandatory public hearing follows receipt of the application, giving the local people as well as organized groups a chance to voice their concerns. As the industry demanded, once the NRC issues the COL, it may not "modify, add, or delete any term or condition of the combined license, the design of the facility, the inspections, tests, analyses, and acceptance criteria contained in the license" (unless of course a significant safety issue comes to light during construction).[106]

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[103] "Nuclear Power Plant Licensing Process," U.S. NRC Backgrounder, Washington D.C.: U.S. NRC Office of Public Affairs, July 2005.

[104] Part 52—Licenses, Certifications, and Approvals for Nuclear Power Plants", pp. 23 – 29; C. J. Fong, Nuclear Regulatory Commission Region II Construction Inspection Organization, Telephone Interview of May 14, 2009; Hossein Hamzehee, Nuclear Regulatory Commission, Telephone Interview of May 14, 2009.

[105] Hossein Hamzehee, Nuclear Regulatory Commission, Telephone Interview of May 14, 2009.

[106] Part 52—Licenses, Certifications, and Approvals for Nuclear Power Plants," pp. 23 – 29.

At the outset of construction of the new reactor facility, the applicant (now licensee) must submit to the NRC a schedule of its "Inspections, Test, Analyses, and Acceptance Criteria" (ITAAC) and must notify the NRC upon completion of the various elements of that schedule. If the Commission finds that the criteria have been met, a date for fuel loading can be set. At that time there is one last opportunity for a public hearing, but only if there is evidence that one or more of the criteria has not been or cannot be met. Barring any fact-based opposition, the NRC then considers the nuclear power plant licensed for operation.

The NRC envisioned an orderly three-step process in which reactor manufacturers would receive design certifications, utility and power companies would get early site permits, and finally, those companies would apply to build and operate a nuclear power plant.[107] In reality, as outlined above, design certifications are being submitted in parallel with COLs. Companies hoping to build on existing nuclear power plant sites have chosen to roll the site permitting into their license applications rather than procure a separate early site permit. Thus, as of October 2009, only four of the 17 COL applicants also had submitted early site permits: Exelon (for its Clinton, IL site), System Energy Resources Inc., (for Grand Gulf, MS), Dominion Nuclear (for North Anna, VA) and Southern Nuclear Operating Company (for Vogtle, GA).[108] The NRC also expected to receive one lead construction and licensing application, to test the new process, followed

[107] Richard Meserve, and Ernest Moniz, "The Changing Climate for Nuclear Power in the United States," *Bulletin of the American Academy of Arts and Sciences*, Vol. 55, No. 2, Winter 2002, pp. 57 – 72.

[108] "Early Site Permit Applications for New Reactors," http://www.nrc.gov/reactors/new-reactors/esp.html, (accessed October 20, 2009).

by others a few years later.[109] Instead, they found themselves deluged with seventeen COLs in the fourteen months between mid-July 2007 and mid-October 2008.[110]

How long will it take to review and accept each application? Although the NRC has claimed it would take about 42 months under its new system, some nonpartisan groups, such as the Congressional Research Service, take a gloomier view and predict that it could take 15 years to complete the process![111]

Unlike the previous round of nuclear power plant construction permit applications during which each individual utility developed its own submission, many of the current applications were created by one company: NuStart Energy Development. NuStart was established in 2004 by ten power companies and two reactor vendors for the purpose of gathering the requisite materials, completing the necessary design engineering, and composing COL applications.[112] The group wanted to demonstrate the viability of the new licensing process. NuStart aimed to provide a forum for the open exchange of ideas and information among the power companies, vendors, and the NRC. Building on the concept of design standardization, NuStart also has attempted to standardize the many parts of the COL application, including descriptions of reactors, mechanical systems, and

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[109] Marilyn Kray, "New Reactor Licensing: Matching Expectations and Reality," Regulatory Information Conference (RIC) 2008: Enhancing Safety During the Global Nuclear Renaissance, March 13, 2008.

[110] "Combined License Applications for New Reactors," http://www.nrc.gov/reactors/new-reactors/col.html, (accessed November 2, 2008).

[111] Janet Elliott, and Tom Fowler, "Deregulation Debate: Second of Two Parts, Market Fix Rests on Bright Ideas," *Houston Chronicle*, October 8, 2007, www.chron.com, (accessed 10/29/08).

[112] www.nustartenergy.com, (accessed May 24, 2008); "NuStart," http://www.entergy-nuclear.com/new_nuclear/nustart.aspx, last accessed 5/24/2008.

components.[113] It has created a baseline COL application that can be used as a template by a variety of power companies and utilities. As a testament to its success, NuStart has been a partner in the COL applications for Entergy's Grand Gulf, MS and River Bend, LA sites, the Tennessee Valley Authority's Bellefonte, AL site, and Progress Energy's Harris, NC and Levy County, FL sites, among others.[114]

Following the NuStart lead, Constellation Energy joined with Areva NP (a reactor manufacturer) and Electricite de France (EdF, the French electric utility company) to form Unistar Nuclear LLC in 2007 to bring the Areva Evolutionary Power Reactor to the U.S.[115] The Unistar business model would cut the risk to any individual investor by building many identical reactors, taking advantage of economies of scale.[116] The venture also capitalizes on the multinational experience of Areva. Likewise, Toshiba (maker of advanced boiling water reactors) and NRG Energy have partnered to build new reactors at NRG's South Texas Project site and then to market, develop, and invest in other reactors around the U.S.[117]

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113 Marilyn Kray, "New Reactor Licensing: Matching Expectations and Reality," Regulatory Information Conference (RIC) 2008: Enhancing Safety During the Global Nuclear Renaissance, March 13, 2008; "Consortium Provides Forum for Standard Plant Design and Licensing," February 27, 2008, www.nustartenergy.com/DisplayArticle.aspx?ID=20080227-1, (accessed May 24, 2008).

114 "NuStart Energy Development," www.sourcewatch.org/index.php?title-NuStart_Consortium, (accessed May 24, 2008); "NuStart Energy Development: Combined Construction and Operating License," www.citizen.org/cnep/energy_enviro_nuclear/newnukes/articles.cfm?ID=14161, (accessed May 24, 2008).

115 "NuStart Successes Prompt Membership Changes," November 6, 2007, www.nustartenergy.com/DisplayArticle.aspx?ID=20071024-1, (accessed May 24, 2008).

116 Matthew L. Wald, "Partnership Formed to Build Nuclear Plants," *The New York Times*, September 16, 2005, Section C, p. 4.

117 Matthew L. Wald, "NRG Energy Sets Up an Entity to Build Nuclear Plants," *The New York Times*, March 26, 2008, Section C, p. 2.

3.2.7 Environmentally Sound Energy

Deregulation, design standardization, and changes in the licensing process were not the only factors contributing to the renewed interest in nuclear power for electrical generation. In the 1960s and 1970s Americans focused on getting rid of air and water pollution; in the 1990s and 2000s, the contribution of "greenhouse gases" to global climate change grabbed their attention. Emissions from fossil fuel burning power generation facilities, particularly carbon dioxide, which can easily trap heat, have been implicated in the changes in global temperatures and precipitation patterns, and the increased severity of storms and droughts.[118] Over 180 nations have ratified the Kyoto Protocol since it was adopted in 1997 in an international attempt to reduce emissions of greenhouse gases. And, because nuclear power plants emit almost no carbon dioxide during their operation, many of those countries have renewed their interest in nuclear power.[119] "There is a growing recognition that if we are going to meet our future need for electric energy and also reduce our emissions of greenhouse gases . . . we simply must build the next generation of advanced nuclear energy plants."[120]

Although the U.S. did not sign the Kyoto Protocol, groups of states on the west and east coasts have banded together to implement carbon dioxide (CO_2) emission

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[118] W. J. Nutall, *Nuclear Renaissance: Technologies and Policies for the Future of Nuclear Power*, London, England: Taylor and Francis, 2004; "Kyoto Protocol," http://unfcc.int/kyoto_protocol/items/2830.php, (accessed June 23, 2008).

[119] Although nuclear power plants emit almost no carbon dioxide during their operation, when the entire life cycle of is considered (mining through electric production), nuclear power does contribute greenhouse gases to the atmosphere. See, for example, Jef Beerten et al., "Greenhouse Gas Emissions in the Nuclear Life Cycle: A Balanced Appraisal," *Energy Policy*, 37, 2009, pp, 5056 – 5068.

[120] "Thirst for Energy Leads U.S. Down Old Path: Nuclear Power," www.usatoday.com/tech/news/2005-06-12-nuclear-resurgence_x.htm, (accessed May 24, 2008).

reduction programs. The West Coast Governor's Global Warming Initiative focused on increased use of renewable energy sources and increased efficiency of all products, especially automobiles.[121] On the opposite coast, the Regional Greenhouse Gas Initiative (RGGI) has implemented a "cap and trade" program to limit and reduce CO_2 emissions from electric power plants ("RGGI Inc.").[122] Each of the ten participating states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) is working to establish a total number of CO_2 allowances for its electric generating plants (the "cap"). Facilities using less than their allowance would be able to auction them off in a regional auction to those needing extra allowances (the "trade"). Companies or utilities with nuclear plants in their portfolios would be allowed to transfer allowances to bigger polluters, such as coal fired plants, or to sell them at auction for a profit. Those profits could then be used to invest in other technologies with low emissions.

A carbon tax system also aims to reduce CO2 emissions. Such a system would tax each ton of carbon emitted by any type of electric generating plant, any industry, and any vehicle.[123] Owners of low carbon nuclear, wind, or solar power plants would benefit by paying little or no carbon tax. The tax would provide an incentive for companies to

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[121] "West Coast Governor's Global Warming Initiative," http://www.ef.org/westcoastclimate/, (accessed January 9. 2009).

[122] "RGGI Inc." www.rggi.org/rggi, (accessed January 9, 2009).

[123] Juliet Eilperin, and Steven Mufson, "Tax on Carbon Emissions Gains Support: Industry and Experts Promote it as Alternative to Help Curb Greenhouse Gases," April 1, 2007, www.washingtonpost.com, (accessed January 9, 2009); Timothy Gardner, "Carbon Tax Seen as Best Way to Slow Global Warming," October 9, 2008, www.reuters.com, (accessed January 9, 2009).

forego investment in carbon emitting technologies in favor of those "cleaner" alternatives.

Carbon taxes and cap and trade were not included in its energy policy when the Bush/Cheney administration took office in 2001. However the administration did offer a plan for "dependable, affordable, and environmentally sound energy", a plan that promoted not only increased oil and natural gas exploration but also expansion of domestic renewable energy sources and nuclear energy.[124] With regards to nuclear power in particular, the Report of the National Energy Policy Group of May 2001 asked the President to support "the expansion of nuclear energy as a major component of our national energy policy."[125] The report, *National Energy Policy: Reliable, Affordable, and Environmentally Sound Energy for America's Future*, often called the "Cheney Report", asked the Department of Energy (DOE) to address the potential for nuclear power to improve air quality. It encouraged the NRC to ensure that safety and environmental protection were considered with high priority as it "prepared to evaluate and expedite applications for new advanced-technology reactors."[126] The Policy also recommended the extension of the Price-Anderson Act of 1957. In short, the National Energy Policy of 2001 set the stage for the pro-nuclear governmental activity and legislation that followed.

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[124] "National Energy Policy Report of the National Energy Policy Development Group: Reliable, Affordable, and Environmentally Sound Energy for America's Future," Washington D.C.: U.S. Government Printing Office, May 2001, pp. viii and 5-1 through 5-22.

[125] Ibid, p. 5-21.

[126] Ibid, p. 5-21.

A Roadmap to Deploy Nuclear Power Plants in the United States by 2010 (commonly referred to as "Nuclear Power 2010") was released in October 2001. The document, prepared by the members of industry and of the Department of Energy expanded on ideas set forth in the National Energy Policy.[127] It outlined the steps necessary for new nuclear plants to be operational by 2010. Among the conclusions:

1. The electricity generated by new nuclear power plants would have to be economically competitive for them to remain a viable option, ("Investors are going to want to have confidence, if they look at financing a competitive generation asset, that that asset is going to be able to earn a reasonable return in the market in which they have to operate in" James K. Asselstine, Managing Director, Lehman Brothers Inc., during testimony before the Committee on Energy and Natural Resources of the U.S. Senate, "Nuclear Power Industry," p. 44),

2. The regulatory process for siting and licensing new plants would need to be proven timely, efficient and appropriate to the task at hand,

3. Utilities and power companies would need to order new plants by the end of 2003 to have them operational by 2010,

4. The most advanced new reactor designs would not be available but those derived from existing reactors (such as those outlined in Appendix 5) could be deployed by 2010, and

5. Although the decision to build a new nuclear power plant must be market driven and supported by private investment, government support (in terms of legislative support as well as cost sharing programs) would be essential. [128]

"Nuclear Power 2010" recommended that the DOE investigate financial incentives (such as tax credits, tax exempt financing, and power purchase agreements) to motivate design

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[127] "A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010, Volume 1, Summary Report," Prepared by the Near Term Deployment Group for the United States Department of Energy, Office of Nuclear Energy, Science and Technology, and the Nuclear Energy Research Advisory Committee, Subcommittee on Generation IV Technology Planning, Washington D.C., October 31, 2001.

[128] "Nuclear Power 2010," Vol. 1, p. vi.

and construction projects.[129] It also put into place a 50-50 cost sharing program to help the first movers demonstrate the NRC's revised site permitting and reactor licensing procedures. The object of this aspect of "Nuclear Power 2010" was to help the NRC identify and resolve issues in those procedures before the industry had committed too much of its own resources to new nuclear power plant construction.[130] Exelon took advantage of the program for an early site permit for its new Clinton site, as did System Energy Resources for Grand Gulf, and Dominion Nuclear for North Anna.[131] And, in 2005, NuStart received $260 million under the cost sharing program to complete the design and engineering work for COL applications for new reactors at Bellefonte and Grand Gulf.[132]

3.2.8 The Energy Policy Act of 2005

Years of Congressional hearings about the role of nuclear power in the energy future of the U.S. preceded the passage of the Energy Policy Act of 2005 (EPAct). As a result, according to Keith Martin, Partner, Chadbourne & Parke, "[F]or the first time, both Congress and the President are on record nuclear is one of the things we need to

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[129] Ibid, p. 46.

[130] "Nuclear Power 2010 Program," Hearing Before the Committee on Energy and Natural Resources of the United States Senate, April 26, 2005, Washington D.C.: U.S. Government Printing Office, 2005, p. 31.

[131] "Combined License Applications for New Reactors," http://www.nrc.gov/reactors/new-reactors/col.html, (accessed November 2, 2008).

[132] "NuStart Energy Development: Combined Construction and Operating License," www.citizen.org/cnep/energy_enviro_nuclear/newnukes/articles.cfm?ID=14161, (accessed May 24, 2008).

pursue as a country."[133] In an effort to induce companies to pursue investment in nuclear power plants, EPAct established a production tax credit of 1.8 cents per kWh of electricity produced for the first 6000 *MW* (not MWh) of power produced each year (Holt). To get the tax credit, utilities and power companies would need to file their COL by the end of 2008 and begin construction before 2014.[134]

EPAct renewed the Price-Anderson Indemnity Act of 1957 and extended its expiration date to December 31, 2025.[135] Nuclear power plant operators now must obtain $300 million per plant in liability insurance from a private insurer and contribute another $10 million annually to the industry pool. As a result of those annual contributions, the total industry liability for a nuclear accident now stands at about $10 billion.[136]

EPAct also created a "delay risk insurance" policy for the power companies and utilities.[137] Many of the delays and cost overruns of the first round of nuclear plant construction have been attributed to changing regulations and to lawsuits brought by nuclear opponents. To mitigate the impact of those types of problems in the future, the EPAct authorizes the DOE to cover some of the cost of delays due to regulatory issues or

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[133] Gerelyn Terzo, "A Nuclear Renaissance? The Divisive Energy has Drawn Increased Interest, but its New Day Hasn't Yet Arrived," *The Investment Dealers' Digest*, December 4, 2006, p. 1.

[134] Terzo; "Implementation of the Provisions of the Energy Policy Act of 2005," Hearings Before the Committee on Energy and Natural Resources of the United States Senate, May 15, 2006, May 22, 2006, June 12, 2006, June 9, 2006, Washington D.C.: U.S. Government Printing Office, 2006.

[135] "The Price-Anderson Act: Background Information," American Nuclear Society, November 2005, www.ans.org, (accessed July 2, 2008).

[136] "Insurance Coverage Key to Nuclear Expansion Plans," June 30, 2008, http://0-premium.hoovers.com.cals.evergreen.edu/subscribe/co/news/detail.xhtml, (accessed July 8, 2008).

[137] Terzo.

litigation coming outside of the established licensing process.[138] In 2007, the DOE announced it would insure the first two new nuclear power plants against delays for an amount up to $500 million each and the subsequent four plants up to $250 million each.[139]

The final incentives for the nuclear industry outlined in the Energy Policy Act of 2005 were not finalized until October of 2007: Loan guarantees. Loan guarantees help power companies deal with the high up front capital costs of constructing new nuclear facilities. They assure the lenders that the government will pay back the loans if the borrowers (the power companies) default, reducing the risk to the lenders and increasing their willingness to provide the needed funds. Financial industry experts had convinced Congress that without loan guarantees, banks and Wall Street investors would not support a new round of reactor construction.

Wall Street's position may have resulted from the 1983 default on over $2.5 billion in nuclear power plant construction revenue bonds by the Washington Public Power Supply System (WPPSS). WPPSS had undertaken an ambitious program to build five new nuclear power plants in Washington State, but management problems, schedule delays, and cost overruns plagued the projects.[140] WPPSS originally quoted a cost

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[138] "Implementation of the Provisions of the Energy Policy Act of 2005," p. 53.

[139] "Howard Baker Center for Public Policy Nuclear Power Conference, Remarks as Prepared for Secretary Bodman," U.S. Department of Energy, Office of Public Affairs, October 4, 2007, http://www.energy.gov/print/5571.htm, (accessed July 7, 2008).

[140] "Causes of Cost Overruns and Schedule Delays on the Five WPPSS Nuclear Power Plants," Report to the Washington Sate Senate and 47th Legislature of the Washington State Senate Energy and Utilities Committee, WPPSS Inquiry, Vol. 1, January 12, 1981; D. Victor Anderson, *Illusions of Power: A History of the Washington Public Power Supply System*, New York: Praeger, 1985; James Leigland, and Robert Lamb, *WPP$$: Who is to Blame for the WPPSS Disaster*, Cambridge, MA: Ballinger Publishing Co., 1986.

between $4.1 billion and $6.6 billion for all five plants, but by 1983 had revised that estimate, saying it would take about $17.3 billion to complete the projects.[141] When the Washington Sate Supreme Court voided its contracts with local utilities for two of the nuclear plants, WPPSS could pay neither the interest nor the principal on some of its bonds, and defaulted.[142] In the end, WPPSS completed only one of the five plants--the Columbia Generating Station.[143]

Thus, for the next round of nuclear power plant construction, the DOE can guarantee up to 100 percent of a loan but in an amount not to exceed 80 percent of the total cost of the project.[144] And, in a departure from past loan guarantee programs, the volume of loan guarantees sought per year would not be capped—the DOE can approve as many as it deems necessary.[145] The government and not the project financers will be ultimately responsible if a utility defaults on the loan. Unfortunately, the companies that have submitted applications are seeking $122 billion in loan guarantees, far exceeding the $18.5 billion allocated.[146]

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[141] “Causes of Cost Overruns and Schedule Delays on the Five WPPSS Nuclear Power Plants.”

[142] Anderson, pp. 132 – 133.

[143] Ibid, p. 138.

[144] “Howard Baker Center for Public Policy Nuclear Power Conference, Remarks as Prepared for Secretary Bodman,” U.S. Department of Energy, Office of Public Affairs, October 4, 2007, http://www.energy.gov/print/5571.htm, (accessed July 7, 2008).

[145] Edmund L. Andrews and Matthew L. Wald, “Energy Bill Aids Expansion of Atomic Power,” *The New York Times*, July 31, 2007.

[146] “DOE Announces Loan Guarantee Applications for Nuclear Power Plant Construction,” Press Release of the United States Department of Energy, Office of Public Affairs, http://www.lgprogram.energy.gov/press/100208.pdf, (accessed May 4, 2009).

Those who do not receive funds under the EPAct loan guarantee program may have access to additional backing. The Senate's Clean Energy Jobs and American Power Act (S. 1733), introduced in September 2009 by Senators John Kerry and Barbara Boxer, includes new provisions for investment tax credits, $18.5 billion or more in additional loan guarantees, and federally financed training for nuclear workers.[147] According to Senator Lindsey Graham of South Carolina, a strong proponent of the bill, "America's turned the corner on nuclear power."[148]

3.2.9 Addressing Nuclear Power Plant Safety

Changes in the licensing process and generous funding packages will reduce licensing and financial uncertainty associated with new nuclear power plant construction. Another contextual element that has changed since the 1960s and 1970s that could affect new construction is the way in which the NRC approaches nuclear power plant safety. In the early years of the industry, the NRC relied on "defense in depth", multiple layers of protective devices and processes, backup power supplies and emergency response systems incorporated into a power plant design.[149] Such redundancy of systems and ample safety margins were expected to prevent accidents or to protect the health and

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[147] "Can We Afford More Subsidies for Nuclear Power?" Union of Concerned Scientists, October 20, 2009, http://www.ucsusa.org/news/press_release/can-we-afford-more-subsidies-0296.html, (accessed November 2, 2009); "111th Congress, 1st Session, S. 1733," The Clean Energy Jobs and American Power Act, September 30, 2009, http://www.govtrack.us/congress/billtext.xpd?bill=s111-1733, (accessed November 2, 2009).

[148] Steven Mufson, "A Nuclear Power Boost for Bill," *The Washington Post*, October 28, 2009, http://www.washingtonpost.com/wp-dyn/content/article/2009/10/27/AR2009102704081-pf.html, (accessed November 2, 2009).

[149] Perin, p. 6.

safety of the public in the unlikely event that an accident did occur.[150] Likewise, the NRC took a "defense in depth" approach to safety regulation, developing rules to cover just about every conceivable situation, and updating the rules as new situations arose. In the 1970s, the NRC began adopting and refining a new approach to complement defense in depth: Probabilistic risk assessment and risk informed regulation.

Probabilistic risk assessment (PRA) examines the parts of a complex system and factors related to them that could affect safety.[151] It looks at the potential hazard or failure to be avoided (such as a valve leakage, a power outage, or a core meltdown), then backtracks to understand the multitude of "initiating events" that might lead to that hazard. It also examines the possible sequences of events between the initiating event and the failure. PRA then assigns estimated frequencies to each step along the way and for each entire pathway. In this way, PRA gives the NRC (and the industry) an idea of the relative risks associated with potential hazards or failures for a nuclear power plant. Both can use that information to isolate areas of concern as well as areas that no longer need strict attention or regulation.[152] (See Appendix 8 for more information about PRA.)

PRA and the associated use of computer modeling have allowed analysts to quantify risks of operating nuclear power plants and to pinpoint weaknesses in new reactor designs. Unfortunately, PRA cannot account for all human elements (errors in judgment, procedural mistakes, and the like), modifications to equipment not reflected in

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[150] Meserve.

[151] "Fact Sheet on Probabilistic Risk Assessment," The Nuclear Regulatory Commission, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/probabilistic-risk-asses.html; Rick Grantom, The South Texas Project, Telephone Interviews, Spring 2009.

[152] Meserve; "Fact Sheet on Probabilistic Risk Assessment;" Grantom.

design documents, or quirks in a system.[153] Some experts argue that it should only be used retrospectively, since forward-looking estimates of risk (or those associated with new designs) must be based on best guesses and not actual data.[154] In either case, there will always be a degree of uncertainty associated with the PRA risk estimates.

By the middle of the 2000s, the time was ripe for a "nuclear renaissance." Oil and natural gas prices had jumped to record highs. (Figures 6 to 8.) Although coal remained relatively inexpensive, increased reliance on coal raised concerns about greenhouse gas emissions. The industry itself was demonstrating that the older nuclear plants could be operated safely and economically as capacity factors increased and the number of unplanned shutdowns dropped (Figures 4 and 5). The NRC had revamped its licensing process and the U.S. government showed its support for new nuclear power plant construction by providing financial incentives in the form of production tax credits and loan guarantees. Utilities and consortia submitted combined construction and operating licenses for new nuclear power plants. But it will be a few more years before we know if anyone actually builds a facility, if the "renaissance" has in fact begun.

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[153] Grantom; Perin, p. xi – xiii.

[154] Rodney P. Carlisle, "Probabilistic Risk Assessment in Nuclear Reactors: Engineering Success, Public Relations Failure," *Technology and Culture*, Vol. 38, No. 4 (October 1997), pp. 920 – 941.

3.3: More Information About Federal Loan Guarantees

Parts 3.1 and 3.2 briefly reviewed the environmental and regulatory context of nuclear reactor construction in the United States during the 1960s, 1970s and today. Table 2 below summarizes some of the major differences between the state of the nuclear industry during the original round of reactor construction in the United States and that of the current "renaissance."

	Then (1960s - 1980s)	Now (2000s)
Regulatory Bodies	Atomic Energy Commission (AEC)	Nuclear Regulatory Commission (NRC)
Industry Groups		Institute of Nuclear Power Operations (INPO) World Association of Nuclear Operators (WANO)
Approach to Safety	Defense in Depth	Defense in Depth and Probabilistic Risk Assessment
Licensing	Two- Step Licensing Process	Combined Construction and Operating License Early Site Permitting Standardization of Reactor Designs Consortia Creating Applications
Energy Context	Energy Crisis of the 1970s/Desire for Energy Independence Fuel Price Volatility	Instability in Iraq and the Middle East/Desire for Energy Independence Fuel Price Volatility
Industry Context	Regulated Industry Fragmented Industry Domestic Suppliers	Deregulated Electric Markets and Industry Competition in Some States Industry Consolidation and Reorganization Global Supply Chain, Global Competition for Parts
Regulatory Context	Clean Air Act Price Anderson Indemnity Act	Kyoto Protocol; Concerns over Global Climate Change, Carbon Taxes Government Encouraged Investment in New Nuclear Renewal of the Price-Anderson Indemnity Act of 1957 Delay Risk Insurance, Production Tax Credits Loan Guarantees

Table 2: The State of the Nuclear Industry, Then and Now: A Comparison of Factors Affecting the Industry in the 1960s – 1980s and in the 2000s

Table 2 reveals that while the U.S. electric generation industry faced energy supply issues and concerns over air quality both during the first round of reactor construction and today, much else has changed. That leads to the question "Which of the changes actually has spurred the recent spate of investment and applications for licenses to build new nuclear reactors in the United States?" What provoked utilities to finally say “Let’s do it!”? And, why now? For decades politicians have aspired to wean the country from its dependence on foreign oil and environmentalists have voiced concerns about the environmental degradation caused by a reliance on coal. But those factors alone did not spur a renewed interest in nuclear power, nor did the codification of safety standards or the NRC certification of new reactor designs. Regional initiatives to curb greenhouse gases even failed to spur reactor construction in those areas. The historical review presented in this thesis suggests that the federal loan guarantees promised by the Department of Energy as part of the Energy Policy Act of 2005 served as the catalyst for the nuclear renaissance.

Timing provides one clue as to the importance of the loan guarantees. The NRC revised its license application procedures and started calling for standard reactor designs to review in the 1990s, yet those actions did not spur any construction and operating license applications. The electric industry began deregulating in the mid 1990s. Some states moved early to open their markets to competition; others remain regulated today. However, as seen earlier, whether a state is (or was) regulated or competitive had little impact on a utility’s decision to consider building a new nuclear power plant. Finally, while Nuclear Power 2010 did spur the formation of consortia, and the risk insurance and tax credits of the Energy Policy Act of 2005 did provide some financial incentives, the NRC received no license applications until most of the details of the loan guarantee program were in place in late 2007. (Recall that the first complete application came from NRG Energy in September 2007, for its third and fourth reactors at its South Texas Project.)

As early as March of 2004, the Senate Committee on Energy and Natural Resources heard statements indicating that federal financial support would be necessary to spur investment in new nuclear plants. Marvin S. Fertel, Senior Vice President and Chief Nuclear Officer of the Nuclear Energy Institute (a policy organization of the nuclear energy and technologies industry) reported that "[t]he financial community has indicated that it is unlikely to provide external debt financing from the capital markets, given the regulatory risks associated with the first several new nuclear power plants. This means that companies considering building new nuclear power plants must either finance the first few plants with 100 percent equity, or obtain government loans, loan guarantees, or some other form of comparable government insurance . . ."[155]

James K. Asselstine, Managing Director of Lehman Brothers, Inc., research analyst responsible for covering the electric utility and power sector, and member of the Secretary of Energy Advisory Board's Nuclear Energy Task Force, testified before that same Senate Committee regarding its Nuclear Power 2010 Program on April 26, 2005. (Recall that Nuclear Power 2010 involved a cost sharing program designed to identify sites for new nuclear power plants, bring new reactor technology to market, and demonstrate the new NRC licensing process.) He commented that one of the two key questions of interest to analysts and potential investors would be "Is the proposed new nuclear plant cost competitive with other available alternatives for new baseload generating capacity?[156] The first three to four plants of each design likely would not be

[155] "Nuclear Power in the United States," Hearing Before the Subcommittee on Energy of the Committee on Energy and Natural Resources of the United States Senate, March 4, 2004, Washington D.C.: U.S. Government Printing Office, 2004, p. 29.

