The Downside of Nuclear Power- by an Advocate

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I. INTRODUCTION

For land-based generation of electricity, nuclear power was at its beginnings and still is supported by almost the entire scientific and engineering community. For forty years, the controversy has been a political issue because it is a dispute over value-based judgments, rather than scientific facts or engineering conclusions. The few scientists and engineers who oppose it, do so on the basis of their personal value judgments about what is safe enough for society. There is *no* dispute about what science finds or engineering demonstrates, only the meaning of the results.

The following essay discusses the Origins of the Conflict; the Downside, including the Opponent's[1] Case; Policies proposed by the Opponents and Mistakes of the Advocates; an Analysis of the Debate; and Future Paths, which are the author's predictions.

II. ORIGINS OF THE CONFLICT

By the mid-twentieth century, our entire infrastructure and economy was built on the belief that the earth is an unlimited store of resources and the environment is an unlimited sewer.[2] This was not a stated belief, but may be concluded from the way society behaved. Implying infinite

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∗ Howard C. Shaffer has been seeking to understand, and has been active in, the conflict over nuclear power for over thirty years while working in power plants at the same time. At first he wanted to know whether or not he was involved in the correct pursuit. He soon learned that the Opponents are correct about conservation, efficiency, alternatives and care for the environment. With his background, B.S.E.E. (1962—Duke), Submarine Officer nuclear training and service, M.S. in Nuclear Engineering (1976—MIT), daily work in the industry, and professional society participation and conferences, it became apparent to him that the technical objections were not valid and were only a vehicle for an underlying debate about values. From a scientific and engineering viewpoint that compares the risks and benefits of alternatives for any problem's proposed solutions, nuclear power is highly desirable. He has studied both sides of the issue, spoken, debated, written, been active in politics, attended public meetings and hearings, and met face to face with the Opponents. The history presented is from his years of experience and is common knowledge in the industry. He was a 2001 AAAS Congressional Fellow serving on the House Committee on Science, Energy Subcommittee, and is a Licensed Professional Engineer in Nuclear Engineering in Vermont, New Hampshire, Massachusetts, and Illinois. He is a Christian who believes that building toward and achieving full sustainability is a moral imperative.

1. Hereinafter, "Opponents" is the term used for those individuals opposed to the use of nuclear power.

2. *E.g.*, Al Gore & David Blood, Editorial, *For People and the Planet*, WALL ST. J., Mar. 28, 2006, at A-20 (stating explicitly that our Keynesian economics assumed natural and human resources as limitless).

resources, popular expressions were, "You're using it up like water" and "Do you think that grows on trees?" This worked satisfactorily for centuries because the population was small and technologically limited. When it became apparent that this belief was no longer valid, many understood the need for change.

Institutions resist change, even when the need for change is recognized. In order to be accepted, changes must take place while society and the economy continue. New ideas and technologies must grow into use and displace former things because these technologies are superior. Attempting to force change will create resistance if there is no transition plan. For example, there was no campaign needed to force the use of computers for word processing instead of typewriters. The better technology simply grew into the economy and almost completely took over.

When those concerned about the environment first challenged how it was being used, there was no stated viewpoint to attack. Environmentalists attacked the nuclear industry's practices and their results without separating them from the institutions of society. These institutions had overcome the Great Depression, won World War II, formed the UN, and felt themselves engaged in a long twilight struggle against Communism. Perhaps it is not surprising that the institutions felt attacked, since environmentalists did not "separate the sins from the sinners."

The electric power system had experienced continual growth and declining real costs since its founding at the end of the nineteenth century. This was due to economies of scale, which has occurred in many technologies. Declining real costs ended in the 1960s and real costs began to rise, shocking consumers. Soon after electric power usage began, it was judged a social good and government institutions encouraged its growth. Government understood that growth would lead to lower costs and lower costs meant that electric power use could spread through the entire economy. Where privately-owned utilities or companies could not yet afford to offer service, government entities were created.[3] The electric power industry followed the general philosophy of using the environment as an unlimited resource.