[156] "Nuclear Power 2010 Program," p. 5.

competitive, due in part to the first-of-a-kind-engineering costs incurred to sufficiently complete a new reactor design for NRC regulatory approval. The Energy Advisory Board's Task Force had concluded that some federal government financial incentives would be needed to ensure cost competitiveness and to mitigate the commissioning risks associated with the initial group of new nuclear plants. At that time, [t]he Task Force recommended the following financial incentives: a Federal loan guarantee or direct government loans; a Federal power purchase agreement; accelerated depreciation; an investment tax credit; and a production tax credit."[157]

Later testimony before the Department of Energy (DOE) and its Chief Financial Officer in June 2007 provides further clues as to the importance of loan guarantees to the nuclear power industry.[158] The loan guarantee program already had been approved by Congress. Still, high level executives from energy companies made their way to Capitol Hill to stress the need for the government to show its support for nuclear power in that material way. For example, Steve Winn, Executive Vice President for NRG Energy remarked

> NRG believes the coming wave of nuclear plants in the U.S. will require the commitment of developers like NRG, equipment suppliers, and state and local governments, and we believe that all of the parties have tangibly shown their commitment . . . The remaining piece in the future success of nuclear is a strong commitment on the part of the Federal government . . . providing the capital necessary for a nuclear resurgence, can only be accomplished by using the DOE Loan Guarantee Program . . .").[159]

[157] Ibid, p. 7.

[158] "LPG Public Meeting," U.S. Department of Energy, Office of the Chief Financial Officer, Washington D.C.: Executive Court Reporters, Inc., June 15, 2007.

[159] Ibid, pp. 9 – 11.

Paul Hinnenkamp of Entergy Nuclear echoed those sentiments, claiming that "loan guarantees are essential to reduce the financial risk of new nuclear deployment and enable Entergy to leverage the large investment required . . . We cannot take on the debt required to finance a new build without an effective loan guarantee program."[160] Jeff Lyash, President of Progress Energy Florida, also emphasized the need for the loan guarantee program as a way to "send a strong, clear signal that the federal government supports commercial nuclear operations as a part of our solution [to meeting growing energy needs in a way that's environmentally responsible]."[161]

The DOE also accepted written statements about the loan guarantee program through July 2 of that summer. The documents received reminded the DOE of the magnitude of investment required to build a nuclear plant. Michael J. Wallace, President of Constellation Generation Group, advised:

> . . . the production tax credits contained in the Energy Policy Act are necessary to incentivize early movers who may otherwise be reluctant to be the first to market.
>
> But the most important Energy Policy Act incentive for new nuclear is the Title XVII loan guarantee program, which we view as indispensable. The loan guarantees are meant to address a market financing gap that results from the combination of several factors including (i) the prior nuclear plant construction cycle that . . .was burdened by regulatory uncertainty and resulting delays and cost over-runs, (ii) perceived uncertainty of an untested . . . regulatory system, (iii) perceived technology risk, and (iv) an institutional loss of understanding regarding the reality of nuclear financial risk in some elements of the financial community.[162]

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[160] Ibid, p. 57.

[161] Ibid, p. 133.

[162] Michael J. Wallace, "On the Notice of Proposed Rulemaking Implementing the Loan Guarantee Program for Projects that Employ Innovative Technologies," Jun15, 2007, http://www.lgprogram.energy.gov/nopr-comments/comment03.pdf, (accessed March 19, 2009).

Executives from Constellation Energy Group, Inc., Entergy Corp., and Exelon submitted a joint statement that outlined the millions of dollars and years of effort already committed by the companies interested in applying for combined construction and operating licenses.

> The size and scale of nuclear projects, and the multi-year commitments that need to be made by private industry, make it imperative that DOE create certainty in the near-term around the future availability of the Title XVII Loan Guarantee Program for nuclear power projects . . . the multi-year commitment being made by private parties needs to be matched with a multi-year commitment from the federal government.[163]

Likewise, a statement released by Dominion Resources, a company in the process of developing its application for a new reactor at its North Anna site, claimed that "through all of its planning and preparation, Dominion has understood the economic reality that a federal loan guarantee is essential to raise the capital necessary to build this plant."[164]

"Essential." "Most Important." "Imperative." Whether in oral or written testimony to the DOE, these industry representatives (and others) expressed their conviction that without the financial backing of the U.S. government, the nuclear renaissance would not occur.

Similar sentiments surfaced in the media and in interviews conducted expressly for this thesis, to explore the reasons companies had submitted applications to build new nuclear power plants. When asked about the role of loan guarantees in the future of new

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[163] Joe C. Turnage, Theodore Bunting Jr., John F. Young, and Steve Winn, "Written Comments in Response to RIN 1901-AB21, Loan Guarantees for Projects that Employ Innovative Technologies, 72 Federal Register 27471 (May 16, 2007)," July 2, 2007, http://www.lgprogram.energy.gov/nopr-comments/comment41.pdf, (accessed March 19, 2009).

[164] "Comments of Dominion Resources Inc. on DOE Notice of Proposed Rulemaking 10 CFR Part 609, RIN 1901 – AB21," July 2, 2007, http://www.lgprogram.energy.gov/nopr-comments/comment36.pdf, (accessed March 19, 2009).

nuclear power plant construction in the United States, Richard Zuercher of Dominion, Danny Blanton, Entergy Nuclear, and a spokesperson for PPL Corp. of Pennsylvania all agreed on their importance. For PPL, the guarantees “are a necessary component for getting financing at reasonable rates. They are a big part of the decision.”[165] PPL CEO James Miller explained that federal loan guarantees were needed because Wall Street probably would not loan the money without them.[166] According to Dominion’s Zuercher, “They serve as handholding for investors, if you fail. But you hope you never have to draw on them.”[167] He felt that Dominion was ‘well positioned’ to receive a guarantee. Entergy’s Blanton tempered his expectations, recalling that getting a loan guarantee required a company to have its NRC license approval in hand—and such an approval is still years out for all applicants.

In addition, politicians like Washington State’s Senator Maria Cantwell, member of the Senate Commerce, Energy, Finance, and Natural Resources Committees, supports the expansion of nuclear power as part of a plan to make the United States’ energy system “cleaner, more efficient, and more diverse.”[168] Ms. Cantwell has recommended financial backing for investment in wind and solar technologies and upgrades in the electric grid, tax credits for plug-in electric vehicles, and the loan guarantees for new

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[165] Anonymous, PPL, Telephone Interview of February 26, 2009.

[166] “PPL CEO Sees More Fast Growth in Merchant Unit,” March 25, 2008, http://www.reuters.com/article/companyNews/idUSN25299610120080325, (accessed March 25, 2009).

[167] Rick Zuercher, Manager, Public Affairs, Dominion Virginia Power, Telephone Interview of March 12, 2009.

[168] Maria Cantwell, United States Senator, Personal Correspondence of July 15, 2009.

nuclear power plants: "I continue working with my colleagues to further develop balanced and sustainable solutions to our nation's long term energy needs."[169]

Somewhat surprisingly, however, Progress Energy Florida withdrew from the loan guarantee competition, but continues to press forward to build its Levy County, Florida plant. According to Rick Kimble, Manager of Nuclear Communications, that decision rested on the high cost of applying and the provision contained in the guarantees giving the DOE possession of the power plant if a company defaulted on its loan.[170] Progress Energy did not want the DOE to take over their nuclear facility (EPAct of 2005 designates the DOE as the primary project manager in the event of a default[171]), nor did they have faith in the DOE's ability to carry out the loan guarantee program as intended.

The Tennessee Valley Authority (TVA) also has moved ahead with its plans for new nuclear without loan guarantees. Because the TVA is a federal agency, it may not qualify. Furthermore, it has been sitting on its own unused nuclear assets since the mid-1980s, when it shuttered several partially complete nuclear units. TVA updated then reopened Browns Ferry Unit 1 in 2007, more than 30 years after fire damage shut it down in 1975, and 20 years after all other Browns Ferry units closed in 1985 due to safety and management concerns. Also in 2007, the TVA Board of Directors approved the spending

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169 Ibid.

170 Rick Kimble, Manager of Nuclear Communications, Progress Energy Florida, Telephone Interview of January 29, 2009.

171 "Loan Guarantee Provisions in the 2007 Energy Bills: Does Nuclear Power Pose Significant Taxpayer Risk and Liability?" Environmental and Energy Study Institute Briefing, October 30, 2007, Washington D.C., http://www.eesi.org/103007_Nuclear_Loan_Guarantee_Briefing, (accessed December 15, 2009).

of $2.5 billion over five years to complete Watts Bar 2. The proposed new nuclear units for TVA will be built on another site with partially complete reactors, in Bellefonte, AL.

Thus, while industry analysts and many utilities deem loan guarantees crucial to the future of new nuclear power plant construction, some companies are proceeding without them. Why? What is the rationale for their multi-billion dollar investments? The sections that follow examine in more detail the reasons expressed, in the media and in phone interviews, by many of the companies that have submitted applications to build new nuclear plants. They review what the companies themselves reveal about the driving force(s) behind the nuclear renaissance in the United States.

4.0 What the Electric Companies and Utility Owners Tell Us

The Nuclear Regulatory Commission's list of COL applicants served as the basis for finding interview candidates for this research. Although phone calls to company executives were not returned, calls to the media/press and operating departments did result in interviews with representatives from 8 of the 18 applicant companies: AmerenUE, Dominion, Duke Energy, Entergy, NRG Energy (South Texas Project), PPL, Progress Energy Florida, and the Tennessee Valley Authority (TVA). The sample may suffer from a voluntary response bias. However, the nuclear facilities owned by these companies do cover a wide geographical area: from Texas to South Carolina and Florida to Maryland. The sample also includes companies operating in both regulated and deregulated states, as well as private entities, public utilities, and a federal agency. The sample is adequate for this exploratory research.

In newspapers, magazines, journal articles, company annual reports and press releases, and in response to phone interview questioning, companies that have submitted applications to build new nuclear facilities most often cited concerns about climate change and emissions regulation as driving their renewed interest in nuclear power. The volatile price of fossil fuels (particularly natural gas), the ability to secure federal loan guarantees, the mandate for energy companies to be able to meet future demand for electricity, and a firm's past experience with operating nuclear reactors also influenced that decision. (See Table 3 at the end of this Chapter.) Thus, a picture emerges showing companies becoming increasingly aware that carbon taxes or a cap and trade system designed to curb greenhouse gas emissions lie in the not too distant future. They realize that either of those options will affect their ability to produce electricity using coal, increasing their generating costs as they implement cleaner coal technologies or limiting the amount of coal-fired electricity they can produce. Higher and more widely fluctuating prices for natural gas and oil increase the risk associated with reliance on either of those sources. But the companies need something to meet customer demand for electricity. So, with the financial backing of the federal government, they look to expand their fleet of nuclear power plants, the non-carbon emitting baseload generation they will need in the years to come.

But the story is not quite that simple. As explained below, companies have followed different paths to arrive at their decisions to submit an application for a combined construction and operating license to the NRC, and each of them faces a unique set of constraints and opportunities. Not all of the companies submitting combined construction and operating license applications to the NRC are discussed. The selection represents those for which contact information was available and whose representatives responded to requests for telephone interviews during a five month period in the spring of 2009. That selection presented does provide a look at the wide range of factors driving the interest in new nuclear power plants.

4.1 NRG Energy

With its September 20, 2007 submission, NRG Energy became the first company to file a complete "one-step" construction and operating license application with the NRC.[172]

[172] "First Full COL Application Submitted," *Nuclear Engineering International*, November 2007, Vol. 52, No. 640, p. 4; "NRG Energy Asks NRC for COLA to Build 2,700 MW in Nuclear Capacity," *Power Engineering*, October 2007, Vol. 111, No. 10, p. 14; Vicki Vaughn, "Application is First in Decades for New Nuclear Reactor," *San Antonio Express-News*, September 24, 2007.

NRG was founded in 1989 and has operated as a wholesale power generating company, with facilities reaching from New York to California (but mostly concentrated in the Northeast).[173] In 2003, the company filed for Chapter 11 bankruptcy, emerging a year later. It acquired an ownership stake in the South Texas Project, a two-unit nuclear plant outside of Houston, TX, in 2006. Then, in June 2006, NRG announced its intentions to partner with General Electric in constructing two new Advanced Boiling Water Reactor units at the South Texas Project (STP). (The G.E. ABWR design initially had been certified by the NRC in 1997, but it would need some modifications to accommodate an updated control room and the safety systems required in a post 9/11 world.)

NRG signed an agreement with Toshiba of Japan to construct the two ABWR reactors.[174] According to David Crane, CEO of NRG, "Toshiba has an unblemished record of on time, on budget delivery of advanced nuclear plants and we look forward to working with them to make this essential no-carbon baseload plant a technical, commercial and environmental success."[175] Austin Energy, co-owner of the existing

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[173] "Resource News: Market Commentary on NRG Energy, Inc.," *M2 Presswire*, June 11, 2007, http://goliath.ecnext.com/coms2/gi_0199-6416405/Market-Commentary-on-NRG-Energy.html, (accessed February 14, 2008); "Resource News: In-Depth Research on NRG Energy, Inc.," *M2 Presswire*, March 1, 2007, http://goliath.ecnext.com/coms2/gi_0199-6294936/In-Depth-Research-on-NRG.html, (accessed February 14, 2008).

[174] "Toshiba Signs EPC Agreement with STP Nuclear Operating Company," March 2, 2009, http://nuclear.energy-business-review.com/news/toshiba_signs_epc_agreement_with_stp_nuclear_operating_company_020309/, (accessed April 22, 2009).

[175] "NRG Energy Signs Project Services Agreement with Toshiba Corporation for South Texas Project Nuclear Power Plant Expansion," Company News Release, August 9, 2007, http://ir.nrgenergy.com/phoenix.zhtml?c=121544&p=irol-newsArticle_Print&ID=1038695&highlight=, (accessed February 14, 2008).

units, bowed out of the project due to concerns over the cost, schedule, and financial risk associated with the project; the city of San Antonio (through CPS Energy) remained a partner.[176] For CPS Energy, a diversified fuel mix was essential for keeping its customers' electric bills low and nuclear fit well into that mix:

> Nuclear is the best choice for additional power because it is safe, cost-effective and provides a clean source of energy. . . Nuclear fuel costs remain significantly lower than coal, natural gas and renewables. Also, the operating costs of nuclear plants have remained steady over time. Finally, nuclear is an environmentally friendly source of energy because it does not emit any greenhouse gases or other air pollutants into the atmosphere.[177]

The two companies signaled early in the project that they looked to nuclear power to provide a source of baseload electricity with a relatively low, stable cost and essentially no carbon dioxide emissions.

Thad Hill, President, NRG Texas, echoed those sentiments. In an article in the Houston Chronicle in October of 2007, Hill was quoted as saying, "The market is ready for new nukes, especially in Texas where consumers have seen electric rates rise because of higher natural gas prices. What Texas needs is more fuel diversity." Hill also expressed his belief that the federal government would soon legislate carbon. "Nukes . . . have no carbon emissions, so by the time the new STP units are operational, they're likely to have a built-in tax benefit."[178]

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[176] "NRC Postpones Public Comments on STP Units," *Bay City Tribune*, February, 18, 2008; Vicki Vaughn, "Nuclear Stakes Could Change," San Antonio Express-News, February 12, 2008, http://www.slate.com/id/2176189/, (accessed February 21, 2008).

[177] "Frequently Asked Questions About Nuclear Energy," http://www.citypublicservice.com, (accessed February 22, 2008).

[178] "The Nuclear Option Detailed (Updated)," October 19, 2007, http://blogs.chron.com/lorensteffy/2007/10/the_nuclear_opt_1.html, (accessed February 21, 2008).

The desire to turn toward a non-carbon-emitting source also appeared in a *Fortune* magazine article, "The Man Who Would Be Mr. Clean," that described NRG as "a ferocious polluter, responsible for generating more than 70 million tons of atmospheric carbon annually," and tying NRG for eighth place among U.S. carbon emitters. "NRG overall is fundamentally about coal." But, according to CEO Crane, "If we clean up our carbon situation over the next 20 years, principally with nuclear, then we will be seen as clean."[179] Crane has become a zealous supporter of federal cap and trade regulation. He does not believe wind and solar power, conservation, and efficiency can solve the U.S. energy problems and thus backs futuristic coal and nuclear technology. However, "[h]e needs scissors to cut through red tape so NRG can bury sequestered carbon. . .He needs support for his burgeoning nuclear program: tax credits, loan guarantees, insurance to cover licensing delays, and federal dollars to educate nuclear engineers. . ."[180] Thus, although investing in nuclear and clean coal may be the right thing to do, Crane has indicated that NRG cannot, and perhaps will not, do so without support from the federal government.

In a startling turn of events, in February of 2008, NRG asked the NRC to delay indefinitely its application, citing issues with vendor support and the completeness of the ABWR reactor design.[181] However, in early 2009, the NRC reinstituted the application

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[179] "The Man Who Would be Mr. Clean," *Fortune*, December 24, 2007, Vol. 156, No. 13, p. 69ff.

[180] Ibid.

[181] Dan Caterinicchia, "NRG Energy Nuclear Project Delayed," February 14, 2008. www.chron.com/disp/story.mpl/ap/fn/5541925.html, (accessed February 18, 2008); Tom Fowler, "Snags Seen for Nuclear Power," February 15, 2008, www.chron.com/disp/story.mpl/headline/biz/5546664.html, (accessed February 18, 2008); "Nuclear Application Delayed," *The New York Times*, February 14, 2008.

review. Toshiba had signed an engineering, procurement, and construction agreement with South Texas for the new reactors. In addition, NRG and Toshiba announced they had formed a new firm, Nuclear Innovation North America, to bring the ABWR to the United States.[182]

Because Texas deregulated its electricity markets, NRG cannot pass on the costs of new nuclear power plants directly to its customers through rate increases. To spread the investment risk, NRG, like other utilities in deregulated states, hopes to partner with other companies. Although CPS would provide some of the funds for the project, Crane had told reporters "having a Japanese partner might help the company obtain the financial support from the Japanese government, along with the U.S. loan guarantees and other incentives for nuclear generation. . ."[183] The Toshiba deal undoubtedly will help Crane and NRG get that extra support.

Having Toshiba as a partner also will help calm the fears of NRG investors and lenders. According to CEO Crane, "the one principal risk you cannot lay off is who's going to build this thing on time and on budget."[184] Since it has a financial stake in the project, Toshiba has every incentive to meet those criteria.[185]

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[182] Matthew L. Wald, "NRG Energy Sets Up an Entity to Build Nuclear Plants," *The New York Times*, March 26, 2008, Section C, p. 2.

[183] "Update 1-- Utility Delays Nuclear Vote; NRG Seeks Partners," October 2, 2007, http://www.reuters.com/article/bondsNews/idUSN0244497720071002, (accessed March 19, 2009).

[184] Wald, March 26, 2008.

[185] "The Power Broker," *Smart Money*, October 2008, pp. 22 – 23.

Still, Crane would like the public to believe in his commitment to the environment above all .[186] Shortly after the application for the STP units was announced, he proclaimed, "It is a new day for energy in America. Advanced technology nuclear power plants like STP 3 & 4, generating a vast amount of electricity cleanly, safely and reliably, will make an enormous contribution toward the greater energy security of the United States. But equally, this announcement heralds a new day for the environment."[187] Later, in the interview with *SmartMoney* magazine, he admitted, "Global warming is just a massive issue. Like every CEO, I'm trained that it's all about shareholder value and almost everything is a bottom-line question. But when I looked at possible consequences of global warming, it's a moral obligation . . . the more important thing is to do something about global warming; every year we delay makes the remedies more severe."[188]

In short, environmental/global climate change issues seem to have dominated NRG's initial decision to build a new nuclear power plant, and the cost of fuel supplies was a factor. However, construction will not occur without financial backing of its partners and the U.S. government.

4.2 Entergy Operations, Inc.

The River Bend Nuclear Power Station lies not too far from NRG's South Texas Project, near St. Francisville, LA. Entergy Operations has chosen River Bend as the site

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[186] "NRG Facing Carbon Head On; Betting on Nukes," *Natural Gas Week*, June 8, 2007, p. 1.

[187] "NRG Energy Submits Application for New 2,700 Megawatt Nuclear Plant in South Texas," Company News Release, September 24, 2007, http://phx.corporate-ir.net/phoenix.zhtml?c=121544&p=irol-newsArticle_Print&ID=1054822&highlight=, accessed February 14, 2008).

[188] "The Power Broker," *Smart Money*, October 2008, p. 22 – 23.

for one of the new reactors planned for its nuclear fleet. Entergy initially chose the G.E.-Hitachi Economic Simplified Boiling Water Reactor for the site. Design concerns and issues with component costs ("They essentially tripled the price they wanted to build it for") led Entergy to ask the NRC to suspend its review of their COL in January of 2009.[189] G.E.-Hitachi has submitted revised design documents to the NRC; Entergy continues to examine designs from other vendors.[190]

Like many of the electric companies in the U.S., Entergy has its roots in regional utilities that were combined under a large holding company.[191] In the case of Entergy, Middle South Utilities united the operations of smaller utilities in Arkansas, Mississippi, and Louisiana. In 1974, Middle South Utilities formed Middle South Energy to bring its first nuclear plant on line at Grand Gulf, MS. Cost and schedule overruns plagued the project and the second unit at the site was cancelled. In a bid to distance itself from controversy surrounding paying for Grand Gulf through rate increases, Middle South changed its name to Entergy in 1989.[192] It wasn't until 1999 that Entergy began investing in more nuclear capacity, buying the Pilgrim plant in Massachusetts, and

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[189] Danny Barrett, Jr., "Grand Gulf Sets Sights on Ramping Up Output," *The Vicksburg Post*, October 8, 2009, http://www.vicksburgpost.com/articles/2009/10/08/news/doc4ace0c6e5708d778634565.prt, (accessed October 25, 2009); Eileen O'Grady, "Update 2 – Two US Firms' Reactor Deals with GE Hitachi Fail," January 9, 2009, http://www.reuters.com/article/rbssUtilitiesMultiline/idUSN0931235920090110, (accessed March 19, 2009).

[190] Barrett.

[191] "Entergy History," http://0-premium-hoovers.com.cals.evergreen.edu/suscribe/co/history.xhtml?ID=ffffrfhtcxfskcsffh, (accessed July 8, 2008).

[192] Ibid; Dianna Solis, "Electric Company Wants to Change its Name and Image—Middle South Utilities Inc. Chooses Entergy, Joining Others in 'En' Craze," *The Wall Street Journal*, January 31, 1989, p. 1.

contracting to operate Nine Mile Point in New York.[193] Entergy subsequently purchased the Fitzpatrick and Indian Point 3 units, also in New York, Vermont Yankee (in Vermont), and the Palisades Nuclear plant in Michigan.[194]

In 2007, Entergy announced plans to spin off half of its nuclear power plants and create a stand alone, publicly traded nuclear energy company.[195] Why? According to an article in the *Wall Street Journal* dated November 6, 2007,

> Less than a decade ago, Entergy was picking up distressed nuclear assets on the cheap. In one case, it bought a plant for little more than the value of the fuel on hand . . . The company reaped most of its third-quarter [2007] profits from its nuclear fleet, not its regulated utilities . . . Entergy, Exelon, and other consolidators have increased the productivity of nuclear plants, and they are able to collect rising prices in deregulated markets as supply margins shrink . . . During the next five years, sales contracts on the output of the five plants Entergy plans to spin off are expiring. It is negotiating new prices that are as much as triple the old ones.[196]

It would seem that for Entergy, nuclear plants are the "cash cows" of its business.

Decoupling those five nuclear power plants also protects Entergy from any costs that would be associated with updating, modifying, or eventually decommissioning and dismantling the facilities.[197] The operating license for Pilgrim 1 expires in 2012. The NRC currently is reviewing a license renewal for Indian Point 3 (the current license expires in 2015). Nine Mile Point, the oldest of the plants, started operations in 1969 but

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[193] Matthew L. Wald, "Nuclear Power's Second Act; Rising Demand for Electricity Revives Aging Reactors," *The New York Times*, December 20, 2000.

[194] Rebecca Smith, "Entergy to Buy Nuclear Plants from Power Utility," *The Wall Street Journal*, February 15, 2000, p. B15.

[195] Rebecca Smith, "Entergy Nuclear Spinoff Taps Rising Plant Values," *The Wall Street Journal*, November 6, 2007, p. A.15.

[196] Ibid.

[197] Ken Silverstein, "Spinning Value," *Energy Biz Insider*, December 1, 2008.

has had its license extended until 2029.[198] No one knows what expenses will be incurred by those older plants.

Danny Blanton, Entergy Nuclear media contact, indicated in a February 14, 2009 interview that Entergy's interest in adding new nuclear plants has been driven by three main factors: (1) Concerns about carbon/greenhouse gas emissions, (2) The current "energy crisis", and (3) Nuclear power's ability to provide large baseload capacity with a small "footprint."[199] He did not mention the profit potential. Instead he pointed out that, like David Crane of NRG Energy, Entergy management supports cap and trade programs for carbon emissions. Under such programs, Entergy would receive or would buy a set number of carbon emissions allowances, which would allow it to continue to operate its fossil-fueled facilities. Unused allowances could be sold or traded to other companies who emit more carbon. According to Blanton, since nuclear plants do not give off carbon dioxide, adding more of them to the generating fleet would mean Entergy would not use and might profit from selling its emissions allowances.

In addition, "[t]he population is growing and we all have more 'stuff'" (Blanton Interview).[200] Entergy plans to address that increasing demand using clean air energy sources, like nuclear. Entergy also prefers nuclear because it would take only one pellet of uranium to produce the same amount of electricity as one ton of coal—giving nuclear a much smaller environmental footprint than its rival in baseload generation, coal.

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[198] "Nine Mile Point Nuclear Station, New York," http://www.eia.doe.gov/cneaf/nuclear/page/at_a_glance/reactors/nine_mile.html, (accessed October 25, 2009).

[199] Danny Blanton, Nuclear Media Contact, Entergy, Telephone Interview of February 18, 2009.

[200] Ibid.

When asked specifically about the regulatory and licensing process changes that had occurred since the first round of reactor development, Blanton acknowledged that federal loan guarantees were a big part of Entergy's decision about investing in new nuclear generation, mainly due to the high capital costs associated with building the plants. Unfortunately, the program expires in September of 2009—long before any company will have its required NRC license approval in hand. Blanton went on to say that the extension of the Price-Anderson Act was not as critical to Entergy as the loan guarantees.

Other factors taken into account in Entergy's decision to apply for a construction and operating license included the NRC's streamlining of the licensing process, the ultimate cost to the customers, and other fuel options available. "We want to produce electricity that's affordable for the people. And the most affordable is nuclear. But Entergy is not closing the doors on other renewable sources. What you can use depends on your baseload needs and your geographic region. There are parts of Mississippi that can't get a radio signal let alone enough wind to produce electricity![201]

Recall that in their joint letter to Mr. Howard Borgstrom of the DOE, executives from Entergy, Constellation Energy Group, NRG Energy, and Exelon stressed their belief that loan guarantees were "critical to their continued efforts to develop the first new nuclear generating units to be ordered and built in the United States in nearly thirty years"[202] and that "the size and scale of nuclear projects, and the multi-year commitments

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[201] Ibid.

[202] Joe C. Turnage, Theodore Bunting Jr., John F. Young, and Steve Winn, "Written Comments in Response to RIN 1901-AB21, Loan Guarantees for Projects that Employ Innovative Technologies, 72 Federal Register 27471 (May 16, 2007)," July 2, 2007,

that need to be made by private industry, make it imperative that DOE create certainty in the near-term around the future availability of the Title XVII Loan Guarantee Program for nuclear power projects."[203] Thus, while Entergy's Senior Vice President of Finance focused (understandably) on the monetary aspects of the decision to build a new nuclear power plant, Mr. Blanton's comments seem to indicate that the loan guarantees are only part of a wider array of forces behind Entergy's interest. The interest in new nuclear power stems from Entergy's need to invest in non-carbon emitting baseload generation, but it is the federal incentives behind the nuclear program that make it highly desirable and fiscally feasible at this particular point in time.

4.3 Duke Energy

The environment and the potential for nation-wide restrictions on carbon emissions also played a role in Duke Energy's decision to apply to build a new nuclear power plant. Founded in 1899 as Catawba Power but renamed Duke Power in 1924, Duke has been a mainstay in Southeast for over a century.[204] The company now serves over four million customers in Ohio, Kentucky, Indiana, and the Carolinas. Most of Duke's generation facilities run on coal or natural gas, but it does operate seven reactors at three sites in North and South Carolina.

Duke's CEO, Jim Rogers, immersed himself in the science of global warming as early as the 1990s and became enthusiastic about the technological opportunities it presented. "Rogers's environmentalism is practical, enthusiastic and intrigued by clean-

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http://www.lgprogram.energy.gov/nopr-comments/comment41.pdf, (accessed March 19, 2009) p. 1.

[203] Turnage et al., p. 3.

[204] "Duke Energy, History," www.duke-energy.com (accessed January 19, 2009).

tech innovations, not given to heartstring-tugging rhetoric about vanishing species or redwood trees."[205] Rogers became an outspoken advocate of a market based approach to limiting greenhouse gas emissions, testifying before Congress in favor of a cap and trade program for carbon dioxide.[206] In 2007 he made it known that the issues related to carbon emissions served as the "tipping point" for the company's decision about nuclear power: "You wouldn't take such a big risk if you weren't going to be in a carbon-constrained world."[207]

Even as Rogers publicly proclaimed Duke's 'green' intentions, other company spokespeople conveyed different messages. For example, early in 2005, Bryan Dolan, Duke's Manager of Nuclear Projects, told the New York Times that Duke became increasingly interested in nuclear power based on the costs of alternatives. "[T]he numbers we have today tell us that nuclear will be very competitive." The price of natural gas had nearly tripled and showed no signs of falling, and analysts were unsure of the potential costs of coal-fired generation due to uncertainty surrounding its regulation.[208] The 2005 Summary Annual Report blended that sentiment with the environmental issues.

[205] Clive Thompson, "A Green Coal Baron?" The New York Times, June 22, 2008.

[206] "Duke Energy CEO Jim Rogers Voices Support for USCAP's Blueprint for Legislative Action," PRNewswire, January 15, 2009, http://sev.prnewsire.com/oil-energy/20090115/CLTH04315012009-1.html, (accessed January 21, 2009); Bruce Henderson, "Duke Joins Plan to Lower Emissions," *McClatchy – Tribune News*, January 16, 2009, http://www/proquest.umi.com/pqdweb?did=1627783831&Fmt=3&clientId=10024&RQT=309&VName=PQD, (accessed March 12, 2009); Reshma Kapadia, "Duking it Out Over Pollution," *Smart Money*, April 2009, pp. 16 – 18.

[207] "Boom," *The Economist*, Vol. 383, No. 8531, June 2, 2007, pp. 20 – 22.

[208] Matthew L. Wald, "Duke Power May Seek to Build Nuclear Plant," *The New York Times*, March 15, 2005.

> [G]rowing concern about greenhouse gases, skyrocketing fuel prices and a need to develop a next generation of capacity will challenge the industry like it has never been challenged before . . . Our newly combined fleet [Duke plus Cinergy] uses a diverse combination of fuels —nuclear, coal, gas and hydro—reducing our dependence on any one commodity.[209]

The 2006 Summary Annual Report added yet another dimension to the problem: Customer demand. Duke reported gaining 40,000 to 60,000 customers each year in the Carolinas. "We are required by law to meet the electric power needs of our customers as economically and reliably as possible."[210] The Report then summarized actions taken by Duke in the previous year to meet the growing demand, including building new power plants; using a diverse mix of fuels and technologies to limit future price, reliability, and environmental risks; obtaining legislation and regulatory treatment that would allow Duke to recover financing costs as they constructed new and more efficient power plants; and helping shape federal rules limiting carbon to ensure Duke customers were fairly treated. Environmental issues received a bit more attention later in the report, but the approach was tempered by financial obligations. "[W]e are mindful of our environmental responsibilities . . . We are committed to making the best technological choices, ones that will limit our emissions and optimize our investments so that we can keep our prices competitive."[211] However, the crucial piece in constructing new nuclear power plants is the company's ability to recover up front its financing costs during construction. "We

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[209] "What Can We Expect from the Merger of Duke Energy and Cinergy? Duke Energy 2005 Summary Annual Report," http://www.duke-energy.com/pdfs/Duke_Energy_2005_Annual_Report.pdf, (accessed March 13, 2009). p. 4.

[210] "Changing Minds. Changing Habits. Duke Energy 2006 Summary Annual Report," http://www.duke-energy.com/pdfs/Duke_Energy_2006_Annual_Report.pdf, (accessed March 13, 2009). p. 7.

[211] Ibid, p. 10.

have been clear that we will not move forward with a nuclear plant unless we know that we can recover our financing costs in rates as we build."[212]

Duke titled its 2007 Annual Report "Building Bridges to a Low-Carbon Future." With favorable cost recovery legislation on the books, the company emphasized the role nuclear power would now play in that low-carbon future. They had filed a construction and operating license application with the NRC to build a two-unit facility in Cherokee County, SC. "We are using our more than three decades of experience in building and operating nuclear plants to plan a new 2234 megawatt power plant in South Carolina—a plant that will have zero CO_2 emissions."[213] Despite the fact that the first unit was not anticipated to be on line until 2018, Duke reassured its investors. "People today aren't used to looking far into the future or contemplating issues of the scale and complexity of global climate change. We focus on the quick fix. We deal with problems now—then we move on to the next one. Climate change is different. The future can only be changed if we begin today and keep going . . ."[214]

For Rita Sipe, who grew up in the Southeast and had many family members working in the energy industry, taking a job with Duke Energy seemed a natural thing to do.[215] She now serves as Nuclear Media Relations contact. According to Sipe, the Duke license application for a new nuclear power plant was driven, first and foremost, by the

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212 Ibid, p. 8.

213 "Building Bridges to a Low-Carbon Future, Duke Energy 2007 Summary Annual Report," http://www.duke-energy.com/pdfs/Duke_Energy_2007_Annual_Report.pdf, (accessed March 13, 2009). p. 19.

214 Ibid, p. 25.

215 Rita Sipe, Nuclear Media Relations, Duke Energy, Telephone Interview of February 20, 2009.

needs of the customer. The local Utilities Commissions require Duke to file a yearly resource plan, looking at existing generating capacity, current and projected demand, and plans for meeting the demand. Due to the long lead time for designing, permitting, and building new baseload generation facilities, planning needs to start 10 to 15 years in advance. Duke has not added new baseload capacity since the Catawba nuclear plant came on line in 1986. Some of the coal plants now in use date back to the 1920s and it is not clear how long they can continue to serve. Duke will need new capacity.

Ellen Ruff, Duke's first President of Nuclear Generation, echoed Sipe's focus on the customer: "[W]e're going to have reliable, affordable source of generation for our customers, because at the end of the day, this is about our customers . . . primary in our obligation is to have reliable, low-cost electricity available . . . We will always have to get there."[216]

Both Sipe and Ruff deem the choice of nuclear power as driven in part by the possibility of carbon legislation in the United States. From Sipe: "Nuclear doesn't emit CO_2" (Interview). And according to Ruff, "[W]e are very anxious to find a way to develop nuclear in terms of being a clean source of energy, and non-carbon emitting."[217]

In addition, Sipe views nuclear as the safe option, based on the amount of training operators receive (at Duke every fifth week is spent in training) and on the company's history. "Duke has years of experience. And, nuclear is quite a regulated industry. It's very structured with lots of procedures and processes. It's also an industry that prides

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[216] Adam Bell, "Forging Next Nuclear Age: Ellen Ruff is in Charge of Duke Energy's First New Nuclear Plant in 20 Years," *McClatchy – Tribune News*, January 4, 2009, http://www.proquest.umi.com/pqdweb?did=162118251&Fmt=3&clientId=10024&RQT=309&VName=PQD, (accessed March 12, 2009).

[217] Bell.

itself on freely sharing information. If one plant experiences something, they share that with the others."

As for the role of federal loan guarantees in the Duke decision to look into new nuclear plants, Sipe contends that even without loan guarantees, the company would be interested in new nuclear.

The picture that emerges for Duke Energy is one dominated by a need to respond to customers' growing need for electricity and a desire to maintain a diversified fuel base to adapt to changing prices (and availability), underscored by a real concern about global climate change and its potential impact on electrical generation in the U.S. On the financial side, loan guarantees are nice, but the ability to recover costs during construction ("Construction Work In Progress" or CWIP financing) is a necessity.

4.4 Progress Energy Florida

Baseload power fuel diversification has driven Progress Energy Florida's interest in new nuclear plants. According to Rick Kimble, Manager of Nuclear Communications, in a January 2009 interview, Florida law mandated that power companies always build the least cost option for baseload power. Until recently, that meant gas-fired plants. When the 2005 hurricanes in the Gulf of Mexico disrupted gas processing in Texas and Louisiana, gas prices soared. Since Florida law also allows those fuel prices to be passed on to the customer, local residents saw their electricity bills rise as well, creating hardship particularly for those on fixed incomes (such as retirees). With forecasts showing extra capacity would be needed by about 2017 or 2018, Progress Energy began looking into alternative sources for baseload power.

Whereas in some parts of the country utilities may be able to purchase power via long term contracts from neighboring states, few transmission lines join Florida to its neighbors. The Wall Street Journal described Florida as "a virtual island to which it is difficult to export power."[218] In addition, utilities that might serve parts of Florida also expect to see increases in demand for electricity and are reluctant to enter into long-term contracts.

Since Florida has no hydropower for Progress Energy to tap, and with an expectation that coal may be subject to a carbon tax in the near future, the company turned to nuclear power to supplement its baseload generating capacity. The 2006 Annual Report stated, "We face fuel price volatility and complex environmental issues such as global climate change. On the positive side, there's an opportunity to reap the benefits of today's greater potential for energy efficiency and renewable energy as well as for new advanced nuclear and clean-coal technologies."[219] The 2007 Annual Report indicated that "[t]oday we face several new energy realities: growing population and energy demand, the need to reduce greenhouse gas emissions and address global climate change, and concerns over dependence on fossil fuel. At Progress Energy, we believe strongly that new nuclear is a good option for addressing these issues."[220] Likewise, Jeff Lyash, President, Progress Energy Florida, stated, "We believe that new nuclear

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[218] Nikhil Deogun and Rebecca Smith, "FPL Group, Energy Strike Merger Deal—Combination Could Create Top Electric Producer, Serve 6.3 Million People," *The Wall Street Journal*, July 31, 2000, p. A.3.

[219] "The Road Ahead: Shifting into High Gear," Progress Energy 2006 Annual Report, Raleigh, NC: Progress Energy, Inc., March 2007, p. 4.

[220] "We're Looking at Power in a New Light," Progress Energy 2007 Annual Report, Raleigh, NC: Progress Energy, Inc., March 2008, p. 11.

generation is a critical hedge against future risk of volatile and increasing fossil-fuel prices, and the likely significant future costs of emissions regulations."[221] Bill Johnson, Chairman, President and CEO of Progress Energy, Inc., reiterated the company's position in 2008: "The over-arching issue is how to address climate change and demand growth while maintaining a secure supply, reliable service and affordable rates for customers and creating shareholder value for investors. . ."[222] Even the data sheets about the Levy County, FL nuclear project claim that "[w]ith growing concerns about climate change, nuclear power is a sound environmental choice. Nuclear also protects customers from price volatility associated with oil and natural gas prices and ensures a reliable supply of electricity."[223] For Progress Energy then, the volatility of natural gas prices, potential taxes on carbon emissions, a desire to address global climate change, and increasing demand for electricity have been and continue to be the key drivers of capacity expansion plans.

In order for Progress Energy Florida to expand its nuclear fleet (it currently operates one nuclear reactor at Crystal River, FL), it had to be able to recover some of the costs of the new plant during construction.[224] According to spokesman C.J. Drake, "Early cost-recovery is a key for Progress. If it weren't for that, nuclear would be too

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[221] "Update 1--Progress Seeks Florida OK to Build New Reactors," March 11, 2008, http://www.reuters.com/article/companyNews/idUSN1160205320080311, (accessed March 19, 2009).

[222] "Progress Energy CEO Says Company Focused on Securing the Energy Future," Company Media Release, February 29, 2008, http://www.progress-energy.com/aboutus/news/article.asp, (accessed January 22, 2009).

[223] "Frequently Asked Questions," www.progress-energy.com/aboutenergy/poweringthefuture_florida/levy/faq.asp, (accessed January 22, 2009).

[224] Rick Kimble, Manager of Nuclear Communications, Progress Energy Florida, Telephone Interview of January 29, 2009; "Update 1-- Progress Seeks Florida OK to Build New Reactors."

expensive." The Florida legislature has agreed. Section 366.93 of the Florida statutes allows for up front recovery of nuclear power plant costs, including nuclear related transmission expenses; and the annual expensing of pre-construction costs (such as costs related to site selection) and the carrying costs on the construction cost balance.[225] The early cost recovery program is expected to save customers about $13 billion in interest and other charges over the life of the plant. Progress Energy Florida customers began paying for the new Levy County nuclear facility in January of 2009.

Unlike other utilities, Progress Energy Florida will not rely on federal loan guarantees to assist in gaining financing for the plant. Rick Kimble mentioned that Progress was not willing to accept some of the terms of the loan guarantee program (DOE taking first mortgage rights on the facility for example). In addition, the program has high costs: $50 million for the first part of the application and about $450 million for the remaining parts.[226] Progress Energy remains optimistic that it could secure loans on its own, without the government guarantees.

Danny Blanton of Entergy had described the loan guarantees as critical to that company's reactor construction program, whereas the continuation of the Price-Anderson insurance was nice but not absolutely necessary. Progress Energy chose not to rely on loan guarantees, but, according to Kimble, the Price-Anderson Indemnity Act had to

[225] Bill McNulty, "Nuclear Power Plant Cost Recovery in Florida," PowerPoint Presentation to the Louisiana State 2008 Energy Summit, http://www.enrg.lsu.edu/Conferences/energysummit2008/es2008_mcnulty.pdf.

[226] Rick Kimble, Manager of Nuclear Communications, Progress Energy Florida, Telephone Interview of January 29, 2009.

remain intact for Progress to pursue new nuclear plant construction.[227] Limitations on liability resulting from nuclear accidents are important to Progress Energy.

Progress Energy also has expressed anxiety about the fluctuations in price of alternative fossil fuel supplies and about meeting customers' growing energy demand, and is therefore looking into new nuclear power. Progress Energy is concerned about the possible taxes on greenhouse gas emissions and wants to minimize the cost impacts on customers and shareholders. Interestingly, unlike utility companies to the west and to the north of them, neither Duke nor Progress Energy has relied on the availability of loan guarantees in their decision to submit an application to build a new nuclear power plant. However, both revealed the importance of CWIP financing for that new construction.

(Note: As of this writing, Progress Energy Florida is the only company to submit a COL during 2009. On June 30, 2009, the NRC received the application to construct and license two AP1000 units at the Turkey Point site near Homestead, FL.[228])

4.5 Tennessee Valley Authority (TVA)

As part of his plan to lift the country from the depths of the Great Depression, President Franklin D. Roosevelt asked Congress to create a natural resource agency "clothed with the power of government but [which] possessed of the flexibility and initiative of a private enterprise."[229] Thus, the Tennessee Valley Authority, or TVA, was born. It has grown from an organization that taught farmers how to get the best yield from their crops into one of the country's largest electric companies. The TVA currently

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[227] Ibid.

[228] "Turkey Point, Units 6 and 7 Application," http://www.nrc.gov/reactors/new-reactors/col/turkey-point.html, (accessed 9/15/09).

[229] "From the New Deal to a New Century: A Short History of TVA," http://www.tva.gov/abouttva/history.htm, (accessed May 3, 2009).

operates 11 fossil fuel-fired plants, 29 hydroelectric dams, three nuclear facilities (six reactors) and six combustion turbine facilities, and is seeking to add more generation capability.[230]

The TVA started construction of the first of its 17 planned nuclear reactors in 1967. Browns Ferry Unit 1 began operations in 1974; Unit 2 followed in March of 1975.[231] Unfortunately, that same month, a maintenance worker using a candle to check for air leaks around electrical cables ignited polyurethane foam insulation. The fire spread quickly through the wall, damaging emergency core cooling system equipment, and backup generators for Units 1 and 2.[232] TVA repaired the damaged units and completed a third unit on the site—Unit 3 commenced operations in 1977.

Undeterred, TVA completed two additional units at the Sequoyah Nuclear Plant and brought them on line in 1980 and 1981. But the aftermath of the Three Mile Island accident in 1979--the changes in NRC regulations and resulting cost increases for nuclear plants--led TVA to cancel orders for eight reactors whose construction it had already postponed and place four others on hold.[233] Then, due to concerns over faulty workmanship, inadequate training of personnel, violations of safety and security

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[230] "Overview," http://premium.hoovers.com.cals.evergreen.edu/subscribe/co/overview.shtml?ID=ffffcfcjfffrxxyfyt, (accessed July 8, 2008).

[231] "Browns Ferry Nuclear Power Plant, Alabama," http://www.eia.doe.gov/cneaf/nuclear/page/at_a_glance/reactors/brownsferry.html, (accessed October 27, 2009).

[232] David Dinsmore Comey, "The Fire at the Brown's Ferry Nuclear Power Station," in *Not Man Apart*, CA: Friends of the Earth, 1976, http://www.ccnr.org/browns_ferry.html#ca, (accessed October 27, 2009).

[233] Judith Miller, "For Nuclear Power, New Blows," *The New York Times*, May 29, 1982, p. 2.35; "Around the Nation; T.V.A. Cites Lack of Need in Scrapping 4 Reactors," *The New York Times*, August 26, 1982, p. A.16.

regulations, a culture of indifference, and persistent management problems, the NRC shut down all TVA's operating reactors in 1985.[234]

TVA was determined not to turn its back on its nuclear investment. The Authority hired a group of people experienced in the Navy nuclear propulsion program and in the private nuclear industry to oversee its reactor projects.[235] Admiral Stephen A. White took over as director.[236] The technical knowledge, high standards for excellence, and leadership skills he brought with him helped TVA gain the NRC's approval for restarting Sequoyah Unit 2 in 1988.[237] In 1991, after $1.3 billion in improvements, TVA was granted permission to reopen Browns Ferry.[238]

In the mid-90s, the TVA announced that it would not complete three partially built reactors that had been ordered in the 1970s: Watts Bar 2 in Tennessee and Bellefonte 1 and 2 in Alabama. A slowdown in demand for electricity, increasing costs and the time needed to build and license nuclear plants, and the failure of existing units to operate as reliably and efficiently as expected all contributed to the decision. According

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[234] Matthew L. Wald, "T.V.A. Shuts Down Last Nuclear Plant," *The New York Times*, August 24, 1985, p. 1.6; Stuart Diamond, "Management Cited as Key to Safety at U.S. Nuclear Reactors," The *New York Times*, May 23, 1986, p. A.10; Ben A. Franklin, "Nuclear Program of T.V.A. Sharply Criticized," *The New York Times*, March 2, 1986, p. A.29; Ben A. Franklin, "T.V.A. Reactor to be Restarted," *The New York Times*, March 23, 1988, p. A.18.

[235] Ben A. Franklin, "The T.V.A. Mothballs its Nuclear Ambitions," *The New York Times*, June 8, 1986, p. A.6.

[236] "T.V.A. Reinstating Admiral as Manager of Nuclear Program," *The New York Times*, January 8, 1987, p. B.9.

[237] Ben A. Franklin, "T.V.A. Reactor to be Restarted," *The New York Times*, March 23, 1988, p. A.18; Matthew L. Wald, "Trouble at a Reactor? Call in an Admiral," *The New York Times*, February 17, 1989, p. D.1.

[238] "After 6-Year Shutdown, Reactor Begins Warmup," *The New York Times*, May 25, 1991, p. 1.9; Keith Schneider, "Ideas & Trends; Is Nuclear Winter Giving Way to Nuclear Spring?" *The New York Times*, May 12, 1991, p. A.4.

to Craven Crowell, then TVA Chairman: "It's the end of the line for this generation of nuclear plants."[239] Only 6 of its 17 reactors originally planned by TVA had been brought on line.

Mr. Crowell's prediction proved false when, in 2002, the Board of Directors of the TVA voted to restart Browns Ferry Unit 1. The "reactor was left idle because its capacity was not needed, but . . . with electricity demand growing, they needed a generator that would not add to the region's air quality problems."[240] The TVA had been implicated as one of the biggest emitters of nitrogen oxides, mercury, and carbon dioxide in the power industry.[241] It needed to clean up its electrical generating fleet. This time, Crowell told the Reuters news agency "I don't see any other viable option for baseload generation."[242]

The decision to restart Browns Ferry Unit 1 saved the TVA time and money. Unit 1 already had an operating license for the facility and could add capacity under that existing license (increasing output from 1000 MW to 1300 MW). The project required only five years to complete as opposed to 12 to 15 years for permitting and building a new plant. The TVA did have to install about 150 miles of new cable and six miles of new pipe, and had to maintain the proper documentation to ensure that all of the work

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[239] Matthew L. Wald, "T.V.A. Plans to Stop Work on 3 Partly Built Reactors," *The New York Times*, December 13, 1994, p. B.10.

[240] David Firestone, "Utility Board Votes to Restart a Nuclear Reactor in Alabama That Has Been Idle Since 1985," *The New York Times*, May 17, 2002, p. A.12.

[241] Neela Banerjee, "Study Ranking Utility Polluters Aims to Sway Emissions Debate," *The New York Times,* March 21, 2002, p. C.1.

[242] "U.S. Power Industry Sees Nuclear Renaissance Near," February 16, 2007, www.reuters.com/article/bondsNews, (accessed March 19, 2009).

was up to contemporary nuclear construction standards.[243] But the price tag for the project was only about $1.9 billion versus the $5 to 8 billion needed to design and build a new nuclear power unit. The NRC also granted a 20-year license extension for the facility. Browns Ferry Unit 1 reopened in May of 2007.

Bolstered by the Browns Ferry success, described by one analyst as a "rehearsal for new plant construction,"[244] and with growing concern about the environment, the TVA Board of Directors approved $2.5 billion over five years to update and complete Watts Bar 2. (Watts Bar 2 was about 60% complete when the project was stopped.) The Board also voted in favor of submitting an application to the NRC for a license to build and operate two new reactors at its Bellefonte site in Alabama.[245]

The TVA's interest in new nuclear preceded the 2007 Board votes. According to Terry Johnson of TVA Nuclear Communications, the TVA recognized the future need for baseload generation in the early 2000s.[246] "TVA historically has experienced a 2% *demand growth* each year. That means that every four to five years they need another five to six hundred MW." In 2004, they joined the NuStart consortium to help demonstrate the new NRC reactor licensing process.[247] NuStart chose the AP1000 and ESBWR reactor designs and the existing TVA Bellefonte site for the reference

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[243] Matthew L. Wald, "A Nuclear Reactor Reborn," *The New York Times*, May 11, 2007, p. C.3.

[244] Ibid.

[245] "TVA Board Advances New Alabama Nuclear Reactors," September 27, 2007, http://reuters.com/article/companyNewsAndPR/idUSN2733770920070927, (access March 19, 2009).

[246] Terry Johnson, Nuclear Communications, Tennessee Valley Authority, Telephone Interview of March 10, 2009.

[247] Ibid; John J. Fialka, "New Nuclear Plants in U.S. Get Study," *The Asian Wall Street Journal*, April 26, 2004, p. A.4.

applications it prepared in 2004 and 2005. Not only was the TVA familiar with Westinghouse reactors, but it also had some of the infrastructure already in place from its earlier work on the partly completed Bellefonte Units 1 and 2.

Johnson also mentioned that constructing new nuclear plants will allow the TVA to shut down some of its older coal-fired facilities. The price of coal tends to be more volatile than that of uranium. In addition, that move would reduce the uncertainty associated with Congressional action on restrictions or taxes on the carbon emissions from coal plants.

For the TVA, renewable sources of energy cannot provide the needed baseload power. "Renewables require Mother Nature's input. But she cooperates better in some places than in others. Renewables also require distribution and storage facilities that may not now exist."[248] Conservation and efficiency efforts alone cannot meet the increasing demand either, because "[e]ach person would need to conserve enough to offset the new demand."[249] Still, TVA has been upgrading the generators in their hydroelectric facilities to increase electricity production without building new dams. And it will be looking to a combination of hydroelectric power, nuclear, wind, solar, and methane gas from a wastewater treatment plant near Memphis, Tennessee to provide about half of its electricity generation by 2030.

Thus, with their coal facilities facing an uncertain future and having ruled out renewable sources for baseload generation, TVA looks to new nuclear plants to help it meet the growing demand for electricity. Completion of several of its original plants has

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[248] Johnson Interview.

[249] Ibid.

helped TVA put their past experiences with nuclear construction behind them and has given the company the confidence to move forward in completing two existing reactors and in applying to construct one or two new AP1000s, at its Bellefonte site.[250]

What role did loan guarantees play in TVA's decision? TVA did not even apply. First of all, being a federal agency, the TVA probably would not qualify for the guarantees. Secondly, Bellefont Unit 1 was almost 90 % complete when construction stopped, and Unit 2 was over 50 % finished. It is doubtful whether loan guarantees devoted to advancing "new" and "significantly improved" technologies could be used to complete those units.[251] However, any new AP1000 units might have met the DOE criteria.

4.6 Constellation Energy Group

Although Constellation Energy Group traces its roots to gas lighting companies in the Baltimore, Maryland area, it currently gets 35 % of its generation from coal, gas, and oil; 61 % from nuclear power; and the balance from renewable sources.[252] Constellation, then called Baltimore Gas and Electric, built its first two nuclear plants in the 1970s at Calvert Cliffs in Maryland. In 2001, the company expanded its nuclear capacity with the purchase of Nine Mile Point 1 and 82 % of Nine Mile Point 2 from Niagara Mohawk in

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[250] "NRC Restores Permit to Build Bellefonte Plant," Chattanooga Times Free Press, March 13, 2009, http://www.timesfreepress.com/news/2009/mar/13/nrc-restores-permit-build-bellefonte-plant/, (accessed October 27, 2009); "TVA Reconsiders Bellefonte Plans," World Nuclear News, August 10, 2009, http://www.world-nuclear-news.org/print.aspx?id=25784, (accessed October 27. 2009).

[251] "Title XVII – Incentives for Innovative Technologies," Public Law 109 – 58, August 8, 2005, http://www.lgprogram.energy.gov/EPA2005TitleXVII.pdf, (accessed October 27, 2009).

[252] "Constellation Energy Power Generation," http://www.constellation.com/portal/site/constellation/menuitem.16c4d66a696c12875fb60610025166a0/, (accessed March 13, 2009).

up-state New York. Ginna Nuclear Operating Station, also in New York, was added in 2003. According to a November 26, 2003 article in *The New York Times*, the expectation of high power prices in the deregulated New York market spurred those acquisitions.[253]

The company's pride in its nuclear operations shone through in its 2005 Annual Report. "As one of the nation's premier nuclear power plant owners and operators, we're demonstrating that nuclear power is reliable, cost-effective and environmentally friendly."[254] President Bush had chosen Calvert Cliffs to announce his energy policy that year, advocating the expansion of "the one energy source that is completely domestic, plentiful in quantity, environmentally friendly, and able to generate massive amounts of electricity, and that's nuclear power . . . It is time for this country to start building nuclear power plants again."[255]

In 2005, Constellation had formed a partnership with Areva of France to develop, manufacture, construct, and operate the largest nuclear reactor in the United States—1600 MW(e)—and a fleet of standardized reactors nation-wide.[256] The venture, UniStar Nuclear, also included the French utility Electricité de France (EdF) as a partner. Constellation felt they had gained good experience from their nuclear operations and

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[253] Matthew L.Wald, "Rochester Utility Sells Nuclear Power Station," *The New York Times*, November 26, 2003.

[254] "We Turn it On, Constellation Energy 2005 Annual Report," Baltimore, MD: Constellation Energy, April 2006, p. 15.

[255] "President Bush's Speech at Calvert Cliffs Nuclear Power Plant," June 22, 2005, http://somd.com/news/headlines/2005/2224.shtml.

[256] "We Turn it On, Constellation Energy 2005 Annual Report;" Matthew L. Wald, "Nuclear Power Venture Orders Crucial Parts for Reactor," *The New York Times*, August 4, 2006, Section C, p. 2; Matthew L. Wald, "Partnership Formed to Build Nuclear Plants," *The New York Times*, September 16, 2005, Section C, p. 4.

could "continue to do well in nuclear and shouldn't shy away from their responsibility."[257] Unistar would put them at the "fore-front of next-generation nuclear power."[258]

UniStar Nuclear began ordering critical components for its reactor as early as 2006. According to Michael J. Wallace, then President of the Constellation Operating Division, one large reactor part already had been forged, and others would be manufactured, then stored until needed.[259] UniStar also struck a deal for welding and machining of parts with an Ohio company, BMX Technologies. These investments would ensure critical parts were on hand and the company would be ready to "move aggressively for construction of the first EPR (Evolutionary Power Reactor) if everything else continues to line up correctly."[260] It was not until July of 2007 that UniStar Nuclear filed an application with the NRC to build that reactor at the Calvert Cliffs site. Later that year, Areva submitted materials to begin NRC certification of its U.S. EPR reactor design. Mayo Shattuck III, Chairman, President, and CEO of Constellation Energy Group, announced

> Constellation Energy strongly believes nuclear power must play a prominent role in our nation's energy future, which will be vitally important in helping America achieve its goals of reducing greenhouse gas emissions and moving toward greater energy independence . . . This alliance represents a major accomplishment. It allows us to move

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[257] Matthew L. Wald, "Even the Utilities Differ Over Whether Nuclear is the Energy Answer," *The New York Times*, August 22, 2006, p. C.1.