Coal was used for electric power generation and most other heating, where hydropower was insufficient. Coal mining was dangerous, and accidents were frequent. The negative environmental impacts of coal mining were recognized, but in those days were thought to be localized. The need for substantial improvement in the use of coal was also understood, but no alternatives were immediately available. Natural gas

3. The Rural Electrification Administration and the Tennessee Valley Authority are examples.

use, to replace manufactured gas, began to expand in the 1950s, but widespread use requires long distance pipelines that have taken years to build.

Nuclear power was touted as an unlimited source of power. It was introduced into a society and an institution, the electric power system, which believed that continual growth was for the public good and which saw the environment as an unlimited resource. Coincidently, the introduction of nuclear power occurred just as the environmental movement was forming and growing.[4] In hindsight, it appears that conflict was inevitable.

The environmental movement may have concluded that continual growth and unlimited use of the environment were necessary to make nuclear power economical. The assumption that nuclear power would use the environment as a limitless resource could be seen as a natural conclusion, considering society's practices and the practices of the electric power industry. Because it was new, with characteristics frightening to the public and linked to powerful weapons, nuclear power was a convenient target to illustrate the changes believed to be needed in environmental policy. In truth, the historical record of the use of radiation and radioactive materials allays concerns about the environment. Early experimenters in the late nineteenth century were severely injured by overexposure. The need for understanding the biological consequences of radiation was apparent, and research on these issues began and was never stopped. The need for specific limits and procedures was plain. International conferences and standards were in place as early as the 1920s.[5]

In 1939, it was proven that energy could be released by splitting atoms. By the end of 1941, after more information was gathered and U.S. government support was obtained, the attempt to build a controlled chain reaction assembly, a reactor, began.[6] Those in charge realized that reactors would create vastly greater amounts of radiation and radioactive material,[7] and accordingly understood the absolute necessity to protect life. They foresaw the need for a separate organization with individuals dedicated only to safety. The profession titled "Health Physics,"[8] which continues to this

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4. Many trace the beginning of the modern environmental movement to the book SILENT SPRING (1962) by Rachel Carson.

5. *See, e.g.*, International Commission on Radiation Protection homepage, http://www.icrp.org (last visited Apr. 22, 2006) (stating that the ICRP was organized in 1928); U.S. National Commissions on Radiation Protection, http://www.ncrponline.org/AboutNCRP/ (last visited Apr. 22, 2006) (stating that the first report was in 1934).

6. HENRY DEWOLFE SMYTHE, ATOMIC ENERGY FOR MILITARY PURPOSES 88 (1945).

7. *Id.* Drs. E.O. Lawrence, H.C. Urey, and A. H. Compton.

8. *Id.* at 90. This was originally called the "Health Division" under Dr. R. S. Stone. *See also* Health Physics Society, Answer to Question No. 2561 Submitted to "Ask the Experts,"

day, was created within the Manhattan Project in the U.S., an Allied World War II effort to create nuclear weapons. The name was created to maintain wartime secrecy since a title like "Radiation Safety" would disclose the project's intent.

The safety and environmental record since the origin of reactors has conclusively proven that nuclear power can be used safely. Research into environmental and health effects has been continuous, while standards have been revised to conform to current research. The standards have *huge* margins of safety;[9] unfortunately, this has not been adequately explained to the public. News items reporting leakage "above government limits" generate public fear, despite the fact that these limits are the equivalent of an interstate highway speed limit of ten miles per hour.[10]

Reactors for the creation of weapons grade plutonium were built during World War II. Post war, submarine and ship propulsion reactors were developed. Before the war, the scientific community had recognized that reactors could replace the use of coal. Technical development of reactors for the electric power system began, and it was proven to Congress that

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http://hps.org/publicinformation/ate/q2561.html (last visited May 11, 2006) (The question was "What is the definitive origin of the title/subject 'Health Physics'?"). The website's excerpt describes the term's origin from the perspective of a participant. There is some uncertainty as to who first coined the term. Apparently in the wartime situation, there was no time to document everything so a term that came into common usage and later became important cannot now be credited to any one individual. This is similar to the now common term "SCRAM," which is used to indicate a rapid reactor shutdown that is most often automatic, but can be manually initiated. The term also came from the first reactor project and I recall reading on the 40th anniversary of the first chain reaction in 1982 that people who were there differed as to what the acronym stood for. It was either "Safety Control Rod Ax Man" or "South Chicago Control Rod Ax Man" and, of course, it also meant "leave in a hurry" from this experimental setup.