[258] "Energy Matters, Constellation Energy 2006 Annual Report," Baltimore, MD: Constellation Energy, March 2007, p. 12.

[259] Matthew L. Wald, "Nuclear Power Venture Orders Crucial Parts for Reactor," *The New York Times*, August 4, 2006, Section C, p. 2.

[260] Ibid.

> forward confidently, leveraging the considerable value of our complementary strengths and operational capabilities, while also maintaining our highly disciplined, risk-managed and value-driven approach to new nuclear.[261]

His words echoed words that Michael Wallace (President of Constellation Operating Division) had used a month earlier before the DOE. Both hinted at an interest in nuclear power not just for the sake of a renaissance, but to help in the battle against *greenhouse gas emissions* and global climate change, and to reduce the country's dependence on imported oil.

The Constellation 2007 Annual Report reiterated that stand for the sake of investors.

> On the most important environmental issue of our time, climate change, our company's policy is unequivocal. We believe it is imperative to slow, stop and then reverse the growth of greenhouse gas emissions. We believe nuclear power can and must make a meaningful contribution in the world's efforts to deal with threats posed by human influence on climate change. The result will be a dramatic lessening of our country's—and the world's—reliance on fossil fuels.[262]

Fall 2008 was a turbulent time for Constellation. In September, the company submitted its COL application for a third unit at the Nine Mile Point site. Due to the worsening credit situation in the U.S. in the summer and fall of 2008, Constellation had an urgent need for cash. It entered into merger talks with Warren Buffett's Mid-America Energy Holdings Co., but instead sold a 49.9 % stake in its nuclear holdings to Electricité

[261] "Constellation Energy and EDF Form Joint Venture for Developing Next-Generation Nuclear Facilities in the United States and Canada," Constellation Energy Press Release, July 20, 2007, http://ir.constellation.com/phoenix.zhtml?c=112182&p=irol-news, (accessed July 8, 2008).

[262] "Responsible Leadership, Constellation Energy 2007 Annual Report," Baltimore, MD: Constellation Energy, April 2008, p. 11.

de France.[263] Constellation President Michael Wallace liked EdF because the French company already felt comfortable with the Areva technology and, "[t]hey never stopped building."[264]

Despite Constellation's long-standing commitment to the revival of nuclear power plant construction in the U.S., President Wallace testified before the DOE in June, 2007, regarding the importance of loan guarantees to that construction plan.

> We at Constellation recognized quite early that the incentives contained in the Energy Policy Act would be necessary to bring about the new nuclear renaissance . . . the most important Energy Policy Act incentive for new nuclear is the Title XVII loan guarantee program, which we view as indispensable . . . The loan guarantee program is intended to fill [a] financing gap by creating a non-recourse financing platform whereby energy companies . . . are allowed to leverage their equity in a manner not possible without the benefit of the guarantee.[265]

The company also revealed that it would not break ground on a new nuclear plant without the aid of a federal loan guarantee program.[266] If the DOE had the loan guarantee program in place by the end of 2008, Constellation would move forward with its plans for construction. "If it doesn't, we won't," according to Wallace.[267] (Although the DOE had not disclosed its decision about the distribution of the loan guarantees as of the

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[263] Rebecca Smith, "Buffett Rescues Power Firm for $4.7 Billion," *The Wall Street Journal*, September 19, 2008, p. B.1.

[264] Matthew L. Wald, "French-American Venture Plans New Reactors in U.S.," *The New York Times*, July 21, 2007, p. C.4.

[265] "LPG Public Meeting," U.S. Department of Energy, Office of the Chief Financial Officer, Washington D.C.: Executive Court Reporters, Inc., June 15, 2007, p. 3.

[266] "Industry Pushes Nuclear Loan Guarantees," November 28, 2007, http://www.fool.com/news/associated-press/2007/11/28/industry-pushes-nuclear-loan-guarantees.aspx, (accessed March 19, 2009).

[267] Ibid.

publication of this thesis, a Reuters news release of February 2008 suggested that Constellation's Calvert Cliffs project is one of five still under DOE consideration.[268])

In short, Constellation Energy has made considerable investments to bring about a nuclear renaissance in the U.S. and avidly supports nuclear power as a key in helping the country confront global climate change. However, it likely will take the final step of building its first reactor only if the company receives federally backed loan guarantees.

4.7 AmerenUE

For AmerenUE, headquartered in St. Louis, Missouri, the ability to recover some of its costs during the construction was vital to its plan to expand its Callaway Nuclear Station. The Callaway facility had been completed in 1984 and is the largest single plant in the AmerenUE fleet—1143 MW(e). The 2005 Annual Report reflected the company's pride in its nuclear plant when it reported,

> One of the most amazing achievements of our generating fleet was the refueling and maintenance outage at our Callaway nuclear plant. This outage included replacing all four steam generators and turbine rotors, in addition to thousands of maintenance activities, modifications, inspections, and tests throughout the plant. Despite the massive amount of work, the outage was completed in only 63 days—a new world record. . ."[269]

In 2008, Callaway set another record, this time for the longest "breaker-to-breaker" run of any plant in the U.S., operating for 520 consecutive days without ever being out of

[268] Eileen O'Grady, "Five U.S. Nuclear Plants on DOE Loan Short List," February 18, 2009, http://uk.reuters.com/article/idUKTRE51H64R20090218?sp=true, (accessed March 19, 2009).

[269] "Geared Up, Ameren 2005 Annual Report," St. Louis, MO: Ameren.

service.[270] Given such accomplishments, it is not surprising that AmerenUE looked to nuclear power to meet its growing demand for electricity.

AmerenUE grew out of the Union Electric Company, provider of the electric illumination for the St. Louis World's Fair in 1904.[271] It now operates 14 power plants with a generating capacity of over 12,600 MW(e) for customers in Missouri and parts of Illinois. But, according to Mike Cleary, Communications Executive for AmerenUE, demand has grown by about 50% since the 1980s when Callaway went on line, and demand is expected to grow another 30% by 2030.[272] The company has calculated that it will need new baseload generating capacity on line by 2018 or 2020. Carbon emission regulations and/or a carbon tax may make coal uneconomical. Fossil fuel prices also tend to be very volatile. But since the cost of fuel is a very small component of the cost of nuclear generation, changes in the price of uranium have little impact on nuclear plant operating costs. "Nuclear is more like a dam in that its costs are mostly in the structure itself, after that it's mostly operation and maintenance."[273] Thus, for AmerenUE, as for Progress Energy Florida, fuel-related issues made nuclear power a front-runner for baseload generation.

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[270] "AmerenUE's Callaway Plant Achieves First "Breaker-to-Breaker" Run, Generating Continuously for 520 Days," Ameren Media Release, October 13, 2008, http://ameren.mediaroom.com/index.php?s=43&item=551, (accessed April 25, 2009).

[271] "Ameren History 1902 – 2002," http://www.ameren.com/centennial/default.htm, (accessed March 3, 2009).

[272] Mike Cleary, Communications Executive, Public and Media Relations, AmerenUE, Telephone Interview of February 25, 2009.

[273] Ibid.

The small environmental footprint of a nuclear facility also drew AmerenUE to nuclear power. According to Cleary, "[t]he spent fuel from Callaway 1's forty years of operation would fit into an area the size of a tennis court . . . A coal plant uses hundreds of train car loads of coal per day. That results in a lot of ash to dispose of . . ." and a "wind farm would require 280 square miles of land to generate as much electricity as Callaway 1—which occupies only one square mile."[274] Unfortunately, Missouri does not get the steady wind preferred for electric generation, so AmerenUE would need to import its renewable energy from other states, at high cost to its customers.

A 1976 initiative passed by Missouri voters prevents power plant owners from recovering any plant development costs while the facilities are under construction.[275] AmerenUE estimated that the higher costs of financing added $1 billion to the cost of its existing nuclear unit, Callaway 1. In addition, even after Callaway 1 came on line, the Missouri Public Service Commission cut $165 million from the $639 million the company sought to recoup from its customers through rate increases. (The Public Service Commission cited "inefficient, imprudent, unreasonable, or unexplained costs" as the reason for that decision.[276]) The company was forced to write off the disallowed costs, reducing the company's net income for that year.[277] To avoid similar cost recovery

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[274] Cleary Interview.

[275] Ibid; "Ameren Suspends New Nuclear Plant Plans," World Nuclear News, April 24, 2009, http://www.world-nuclear-news.org/print.aspx?id=25101, (accessed March 25, 2009).

[276] "Union Electric Wins Appeal for Rate Raise to be Reconsidered," *The Wall Street Journal*, February 28, 1985, p. 1; Bill Richards, "Union Electric Co. Rate Increase Bid is Cut by Missouri," *The Wall Street Journal*, April 3, 1985, p. 1.

[277] John Curley, "Union Electric Says it May Post Charge of $250 Million," The *Wall Street Journal*, April 24, 1985, p. 1.

issues with the construction of a new nuclear plant, AmerenUE asked the Missouri legislature to consider a bill that would allow them to recover the financing costs during the construction period (not the cost of steel or concrete, just the financing costs).[278] Passage of the Construction Work in Progress bill would have resulted in a 1.8 % rate increase for customers during each of the estimated six years of construction. Without it, AmerenUE customers would see a massive rate increase once the plant came on line.

Missouri Governor Jay Nixon opposed the bill, calling it "premature for Ameren 'to saddle' customers with the cost . . . before regulators have even awarded a permit and Ameren has made its final decision to build."[279] On April 23, 2009, AmerenUE CEO and President Thomas Voss requested the legislative sponsors to withdraw the bill.

> As we were moving forward to preserve the option for nuclear energy for our state, we stressed that we needed financial and regulatory certainty before we could begin construction. However, the current version of the bill being debated in the Senate strips the legislation of the very provisions we needed most to move forward. As a result, AmerenUE is suspending its efforts to build a nuclear power plant in Missouri . . . without supportive state energy policies, we believe getting financial backing for these projects is impossible.[280]

AmerenUE had submitted the first and second parts of its loan guarantee application to the DOE. Unfortunately, the company was not among the five that made

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[278] Robert D. Hershey, "Utilities Allowed Faster Rate Rises to Pay for Plants," *The New York Times*, March 11, 1983, p. A.1; "Pay-As-You-Build Power," *The New York Times*, February 13, 1984, p. A. 20.

[279] Kelsey Volkman, "Nixon: Ameren Charging Customers for Plant 'Premature'," *St. Louis Business Journal*, February 27, 2009, http://stlouis.bizjournals.com/stlouis/2009/02/23/daily96/html, (accessed March 3, 2009).

[280] "AmerenUE Requests Sponsors to Withdraw Missouri Clean and Renewable Energy Construction Bills in General Assembly," Ameren Media Release, April 23, 2009, http://ameren.mediaroom.com/index.php:s=43&item=634&printable, (accessed March 25, 2009).

the "short list" for receiving that backing.[281] In the end, for AmerenUE, fuel costs and environmental concerns may have ignited an interest in building a new nuclear reactor in Missouri, but concerns over the inability to finance the project doused the flame.

4.8 Dominion Virginia Power

Dominion Virginia Power did not have to petition for cost recovery assistance as AmerenUE did. Under Virginia law, the company can apply to recover the financing *costs* of generation facilities as they are incurred.[282] The law allows Dominion to recover the costs of the fuel used in the facility—those costs can be passed through to the customer in the rates charged—and ensures Dominion a competitive return on its equity, a return guaranteed to be no lower than the average earned by their peer group in the Southeast. That favorable economic context and a governor who supports coal, nuclear, and renewable power make Virginia an appealing site for the construction of new electrical generation facilities.

The need for "home grown" power also makes Virginia attractive for Dominion. Virginia currently imports about 30 % of its electricity from neighboring states, ranking it second in the nation, just behind California. Yet the area is home to the Pentagon, two major military installations, the Washington D.C. suburbs, and businesses like internet provider AOL and the banks of computers that serve its on-line customers. Dominion

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[281] John C. Slocum and John H. Reed, "Maximizing U.S. Federal Loan Guarantees for New Nuclear," *Bulletin of the Atomic Scientists*, July 29, 2009, http://www.thebulletin.org/web-edition/features/maximizing-us-federal-loan-guarantees-new-nuclear-energy, (accessed October 28, 2009).

[282] "There's More to This Light Switch Than Meets the Eye. Behind it is an Entire Company. Dominion 2008 Summary Annual Report," Richmond, VA: Dominion Resources, Inc., 2009, p. 21.

estimates that 50 % of the nation's internet traffic flows through northern Virginia![283] They need reliable energy.

Dominion analysts have calculated that the area will need an additional 4000 MW of electricity by the year 2018, including 2000 MW of baseload power.[284] Renewable sources and conservation cannot provide the electricity whenever a customer flips the switch. So, to meet about 520 MW of that new baseload demand, the company is looking to clean coal (carbon sequestration and the conversion of coal to pipeline quality gas) and woody biomass technologies; the remainder likely will come from a new nuclear reactor.[285]

Dominion operates seven nuclear units at four sites: two at Millstone in Connecticut; one at Kewaunee, near Green Bay, Wisconsin; two at the Surry facility and two at North Anna, all in Virginia.[286] Of those, the Surry and North Anna plants were constructed by Dominion's predecessor, Virginia Power; the others were purchased in 2000 and 2005. As the company indicated to the DOE in 2007,

> A strong commitment to nuclear generation has been, and will remain, a fundamental attribute of Dominion . . . Dominion has seen six of its seven nuclear units through the Nuclear Regulatory Commission's ("NRC's") license extension process. Similarly, Dominion has been in the forefront of planning for the development of new reactors . . . since 2001, the company has been systematically working through the issues leading to a decision to

[283] Ibid, p. 20; Rick Zuercher, Manager, Public Affairs, Dominion Virginia Power, Telephone Interview of March 12, 2009.

[284] Zuecher; "There's More to This Light Switch Than Meets the Eye," p. 20.

[285] Zuercher; "Dimensions 2008: A Report to Stakeholders on Values, Goals and Performance," Richmond, VA: Dominion Resources, Inc., 2008, p. 13.

[286] "Electric Generating Stations," http://www.dom.com/about/stations/index.jsp, (accessed January 18, 2009).

deploy a new reactor.[287]

In September of 2003, Dominion submitted an application to the NRC for an Early Site Permit (ESP) for two new reactors at the North Anna site. At the time, they did not specify the desired size for the units (in MW) but did choose the G.E.-Hitachi ESBWR design. The NRC issued the ESP in November of 2007. Unfortunately, due to contract issues with G.E.-Hitachi, Dominion re-opened the reactor design process to competitive bidding in early 2009.[288] The evaluation of the reactor unit designs and associated proposals continued into the fall of 2009.[289]

Dominion continues to evaluate the true cost of constructing and maintaining a new nuclear power plant. According to Rick Zuercher, Manager of Nuclear Public Affairs, in the end "economics will determine whether they choose nuclear or some other option."[290] The company has submitted an application for federal loan guarantees and feels "well-positioned" to get one. In comments before the DOE, the Dominion Resources Legal Department asserted that "[t]hrough all of its planning and preparation, Dominion has understood the economic reality that a federal loan guarantee is essential to raise the capital necessary to build this plant . . . Dominion has not made a final decision

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[287] "Comments of Dominion Resources Inc. on DOE Notice of Proposed Rulemaking 10 CFR Part 609, RIN 1901 – AB21," July 2, 2007, http://www.lgprogram.energy.gov/nopr-comments/comment36.pdf, (accessed March 19, 2009).

[288] Zuercher; Eileen O'Grady, "Update 2 – Two US Firms' Reactor Deals with GE Hitachi Fail," January 9, 2009, http://www.reuters.com/article/rbssUtilitiesMultiline/idUSN0931235920090110, (accessed March 19, 2009).

[289] "New Nuclear in Dominion's Long Term Plan," World Nuclear News, September 22, 2009, http://www.world-nuclear-news.org/NN-New_nuclear_features_in_Dominions_long_term_plan-2209097.html, (accessed October 28, 2009).

[290] Zuercher.

to proceed with North Anna Unit 3, and the uncertainties surrounding the loan guarantee program represent one of the major reasons for the delay in final decision making."[291] Thomas Farrell, Chairman, President, and CEO of Dominion Virginia had a similar message for the PowerGen Conference in December 2008: "Nuclear power is the green alternative to fossil fuels . . . It potentially complements renewable energy by compensating for its limitations. Of course, this involves numbers that are downright scary. The financing of nuclear power has the potential to put more power company CEOs into forced retirement than any other single subject."[292] (Regrettably, Dominion was not among the companies on the DOE "short list" to receive federal loan guarantees.[293])

The message from the Dominion executives is clear. Despite concerns about emissions, despite the projected demand growth in the region, and despite Dominion's commitment to nuclear power, a new nuclear power plant will not be built unless the dollars work in their favor.

4.9 PPL (formerly Pennsylvania Power and Light)

PPL has its roots in coal. The company was founded to mine and bring Pennsylvania coal to Philadelphia.[294] It later moved into electric distribution, joining

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[291] "Comments of Dominion Resources Inc. on DOE Notice of Proposed Rulemaking 10 CFR Part 609, RIN 1901 – AB21," July 2, 2007, http://www.lgprogram.energy.gov/nopr-comments/comment36.pdf, (accessed March 19, 2009).

[292] Thomas F. Farrell, II, "Realistic View of National Energy Challenge is Needed," Remarks to the PowerGen Conference, Orlando, FL, December 2, 2008, http://www.dom.com/about/speeches/120208_print.jsp, (accessed January 6, 2009).

[293] Slocum and Reed.

[294] "PPL Corporation," http://0-premium.hoovers.com.cals.evergreen.edu/suscribe/co/factsheet.xhtml?ID=rrrjtxyhcyyxyf, (accessed July 8, 2008).

with utilities in New Jersey and Maryland to form a fully integrated power pool. Having its own coal mines insulated PPL from the fossil fuel price fluctuations of the 1970s, but, perhaps in response to concerns about air pollution in the Northeast, the company decided to build its first generating units that did not burn coal—the Susquehanna 1 and 2 nuclear reactors.[295] The units came on line in the mid-1980s. PPL replaced the high-pressure turbines in the Susquehanna units in 2003 and applied for operating license renewals in 2006. The NRC approved an increase (by 100 MW(e) each) in the output of the two reactors in 2008. Although PPL did not expand its nuclear fleet, it has continued to devote resources to upgrading the facilities.

In the 2006 PPL Annual Report, Jim Miller, Chairman, President, and CEO spoke of expanding the PPL generating portfolio.[296] At that time, PPL did not have plans to build a new nuclear plant, due to the "significant uncertainties" of the process (although one-step licensing had removed some of those uncertainties). Miller did not rule out the possibility, particularly if PPL could be part of a consortium devoted to licensing and building nuclear plants.[297] By 2007, both Miller and PPL, had changed their stance.

> In the evolving U.S. electricity business, no one can accurately predict the future. It's impossible, for example, to precisely forecast the prices of various *fuels*, the impact of environmental regulations, actions that might alter competitive generation markets or technological advances in electricity generation. Given the uncertainties in this sector, we think the wise course is to create a wide range of opportunities . . . That's the reason we are pursuing a construction and operating license for a potential new reactor in Pennsylvania. That's why we are seeking approvals to double

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[295] "PPL History," http://pplweb.com/about/our+history/ppl+corporation+timeline.htm, (accessed March 2, 2009).

[296] "Business as Unusual, PPL," PPL Corporation 2006 Annual Report, Allentown, PA: PPL Corporation, March 2007.

[297] Ibid, p. 7.

> our hydroelectric generating capacity in Pennsylvania. That's why we are planning to spend more than $100 million to develop new renewable energy projects . . .[298]

A new nuclear power facility became one of several options for the future expansion of PPL.

In a phone interview, a PPL representative (who wished to remain anonymous) put the interest in nuclear power into a more environmentally oriented context. He asserted that the popularity of coal-fired generation had diminished over the past ten years due to its carbon emissions and related climate change issues. Clean coal technology "isn't there yet", and the infrastructure does not yet exist for renewables. Natural gas could be used for baseload generation, but its prices "are all over the place." Nuclear fuel prices have not varied as much as those of either coal or natural gas. Thus, for PPL, nuclear power then emerges as a good option.

Another factor for PPL has been the acceptance of nuclear power in Pennsylvania, despite the legacy of Three Mile Island. "Three Mile Island isn't even on the radar screen for today's generation."[299] In addition, PPL has purchased land adjacent to its Susquehanna facility for potential new nuclear development. "PPL has reactors in the area already so people are generally positive toward nuclear (77 % in favor of nuclear). The Susquehanna plant has been a good neighbor."[300]

Still, the cost of new nuclear looms large. PPL has estimated the cost of the new plant will be about $15 billion, including fuel and financing costs, and assuming a 54-

[298] "Our Formula for Growth? PPL Corporation 2007 Annual Report," Allentown, PA: PPL Corporation, April 2008. p. 4.

[299] Anonymous, PPL, Telephone Interview of February 26, 2009.

[300] Ibid.

month construction period. "The production credit for the first 6000 MW has been an incentive for PPL. Loan guarantees are too . . . They represent a backing for expenditures which allows for project financing."[301] Loan guarantees are necessary to secure financing from Wall Street. PPL also seeks a partner to share the cost: "PPL will not do it alone."[302] In a news release of March 25, 2008, CEO Miller was quoted as saying that the high cost of a new reactor made it risky for PPL "to build a nuclear plant without partners and help from the federal government."[303]

PPL selected the Areva EPR in part because they expect the French company's experience with building reactors of that design will help keep down the cost of components and construction.[304] The EPR can resist airplane impacts and its size (1600 MW(e)) fits with the company needs. In addition, PPL can visit the construction sites in Europe to learn from their experiences. Areva has submitted its application to have the design certified by the NRC. PPL claims it needs to have both its construction and operating license and the design certification in hand by 2012 for the company to move forward with new nuclear plant construction.[305]

In the end, for PPL, no one factor dominates the decision-making process. A concern over carbon dioxide emissions from coal, access to production tax credits, loan

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[301] Ibid.

[302] Ibid.

[303] "PPL CEO Sees More Fast Growth in Merchant Unit," March 25, 2008, http://www.reuters.com/article/companyNews/idUSN25299610120080325, (accessed March 25, 2009).

[304] Anonymous, Interview.

[305] Ibid; Bernie Woodall, "Update 1 – PPL Applies for Pennsylvania Nuclear Power Reactor," October 10, 2008, http://www.reuters.com/article/rbssUtilitiesElectric/idUSN1039915720081010, (accessed March 10, 2009).

guarantees, the costs of building a new nuclear facility (and the ability to find a partner with whom to share the costs), and the acceptance of a nuclear neighbor all play an important role in the company's choice to pursue new nuclear capacity.

4.10 Exelon Corporation

Exelon is a relatively new player in the utility game; founded in 2000 when Philadelphia based PECO Energy (formerly Philadelphia Electric) purchased Chicago based Unicom.[306] Philadelphia Electric had built and operated nuclear plants in Limerick, Pennsylvania and at Peach Bottom, outside Lancaster, Pennsylvania. It joined forces with British Energy in 1997 to form AmerGen, a company devoted to buying nuclear plants from companies eager to unload them. AmerGen subsequently acquired Three Mile Island Unit 1, Oyster Creek in New Jersey, and the Clinton station in Illinois. When PECO merged with Unicom, it petitioned the NRC to have the AmerGen nuclear assets integrated into Exelon Nuclear. That approval came in 2009.[307] Exelon Corporation now operates the third largest nuclear fleet in the world, with 17 reactors at 10 sites in Illinois, Pennsylvania, and New Jersey.[308]

For Exelon, having a portfolio of nuclear generating plants has meant more than economies of scale in purchasing and procurement or operating and maintenance costs.

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[306] "Exelon History," http://0-premium.hoovers.com.cals.evergreen.edu/subscribe/co/history.xhtml?ID=ffffrrrkkffrxfkrhf, (accessed January 19, 2009).

[307] "Exelon Takes Direct Control of Clinton Nuclear Plant," *Herald & Review*, January 9, 2009, http://uaelp.pennnet.com/news/print_screen.cfm?NewsID=172328, (accessed January 18, 2009).

[308] "Operating Clean, Safe, Reliable and Affordable Nuclear Energy Plants," Exelon Nuclear, www.exeloncorp.com, (accessed March 4, 2009); "Exelon's Proposed Nuclear Generating Station in Victoria County," October 27, 2008, www.ExelonNuclearTexas.com, (accessed March 4, 2009).

Craig Nesbitt, Exelon Communications Officer asserted, "We've gotten pretty good at managing a fleet of nuclear plants . . . We have a management model that is published and proven."[309] Bruce Paulsen, spokesman for the Clinton station agreed: "Exelon has become known worldwide for its efficiencies and its good processes for safely running nuclear plants."[310]

Exelon opted to first test the NRC's new permitting and licensing process with an application for an ESP to build another unit at the Clinton site. The NRC received the application in September of 2003 but it took over three years for all of the agency reviews, public hearings, and inspections to be completed. The permit was issued March 15, 2007.[311] However, by that time, Exelon no longer had plans to build there. According to Marilyn Kray, Exelon Vice President, "Certain conditions would have to fall into place before Exelon would consider building a plant: a workable solution to the spent fuel disposal problem; community acceptance; the right reactor technology; and the economics must be favorable."[312]

Despite Kray's earlier comments about spent fuel disposal and the lack of progress on a national solution to the nuclear waste issue, in December of 2007 Exelon announced plans to build a new nuclear plant in Victoria County, Texas.[313] The

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[309] Richard Stavros, "A Nuclear Liability?" *Business & Money*, http://www.pur.com/pubs/4495.cfm, (accessed January 18, 2009).

[310] "Exelon Takes Direct Control of Clinton Nuclear Plant."

[311] Tom Doggett, "Update 1 – U.S. OKs Early Site Permit for Nuclear Power Plant," March 8, 2007, http://www.reuterscom/article/companyNewsAndPR/idUSN0834009020070308, (accessed March 19, 2009).

[312] Ibid.

[313] "Exelon to Apply or Nuclear Plant License in Texas," December 18, 2009, http://www.reuters..com/article/governmentFilingsNews/idUSN1849237320071218, (accessed

company also signed a deal with G.E.-Hitachi for the ultra-large forgings, reactor pressure vessel, and steam turbine fabrication.[314] The formal application to the NRC followed in September 2008. Shortly thereafter, in November of 2008, Exelon reversed its decision to build the G.E-Hitachi ESBWR. *World Nuclear News* reported that "Exelon's change of mind has been driven by the need to secure federal loan guarantees, which the company says are essential for financing the project. 'We are seeking improved eligibility for federal guarantees, which is critical to the advancement of the project' said Exelon Vice President for New Plant Development Thomas O'Neill."[315] Since the speed at which the technology could be commercialized was one of the DOE selection criteria for the loan guarantee program, Exelon executives felt the company had a better chance of receiving the government backing using a reactor whose design was farther along in the NRC certification process.[316] Craig Nesbitt commented that any decision to build a new nuclear reactor would be based on the availability of financing.[317]

Exelon also made the news in the fall of 2008 with a proposed takeover of NRG Energy. In October, Exelon announced plans to acquire all outstanding shares of NRG

March 19, 2009); "Exelon Applies for Nuclear Permits," UPI.com, September 4, 2008, http://www.upi.com/Science_News/Resource-Wars/2008/09/04/Exelon-applies-for-nuclear-permits/UPI-87171220538811/, (accessed January 20, 2009).

[314] "Exelon Nuclear Signs Agreement with GE Hitachi for Major Components for Two ESBWR Nuclear Reactors in Texas," December 11, 2007, http://www.allbusiness.com/energy-utilities/utilities-industry-electric-power-power/324762-1.html, (accessed January 20, 2009).

[315] "Exelon Changes Mind Over Design of New Reactor," World Nuclear News, November 25, 2008, http://www.world-nuclear-news.org/print.aspx?id=23724, (accessed January 18, 2009).

[316] Ibid; Eileen O'Grady, "Exelon Seeks New Nuclear Design for Texas Project," November 24, 2008, http://www.reuters.com/article/americasDealsNews/idUSTRE4AN8EW2001124, (accessed March 19, 2009).

[317] Ibid.

common stock in an all-stock transaction.[318] NRG management rejected the offer, and Exelon took a stock exchange offer directly to the shareholders. By mid-March, the Exelon offer had received support from a majority of the NRG shareholders. Exelon announced that should it take over NRG Energy, it would build the two reactors proposed for the NRG South Texas Project site and would delay building in Victoria County. "That's not to say we wouldn't build a site in Victoria . . . It's impossible to predict how long that would push back Victoria's plant build. It might not mean anything, but it might mean a lot."[319] In an interesting twist, about the same time, the press reported that the South Texas Project has made the "short list" for DOE loan guarantees whereas the Victoria County project has not.[320] Together, those facts would support Exelon's contention that the loan guarantees were a decisive factor in new reactor construction for the company. Unfortunately for Exelon, however, during the summer 2009, NRG shareholders expressed concern they were not being adequately compensated and rejected the proposed expansion of the NRG board to accommodate Exelon representatives.[321] The deal fell through, leaving Exelon without a candidate for federal loan guarantees.

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[318] "Exelon Gains Ground in Bid to Take Over NRG; Majority of Shares Tendered; Fight Now is for Board Seats," The Chicago Tribune, February 27, 2009, http://www.tmcnet.com/usubmit/2009/02/27/4018793.htm, (accessed March 4, 2009).

[319] "Exelon Moves Forward: NRG Bid Supported by Shareholders, but Offer's Terms Still not Agreed Upon," *Victoria Advocate (TX)*, February 27, 2009, http://www.istockanalyst.com/article/viewiStockNews/articleid/3075873, (accessed March 4, 2009).

[320] Jim Fuquay, "EFH Project Said to be on Loan Short List," *Fort Worth Star-Telegram (TX),* February 19, 2009, p. C02; O'Grady, November 24, 2008.

[321] Mark Peters, "NRG Holders Balk; Exelon Drops Bid," *The Wall Street Journal*, July 23, 2009, p. M4.

Did concern about the environment or global warming affect Exelon's interest in new nuclear reactor construction? Not to a great degree. Exelon launched "Exelon 2020: A Low-Carbon Roadmap" in 2008.[322] "Exelon 2020" outlines the company's approach to lowering carbon dioxide emissions within the corporation and among its customers and suppliers. In that document, Exelon brags that it already had a carbon footprint smaller than that of its competitors as a result of its large nuclear fleet. "Exelon's CO_2 emissions per unit of electricity generated are almost 90% below the national average for our industry."[323] Exelon is committed to making its existing nuclear facilities as safe and reliable as possible: "Over the next five years, Exelon Generation will invest $700 million - $900 million annually in equipment reliability, life extension and enhanced generation at existing plants. By completing the re-licensing of all its nuclear facilities, Exelon can provide nearly 17,000 MW of virtually zero-carbon electricity over the next 20-plus years."[324] Although the company continues to explore its options, "Exelon will not commit to building new nuclear plants . . . until we are satisfied that our conditions for safety, regulatory stability, bipartisan federal, state, and local support, spent fuel management and cost have been met."[325] Exelon has the luxury of operating 17 non-

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[322] "Exelon Unveils Roadmap to Eliminate Equivalent of Current Annual Carbon Footprint by 2020," Exelon Press Release, July 15, 2009, http://phx.corporate-ir.net/phoenix.zhtml?c=124298&p=irol-newsArticle&ID=1175027&highlight=, (accessed January 18, 2009); Matthew L. Wald, "To Set Tone, Exelon Plans Huge Cut in Emissions," *The New York Times*, July 15, 2009.

[323] "Exelon 2020: A Low Carbon Roadmap," http://www.exeloncorp.com/NR/rdonlyres/6BF790FC-6ADB-422D-A7A5-36F3776748CC/0/080716Exelon2020_A_Low_Carbon_Roadmap.pdf, (accessed January 18, 2009), p. 6.

[324] Ibid, p. 18.

[325] Ibid, p. 19.

CO_2-emitting reactors at its ten sites. It can wait until conditions are right to make further investments.

4.11 What Have We Learned?

As explained at the beginning of this chapter, the decision to submit an application to build a new nuclear reactor emerged from the confluence of a number of factors: (1) Increasing demand for electricity and a need for greater baseload generation capacity, (2) Concerns about greenhouse gas emissions and potential regulation or taxation, increasing demand for electricity, (3) Questions about the availability of alternative fuel sources and the volatility of fuel pricing, (4) The availability of financial backing for new nuclear construction. The previous sections detailed the importance of those factors to each of the ten companies that were part of this study. This section takes a step back to look at the information as part of a larger picture of new nuclear construction.

Table 3 summarizes all of the data gathered through the interviews and from media sources. (Note: The X's in the table indicate reasons discussed during the interviews whereas the M's show the factors mentioned in the various media sources.)

		Environmental	Energy Security	Financing			Regulatory			Meeting Demand		Fuel-Related		Nuclear Experience	Other
		Climate Change / Emissions Concerns/Environmental	National Energy Security	Availability of Loan Guarantees	Production Tax Credits	Ability to Recoup Costs during Construction	Risk Insurance	Price Anderson Insurance Backing	One Step Licensing	Demand/Need for more baseload generation	Renewables/Efficiency Aren't Enough	Need for Fuel Diversity	Fuel Usage/Costs	Past Experience with Nuclear	
NRG Energy	Media	M	M	M			M				M	M	M		M
Entergy	Interveiw	X		X				X	X	X			X		X
	Media			M									M		
Duke Energy	Interveiw	X		X							X	X			
	Media	M				M				M		M	M	M	
Progress Energy Florida	Interveiw			not a factor		X		X		X	X	X	X		X
	Media	M	M			M				M	M	M	M	M	M
Tennessee Valley Authority	Interveiw	X		not a factor					X	X	X		X	X	
	Media	M								M			M	M	
Constellation Energy	Media	M	M	M	M					M				M	
AmerenUE	Interveiw	X				X			X	X	X		X		
	Media	M				M				M	M				
Dominion Virginia Power	Interveiw	X		X				X	X	X			X	X	
	Media	M				M				M		M	M	M	
PPL	Interveiw	X		X	X				X				X		X
	Media	M		M						M		M		M	M
Exelon	Media	M		M										M	M

X = Information obtained during an interview M = Information from media sources

Table 3: Factors Affecting Decisions to Apply to Build New Nuclear Power Plants as Reported in Interviews and the Media

The different numbers of Xs and Ms in the table indicate dissimilarities between the factors deemed important by the media versus the companies themselves. For example, as seen by the large number of Ms in the columns, the media focused on environmental factors and potential carbon taxes or cap and trade programs, on the need to meet customer demand through increased baseload generation, and on a company's prior experience with nuclear power. On the other hand, the companies talked about the importance of the Price Anderson Insurance to the industry and about the role the change to the one-step licensing process had in their decision to submit a COL application to the NRC. The media paid attention to external factors readily visible to and easily understood by the general public, whereas the companies mentioned reasons that involved the process and context currently faced within the industry.

Interestingly, although the Bush/Cheney administration often put national energy security at the core of their policies and actions, that potential driver of the interest in new nuclear power plants received little attention by either the media or the companies applying to build new plants (See "National Energy Policy Report" as well as the statement of D. Spurgeon, Office of Nuclear Energy, Department of Energy, in "Implementation of the Provisions of the Energy Policy Act of 2005," p. 54 ff).[326]

The investment community had expressed concerns about the potential delays in bringing new reactors on line:

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[326] "National Energy Policy Report of the National Energy Policy Development Group: Reliable, Affordable, and Environmentally Sound Energy for America's Future," Washington D.C.: U.S. Government Printing Office, May 2001; "Implementation of the Provisions of the Energy Policy Act of 2005," Hearings Before the Committee on Energy and Natural Resources of the United States Senate, May 15, 2006, May 22, 2006, June 12, 2006, June 9, 2006, Washington D.C.: U.S. Government Printing Office, 2006.

> The industry and financial community remember that a number of the existing plants that received their operating licenses in the 1980s and 1990s experienced delays due to regulatory or licensing issues that arose after most or all of the capital investment in the plant had been made. These delays were caused by a number of factors, including construction issues, quality assurance weaknesses, coordination issues between plant design and construction work, changing requirements, and the mechanics of the two-stage licensing process, which resulted in litigation at the pre-operation stage.[327]

Yet Table 3 shows that the Delay Risk Insurance did not factor highly in utility or nuclear investment companies' decisions. These results indicate that Delay Risk Insurance may not influence the initial decision to build a new nuclear facility, but it may be important in attracting external financing for a nuclear plant once that decision has been made. The results also suggest the COL applicants feel confident that the new licensing process and changes implemented since the first round of reactor construction will indeed keep their projects on schedule and delay insurance will be unnecessary.

The Production Tax Credit also had been touted as necessary to lure capital investment in new nuclear power and to put nuclear on equal footing with renewable energy sources. In his statement before the Committee on Energy and Natural Resources of the U.S. Senate, Marvin Fertel, President and Chief Nuclear Officer of the Nuclear Energy Institute had stated that "The $18-per-megawatt-hour production tax credit provided . . . is an important step toward making investment in the first few new nuclear plants attractive to the private sector. This tax credit is comparable to that provided for other sources of new, emission-free electricity generation."[328] Yet, during the interviews, only PPL indicated that the availability of Production Tax Credits played a role in their

[327] "Nuclear Power in the United States," Hearing Before the Subcommittee on Energy of the Committee on Energy and Natural Resources of the United States Senate, March 4, 2004, Washington D.C.: U.S. Government Printing Office, 2004, p. 41.

[328] Ibid, p. 27.

decision to undertake a new nuclear construction project. This may be because large amounts of capital will be needed prior to and during the construction phase whereas a Production Tax Credit would not take effect until after the unit came on line and began producing electricity—well after the bulk of the funds had been expended. The promise of a "rebate" years in the future did not seem to be motivating factor in the new nuclear decision.

Unlike Delay Risk Insurance and Production Tax Credits, Federal Loan Guarantees did factor highly into decisions to apply for licenses to build new nuclear reactors. The loan guarantees assure lenders that the money lent will indeed be repaid, and also ensure that the companies undertaking these capital intensive, multi-year projects will continue as going concerns even if the unthinkable happens and the reactor unit never produces electricity. They will not suffer the fate of the public utility, Long Island Lighting Company (LILCO), whose Shoreham Nuclear Power Plant received a conditional, lower power, license but failed to receive its full power operating license from the NRC.[329] The state of New York and its Long Island Power Authority (LIPA) took control of Shoreham in 1989, closed it, and decommissioned the facility. LILCO struggled to repay its debt through annual rate increases (its rates rose to the highest levels in the continental U.S. by the mid-1990s), but eventually LILCO sold its

[329] "Shoreham Nuclear," Exponent Engineering and Scientific Consulting, 2008, http://www.exponent.com/Diesel-Generator-Stress-Evaluating-Failures-in-the-Shoreham-Plant-on-Long-Island/, (accessed October 29, 2009); "Shoreham," August 9, 2007, http://www.nukeworker.com/nuke_facilities/North_America/usa/NRC_Facilities/Region_1/shoreham/index.shtml, (accessed October 29, 2009).

transmission and distribution system and transferred its debt to LIPA, and merged its remaining assets with the Brooklyn Union Gas Company.[330] LILCO was no more.

In sum, looking at the data as a whole, the primary factors behind companies' decision to submit a COL application to the NRC are:

1. Environmental Concerns (emissions, potential carbon taxes), mentioned for nine of the companies in the media and by six of the company representatives;

2. Meeting Customer Demand through Increased Baseload Generation, with seven media and five company references;

3. Fuel Usage and Costs, brought up for six companies in the media and by six of the companies representatives interviewed; and

4. The Availability of Federal Loan Guarantees, mentioned in the media for five companies and by four company representatives.

[330] Bruce Lambert, "Lilco Merger Receives Conditional Support," *The New York Times*, April 11, 1997, p. B.8; Richard Perez-Pena, "Lilco's Hard Journey," *The New York Times*, July 21, 1997, p. B.4.

5.0 What Do These Results Tell Us?

Chapter 1 of this thesis asked the question: What factor or combination of factors has motivated the interest in building new nuclear power facilities in the United States? The scientific community has stressed the need to reduce the greenhouse gas emissions implicated in anthropogenic global warming—has that driven the spate of applications for construction and operating licenses for nuclear reactors? Unrest in the Middle East and the potential for a disruption in supply of Middle East oil have led to concerns about supplies and cost of oil and thus national security. Might that have spurred the applications? Or are the utility companies and nuclear plant operators merely responding to increased customer demand for baseload electricity? Concerns over greenhouse gas emissions could raise interest in renewable energy options, the situation in the Middle East might motivate oil exploration closer to home, and increased demand could generate a new look at hydropower or coal. Why then have companies submitted applications to build new nuclear power plants?

This research demonstrated that environmental concerns, customer demand, anxieties about the availability and prices of fuel, and the availability of Federal Loan Guarantees or CWIP financing all contribute to the decision to submit an application to construct and operate a new nuclear power plant in the United States. There was not just one factor behind the companies' choice; it took a blend of several things to prompt the decision.

Now, how do we make sense of the seemingly disparate combination of factors summarized in Table 3 of Chapter 4?

Economic theories of supply and demand could explain when a utility company would choose to add baseload capacity to meet expected future demand, or at what point they would choose to build rather than buy power from neighboring utilities.[331] Very few substitutes exist for electricity from the grid. Unless a company or residence can generate its own supply (through installed photovoltaic panels, for example), the electricity must come from the electric grid and big suppliers like Duke Energy, NRG, or Exelon. That lack of substitutes also means that customers will continue to use electricity even if the price increases. Some customers may reduce their consumption if the price climbs too high, but most will grumble about their bills and continue using electricity as before. Eventually, the neighboring utilities will not be able to supply all of the excess electricity needed. New capacity will need to be added. A utility company probably would construct a new facility when the increase in projected electrical demand just about equaled the capacity of the new plant or when the cost of construction was less than or equal to the price paid to meet customer electrical needs. Unfortunately, economic supply and demand models do not explain why a utility would undertake construction of a new nuclear unit or plant and not add a coal or natural gas plant instead.

Strategic theories of barriers to entry suggest there are factors unique to an industry that make it hard for outsiders to gain a foothold within it (see, for example, Yip; Samuelson and Nordhaus)[332]. Barriers to entry can include product branding; legal

[331] Karl E. Case, and Ray C. Fair, *Principles of Microeconomics, Sixth Edition*, Upper Saddle River, NJ: Prentice Hall, 2002; Paul A. Samuelson and William D. Nordhaus, *Economics, Seventeenth Edition*, New York, NY: McGraw-Hill, 2001.

[332] George Yip, "Diversification Entry: Internal Development Versus Acquisition," *Strategic Management Journal*, Vol. 3, No. 4, October – December 1982, pp. 331 – 345; Samuelson and Nordhaus.

restrictions, tariffs, and patents; or access to raw materials. For the nuclear industry, those factors could include the length of time it takes to build and license a new commercial nuclear power plant, the high capital costs associated with that construction, or the steep learning curve and long time it takes for a reactor unit to reach a 90% operating capacity (Recall Figure 4). Barriers to entry could explain why a company like Constellation would choose to purchase existing nuclear power plants in order to get into the nuclear business. Constellation did not have to wait for years before its plants would begin producing electricity, as it would have had it started from scratch. It did not have to endure several years of low capacity factors as it ironed out the kinks in its new systems or trained new personnel. Purchasing an existing facility also ensured that the community accepted (or least tolerated) having a nuclear power plant in their back yard—they would not face the protests and legal battles that delayed the completion of many of the early nuclear power plants. (PPL chose to expand its existing Susquehannah site because it "has reactors in the area already so people are generally positive toward nuclear (77 % in favor of nuclear). The Susquehannah plant has been a good neighbor. Thus, nuclear is a good option."[333])

The theory of barriers to entry also clarifies why the utilities that have applied to build a new nuclear plant are ones that have one or more existing nuclear plants in their portfolios: They have the requisite experience with nuclear power plant operation. But barriers to entry do not explain why a utility like Duke Energy, which already owns and operates both nuclear and fossil fuel-based electric generating plants, would choose to

[333] Anonymous, PPL.

build a new nuclear plant and not use those funds to invest in an advanced, combined cycle coal facility or in other renewable technologies.

First mover advantages suggest that the initial investors in a new technology, new product, or new business will benefit more than those who come later—in the case of new nuclear construction, the first movers would receive a share of the limited number of federal loan guarantees available.[334] The first movers would submit their applications early, and thus would have time to revise them or strengthen their case for the federal support. First mover advantages also help us understand why companies selected the AP1000 reactor design (which had received initial NRC certification in January 2006) over the unlicensed Areva EPR, and why some have changed their chosen reactor design, moving away from the GE-Hitachi Economic Simplified Boiling Water Reactor, to make sure the reactor design is one that, according to the DOE, "can be commercialized more quickly" and thus meets the criteria for loan guarantees. But if the first mover advantages of loan guarantees are so important, why then did a company like Progress Energy Florida withdraw itself from the loan guarantee competition? Likewise, why is the TVA proceeding down the path of new nuclear without access to the Federal Loan Guarantee program?

The literature on corporate volunteerism provides insight into why utilities would choose to invest in baseload capacity that does not rely on fossil fuels. The Kyoto Protocol, Regional Greenhouse Gas Initiative (RGGI), and the Western Climate Initiative all set caps on the levels of emissions of carbon dioxide and other greenhouse gases.

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[334] Marvin B. Lieberman and David B. Montgomery, "First Mover Advantages," *Strategic Management Journal*, Vol. 9, Special Issue: Strategy Content Research, Summer 1988, pp. 41 - 58.

Some countries, companies, and states may voluntarily sign onto such initiatives to preempt more stringent regulation in the future.[335] Others may choose to reduce emissions in response to consumers' and investors' calls for "green energy." For example, Rita Sipe of Duke Energy acknowledged that Duke's interest in new nuclear stemmed in part from the possibility of carbon legislation. Progress Energy Florida listened to its customers' appeals for increased energy efficiency and more wind and solar power. However, since neither wind nor solar energy can yet provide baseload electrical generation, Progress Energy looked to non-polluting nuclear instead. Still, without other factors such as increased demand and the access to loans or CWIP financing, neither Duke nor Progress Energy would have considered building a new nuclear facility that provides 1200 to 1600 MW(e) of baseload capacity.

To find one coherent theory that encompasses a utility/investment company's environmental concerns, their anxieties about the availability and prices of fuel, the availability of Federal Loan Guarantees or CWIP financing, and customer demand, we turn to Political Ecology.

The term Political Ecology first emerged in the 1970s as people became increasingly aware of how highly politicized the natural environment had become.[336] Some traced its origins to political economy and the teachings of (1) Adam Smith (and his ideas of using the fruits of ones labor to generate revenue and of the progress of nations from agricultural states to industrial powerhouses); (2) Thomas Malthus (who

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[335] Eric Welch, Allan Mazur, and Stuart Bretschneider, "Voluntary Behavior by Electric Utilities: Levels of Adoption and Contribution of the Climate Challenge Program to the Reduction of Carbon Dioxide," *Journal of Policy Analysis and Management*, Vol. 19, No. 3, Summer 2000, p. 410.

[336] Roderick P. Neumann, *Making Political Ecology*, Oxford University Press, 2005, p. 33.

believed that population growth and diminishing food supplies would lead to the downfall of society); and (3) Karl Marx (who looked at the relationships between property ownership and the productive activity of a state). Others felt its roots lay in the field of geography and the tensions between human environment and its structures and governing principles on the one hand and the natural environment on the other.

Cockburn and Ridgeway, in their 1979 anthology, *Political Ecology*, defined Political Ecology as a "way of describing the intentions of radical movements in the United States, in Western Europe, and in other advanced industrial countries."[337] Regarding the activism that had grown up to oppose nuclear power plant construction, they wrote

> . . . such an argument [against nuclear power] must confront issues of the economy, of health, of agriculture, of land use, of technology. The argument must present rigorous rather than rhetorical analysis of the energy industry; it must do more than gesture toward alternative energy options. And because we live in the real world of corporate interest, federal and local politics, the ecological argument must by definition be political too.[338]

They later continued:

> While the issue of energy was the central question, more profound was the gradual realization of all the various groups within the movement broadly sketched above that the word "ecology" implies the indivisibility of total systems, and that all their disparate concerns were connected . . . Hence has arisen the term "political ecology". . . [339]

[337] Alexander Cockburn, and James Ridgeway, *Political Ecology*, New York, NY: Times Books, 1979, p. 3.

[338] Ibid, p. 4.

[339] Ibid, p. 6.

Unfortunately, Cockburn and Ridgeway did not attempt to intertwine those different threads in their book; rather, they included excerpts from books and articles written against nuclear power and favoring alternative energy options.

In the 1980s, American and British Political Ecology research sought to understand the relationship between the access to and control over resources and environmental changes occurring in less-developed nations.[340] French Political Ecologists also focused on control issues. They saw society as trying to distance itself from nature and the forces of natural elements by increasingly taking command of production processes and by increasing consumption.[341]

The inaugural volume of the *Journal of Political Ecology* appeared in 1994. In their introduction to that issue, Greenberg and Park proposed that Political Ecology had grown out of the questions asked by social scientists about the relationships between human society and a "humanized" nature (that is, one that has been significantly affected by human activities of farming, mining, domesticating animals, building cities and roads, and the like).[342] They described Political Ecology as an exploration of the conflicts between people, their productive activities, and nature, and the influence of cultural and political activity on all three. That first journal set the stage for the diversity of subject matter that has become "Political Ecology." It included articles dealing with water

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[340] Nuemann, p. 5.

[341] Brigit Müller, "Still Feeding the World? The Political Ecology of Canadian Prairie Farmers," *Anthropologica*, Vol. 50, 2008, p. 391.

[342] James B. Greenberg and Thomas K. Park, "Political Ecology," *Journal of Political Ecology*, Vol. 1, No. 1, 1994, p. 1.

conservation, the complicated issues tied to man-made borders, and the impact of externally imposed regulations on shrimp fisheries.

Dr. John Perkins studied the "Green Revolution" in agriculture using a Political Ecology framework in his book *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War*, published in 1997.[343] He examined the history of plant-breeding and the strategic and social decisions made in times of peace and war. He looked at the development of high yield varieties of wheat and rice and the impact the new strains had on the dependency relationships between developed and developing nations. He also explored some of the unintended negative consequences of intensified farming. In doing so he followed one of the basic premises of Political Ecology--that environmental problems cannot be understood without consideration of the historical, political, economic, social, and biophysical contexts in which they are embedded (Neumann, pp. 9 and 41).[344]

In his book, Perkins demonstrated how technology mediated between human needs and wants and the natural environment/natural resources (See Figure 11).

Natural Resources and The Environment ⟷ Technology ⟷ Human Wants and Needs

Figure 11: Political Ecology Model of Agricultural Developments (From Perkins, p. 5)

[343] John H. Perkins, *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War*, New York, NY: Oxford University Press, 1997.

[344] Neumann, pp. 9 and 41.

The first set of double arrows in the model suggest not only that the type of natural resources being exploited and the environmental context affect the type of technology adopted, but also that changes in technology can influence the environment. For example, farmers in the American West require a predictable source of water so their crops will flourish. When natural rainfall and local streams have not met their needs, they have diverted water from rivers using large dams and series of canals, and watered the crops using mobile overhead irrigation systems.[345] Unfortunately, those extension irrigation networks have wreaked havoc on the amount of water available for fish populations, navigation, and other uses of the river (Harden).[346]

Technology also influences and is influenced by human wants and needs. Again using western farming as an example, the ability to grow crops locally meant that more people could find a food supply and settle in the area. Population increases resulted in larger farms producing an increasing variety of crops, not just those particularly suited to the climate, but also ones the new settlers had brought with them from other parts of the country and the world. The advent of refrigerated rail cars and trucks meant that produce could be shipped longer distances, opening up new markets. The increased demand led to the establishment of larger farms and the development of new varieties of crops that would travel well over long distances.

A Political Ecology framework like the one used by Perkins can be adapted for understanding the interplay of the many reasons for submitting a COL application to the

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[345] Marc Reisner, *Cadillac Desert: The American West and Its Disappearing Water*, New York, NY: Penguin Books, 1993.

[346] Blaine Harden, *A River Lost: The Life and Death of the Columbia*, New York, NY: W. W. Norton, 1996.

NRC to build a new nuclear reactor. First, in the case of commercial nuclear reactors and other energy technologies, the natural resources/environment of interest would include the concerns over supplies of fuels to power electrical generation (such as the dwindling supply of natural gas and its price fluctuations, or the environmental destruction associated with coal mining) and the carbon dioxide emissions linked to global climate change. The human want/need to be satisfied would be the almost unlimited access to electrical power that drives modern life. People want their lights to turn on, their heaters to blow warm air, their coffee makers to brew, and their washing machines to agitate when they flip the switches. Finally, the technology that provides that electricity would be a turbine generator, fired by coal, hydropower, fossil fuels, or nuclear reactions. Thus, utility companies would examine their various technology options to meet increased electrical demand and as their concerns grow over potential carbon taxes or cap and trade programs.

Perkins' model needs to be modified to include the one other factor that drives the decision to build a new nuclear power plant: The availability of financial resources and capital investment. The interviews and media sources reviewed for this thesis point to loan guarantees and access to CWIP (construction-work-in-progress) financing as crucial for new nuclear construction. Recall the words of Paul Hinnenkamp of Entergy Nuclear: "[L]oan guarantees are essential to reduce the financial risk of new nuclear deployment and enable Entergy to leverage the large investment required . . . We cannot take on the debt required to finance a new build without an effective loan guarantee program" ("LPG Public Meeting," p. 57).[347] Remember too that AmerenUE withdrew their application

[347] "LPG Public Meeting," p. 57.

when it appeared certain that the Missouri legislature would deny them the CWIP financing they had requested. The new model therefore adds Capital Investment/Financing to the original Perkins model:

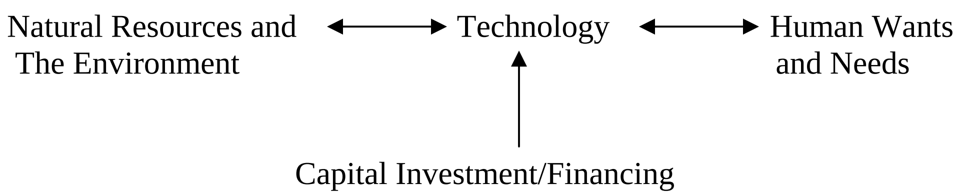

Figure 12: The Political Ecology of New Commercial Nuclear Power Plants

Unlike the arrows linking technology to human wants and needs, and natural resources, the arrow between the technology choice and Capital Investment/Financing has been drawn with a single head, indicating a one-way flow of capital. Some might argue that the arrow should be two-headed since the companies involved could influence the availability of the capital from the local or federal government through their political contributions. For example, in 2005, the year the Energy Policy Act was passed, renewing the Price Anderson Indemnity Insurance program and outlining the Federal Loan Guarantee program for new nuclear reactors, Duke Energy spent over $2 million lobbying the federal government.[348] The electric utility portion of Entergy paid out over $1.5 million in lobbying, and Areva, the French company hoping to certify the U.S. Evolutionary Power Reactor (EPR), spent over $700,000.[349] Although those figures may

[348] "Lobbying, Duke Energy," http://www.opensecrets.org/lobby/clientsum.php?year=2005&lname=Duke+Energy&id=, (accessed September 19, 2009).

[349] "Lobbying, Entergy," http://www.opensecrets.org/lobby/clientsum.php?year=2005&lname=Entergy+Corp&id=, (accessed September 19, 2009); "Lobbying, AREVA Group,"

pale compared to those of the "heavy hitters" like the United Auto Workers, the National Rifle Association, Microsoft, or the Boeing Company, they do indicate intent to influence members of Congress and their positions on key issues. Still, such contributions are meant to influence ideas and votes, and cannot be considered the same type of investment as loans, which return interest to the lender, or outlays for physical structures, which may generate income during their lifetime or a profit when sold. For these reasons, the arrow is drawn in one direction.

Since much of current Political Ecology deals with the control over access to and use of environmental resources, this thesis discussion would be incomplete without an examination of the various ways control manifests itself in the model of the decision to submit an application to build a new nuclear power plant.

First, there is the power exercised by the federal government. The Bush/Cheney administration characterized uninterrupted access to a diversity of fuel supplies as an issue of national security. Thus, their National Energy Policy focused on increasing domestic supplies of energy. It advocated an increased use of renewable sources (including methane from landfills, wind, and biomass), research into clean coal technology, opening of the Alaska National Wildlife Refuge (ANWR) to oil exploration, and the expansion of nuclear energy in the United States.[350] The Bush/Cheney administration primarily relied upon federal funding and legislation to control use of the associated natural resources. For example, the Energy Policy Act (EPAct) of 2005 provided billions of dollars in production tax credits, subsidies, and loan guarantees for

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http://www.opensecrets.org/lobby/clientsum.php?year=2005&lname=AREVA+Group&id=, (accessed September 19, 2009).