9. *See* DEPARTMENT OF ENVIRONMENTAL SAFETY, UNIVERSITY OF MARYLAND, *Chapter 3: Sources and Effects of Radiation, in* RADIATION PROTECTION TRAINING MANUAL & STUDY GUIDE, *available at* http://www.des.umd.edu/rs/material/tmsg/rs5.html (last visited Apr. 22, 2006). This training manual has information ranging from lethal exposures to background exposures. The size of the safety margins is apparent.

10. This is the author's characterization in an attempt to convey the existing situation to the public. The federal government's current limits for exposure to man-made radiation are based on the National Committee on Radiation Protection's (NCRP) Report No. 116, Limitation of Exposure to Ionizing Radiation (1993). The limits are set so that "risks that are comparable or less than those in safe industries- an average annual risk of fatal cancer of the order of 10^4 or less." NCRP Report No. 116 at 14. This means the limits will make the risk of death from radiation-induced cancer equal to or less than the risk of accidental death in safe industries. This is about a one in 10,000 chance of death each year. For a 100 year lifetime, the risk is one in 100 as compared to a one in four chance of death from cancer from all sources. COMMITTEE TO ASSESS HEALTH RISKS FROM RADIATION EXPOSURE TO LOW LEVELS OF IONIZING RADIATION, NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES, HEALTH RISK FROM EXPOSURE TO LOW LEVELS OF IONIZING RADIATION: BEIR VII PHASE 2 (National Academy Press 2006), *available at* http://www.nap.edu/catalog/11340.html. The basis for the limits is the "Linear No Threshold" (LNT) theory, which maintains that any amount of radiation has some risk and any increase raises risk. *Id.* Applying this to a 10 mph speed limit would mean that driving at 12 mph would increase the risk of an accident some amount.

nuclear reactors could be safely sited throughout the country.[11] Congress authorized power reactors, nuclear medicine, industrial isotope use, the entire civilian program, and established the Atomic Energy Commission.[12] The first demonstration power plants were placed on-line in 1960.[13] They were welcomed and not opposed. A few years of successful operation demonstrated that these plants were practical for the electric power system. Electric utilities ordered many plants in the mid-1960s. These plants were under construction and in licensing hearings just as the environmental movement gained global prominence.[14]

The scientific community and industries that had "won the war" did not take kindly to the environmental movement's criticisms. To many nuclear power advocates, such criticisms implied moral shortcomings and the debate over nuclear power began in earnest.

Adding to the intensity of the debate was an air of moral superiority by some environmentalists,[15] and arrogance on the part of some in the nuclear and utility community.[16] Fortunately, the discipline of the events of the past

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11. The Atomic Energy Act of 1946, Pub. L. No. 79-585, 68 Stat. 921 (codified at 42 U.S.C. § 2011)(amended 1954) (establishing the Atomic Energy Commission (AEC)). The Act was responsible for regulating and developing and promoting all things nuclear, including the weapons program, which it took over from the Army. The unusual arrangement of having an agency "police itself" was made due to the limited amount of scientific and technical expertise available at the time and the need for continued development for Cold War purposes. *Id.* Congress set up the Joint Committee on Atomic Energy (JCAE), which had sole jurisdiction over the Atomic Energy Commission. Atomic Energy Act of 1954, ch. 17, Pub. L. No. 83-703, § 201-07, 68 Stat. 919 (repealed by Pub. L. No. 95-110, 91 Stat. 884 (1997)). This meant that the budget and any AEC matters only came before the Joint Committee, rather than several committees, which is the usual practice. *Id.* This arrangement continued until 1974, when the Nuclear Regulatory Commission and the Energy Research and Development Administration were created. Energy Reorganization Act of 1974, Pub. L. No. 93-438, 88 Stat. 1233 (codified at 42 U.S.C. §§ 5801-91). The Energy Research and Development Administration was later absorbed by the Department of Energy (DOE).

By passing the Atomic Energy Act, which provided for development Congress accepted that nuclear activities were safe enough when compared to alternatives.