[350] "National Energy Policy," p. xiv.

the energy projects favored by that administration, including those outlined earlier for new nuclear power plants.[351] The 2009 Senate version of a clean energy bill would augment those provisions with investment tax credits, additional loan guarantees, and federally financed training for nuclear workers.[352] Those inducements provided a clear signal to researchers, the investment community, and to the utility companies themselves where they should be putting their own money, efforts, and attention.

Likewise, by insisting on Federal loan guarantees before agreeing to provide financing for new nuclear power plants, Wall Street investors control the utility companies' access to actual funding. Regardless of a company's cash flow position or historical record with nuclear power plant operations, regardless of its ability to demonstrate the need for a new baseload facility or its outlook for their future, the company would not get a loan from outside investors without government backing.

Power over access to the natural resource involved in nuclear power generation—uranium--has caused a stir in recent years. With the renewed interest in nuclear power and increases in the price of uranium during the 2000s came a renewed interest in mining the domestic lodes of that ore. According to the Environmental Working Group, new uranium mining claims on federal lands in just four states (Colorado, Wyoming, Utah and New Mexico) jumped from just over 4000 in 2004 to more than 32,000 in 2006 .[353] In

[351] "Title XVII – Incentives for Innovative Technologies," Public Law 109 – 58, August 8, 2005, http://www.lgprogram.energy.gov/EPA2005TitleXVII.pdf, (accessed October 27, 2009).

[352] Mufson, October 28, 2009; "Can We Afford More Subsidies for Nuclear Power?" Union of Concerned Scientists, October 20, 2009, http://www.ucsusa.org/news/press_release/can-we-afford-more-subsidies-0296.html, (accessed November 2, 2009).

[353] "Mining Law Threatens Grand Canyon, Other National Treasures," August 16, 2007, http://www.ewg.org/sites/mining_google/US/analysis.php, (accessed September 25, 2009).

addition, in February 2008, without the customary formal environmental review, the U.S. Forest Service approved a permit for a British company to explore for uranium just outside Grand Canyon National Park.[354] These claims are covered by an 1872 mining law that permits companies to stake an exclusive claim for as little as $1 per acre, pay no royalties, and receive a tax break for up to 22 % of the metals ore they extract.[355] Despite concerns about the toxic water pollution and environmental impacts of uranium mining as expressed by the Sierra Club, the Center for Biological Diversity and others, the existing law gives the mining companies the power over this resource.[356]

In contrast to the lack of advancement in mining law, in April of 2007, the U.S. Supreme Court ruled that carbon dioxide indeed was a pollutant under the Clean Air Act. The Environmental Protection Agency (EPA) followed in April of 2009 with a declaration that carbon dioxide and other greenhouse gases did pose risks to human and environmental health.[357] The federal government had begun to take the steps needed to regulate the emissions from electrical plants powered by fossil fuels. A natural resource once taken for granted as a ubiquitous part of the earth's atmosphere increasingly is coming under government (and not industry) control.

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[354] Felicity Barringer, "Uranium Exploration Near Grand Canyon," *The New York Times*, Feb. 7, 2008, p. A 22.

[355] "Uranium Fever Fuels New Land Rush: Mining Claims on U.S. Public Lands Up 47 %," December 14, 2006, http://www.ewg.org/node/20671/print, (accessed September 25, 2009).

[356] "Bush Ignores Laws Protecting Grand canyon as Uranium Mining Claims Soar," October 2008, http://www.ewg.org/node/27293, (accessed February 1, 2010).

[357] Jonathan Weisman and Siobhan Hughes, "U.S. in Historic Shift on CO2," *The Wall Street Journal*, April 18, 2009, p. A1; "EPA Deems CO2 a Health Risk," *Discovery News*, http://dsc.discovery.com/news/2009/04/17/co2-health-epa.html, (accessed November 3, 2009).

In yet another avenue of control, nuclear investment companies or utilities can regulate the flow of electricity from various electricity sources to their customers. For example, when summertime demand strains the electrical supply system in California, local utilities may ask customers to stop using electricity during certain times of the day as part of a system of "rolling brownouts." Rather than risking failure of the entire system, customers must forego satisfying their needs and wants the appliances and equipment that depend on electricity, for a brief period.

Electric customers are enjoying an increasing amount of power as well. Customers, particularly residential customers, always have had the freedom to reduce their electric consumption, and thus their dependence on utilities. Many produce some of their own electricity by installing solar panels, wind turbines, or small hydroelectric equipment, feeding excess electricity generated into the local electric grid, and receiving a credit on their utility bills (a program called "net metering").[358] Some states now are considering the European model of requiring utilities to pay customers for the electricity they generate.[359] (In Germany, residential customers supplying electricity back to the grid receive a guaranteed payment approximately four times the market rate for electricity whereas small customers in Spain who provide electricity to the grid receive

[358] Database of State Incentives for Renewables and Efficiency, http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=WA01R&re=1&ee=1, (accessed November 3, 2009); Laurel Vernado and Michael Sheehan, "Connecting to the Grid: A Guide to Distributed Generation Interconnection Issues, 6th Edition, 2009," North Carolina Solar Center, Raleigh, NC: North Carolina State University, 2009.

[359] Kate Galbraith, "Europe's Way of Encouraging Solar Power Arrives in the U.S." *The New York Times*, March 13, 2009, p. B1.

$0.43/kWh.[360]) Gainesville, FL was one of the first locations in the U.S. to guarantee its customers payment for their electricity. In February of 2009, the Florida Public Service Commission approved a $0.34/kWh for 20 years for anyone signing up during the first two years of the program.[361] This type of program gives the customers control over the source of their energy and a 'voice' in the future of the local utilities: If enough customers feed into the grid to offset some of the increases in expected demand, the utility may be able to delay investment in new generation facilities of its own. (In an interesting twist, however, the feed-in tariffs could be considered a control mechanism used by the utility companies to entice customers to provide them with the very thing they sell—electricity.)

The proposed smart grid technology also will give both the utilities and their customers' power: The power of having information about exact electrical usage, in real time, and the cost of the electricity at the time of use.[362] Customers then can schedule their energy intensive activities when the costs are low and can reduce their total energy consumption. Utility providers will have details about the precise needs of their residential and industrial customers, and will be better able to forecast their future needs

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[360] Ashley Seager, "Germany Sets Shining Example in Providing a Harvest for the World," *The Guardian*, July 23, 2007, http://www.guardian.co.uk/business/2007/jul/23/germany.greenbusiness, (accessed November 3, 2009); "New Spanish Feed-In Tariff Level Set," *Renewable Energy World.Com*, February 25, 2009, http://www.renewableenergyworld.com/rea/news/article/2009/02/new-spanish-feed-in-tariff-level-set, (accessed November 3, 2009).

[361] "Gainesville Solar Feed-In Tariff a Done Deal," Renewable Energy World.Com, February 9, 2009, http://www.renewableenergyworld.com/rea/news/article/2009/02/gainesville-solar-feed-in-tariff-a-done-deal, (accessed November 3, 2009).

[362] Brendan Koerner, "Fix the Grid! 7 Ways to Transform America," *Wired*, April 2009, pp. 76 – 87; "A Smarter Electric Grid," February 9, 2009, http://www.popsci.com/environment/article/2009-02/smarter-electric-grid, (accessed September 24, 2009).

and thus determine if construction of new baseload generation capacity is in their best interest. But, as with new nuclear construction, it will take a financial stimulus from the federal government to spur the change to the "smarter," more reliable and efficient electric grid system. In 2009, the Obama Administration announced $3.4 billion in grant awards to revamp the electric grid and make electricity distribution and transmission more efficient.[363]

Ultimately, the decision regarding investment in energy technology, whether nuclear, wind, or even upgrades in transmission, boils down to interplay of the same factors as outlined in the modified Political Ecology model. It takes an environmental factor (such as carbon dioxide levels in the atmosphere or a backlash over mining and extraction practices that reduces the availability of coal, oil, or uranium) plus the demand for continuously available electricity to power the 24-hour a day, seven days a week American lifestyle and industrial complex, and financial support for companies in the United States to tackle energy projects. Thus, the model proposed for new nuclear reactor construction can be generalized into a model for the Political Ecology of Energy in the United States:

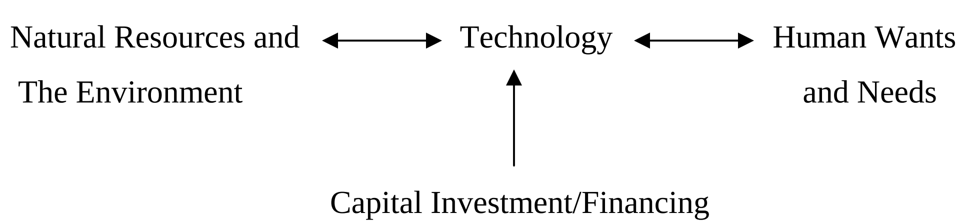

Figure 13: The Political Ecology of Energy in the United States

[363] "President Obama Announces $3.4 Billion Investment to Spur Transition to Smart Energy Grid," U.S. Department of Energy Media Release, October 27, 2009, http://www.energy.gov/news2009/print2009/8216.htm, (accessed November 2, 2009).

The next step in this line of research will be to test this model in other sectors of the electric energy industry in the United States. Do the same relationships hold for investments in "clean coal" technology, tar sands recovery projects, small-scale hydropower, concentrating solar installations, or wind farms? Is public demand for renewable energy sources enough to spur energy firms to put money into new technologies? Or will representatives of renewable energy companies reveal that although they firmly believe Americans must move away from a dependence on oil, a switch to new sources of electricity will occur only with government financial support? Finding the answers to questions like these could have important implications for policy and funding decisions at the national and local levels, decisions that will affect the future direction of energy investments in the U.S. Understanding what drives the renewed interest in new nuclear power plant construction can help in the development of a wide variety of programs supporting new technologies designed meet the growing demand for electricity.

Albert Einstein once said, "The release of atomic energy has not created a new problem. It has merely made more urgent the necessity of solving an existing one."[364] Likewise, the impending construction of new nuclear power plants in the U.S. should stimulate interest in finding other ways to meet the country's energy needs.

[364] "The Quotations Page," http://www.quotationspage.com/search.php3?Search=Energy&startsearch=Search&Author=Einstein&C=mgm&C=motivate&C=classic&C=coles&C=poorc&C=lindsly, accessed March 15, 2010.

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Appendix 1: Reactor Ownership

Reactor Name	Original Owner	Current Owner
Arkansas Nuclear-1	Middle South Utilities via Arkansas Power and Light Co.	Entergy Nuclear
Arkansas Nuclear-2	Middle South Utilities via Arkansas Power and Light Co.	Entergy Nuclear
Beaver Valley-1	Duquesne Light Company; Ohio Edison Company; Pennsylvania Power Company; The Cleveland Electric Illuminating Company; and The Toledo Edison Company	Pennsylvania Power Company (65 percent), Ohio Edison Company (35 percent)
Beaver Valley-2	Duquesne Light Company; Ohio Edison Company; Pennsylvania Power Company; The Cleveland Electric Illuminating Company; and The Toledo Edison Company	Pennsylvania Power Company (65 percent), Ohio Edison Company (35 percent)
Braidwood-1	Commonwealth Edison	Exelon Corp.
Braidwood-2	Commonwealth Edison	Exelon Corp.
Browns Ferry-1	TVA	TVA
Browns Ferry-2	TVA	TVA
Browns Ferry-3	TVA	TVA
Brunswick-1	Carolina Power & Light Company	Progress Energy Carolinas (81.7 percent), North Carolina Eastern Municipal Power Agency (18.3 percent)
Brunswick-2	Carolina Power & Light Company	Progress Energy Carolinas (81.7 percent), North Carolina Eastern Municipal Power Agency (18.3 percent)
Byron-1	Commonwealth Edison	Exelon Corp.
Byron-2	Commonwealth Edison	Exelon Corp.
Callaway-1	Union Electric	Ameren (formerly Union Electric)
Calvert Cliffs-1	Baltimore Gas and Electric	Constellation Nuclear
Calvert Cliffs-2	Baltimore Gas and Electric	Constellation Nuclear
Catawba-1	North Carolina Municipal Power Agency Number One, North Carolina Electric Membership Corporation, Piedmont Municipal Power Agency, and Duke Energy.Operated by Duke Energy	North Carolina Electric Membership Corporation (56.3 percent), Duke Energy Corporation (25 percent), Saluda River Electric Coop, Inc. (18.8 percent).
Catawba-2	North Carolina Municipal Power Agency Number One, North Carolina Electric Membership Corporation, Piedmont Municipal Power Agency, and Duke Energy.	North Carolina Electric Membership Corporation (56.3 percent), Duke Energy Corporation (25 percent), Saluda River Electric Coop, Inc. (18.8 percent).
Clinton-1	Illinois Power	Exelon Corp.
Columbia-2	Energy Northwest, Formerly Washington Public Power Supply System or WPPSS	Energy Northwest
Comanche Peak-1	TXU Power	Luminant Generation
Comanche Peak-2	TXU Power	Luminant Generation
Cooper	Nebraska Public Power District	Nebraska Public Power District
Crystal River-3	Florida Progress Corp; operated thru its subsidiary Florida Power Corp.	Progress Energy
Davis Besse-1	Cleveland Electric Illuminating (CEI) and Toledo Edison (TE).	Cleveland Electric Illuminating
Diablo Canyon-1	Pacific Gas and Electric	Edison International (75 percent), and San Diego Gas & Electric Co., Anaheim Public Utilities Department, and the Riverside Utilities Department
Diablo Canyon-2	Pacific Gas and Electric	Edison International (75 percent), and San Diego Gas & Electric Co., Anaheim Public Utilities Department, and the Riverside Utilities Department
Donald Cook-1	Indiana Michigan Power Company	American Electric Power Co.
Donald Cook-2	Indiana Michigan Power Company	American Electric Power Co.
Dresden-2	Commonwealth Edison	Exelon Corp.
Dresden-3	Commonwealth Edison	Exelon Corp.
Duane Arnold-1	Iowa Electric (later Alliant), Central Iowa Power Cooperative and Corn Belt Power Cooperative	Florida Power & Light (70 percent), Central Iowa Power Cooperative (20 percent) and the Corn Belt Power Cooperative (10 percent).
Enrico Fermi-2	Detroit Edison	Detroit Edison
Farley-1	Alabama Power Co.	Alabama Power Co.
Farley-2	Alabama Power Co.	Alabama Power Co.
Fitzpatrick	Niagara Mohawk Power Corporation	Entergy Nuclear
Fort Calhoun-1	Omaha Public Power District	Omaha Public Power District
Grand Gulf-1	Early 1970s, Middle South Energy and Mississippi Power & Light co-applicants. In 1980, South Mississippi Electric Power Association purchased 10 percent of the station	Entergy Nuclear
H.B. Robinson-2	Duke Energy, Progress Energy, SCANA	Progress Energy Carolina
Hatch-1	Georgia Power, Oglethorpe Power Corp., Municipal Electric Authority of GA, Dalton Water and Light Sinking Fund Commission	City of Dalton, 2.2 percent, Georgia Power Company, 50.1 percent, Municipal Electric Authority, 17.7 percent, and the Oglethorpe Power Corp., 30 percent
Hatch-2	Georgia Power, Oglethorpe Power Corp., Municipal Electric Authority of GA, Dalton Water and Light Sinking Fund Commission	City of Dalton, 2.2 percent, Georgia Power Company, 50.1 percent, Municipal Electric Authority, 17.7 percent, and the Oglethorpe Power Corp., 30 percent
Hope Creek-1	Public Service Electric and Gas	Public Service Electric and Gas
Indian Point-2	Consolidated Edison	Entergy Nuclear
Indian Point-3	New York Power Authority	Entergy Nuclear
Kewaunee	Wisconsin Public Service	Dominion Nuclear
LaSalle-1	Commonwealth Edison	Exelon Corp.
LaSalle-2	Commonwealth Edison	Exelon Corp.
Limerick-1	Philadelphia Electric Co.	Exelon Corp.

Limerick-2	Philadelphia Electric Co.	Exelon Corp.
McGuire-1	Duke Energy	Duke Energy
McGuire-2	Duke Energy	Duke Energy
Millstone-2	Northeast Utilities	Dominion Nuclear
Millstone-3	Northeast Utilities	Dominion Nuclear
Monticelllo	Northern States Power Co.	Xcel Energy
Nine Mile Point-1	Mohawk Power Corp.	Constellation Nuclear
Nine Mile Point-2	Mohawk Power Corp.	Constellation Nuclear
North Anna-1	Virginia Electric and Power Co.	Dominion Virginia Power corporation (88.4 percent) and by the Old Dominion Electric Cooperative (11.6 percent).
North Anna-2	Virginia Electric and Power Co.	Dominion Virginia Power corporation (88.4 percent) and by the Old Dominion Electric Cooperative (11.6 percent).
Oconee-1	Duke Energy	Duke Energy
Oconee-2	Duke Energy	Duke Energy
Oconee-3	Duke Energy	Duke Energy
Oyster Creek	GPU Energy via its subsidiary New Jersey Central Power and Light Co.	Exelon Corp.
Palisades	Consumers Energy Co.	Entergy Nuclear
Palo Verde-1	Arizona Public Service, Salt River Project, El Paso Electric Co., So. Cal. Edison, PNM Resources, So. Cal. Public Power Authority, LA Dept of Water and Power	Arizona Public Service, Salt River Project, El Paso Electric Co., So. Cal. Edison, PNM Resources, So. Cal. Public Power Authority, LA Dept of Water and Power
Palo Verde-2	Arizona Public Service, Salt River Project, El Paso Electric Co., So. Cal. Edison, PNM Resources, So. Cal. Public Power Authority, LA Dept of Water and Power	Arizona Public Service, Salt River Project, El Paso Electric Co., So. Cal. Edison, PNM Resources, So. Cal. Public Power Authority, LA Dept of Water and Power
Palo Verde-3	Arizona Public Service, Salt River Project, El Paso Electric Co., So. Cal. Edison, PNM Resources, So. Cal. Public Power Authority, LA Dept of Water and Power	Arizona Public Service, Salt River Project, El Paso Electric Co., So. Cal. Edison, PNM Resources, So. Cal. Public Power Authority, LA Dept of Water and Power
Peach Bottom-2	Philadelphia Electric Co.	Exelon (50 %), PSEG Power (50%)
Peach Bottom-3	Philadelphia Electric Co.	Exelon (50 %), PSEG Power (50%)
Perry-1	Cleveland Electric Illuminating Company (44.9 percent), Ohio Edison Company (30 percent), Toledo Edison Company (19.9 percent), and Pennsylvania Power Company (5.2 percent)	Cleveland Electric Illuminating Company (44.9 percent), Ohio Edison Company (30 percent), Toledo Edison Company (19.9 percent), and Pennsylvania Power Company (5.2 percent)
Pilgrim-1	Boston Edison	Entergy Nuclear
Point Beach-1	Wisconsin Electric Power Co.	Florida Power and Light
Point Beach-2	Wisconsin Electric Power Co.	Florida Power and Light
Prairie Island-1	Northern States Power Co.	Xcel Energy
Prairie Island-2	Northern States Power Co.	Xcel Energy
Quad Cities-1	Commonwealth Edison	Exelon Corp.
Quad Cities-2	Commonwealth Edison	Exelon Corp.
R.E. Ginna	Rochester Gas and Electric	Constellation Nuclear
River Bend-1	Cajun Elecric Power cooperative, Gulf States Utilities	Entergy Gulf States
Salem-1	Public Service Gas and Electric Company	PSEG Power (57.4 percent), Exelon Corp. (42.6 percent)
Salem-2	Public Service Gas and Electric Company	PSEG Power (57.4 percent), Exelon Corp. (42.6 percent)
San Onofre-2	Southern California Edison (SCE) (78.21%), San Diego Gas & Electric (20%), and the city of Riverside (1.79%).	Edison International (75.1 percent), San Diego Gas & Electric Company (20 percent), Anaheim Public Utilities Department (3.2 percent), and the Riverside Utilities Department (1.8 percent).
San Onofre-3	Southern California Edison (SCE) (78.21%), San Diego Gas & Electric (20%), and the city of Riverside (1.79%).	Edison International (75.1 percent), San Diego Gas & Electric Company (20 percent), Anaheim Public Utilities Department (3.2 percent), and the Riverside Utilities Department (1.8 percent).
Seabrook-1	originally owned by more than 10 separate utility companies serving 5 New England states	Florida Power and Light (88.2 percent), Massachusetts Municipal Wholesale Electric Company (11.6 percent), Taunton Municipal Lighting Plant (0.1 percent), and Hudson Light & Power Department (0.1 percent)
Sequoyah-1	TVA	TVA
Sequoyah-2	TVA	TVA
Shearon Harris-1	Carolina Power and Light	Progress Energy, Inc. (83.8 percent), North Carolina Eastern Municipal Power Agency (16.2 percent)
South Texas-1	Houston Lighting & Power Co. (HL&P), the City of Austin, the City of San Antonio, and the Central Power and Light Co. (CPL)	NRG Energy (44 percent), CPS Energy (40 percent) and Austin Energy (16 percent)
South Texas-2	Houston Lighting & Power Co. (HL&P), the City of Austin, the City of San Antonio, and the Central Power and Light Co. (CPL)	NRG Energy (44 percent), CPS Energy (40 percent) and Austin Energy (16 percent)
St. Lucie-1	Florida Power and Light	Florida Power and Light
St. Lucie-2	Florida Power and Light	Florida Power and Light, Florida Municipal Power Agency, Orlando Public Utilities Commission
Surry-1	Virginia Power	Dominion Nuclear
Surry-2	Virginia Power	Dominion Nuclear
Susquehanna-1	PPL Corporation (90 percent), Allegheny Electric Coop, Inc.	PPL Corp., Allegheny Electric Co-op
Susquehanna-2	PPL Corporation (90 percent), Allegheny Electric Coop, Inc.	PPL Corp., Allegheny Electric Co-op
Three Mile Island-1	General Public Utilities Corp.	Exelon
Turkey Point-3	Florida Power and Light	Florida Power and Light
Turkey Point-4	Florida Power and Light	Florida Power and Light
Vermont Yankee	Central Vermont Public Service Corp. subsidiary Vermont Yankee Nuclear Power Corp.	Entergy Nuclear

Virgil C. Summer- 1	South Carolina Electric & Gas Company, South Carolina Public Service Authority	South Carolina Electric & Gas Company (66.7 percent) and Santee Cooper (33.3 percent)
Vogtle-1	Georgia Power (45.7%), Oglethorpe Power Corporation (30%), Municipal Electric Authority of Georgia (22.7%) and the City of Dalton (1.6%).	Georgia Power Company (45.7 percent), Oglethorpe Power Corporation (30 percent), Municipal Electric Authority of Georgia (22.7 percent), and the City of Dalton, Georgia, (1.6 percent).
Vogtle-2	Georgia Power (45.7%), Oglethorpe Power Corporation (30%), Municipal Electric Authority of Georgia (22.7%) and the City of Dalton (1.6%).	Georgia Power Company (45.7 percent), Oglethorpe Power Corporation (30 percent), Municipal Electric Authority of Georgia (22.7 percent), and the City of Dalton, Georgia, (1.6 percent).
Waterford-3	Louisiana Power and Light	Entergy Louisiana
Watts Bar-1	TVA	TVA
Wolf Creek	Kansas City Power and Light (KCPE) and the Wichita-based Kansas Gas and Electric (KG&E).	Wolf Creek Nuclear Operating Corporation (WNOC): WCNOC is a jointly-owned corporation formed by the owners: Westar, a Western Resources company, Kansas City Power & Light Company (KCPL) and Kansas Electric Power Cooperative, Inc. (KEPCo).

[365]

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Appendix 2: Timeline

That was then

Year	Month	Event of Note	Reactor Commercial Operation Begins	COL Application Received	Significance
1942	December	The first sustained nuclear reaction took place in Chicago, under the direction of Enrico Fermi.			
1946		Atomic Energy Act creates the Atomic Energy Commission (AEC) and Joint Committee on Atomic Energy			From Section 1: ". . . it is hereby declared to be the policy of the United States that the development and utilization of atomic energy shall be directed toward improving the public welfare, increasing the standard of living, strengthening free competition among private enterprises so far as practicable, and cementing world peace." (p. 18) Created a civilian body to formulate policy and strategy for nuclear energy. (p. 19)
1953		President Eisenhower presented his "Atoms for Peace" speech			Asked for international cooperation to use atomic power for "peaceful pursuits of mankind . . . and to provide abundant electrical energy to the power-starved areas of the world." (p. 54)
1954		Atomic Energy Act passed by Congress			Made the commercial application of atomic energy possible.
1957		Price-Anderson Nuclear Industries Indemnity Act enacted into law			Limited the liability of commercial nuclear power companies to $60 million in the case of catastrophic accidents.
1957		International Atomic Energy Agency (IAEA) established under the auspices of the United Nations			Created to provide assurance that member nations would not use nuclear power in military programs
1969	December		Amergen's Oyster Creek, NJ		First large scale commercial nuclear power electrical generating plant . A "turnkey" facility, purchased from GE for a fixed price.
1969	December		Constellation's Nine Mile Point (NY) 1		
1970	January	National Environmental Policy Act (NEPA) signed into law			Section 102 required all federal agencies to evaluate the environmental impact of the programs they sponsored and to prepare environmental impact statements for any activities with adverse impacts. The AEC tried to claim exemption from this Act, but courts ruled against them in 1971. The ruling implied that federal agencies had a responsibility to the environment as well as to the businesses they served. (p. 157-159)
1970		Federal Clean Air Act of 1970 took effect; Environmental Protection Agency established			
1970	June		Exelon's Dresden (IL) 2		
1970	July		Constellation's R.E. Ginna (NY)		
1970	December		FPL Energy's Point Beach (WI) 1		
1971	March		CPL's H.G. Robinson (SC) 2		
1971	April	EPA announced national air quality standards			Required coal fired electric plants to find low sulfer coal sources to reduce air pollution.
1971	June		Nuclear Management Co.'s Monticello (MN)		
1971	November		Exelon's Dresden (IL) 3		
1971	December		Entergy Nuclear's Palisades (MI)		
1972	October		FPL Energy's Point Beach (WI) 2		
1972	November		Entergy's Vermont Yankee		
1972	December		Entergy's Pilgrim (MA) 1		
1972	December		FPL's Turkey Point (FL) 3		
1972	December		Dominion's Surry (VA) 1		
1973-1974		Middle East Oil Embargo			Drove the price of oil up; the price of natural gas followed suit. Forced power companies to look into diversification of fuel supplies.

Year	Month	Event of Note	Reactor Commercial Operation Begins	COL Application Received	Significance
1973	February		Exelon's Quad Cities (IL) 1		
1973	March		Exelon's Quad Cities (IL) 2		
1973	May		Dominion's Surry (VA) 2		
1973	July		Duke's Oconee (SC) 1		
1973	September		FPL's Turkey Point (FL) 4		
1973	December		Nuclear Management Co.'s Prairie Island (MN) 1		
1974		Energy Reorganization Act abolished the AEC and established the Nuclear Regulatory Commission (NRC)			
1974	June		Dominion's Kewaunee(WI)		
1974	June		OPPD's Fort Calhoun (NE) 1		
1974	July		NPPD's Cooper (NE)		
1974	July		Exelon's Peach Bottom (PA) 2		
1974	August		TVA's Brown's Ferry (AL) 1		
1974	August		Entergy's Indian Point (NY) 2		
1974	September		Amergen's Three Mile Island (PA) 1		
1974	September		Duke's Oconee (SC) 2		
1974	December		Duke's Oconee (SC) 3		
1974	December		Entergy's Arkansas 1		
1974	December		Nuclear Management Co.'s Prairie Island (MN) 2		
1974	December		Exelon's Peach Bottom (PA) 3		
1975	February		Florida Power and Light's Duane Arnold (IA) 1		
1975	March		TVA's Brown's Ferry (AL) 2		
1975	May		Constellation's Calvert Cliffs (MD) 1		
1975	July		Entergy's Fitzpatrick (NY)		
1975	August		IMPCO's Donald Cook (MI) 1		
1975	November		CPL's Brunswick (NC) 2		
1975	December		Dominion's Millstone (CT) 2		
1975	December		Southern Nuclear Operating Co.'s Hatch (GA) 1		
1976	August		Entergy's Indian Point (NY) 3		
1976	October		First Energy's Beaver Valley (PA) 1		
1977	March		TVA's Brown's Ferry (AL) 3		
1977	March		Progress Energy's Crystal River (FL) 3		
1977	March		CPL's Brunswick (NC) 1		
1977	April		Constellation's Calvert Cliffs (MD) 2		
1977	June		PSEG's Salem (DE) 1		
1977	December		Southern Nuclear Operating Co.'s Farley (AL) 1		
1978	June		Dominion's North Anna (VA) 1		
1978	July		IMPCO's Donald Cook (MI) 2		
1978	July		First Energy's David Besse (OH) 1		
1979	March	Accident at Three Mile Island			Effectively ended the nuclear power construction program in the U.S. and changed the approach to reactor safety.
1979	September		Southern Nuclear Operating Co.'s Hatch (GA) 2		
1979	December	Institute of Nuclear Power Operations (INPO) began operations			Mission: To promote the highest levels of safety and reliability in the operation of nuclear electric generating plants. Among its principles/assumptions: That members establish a nuclear line organization with clearly defined lines of responsibility and accountability for nuclear plant operation, maintenance, training, technical support, and other activities necessary to ensure safe and reliable plant operation.

Year	Month	Event of Note	Reactor Commercial Operation Begins	COL Application Received	Significance
1980		Fuel rupture in reactor at Saint-Laurent, France			
1980	March		Entergy's Arkansas 2		
1980	December		Dominion's North Anna (VA) 2		
1981	July		TVA's Sequoyah (TN) 1		
1981	July		Southern Nuclear Operating Co.'s Farley (AL) 2		
1981	October		PSEG's Salem (DE) 2		
1981	December		Duke's McGuire (NC) 1		
1982	June		TVA's Sequoyah (TN) 2		
1983	June		PP&L's Susquehanna (PA) 1		
1983	July	Washington Public Power Supply System (WPPSS) defaults on $2.25 billion in municipal revenue bonds for the construction of two nuclear reactors			Highlighted the role of Wall Street in financing nuclear power plant construction projects (including the assignment of credit ratings of the participants, how the municipal revenue bonds were marketed) and also the legal validity of some of the contracts signed by participants in the projects.
1983	August		SCE's San Onofre (CA) 2		
1984	January		SCE & G's Summer (SC) 1		
1984	January		Exelon's LaSalle (IL) 1		
1984	March		Duke's McGuire (NC) 2		
1984	April		SCE's San Onofre (CA) 3		
1984	October		Exelon's LaSalle (IL) 2		
1984	December		Energy NW's Columbia Generating Station (WA)		
1984	December		Amerue's Callaway (MO) 1		
1985		National Academy for Nuclear Training established at INPO			To provide comprehensive training and qualification for nculear power industry personnel
1985	May		PGEC's Diablo Canyon (CA) 1		
1985	June		Duke's Catabwa (SC) 1		
1985	July		Entergy's Grand Gulf (MS) 1		
1985	September		Wolf Creek Nuclear's Wolf Creek (KS)		
1985	September		Exelon's Byron (IL) 1		
1985	September		Entergy's Waterford (LA) 3		
1985	December		PP&L's Susquehanna (PA) 2		
1986	January		APS' Palo Verde (AZ) 1		
1986	February		Exelon's Limerick (PA) 1		
1986	March		PGEC's Diablo Canyon (CA) 2		
1986	April		Dominion's Millstone (CT) 3		
1986	April	Meltdown at Chernobyl, Ukraine			Explosion, fire, and radiation releases killed 28 people immediately and affected the lives of 100s of thousands in the Soviet Union, Eastern and Western Europe due to radiation fallout from the accident
1986	June		Entergy's River Bend (LA) 1		
1986	August		Duke's Catabwa (SC) 2		
1986	September		APS' Palo Verde (AZ) 2		
1986	December		PSEG's Hope Creek (DE) 1		
1987	May		CPL's Shearon Harris (NC) 1		
1987	June		Southern Nuclear Operating Co.'s Vogtle (GA) 1		
1987	August		Exelon's Byron (IL) 2		
1987	November		First Energy's Beaver Valley (PA) 2		
1987	November		First Energy's Perry (OH) 1		
1987	November		Amergen's Clinton (IL) 1		
1988	January		APS' Palo Verde (AZ) 3		
1988	January		Detroit Edison's Enrico Fermi (MI) 2		
1988	March		Constellation's Nine Mile Point (NY) 2		
1988	July		Exelon's Braidwood (IL) 1		
1988	August		South Texas Project 1		
1988	October		Exelon's Braidwood (IL) 2		

Year	Month	Event of Note	Reactor Commercial Operation Begins	COL Application Received	Significance
1989		NRC begins program of reactor design standardization			Aim: To increase predictability and decrease delays in the licensing process; to ensure reactor safety
1989	May	World Association of Nuclear Operators (WANO) formed			Aim: To maximize the safety and reliability of nuclear programs through the exchange of information.
1989	May		Southern Nuclear Operating Co.'s Vogtle (GA) 2		
1989	June		South Texas Project 2		
1990	January		Exelon's Limerick (PA) 2		
1990	August		TXU's Comanche Peak (TX) 1		
1990	August		FPL's Seabrook (FL) 1		
1992		Revision of rules and requirements for applying for licenses to build and operate nuclear power plants in the U.S.			Applicants could now apply for one, combined building and operating license, a COL, rather than submitting sequential applications
1992		Deregulation of electric industry allowed by the Energy Act of 1992			Allowed states to deregulate electric rates and consumers to choose suppliers. Aimed to increase competition in a formerly monopolistic industry.
1993	August		TXU's Comanche Peak (TX) 2		
1994		Nuclear Energy Institute came into being			Served to coordinate policy on issues affecting the nuclear industry. Now a central trade association and lobbying group as well.
1996	May		TVA's Watts Bar (TN) 1		
1997		Kyoto Protocol ratified			Established limits on greenhouse gas emissions to help stave off global climate change; to take effect February 2005.
This is now 1999	September	Accident at Tokai-mura, Japan			Two workers at a nuclear fuel preparation facility received fatal doses of radiation, a third just slightly less,after an uncontrolled reaction resulted from preparation of fuel for a fast breeder reactor. Another 84 workers were exposed to radiation at the plant, and a total of 667 people were exposed to radiation.
2001	May	2001 National Energy Policy published			Established nuclear power as a key element of the Bush administration's energy policy.
2002	February	Nuclear Power 2010 program unveiled			A joint government/industry initiative to identify sites for new nuclear power plants, evaluate the business case for building new plants, demonstrate the as yet untested new licensing process, and bring new technologies to market. Included a 50-50 cost sharing incentive with the Department of Energy.
2004	March	NuStart Energy Development LLC formed			Purpose: To aid in preparation of combined building and operating licenses for new nuclear powered electric generating plants.
2005		Congress passed Energy Policy Act of 2005, providing $500 million in matching funds for new reactor applicants and extending the Price-Anderson Act through 2025			Commercial nuclear power company liability revised upward to $300 million in case of accidents.
2006	February	Repeal of the Public Utility Holding Act of 1935 took effect			
2007	July			Unistar's Calvert Cliffs (MD) 3	
2007	September	First complete new reactor application package received by NRC, from STP		STP/NRG's South Texas Project (TX) 3 & 4	
2007	October			TVA's Bellefonte (AL) 3 & 4	
2007	November			Dominion's North Anna (VA) 3	
2007	December			Duke Energy's William States Lee (SC) 1 & 2	

Year	Month	Event of Note	Reactor Commercial Operation Begins	COL Application Received	Significance
2007	December	Congress passed a $20.5 billion loan guarantee program for the nuclear industry (the Consolidated Approprioations Act, 2008)			Requires the DOE to provide loan guarantees for up to 80% if the total cost of new nuclear plants; allocates $18.5 billion for new plants and $2 billion for uranium enrichment.
2008	February			Progress Energy's Shearon Harris (NC) 2 & 3	
2008	February			Entergy's Grand Gulf (MS) 3	
2008	March			SCE & G's Virgil C. Summer (SC) 2 & 3	
2008	March			Southern Nuclear Operating Co.'s Vogtle (GA) 3 & 4	
2008	July			Ameren's Callaway (MO) 2	
2008	July			Progress Energy Florida's Levy Co. (FL) 1 & 2	
2008	September			Exelon's Victoria Co. (TX) 1 & 2	
2008	September			Detroit Edison's Fermi (MI) 3	
2008	September			Unistar's Comanche Peak (TX) 3 & 4	
2008	September			Entergy's River Bend (LA) 3	
2008	September			Unistar and Nine Mile Point Nuclear Project's Nine Mile Point (NY) 3	
2008	October			PPL's Bell Bend 1 (PA) 1	
2009	June			Florida Power and Light's Turkey Point (FL) 6 and 7	

[366]

[366] D. Victor Anderson, *Illusions of Power: A History of the Washington Public Power Supply System*, New York: Praeger, 1985;
Jack Barkenbus, "Nuclear Power Safety and the Role of International Organization," *International Organization*, Vol. 41, No. 3 (Summer, 1987), pp. 475 – 490.
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Appendix 3: Construction Extremes

Of the five reactors with the most extreme times between construction start and coming on line, three are pressurized water reactors (PWRs) and two are boiling water reactors (BWRs), suggesting that factors other than reactor type drove the construction delays. Those factors are described in this Appendix.

1.0 Westinghouse Nuclear Reactor Systems

1.1 Comanche Peak (PWR near Glen Rose, TX)

Architect/Engineer: Gibbs and Hill
Two 1150 MW Pressurized Water Reactors

The Comanche Peak nuclear power project, Texas Utility Company's first foray into nuclear, got off to a rocky start. The original design firm was fired before the power plant plans were completed.[367] Even after the blueprints were finished, design of reactor components continued to change, with over 500 change documents generated for cable tray supports alone! [368] Construction of Comanche Peak nuclear power plant did begin in October of 1974 with operations scheduled to begin in 1980.[369] However, in 1979 allegations arose of poor quality construction practices, opening the doors to investigations by the Nuclear Regulatory Commission (NRC) that uncovered a myriad of problems at the site. Areas of concern included:

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[367] Randy Lee, "Comanche Peak Given Full License—Unanimous Vote Ends 10-Year Delay," *The Dallas Morning News*, April 17, 1990, p. 1a.

[368] Jim Landers, "Consultants Find 80 Questionable Comanche Peak Design Points," *The Dallas Morning News*, April 27, 1985, p. 42a.

[369] Lee; Mark Edgar, "Comanche Peak Start-up Delayed," *The Dallas Morning News*, April 19, 1986, p. 1a.

- Hiring of companies that had no prior experience building nuclear power facilities and thus were unfamiliar with NRC construction standards.[370]
- Failure to document apparent design deficiencies in components of the reactor system, such as the electric cable trays and pipe supports.[371]
- Failure to keep adequate records of analyses of system structures.[372]
- Problematic welds.[373]
- Faulty earthquake design features.[374] For example, a ceiling in the control room had to be replaced when it was determined it could collapse onto operators during an earthquake.[375]
- Inadequate documentation of the strength of the concrete used and claims that available reports had been falsified.[376]
- Omission of reinforcing bars in a portion of the concrete wall surrounding the reactor cavity.[377]
- Misinterpretation of testing procedures, alteration of those procedures via memo or in conversation, and failure to have test results independently verified.[378]
- Failure to document important safety violations and conduct follow-up reviews.[379]
- Reports of harassment of quality control inspectors and inappropriate handling of whistle-blowers (which led to lawsuits and $5.5 million in payments).[380]
- Insufficient training of plant personnel. Only 45% of candidates for non-supervisory positions passed their Nuclear Regulatory exams in 1983 despite six years of training. In 1985, 47% passed after 18 months of revised training.[381]

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[370] Hossein Hamzehee, Nuclear Regulatory Commission, Telephone Interview of May 14, 2009.

[371] Edgar; Landers; Real, David, "More Study of N-Plant Ordered. . .NRC Official Expects Delay in Fuel Loading," *The Dallas Morning News*, October 2, 1984, p. 1a.

[372] Hamzehee.

[373] Lee.

[374] David Real, "Hearings Crucial to N-Plant, At Stake: Licenses for Comanche Peak," *The Dallas Morning News*, September 23, 1984, p. 37a.

[375] David Real, "Nuclear Plant Reschedules Fuel Loading—Comanche Peak Delay Could Cost Millions," *The Dallas Morning News*, October 10, 1984, p. 23a.

[376] Real, September 23, 1984.

[377] Real, October 10, 1984.

[378] Real, October 2, 1984.

[379] Ibid.

[380] Real, September 23, 1984; David Real, "N-Plant Fueling Delay Requested—Group Cites Court Appeal," *The Dallas Morning News*, October 17, 1989, p. 25a.

In addition, Texas Utilities Generating Company had to renew a construction permit that expired in 1985, and had to contend with a battery of lawsuits initiated by the Citizens for Sound Energy, an anti-nuclear group.

In November of 1985, Texas Utilities turned to the U.S. Navy to help transform operations at Comanche Peak. Rear Admiral Austin B. Scott Jr., former submarine commander and pupil of "nuclear Navy" founder Admiral Hyman Rickover, was hired to instill discipline and uncompromising standards of excellence.[382] Resolving all of the problems added a decade to the construction schedule and billions to the cost of Comanche Peak. But Texas Utilities was financially strong and determined to see the project through to completion.[383] The first unit finally received its operating license on April 16, 1990 and started commercial operations on August 13, almost 16 years after construction started. Originally slated to cost $779 million, the final figure for the plant reached over $9.1 billion.[384]

1.2 Diablo Canyon (PWR outside of San Luis Obispo, CA)

Architect/Engineer: Pacific Gas and Electric
Two Pressurized Water Reactors,1122 MW and 1118 MW

The NRC issued the construction permit for unit 1 of Diablo Canyon in April of 1967. The second unit received its construction permit in 1970. Although there had been

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[381] David Real, "N-Plant Utility Hopes for Better Test Scores—45% Failed Last Reactor Operator Exam," *The Dallas Morning News*, May 12, 1985, p. 33A.

[382] David Real, "Rear Admiral to Head N-Plant," *The Dallas Morning News*, October 22, 1985, p. 17a.

[383] Hamzehee.

[384] Real, David, "Comanche Peak Cost Rises Again—Texas Utilities Announce $2 billion Overrun, Delay Until '89," *The Dallas Morning News*, November 26, 1986, p. 1a; Lee.

some questions about the adequacy of the designs to resist earthquakes, outside consultants concluded that earthquake epicenters in the vicinity did not threaten the safety of the nuclear power plant.[385] Then, in 1971, Shell Oil Co. geologists Hoskins and Griffiths published a paper describing the previously unknown Hosgri Fault three miles off the coast. But it was not until after Pacific Gas and Electric submitted its operating license applications in 1973 that the NRC began an evaluation of that fault and its implications for Diablo Canyon. According to Edison Case, Acting Director of the Office of Nuclear Reactor Regulation of the NRC, in his testimony before the Committee on Interior and Insular Affairs of the House of Representatives, 6/30/77,

> In conjunction with the limited resources available to assist the NRC was the fact that the number of applications under review by us and our consultants was significant and increasing. . . The situation was such that, once a construction permit was issued, the specialists within the staff and its consultants having detailed knowledge of a given safety matter for a specific facility would not likely have the time to survey the literature in order to determine the significance of that information to that facility. Those individuals were involved with other problems on other applications.[386]

Despite the added earthquake concerns, work continued on the Diablo Canyon units.[387] As a result, the newly built structures and equipment had to be modified to meet the more stringent seismic standards.

Astonishing quality assurance issues came to light in 1981 when the NRC issued a low-power operating license for unit 1.[388] Drawings for unit 1 had been interchanged

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[385] "Oversight on Diablo Canyon Nuclear Generating Plant, Oversight Hearing Before the Subcommittee on Energy and the Environment of the Committee on Interior and Insular Affairs, House of Representatives, June 30, 1977," Washington D.C.: U.S. Government Printing Office, 1977, p. 3.

[386] Ibid, p. 5.

[387] Ibid, p. 28.

with drawings for unit 2 so that each unit was analyzed using data gathered for the other unit. That finding led to further discoveries of the structures not conforming to NRC requirements and extensive remedial work on the two units: There were over 300 discrepancies between the NRC safety standards, the design of Diablo Canyon, and the constructed units.[389] Experience of the operators and the adequacy of the emergency preparedness plan also came into question.[390]

Public opinion regarding nuclear power and the NRC eroded in light of the problems that surfaced at Diablo Canyon. The Oversight Hearing of 1984, held in San Luis Obispo, CA, included testimony from a panel of local mayors, members of the San Luis Obispo Mothers for Peace, the Citizens for Adequate Energy, representatives of the Abalone Alliance and the Citizens for Effective Emergency Planning, and over 65 local residents. Another 34 submitted statements to the Committee. Amy Shore expressed concern about the impact of Diablo Canyon on the ocean: "I do not trust the NRC, and I do not trust PG & E. These agencies are concerned only with PG & E's investment and are a detriment to the survival of our ecosystem."[391] Catherine Jacobs spoke about nuclear waste: "[H]ow are we going to transport this waste from our county once it is produced if they put the plant on line? The railroad tracks here are getting in bad

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[388] "Licensing Process at Diablo Canyon Nuclear Power Plant, Oversight Hearing Before the Subcommittee on Energy and the Environment of the Committee on Interior and Insular Affairs, House of Representatives, March 8, 1983," Washington D.C.: U.S. Government Printing Office, 1983, p. 1.

[389] Ibid, p. 6.

[390] "Licensing Process at Diablo Canyon Nuclear Power Plant, Oversight Hearing Before the Subcommittee on Energy and the Environment of the Committee on Interior and Insular Affairs, House of Representatives, August 30, 1984," Washington D.C.: U.S. Government Printing Office, 1984, p. 2.

[391] Ibid, p.104.

condition, and are getting worse. . .If that causes a train to derail with nuclear waste on board, we could have leakage. And there is no way to get out in time."[392] According to Kevin O'Shea: "Our time is short on this Earth and we have no right to poison it for future generations."[393] Most people who testified favored shutting down Diablo Canyon for health and safety reasons. Despite such public concerns, the NRC granted full-power operating licenses. Unit 1 went on-line November 2, 1984. Unit 2 followed on August 26, 1985.

1.3 Watts Bar (PWR, Spring City, TN)

Architect/Engineer: Tennessee Valley Authority
1121 MW Pressurized Water Reactor

In the 1960s, buoyed by forecasts of steadily increasing demand for electricity and concerned about the potential for depletion of fossil fuels in the United States in general and the Tennessee valley in particular, the Tennessee Valley Authority (TVA) undertook the construction of 17 nuclear power plants over a period of ten years.[394] "[W]e know how to build dams, we know how to build coal plants, so we must know how to build nuclear plants."[395] Construction of the Browns Ferry nuclear plant begin in 1966, Sequoyah in 1969, and Watts Bar in 1972. Unfortunately, the TVA had neither the expertise in nuclear power nor the personnel qualified to oversee all of those projects.[396] As Marvin Runyon, then Chairman of the TVA Board of Directors, testified before a

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[392] Ibid, p. 103.

[393] Ibid, p. 115.

[394] "TVA's Nuclear Program: Hearing Before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, House of Representatives, March 22, 1988," Washington D.C.: U.S. Government Printing House, 1988, pp. 1 and 9.

[395] Ibid, p. 10.

[396] Ibid, p. 1.

Congressional subcommittee in 1988, “TVA started more and more nuclear plants and all of a sudden it was building so many of them that it didn’t have the people to do the job.”[397]

By 1980, only five units of the originally planned units were operational.[398] Then in 1985, the TVA shut down all of their nuclear power facilities, including both those in operation and those still under construction, to step back and re-evaluate its nuclear ambitions.

What were the TVA’s major problems? To begin with, demand forecasts underlying the construction program relied on a straight-line extrapolation of historical growth.[399] Like others in the industry, they had not accounted for slowdowns in the economy, changes in technology that made common household machines more energy efficient, or the fuel crisis of the 1970s that spurred conservation programs.[400] The planned nuclear power plants would generate much, much more electricity than the area needed. Revised forecasts of the 1980s looked at different scenarios for growth, describing a range of possible futures, and set boundaries within which the TVA could invest. Those forecasts supported restart of the five units at Sequoyah and Browns Ferry. Bellefonte and Watts Bar 1 were expected to be brought on in the mid early to mid-1990s.

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[397] Ibid, p. 10.

[398] Ibid.

[399] Ibid, p. 16.

[400] Ibid, p. 10.

Quality assurance during construction also was a concern, particularly at Watts Bar, where the integrity of welds became an issue.[401] After the Three Mile Island accident, when the NRC tightened its safety regulations, the TVA did not have the people or the procedures in place to ensure that those regulations were being implemented.[402] Those lapses ultimately led to the shutdown in 1985.

After the shutdown in 1985, TVA brought in Admiral Steven White as Manager of the Office of Nuclear Power. Under his guidance, the TVA implemented programs to identify and correct construction deficiencies. He instituted comprehensive training for TVA managers and team building exercises. He tried to reduce the reliance on contract personnel, a practice that had taken its toll on the experienced staff the TVA did hire.[403]

In the mid-1990s, the TVA decided not to complete the Bellefonte nuclear units or Watts Bar 2, in an effort to control finances ("TVA 1999 Annual Report, Notes to Financial Statements: Nuclear Power Program," "Energy Vision 2020, Executive Summary, Integrated Resource Plan, Environmental Impact Statement").[404] However, in 2005, the TVA applied for a license to install new AP1000 reactors at the Bellefonte site,

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[401] Ibid, p. 50.

[402] Ibid, p. 14.

[403] Ibid, p. 45.

[404] "TVA 1999 Annual Report, Notes to Financial Statements: Nuclear Power Program," http://www.tva.gov/finance/reports/annualreport_99/ar_nuc1.htm, (accessed October 9, 2008); "Energy Vision 2020, Executive Summary, Integrated Resource Plan, Environmental Impact Statement," http://www.tva.gov/environment/reports/wattsbar2/related/2020_exec_summary.pdf, (accessed October 9, 2008).

and in 2007 elected to complete construction of Watts Bar 2 to help meet a renewed growth in demand for electricity ("TVA's Nuclear at a Glance").[405]

2.0 General Electric Nuclear Reactor Systems

2.1 Fermi 2 (BWR, northeast of Toledo, OH)

Architect/Engineer: Sargent and Lundy
1122 MW Boiling Water Reactor

Detroit Edison embarked on an ambitious venture to build the largest nuclear power plant in the country (1100 MW(e)) when it broke ground for Fermi 2 in 1969.[406] Construction was expected to take six or seven years.[407] The first signs of trouble appeared in 1974 when that construction stopped for over two years due to cash shortages at Detroit Edison and the utility sought out other partners for the project to help pay for the plant.[408] Construction did not resume until 1977.

Tightened safety regulations implemented by the NRC in the wake of the 1979 Three Mile Island accident led to costly delays for repair, redesign, and retooling to meet the new requirements.[409] Then in 1985, an operator accidentally and unknowingly triggered a nuclear chain reaction, raising new concerns about safety at the plant. That same year, Detroit Edison began a program of evaluation of the plant equipment and

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[405] "TVA's Nuclear at a Glance," http://www.tva.gov/power/nuclear/nuclear_fact_sheet.pdf, (accessed October 9, 2008).

[406] Christopher Cook, "Fermi Gets Ok to Use Full Power," *Detroit Free Press*, January 16, 1988; John Lear, "How Fermi 2 Stacks Up: Edison Execs Look for a Rosy Future, but Regulators are not yet Convinced," *Detroit Free Press*, January 16, 1989.

[407] George White, "Fermi 2 Starts up Commercially, Rate Increase to Pay for Plant Takes Effect Today," *Detroit Free Press*, January 24, 1988.

[408] "Off by $4 Billion and 14 Years, Michigan Nuclear Plant Starts," *The New York Times*, January 24, 1988 p. 1.28.

[409] White.

operators, in prelude to commencing full power operations. So many problems arose during the evaluation that the NRC restricted the utility's operations at Fermi 2 and levied fines amounting to $600,000 for violations of federal safety regulations and "miscues" during the testing program.[410] The plant also faced fines of up to $100,000 for 26 operating violations found in 1985.[411] In the end, tests that usually take about six months to complete took 2 ½ years at Fermi 2.

Like Diablo Canyon, the Fermi 2 project faced opposition from area environmental groups, such as the Safe Energy Coalition, which distributed balloons bearing the message "The winds which brought you this balloon could also bring you radioactive material from Fermi 2."[412] The Servants of the Immaculate Heart of Mary, a convent of Roman Catholic nuns who resided in the nearby town and feared the potential hazards of having a nuclear reactor in their backyard and worried about the problems of dealing with nuclear wastes, raised the issues during shareholder meetings.[413] And lawsuits filed by the consumer group, the Michigan Citizens Lobby, delayed the project as courts heard arguments over proposed customer rate increases and the issuance of securities to pay for the construction.[414]

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[410] Ibid.

[411] "Around the Nation; Michigan Nuclear Plant is Cited in 26 Violations," *The New York Times,* January 12, 1986.

[412] David Shepardson, "Edison to Close Nuke Plant," The Detroit News, April 12, 1998, http://www-personal.umich.edu/~sanders/214/other/news/fermi2.html, (accessed February 1, 2010).

[413] "Vote Backs Plant for Detroit Edison," *The New York Times*, April 24, 1984; Deborah Kaplan, "Foes Lament Ok for Full Power at Fermi 2; 20 March in Rain, Vow to Continue Nuclear War," *Detroit Free Press*, January 18, 1988.

[414] "Michigan Utilities," *The New York Times*, January 28, 1982, p. D.14;

Despite the years of setbacks, Detroit Edison received the green light from the NRC to run Fermi 2 at full power in January of 1988. When Fermi 2 finally did begin commercial operations, it was 14 years late and $4.1 billion over budget.[415]

2.2 Limerick 2 (BWR near Philadelphia, PA)

Architect/Engineer: Bechtel
1134 MW Boiling Water Reactor

Budget woes and community interests, not construction issues, delayed Philadelphia Electric's Limerick 2 nuclear power plant.[416] Philadelphia Electric proposed its Limerick 1 and 2 plants in 1969 to meet anticipated demand growth in the Philadelphia area. Ground was broken for both facilities in 1974, with the aim of completing them in tandem. But financial problems forced the utility to slow construction in the late 1970s.[417] In May of 1982, the Pennsylvania Public Utilities Commission ordered the company to stop borrowing money to continue building Limerick 2 until Limerick 1 had been completed.[418] In addition, the Utilities Commission expressed concern that Limerick was no longer in the public interest, due to escalating costs and the potential for overcapacity.[419] Construction on Limerick 2 came to a halt; it was only 30% complete.[420]

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[415] "Off by $4 Billion and 14 Years, Michigan Nuclear Plant Starts," *The New York Times*, January 24, 1988 p. 1.28.

[416] Jeff Barker, "PE Granted License for Limerick 2," *The Philadelphia Inquirer*, August 26, 1989, p. A01; Dan Stets, "Limerick 2 Too Costly, PUC Consultant Says," *The Philadelphia Inquirer*, September 15, 1989, p. C13.

[417] Stets, September 15, 1989.

[418] Matthew L. Wald, "Building Reactors the New Way," *The New York Times*, July 17, 1989, p. D.1.

[419] Barker.

[420] Wald, July 17, 1989.

Limerick 1 received its Nuclear Regulatory Commission operating license in 1985.

Work on Limerick 2 resumed in 1986 after a delay of about 3 ½ years. Philadelphia Electric had agreed to hold costs to $3.2 billion, with any cost overruns to be borne by the utility stockholders and not its ratepayers.[421] The utility was able to share some of the schedule risk with its primary contractor, Bechtel, by promising Bechtel a $60 million bonus for finishing the project early. A special agreement with the labor unions barred strikes and limited wage increases for Limerick workers. In addition, the delay allowed Philadelphia Electric to finish the design and engineering for the facility, reducing the number of design changes that occurred in the field.

However, two other issues delayed completion of Limerick 2: (1) The need to get Department of Environmental Resources permission to install an industrial chiller and cooling towers in Bucks County, PA, to equalize the temperature of water from the Delaware River and Perkiomen Creek into which it would be diverted[422] and (2) A lawsuit on behalf of the Limerick Ecology Action group to investigate the need for additional damage control measures at the plant in the event of an accident.[423] As a result of the latter, Philadelphia Electric did agree to strengthen its ability to solidify molten material in case of a core meltdown and to provide a back-up system for preventing

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[421] Ibid.

[422] Dan Stets, "For PE, Two Rounds To Go In the Fight for Limerick 2," *The Philadelphia Inquirer*, May 15, 1989, p. C01.

[423] Dan Stets, "PE Seeks Green Light on Limerick," *The Philadelphia Inquirer*, June 7, 1989, p. B06.

pressure build-up in the containment vessel.[424] The Limerick Ecology Action group also received unprecedented access to the plant for inspections over the next 4 ½ years. Despite those setbacks, the Nuclear Regulatory Commission finally did approve a full-power operating license for Limerick 2 on August 25, 1989, 20 years after groundbreaking.

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[424] Barker.

Appendix 4: Partial Text of H.R. 1029 of 1985[425]

A Bill

To amend the Atomic Energy Act of 1954 to encourage the development and use of standardized plant designs and improve the nuclear licensing and regulatory process.

Short Title

Section 1. This Act may be cited as the "Nuclear Powerplant (sic) Standardization Act of 1985".

2
Findings and Purposes

Sec. 2. (a) The Congress, recognizing that a clear and coordinated energy policy consistent with the public health and safety must include an effective and efficient licensing process for the siting, construction, and operation of nuclear powerplants (sic) that meet applicable criteria, hereby finds that—

(1) interstate commerce is substantially affected by the siting, construction, and operation of nuclear powerplants (sic);
(2) opportunity for meaningful public participation in the siting and licensing of nuclear powerplants (sic) should be assured;
(3) the licensing and construction of nuclear powerplants (sic) will be facilitated and the public health and safety enhanced by the use of preapproved nuclear powerplant (sic) designs, particularly standardized designs;
(4) there is a need to encourage the development and use of standardized nuclear powerplant (sic) designs because (A) such designs can benefit public health and safety by concentrating the resources of designers, engineers, and vendors on particular approaches, by stimulating standardized programs of construction practice and quality assurance, by improving the training of personnel, and by fostering more effective maintenance and improved operations; and (B) the use of such designs can permit a more effective and efficient licensing and inspection process;

425 "Nuclear Powerplant (sic) Design Standardization," Hearings before the Subcommittee on Energy Conservation and Power of the Committee on Energy and Commerce, House of Representatives, July 25 and December 10, 1985, Washington D.C.: U.S. Government Printing Office, 1986.

(5) the licensing process will be facilitated by procedures for the selection and approval of a site for a nuclear powerplant (sic) to be accomplished in advance of a commitment to construction a particular facility of a specific design at such site;
(6) the licensing and regulatory process will be facilitated if the licensing decision are made at the earliest feasible phase of the process and issues resolved in Nuclear Regulatory Commission proceedings are not subject to further adjudication in the absence of a substantial evidentiary showing required by this Act and the regulations of the Nuclear Regulatory Commission;
(7) consistent with the adequate protection of the public health and safety and the common defense and security, the regulatory process should provide greater stability in licensing standards and criteria for approved designs of nuclear powerplants (sic);
. . .

(b) The purposes of this Act are—

(1) to facilitate the use of preapproved sites and designs for nuclear powerplants (sic) and to facilitate the development and use of standardized designs;
(2) to provide for the issuance of a license to construct and operate a nuclear powerplant (sic) under conditions that enhance the protection of the public health and safety and are in accord with the common defense and security; and
(3) to improve the stability of licensing standards, criteria for nuclear powerplants (sic), and prior Nuclear Regulatory Commission licensing approvals.

Approval of Standardized Designs

Sec. 193. Approval of Standardized Designs.—

a. (1) The Commission shall establish procedures, standards, and criteria permitting the approval of standardized facility designs for any utilization or production facility for industrial or commercial purposes, or any discrete subsystem thereof, for a period of ten years, notwithstanding the fact that an application has not been filed for a construction permit or license to construct and operate for such facility. For purposes of this Act, a design approval shall be considered to be a license.
(2) A design approval issued by the Commission under this section shall be conclusive with respect to an application for a construction permit, an operating license, or a license to construct and operate that meets the conditions of the approval and is filed within the period during which the approval remains valid.

b. The Commission shall establish procedures for the renewal of design approvals issued under subsection a. for additional ten year periods from the date of renewal. Upon application for renewal of a design approval, the Commission shall renew the approval unless it finds that significant new information relevant to the design has become available that makes it likely that the design will not

Construction and Operating Licenses

Sec. 185. Construction Permits, Operating Licenses, and Construction and Operating Licenses.—

a. An applicant for a license to construct or modify a utilization or production facility for industrial or commercial purposes shall, after the Commission has provided an opportunity for public hearing pursuant to section 189 and if the application establishes competency and is otherwise acceptable to the Commission, be initially granted a construction permit. Upon filing of additional information by the applicant needed to bring the original application up to date, the Commission shall, after providing an opportunity for public hearing pursuant section 189, issue an operating license to the applicant upon finding that the facility authorized has been constructed and will operate in conformity with the application as amended, the provisions of this Act, and the rules and regulations of the Commission. For purposes of this Act, a construction permit shall be considered a license.

b. (1) The Commission may issue a license to an applicant to construct and operate a utilization or production facility for industrial or commercial purposes after providing opportunity for public hearing pursuant to section 189, if the application is sufficient to enable the Commission to determine that the applicant is competent and that the facility will be constructed and will operate in conformity with the provisions of this Act, and the rules and regulations of the Commission. For the purposes of this Act, a license to construct and operate shall be considered to be a license.

Appendix 5: Brief Overview of New Reactor Design Features

1.0 Evolutionary Power Reactor from Areva Nuclear Power (EPR)[426]

- Builds on experience gained with reactors operating in France and Germany;
  - Now being built in Finland, France, and China;
- Includes four emergency core cooling systems instead of the usual two, allowing one to be shut down for repair or maintenance without compromising reactor safety;
  - Has added a "core spreading area" to trap and cool molten material in case of a core meltdown;
  - "Defense in depth" design;
- Increased efficiency core optimizes fuel use, allows for a longer period between refueling, and reduces waste production;
- Permits access to the containment while the reactor is operating, reducing the down time for maintenance and refueling;
- Designed for a 60 year life versus the current 40 year standard;
- Able to use reprocessed uranium fuels;
- Rated at 1600 MW(e);
- Design certification application received by the NRC in December, 2007.

2.0 General Electric/Hitachi Advanced Boiling Water Reactor (ABWR)[427]

- Already in use in Japan and under construction in Taiwan;
- Designed for ease of maintenance, saving time and money;
- Relies on fewer pumps than previous G.E. designs;
- Eliminates large pipes below the level of the core to reduce the chance of leakage;
- Allows decay heat (heat given off by radioactive material even after the fission reaction has stopped) to escape for 72 hours, even without operator intervention;
- Uses pre-assembled, modularized components, decreasing construction time;
  - Can be constructed in 39 months;

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[426] **"**Design Certification Application Review--U.S. Evolutionary Power Reactor (U.S. EPR)," http://www.nrc.gov/reactors/new-licensing/design-cert/epr.html, (accessed July 2, 2008); "EPR: the first generation III+ reactor currently under construction," http://www.areva-np.com/scripts/info/publigen/content/templates/show.asp?P=715&L=US&SYNC=Y, (accessed November 3, 2008); Matthew L. Wald, "Power Producers Seek Latest Models of Nuclear Reactors," *The New York Times*, March 15, 2005.

[427] "ABWR Overview," http://www.ne.doe.gov/np2010/pdfs/ABWROverview.pdf, (accessed November 3, 2008); "Advanced Boiling Water Reactor Fact Sheet," http://www.gepower.com/prod_serv/products/nuclear_energy/en/downloads/gea14576e_abwr.pdf, (accessed November 3, 2008); "G.E. Advanced Boiling Water Reactor," http://groups.msn.com/AAEA/geabwr.msnw, (accessed July 2, 2008); Matthew L. Wald, "Power Producers Seek Latest Models of Nuclear Reactors," *The New York Times*, March 15, 2005.

- Produces 1350 to 1460 MW(e);
- Design certification for the 1350 MW model issued in May, 1997.

3.0 General Electric/Hitachi Economic Simplified Boiling Water Reactor (ESBWR)[428]

- Designated as the next generation of boiling water reactor, incorporating proven features of the ABWR;
- Incorporates passive safety features and a gravity driven cooling system, thus reducing the number of the pumps, valves, and motors by 25% versus previous reactor designs;
  - Eliminates the need for a backup generator;
  - Leads to faster construction, reduced maintenance, lower costs, and increased reliability and safety;
- Construction time: 42 months;
- Provides about 1600 MW(e);
- Application for design approval submitted in August of 2005.

4.0 Mitsubishi Heavy Industries U.S. Advanced Pressurized Water Reactor (USAPR)[429]

- Higher efficiency version of a design scheduled to start construction in 2010 in Japan;
  - Evolved from the pressurized water reactors currently in operation in the U.S.
- Incorporates four reactor coolant loops and four coolant system loops for enhanced safety;
  - Design modifications should result in 90% fewer shutdowns compared to other four loop pressurized water reactors;
- Able to use fuels made from reprocessed nuclear wastes;
- Produces 1700 MW(e);
- Certification application submitted December of 2007.
- Customer: Luminant Generation Company, LLC for Comanche Peak.

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[428] "Design Certification Application Review--Economic Simplified Boiling-Water Reactor (ESBWR)," http://www.nrc.gov/reactors/new-reactors/design-cert/esbwr.html, (accessed November 3, 2008); "ESBWR Fact Sheet," http://www.gepower.com/prod_serv/products/nuclear_energy/en/downloads/gea14429g_esbwr.pdf, (accessed November 3, 2008); "ESBWR Overview," http://www.ne.doe.gov/np2010/pdfs/esbwrOverview.pdf, (accessed November 3, 2008).

[429] "Mitsubishi US--APR Design Overview," http://www.ne.doe.gov/np2010/pdfs/2%20%20US-APWR%20Overview.pdf, (accessed November 3, 2008); "US—APR Design," http://www.mnes-us.com/htm/usapwrdesign.htm, (accessed November 3, 2008).

5.0 Westinghouse AP1000, Advanced Passive Boiling Water Reactor[430]

- Based on a "tried and true" U.S. reactor design dating back to the 1950s;
- Relies on passive, non-mechanical safety features rather than pumps, generators, and valves, reducing cost and increasing reliability;
    - Contains 83% fewer safety related pipes and 1/3 the number of pumps as its predecessor;
    - Houses the water for emergency cooling inside the containment structure and can provide gravity-driven flow even if all power fails;
- Employs a modular design, allowing portions of the reactor to be fabricated off-site, improving quality control during their manufacture and decreasing the on-site construction time;
    - Estimated time to completion: Three years;
- Provides approximately 1100 MW(e);
- AP600 was certified in 1998; AP1000 was certified in January 2006, but Westinghouse submitted design modifications in May 2007, forcing a re-review by the NRC. In October of 2009, the NRC informed Westinghouse of concerns about the ability of the revised AP1000 shield building (which protects the reactor's primary containment) to withstand severe weather and other events. Design modifications and further testing of the structure may be required.

[430] "AP1000," http://www.ap1000.westinghousenuclear.com, (accessed November 4, 2008); "A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010, Volume I, Summary Report," Prepared by the Near Term Development Group for the United States Department of Energy, Office of Nuclear Energy, Science and Technology, and the Nuclear Energy Research Advisory Committee, Subcommittee on Generation IV Technology Planning, October 31, 2001; Blake, E. Michael, "Renaissance Now?" *Nuclear News*, January 2008, pp. 24 – 30; "Design Certification Application Review--AP1000 Amendment," http://www.nrc.gov/reactors/new-reactors/design-cert/amended-ap1000.html, (accessed November 3, 2008); Matthew L. Wald, "Power Producers Seek Latest Models of Nuclear Reactors," *The New York Times*, March 15, 2005; "NRC Informs Westinghouse of Safety Issues with AP1000 Shield Building," *Power Engineering*, October 16, 2009, http://www.pepei.pennet.com/displayZ_article/370134/6/ARTCL/none/none/1/NRC-informs-westinghouse-of-safety-issues-with-AP1000-shield-building/, (accessed October 27, 2009); "Westinghouse Could Suffer a Setback In Plans to Deploy its AP1000 Reactor After US Regulators Required More Work on the Shield Building," *World Nuclear News*, October 16, 2009, http://www.world-nuclear-news.org/print.aspx?id-26330, (accessed October 27, 2009).

Appendix 6: Select Portion of the Energy Policy Act of 1992[431]

Title XXVIII—Nuclear Plant Licensing

Sec. 2801. Combined Licenses.

Section 185 of the Atomic Energy Act of 1954 (42 U.S.C. 2235) is amended . . .

(3) by adding at the end the following new subsection:

"b. After holding a public hearing under section 189a. (1)(A), the Commission shall issue to the applicant a combined construction and operating license if the application contains sufficient information to support the issuance of a combined license and the Commission determines that there is reasonable assurance that the facility will be constructed and will operate in conformity with the license, the provisions of this Act, and the Commission's rules and regulations. The Commission shall identify within the combined license the inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that, if met, are necessary and sufficient to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the license, the provisions of this Act, an the Commission's rules and regulations. Following issuance of the combined license, the Commission shall ensure that the prescribed inspections, tests, and analyses are preformed and, prior to operation of the facility, shall find that the prescribed acceptance criteria are met. Any finding made under this subsection shall not require a hearing except as provided in section 189 a. (1)(B).

Sec. 2802. Post Construction Hearings on Combined Licenses.

Section 189 a (1) of the Atomic Energy Act of 1954 (42 U.S.C. 2235) is amended . . .

(2) by adding after subparagraph (A) the following new subparagraph:

(B)(i) Not less than 180 days before the date scheduled for initial loading of fuel into a plant by a licensee that has been issued a combined construction permit and operating license under section 185 b., the Commission shall publish in the Federal Register notice of intended operation. That notice shall provide that any person whose interest may be affected by operation of the plant, may within 60 days request the Commission to hold a hearing on whether the facility as constructed complies, or on completion will comply, with the acceptance criteria of the license.

(ii) A request for a hearing under clause (i) shall show, prima facie, that one or more of the acceptance criteria in the combined license has not been, or will not be met, and the

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[431] Energy Policy Act of 1992, H.R. 776, http://thomas.loc.gov/cgi-bin/query/F?c102:1:./temp/~mdbs0MIIy3::, (accessed November 12, 2008).

specific operational consequences of nonconformance that would be contrary to providing reasonable protection of the public health and safety.

(iii) After receiving a request for a hearing under clause (i), the Commission expeditiously shall either deny or grant the request. If the request is granted, the Commission shall determine, after considering petitioners' prima facie showing and any answers thereto, whether during a period of interim operation, there will be reasonable assurance of adequate protection of the public health and safety. If the Commission determines that there is such reasonable assurance, it shall allow operation during an interim period under the combined license.

(iv) The Commission, in its discretion, shall determine appropriate hearing procedures, whether informal or formal adjudicatory, for any hearing under clause (i), and shall state its reasons therefore.

(v) The Commission shall, to the maximum possible extent, render a decision on issues raised by the hearing request within 180 days of the publication of the notice provided by clause (i) or the anticipated date for initial loading of fuel into the reactor, whichever is later . . .

Appendix 7: Probabilistic Risk Assessment

Probabilistic Risk Assessment (PRA) traces it origins to the Fault Tree Analysis (FTA) employed by Bell Labs in 1961 to study the Minuteman Launch Control System and later by Boeing to study the entire Minuteman Missile System. FTA became a mechanism for analyzing the safety of physical systems, based on reliability theory and probability theory.[432] About the same time, McDonald Douglas developed Failure Mode and Effects Analysis (FMEA). Concern over a change in the design of a rear cargo door prompted concerned engineers to issue a document outlining the problem with the change and potential for disastrous consequences.[433] The engineers explained how, when, and why the door might fail. The FTA and FMEA techniques proved so valuable in the aerospace industry that they were soon adopted by the auto industry, the chemical industry, and even the U.S. railroad system.

PRA builds on those early failure models. Instead of just looking at failures, PRA examines the potential outcomes (or consequences) of an initiating event. The initiating event could be an equipment failure, a power outage, or even an incorrect choice of action in a given situation. PRA then constructs an event tree, a logical network that starts with the initiating event and progresses through a series of branches (Top Events)

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[432] Ericson, Clifton A. II, "Fault Tree Analysis—A History," The Boeing Company, Seattle, WA, 1999, http://www.fault-tree.net, (accessed May 10, 2009), p. 1; Keller, William, and Mohammad Modarres, "A Historical Overview of Probabilistic Risk Assessment Development and its Use in the Nuclear Power Industry: A Tribute to the Late Professor Norman Carl Rasmussen," *Reliability Engineering and System Safety*, Vol. 89, 2005, pp. 271 – 285.

[433] "Failure Modes and Effects Analysis (FEMA)," http://www.fmeainfocentre.com/updates/dec08/Failure%20Modes%20and%20Effects%20Analysis%20from%20Superfactory%20Excellence%20Program.PDF, (accessed May 6, 2009).

to the end states. The choice made at each branch results in a “success” or “failure”, which then leads to the next decision point in the network. Assigning a probability to each branch in the network allows the calculation of the end consequences of the event. Figure 14 provides a simple example of an event tree.

Figure 14: Event Tree Example

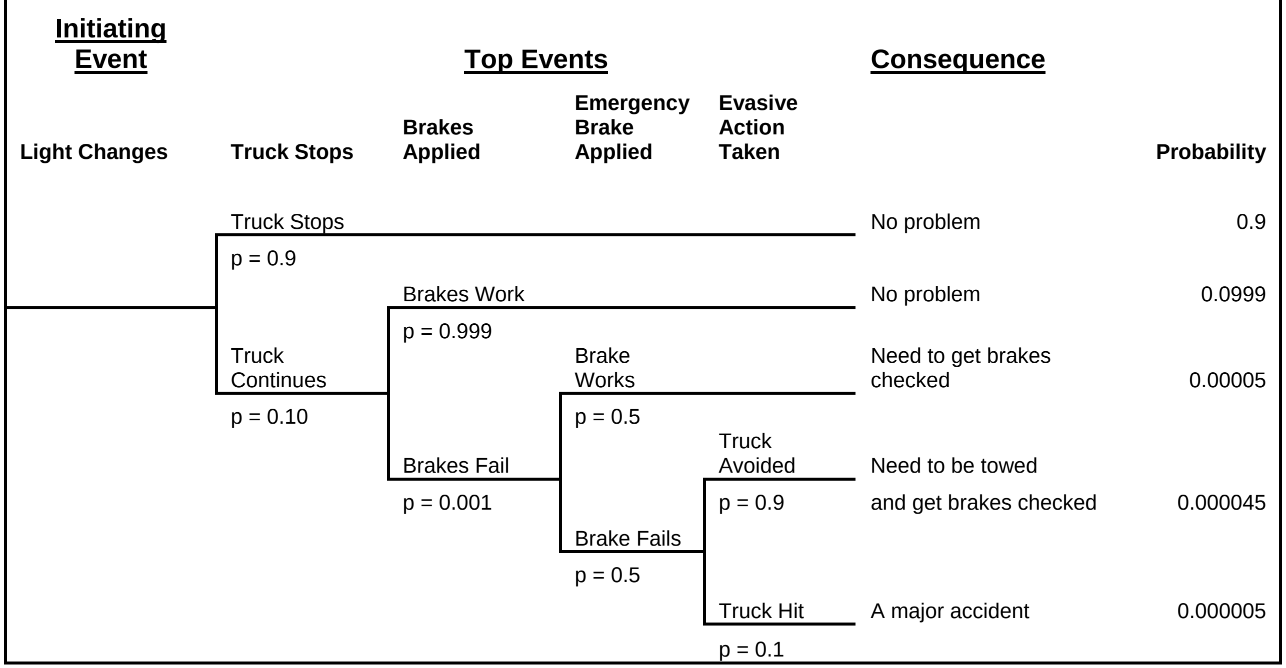

Figure 14: Sample Event Tree Diagram

Source: Adapted from "Event Tree Analysis: Configuration Control and Assessment STP Nuclear Operating Company"[434]

[434] "Event Tree Analysis: Configuration Control and Assessment," PowerPoint Presentation, STP Nuclear Operating Company.

The nuclear power industry greatly increased its use of PRA after the Three Mile Island accident in 1979. The aim was to calculate the frequency of a core damaging event (such as a meltdown) or a large release of radiation that might endanger the public. The PRA began by looking at the key components of each plant and the series of actions (or inactions) that could lead to a reactor shut-down. In 1995, the NRC issued a policy statement on the use of PRA in its nuclear regulatory activities.[435] The NRC advocated the use of PRA to complement its traditional defense-in-depth approach to safety, as a tool to support its regulatory requirements and guidelines, and to promote "stability, efficiency, and predictability" in its regulatory decisions.

Over time, PRA has evolved to include more and more components of the plant, and updated to better reflect the actual probability of each branch of the tree, based on increased industry experience. Building on these improvements, analysts typically model about 2000 different nuclear power plant components and have estimated the annual frequency of a core-damaging event to be in the range of 10^{-5} to 10^{-4}, but with significant uncertainty. The frequency of a large radiation release from containment typically is estimated to be about an order of magnitude smaller.[436]

The engineers and operators at U.S. utilities rely on PRA for much more than just calculating core damage and radiation release frequencies. PRA has allowed them to evaluate the importance of various components in protecting the reactor and to categorize each according to whether it is significant to the safety of the plant. For example, a valve

[435] "Fact Sheet on Nuclear Reactor Risk," U.S. NRC, www.nrc.gov/reading-rm/doc-collections/fact-sheets/reactor-risk.html, (accessed May 15, 2009).

[436] "Risk 101: Basic Training, ESP-100.65," STPEGS, Summer 2008, p. 15; Rick Grantom, The South Texas Project, Telephone Interviews, Spring 2009; Dana Kelly, Idaho National Laboratory, Conversation of January 16, 2010.

may not be directly related to emergency core cooling systems or other safety systems, but its function may be deemed to be significant in the safe function of the reactor. By looking at each component in that way, utilities can focus their most rigorous maintenance activities on those components that are most critical to safety and can perform less exacting maintenance inspections on those of less significance. PRA empowers utilities to manage their resources in a risk-informed manner.

Understanding the risk associated with actions and equipment, and how the various components tie into overall plant performance, allows for better decision making about taking components out of service for repair or replacement. Work can be scheduled so as to minimize the impact on safety. In addition, when the work has been completed, the new operational data can be compared with the data that served as the input to the risk analysis. Data that has been gathered for the PRA can serve as the baseline of operations against which future performance is evaluated.

Events outside the nuclear power plant that might negatively affect operations can also be included in a PRA. High winds, fires, earthquakes, and flooding can be incorporated into the analysis to determine their potential impact and what actions might need to be taken to prevent core damage if they did occur.

PRA can be used as input to the revision of safety standards and regulations. During the early years of the nuclear power industry in the U.S., the NRC had established standards based on its limited experience with small sized reactors and the input of reactor designers and lawyers. In the mid-1990s, the NRC issued a Maintenance Rule (10 CFR 50.65) for commercial nuclear power plants based on risk analysis and actual operating data. The Rule permitted an increasing number of maintenance activities to occur during normal operations—if safety was not compromised, the plant would not have to be shut down. That change meant that reactors could stay on line, producing electricity, and increasing their capacity factors to levels not seen in the U.S. before.

Work currently is underway to include the human element in PRA. Although machines operate fairly consistently over time, people make errors in judgment, deliberately choose to not follow procedures, and respond emotionally rather than logically when under stress. Human Reliability Analysis (HRA) examines the likelihood of particular human actions and how those actions can lead to hazardous situations or adversely impact safety. For example, at nuclear power plants, HRA might look at the probability that an operator would fail to open a valve when faced with a problem in the core cooling system. Operator training could be revised to reduce the probability if the number were deemed too high, or a back up system could be installed to insure the valve would open as needed.

PRA also has been incorporated into the design and certification process for new nuclear reactor design.[437] For example, the technique was used to develop risk assessments for the Westinghouse AP1000. Data from the current fleet of reactors was used as input for the components that would be similar in the old and new Westinghouse designs. For totally new systems, computer simulations together with small-scale model testing in labs were used to develop the likelihood of component failures. In addition, the NRC required each company/utility submitting a COL application to conduct a site-specific PRA. Risk also has informed the Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) developed for the systems and programs at each new facility. The

[437] C. J. Fong, Nuclear Regulatory Commission Region II Construction Inspection Organization, Telephone Interview of May 14, 2009.

ITAAC specifies which factors are most safety critical and will be the focus of inspections during construction. Since the NRC, reactor designers, and utilities all are involved in establishing the ITAAC, there will be more certainty about the requirements and more consistency from inspection to inspection than there was during the previous round of reactor construction.

Whether the new plants will incorporate PRA into their daily operations remains to be seen. Using a risk informed approach would give each plant more flexibility in how it meets the NRC requirements versus having to abide by the strict NRC rules. But performing and updating PRAs does require money and special skills. Some plants, like South Texas, feel the investment is worth the cost, but others do not. Some may decide to bring the new plants on line adhering to the NRC rules and then move to PRA-based method once operational. At this time, the NRC is allowing the licensee of existing facilities to choose the approach that best suits their needs and resources.[438] New plants will be required to have a full-scope PRA and will be required to keep it up to date.[439]

Probabilistic Risk Assessment is a quantitative tool that forces its users to break down complex systems into their component parts, to look at the interrelationships between those parts, to understand which components are vital to the safety of the system, and to assess the likelihood that something will or will not function as expected (potentially leading to a hazardous consequence). PRA permits wise allocation of resources to the areas deemed most critical. It allows for monitoring of performance and thus for information based decision-making. And it can be used to inform practices,

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[438] Ibid.

[439] Kelly.

procedures, standards, and regulations. PRA can make current and future nuclear operations more effective, efficient, and less risky.

Appendix 8. Interview Questions

Interviewee Background

What was your educational background?

How did you become involved with nuclear power?

Have you worked elsewhere in the energy industries?

How did you come to work in your present location/position?

The decision to apply to the Nuclear Regulatory Commission (NRC) for a Construction and Operating License (COL)

Can you tell me when your company started to consider making an application for a license to construct and operate a new nuclear power plant?

When did the discussion move from "whether" to construct to "when" to build?

What do you consider to be the primary factor(s) behind your company's recent application to build a new nuclear power plant?

What other factors contributed to that decision?

To probe specific topic areas, as necessary:

How important was it to your company's application that Congress extended the Price-Anderson Indemnity Act?

How important to your company's application were the loan guarantee programs passed as part of the Energy Policy Act of 2005?

How important to your company's application was the Nuclear Regulatory Commission's revision the licensing process--allowing applicants to receive a construction and operating license at the one time?

The NRC revised its licensing process in the 1990s. What issues led your company to wait until ___________ to submit an application?

Has the volatility in prices of fossil fuels affected your company's decision to apply for a license to build a new nuclear power plant?

The price of uranium also has been rising in the past decade. Is that a concern as your company embarks on such an expensive project?

Even though many support nuclear power as a means of freeing the United States from excessive fuel imports, the World Nuclear Association indicates that the United States possesses only 6% of the world's known recoverable supply of uranium. Another 8% lies in Canada.

How does your company view the security of ample uranium supplies?

Does it matter to your company whether uranium ores are located in the United States/North America?

What about processing of uranium from the raw ore to fuel rods ready to load into reactor?

To what extent did the contribution of fossil fuel to greenhouse gas emissions and to global climate change affect your company's decision to submit a construction and operation license application?

As part of the Energy Policy Act of 2005, the EPA and NRC announced "Delay Risk Insurance" to protect applicants against delays in approving nuclear power plant construction applications. That insurance only benefits the first six applicants. Your company is number ____________ in the queue.

Could you tell me how the availability of Delay Risk Insurance affected your company's decision as to if and when it would submit its application to the NRC?

Reactor Design Issues

Can you tell me how the availability of approved standard designs for new reactors affected your company's decision to build a new nuclear power plant?

The NRC approved several new nuclear power plant designs, hoping that applicants would choose those designs, thus speeding up and simplifying the application review process. Your company has selected a design that is not yet approved by the NRC. Do you think that choice will impact the approval of your combined construction and operating license? If so, in what way(s)?

Will the fact that your company has chosen an approved (or non-approved) design affect your ability to secure financing for the project?

Will the choice of an untried reactor/plant design affect your company's ability to complete the facility on schedule and on budget?

Can you tell me how your company decided on the size (in MW) of the new nuclear plant?

Did your company consider smaller, modular plants, like those now used in France?

If so, what factors led your company to decide on the larger design?

What challenges to you foresee in bringing such a large plant successfully on-line?

In general, what will be among the biggest challenges your company will face in constructing a new nuclear reactor/plant?

Several articles have indicated that the availability of parts, especially the ultra-heavy steel parts, may be an issue when construction begins in earnest.

How is your company dealing with the challenges of this and other supply chain issues?

Could you tell me how your company came to select (a) a site already occupied by an existing reactor rather than a new site for the reactor, or (b) a new site for the reactor rather than a site already occupied by an existing reactor?

What were the pros and cons of each type of site that your company considered for this project?

The Economic Climate

The site your company has chosen lies in a state where electricity is unregulated (or regulated).

Can you tell me how regulation and non-regulation of electricity markets affected your company's decision to invest in nuclear power at this time?

How might the current economic downturn in the United States and around the globe affect your company's decision to construct a new nuclear power plant?

Can you tell me if the election of a Democrat (Obama) as President rather than a Republican will affect your company's decision to build a new nuclear power plant?

Wrap-up

Can you tell me when and how your company will make the final decision on whether or not to initiate construction of a new nuclear power plant?

At this time, can you tell me the likelihood that your company will indeed construct a facility?

What factor(s) might cause your company to withdraw its application from NRC consideration?

Can you tell me if you are optimistic or pessimistic about the future of nuclear power in the United States?

What factor(s) most influence your position?

Are there any other questions I should have asked to gain a good understanding of the decisions your company is making vis-à-vis nuclear power?

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