12. The Atomic Energy Act of 1946 § 8 (a)(1)-(5), Pub. L. No. 79-585, 68 Stat. 921 (codified at 42 U.S.C. § 2051).

13. For any technology, a demonstration plant is a facility that is known to work technically and whose purpose is to prove and work out practical aspects, such as management, economics, operation, and maintenance. For nuclear power, successful operation of the aircraft carrier land-based full-sized prototype proved that a plant with an a-c generator's output would function. The electric utilities needed to prove to the state regulatory commissions that nuclear power plants would not cost the ratepayers too much. The work performed for naval reactors assured the safety of the technology, which preceded the electric power system program.

14. The first Earth Day was in 1970. The author was present to observe the march on Wall Street and the altercation between the marchers and the construction workers from the World Trade Center.

15. *C.f.* Lee Gomes, *Apple's 30 Years Of Selling Cool Stuff With an Uncool Message*, WALL ST. J., Apr. 5, 2006, at B-1 (documenting Apple Computer's Super Bowl television commercial that introduced the Macintosh computer). It used the 1960s idea that moral values can be attached to technological objects and that having certain things makes you better. By extension, not having these things, or not believing in them, makes you morally inferior. This 1960s idea was unstated, but the message came through.

16. Conversation with Governor Thornburgh, Former Governor of Pennsylvania (2001). Governor Thornburgh, governor of Pennsylvania at the time of the Three Mile Island 2 accident in 1979, described

forty years has mellowed both sides.

III. THE DOWNSIDE

The downside of nuclear power consists of the Opponents' position and the Advocates' mistakes. Both receive widespread and enthusiastic media coverage.

A. The Opponents' Case

The Opponents are international organizations, such as Greenpeace; national organizations, such as the Union of Concerned Scientists, Conservation Law Foundation, Public Interest Research Group and Nuclear Information Resource Service; and regional organizations, such as the New England Coalition, Citizens Awareness Network and the Traprock Peace Center. Opposition to nuclear power is only part of the agenda for most of these organizations.

Opponents maintain that nuclear power is unsafe, uneconomical, and unnecessary. The following will discuss each allegation in turn.

1. Unsafe. They claim that the lack of safety is due to the possibility of exposure to radiation and radioactive material from multiple sources. The plants and the whole fuel cycle emit radiation directly and discharge radioactive material to the environment. According to Opponents, these emissions and discharges are inherently unsafe. They quote the government statement that "[t]here is no safe amount of radiation," which they are taking out of context.

The Opponents claim that:

- There will be accidents, which will release lethal amounts of radiation and radioactive material, and that these releases will make large areas of land uninhabitable for very long periods of time.
- Used fuel will be dangerously radioactive for millennia.
- Nuclear power plants and fuel cycle facilities are terrorist targets.
- Having fuel cycle technology available makes weapons proliferation possible.

2. Uneconomical. Opponents claim that nuclear power is uneconomical and cannot exist without massive subsidies. Plants are too expensive to build.

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the utility industry that he knew as "arrogant," in response to a direct question from the author. *Id.* The response was made to the author one-on-one after a staff briefing for the House Committee on Science in 2001.

3. Unnecessary. Opponents claim that efficiency, conservation, and alternative energy supplies that are sustainable will provide all the energy we need. All that is required is government financial and policy support, and nuclear power plants will be in excess and can be shut down.

B. Policies proposed by Opponents

1. Shutdown all nuclear power plants now, or at least as soon as possible.
2. Promote an energy efficient economy and life style.
3. Propagate alternative energies.
4. Change society's beliefs about the environment by changing energy sources.

C. Mistakes of the Advocates

1. The mistakes and problems of this new technology were poorly explained to the public. Apologies were insufficient for those most affected by the events. The most egregious example was the accident at Three Mile Island 2 in 1979, where the reactor fuel was partially melted by operator error and some of the products got out into the containment. Even though no excess releases from the plant occurred, the communications with the public were so badly butchered that many in surrounding communities were traumatized, and some still acutely remember their terror.
2. The scientific and engineering communities were slow to grasp the truth in the environmental movement's message that the world must achieve total sustainability in everything.
3. The utility industry and state regulatory commissions did not adequately explain to the public that the historical trend of declining real costs for electric power ended in the 1960s. As a result, the rising costs were blamed on nuclear power for the most part.
4. The nuclear industry was slow to grasp the fact that they would have to educate the public at the grassroots level. The federal government did not fulfill its responsibility to adequately educate the public about nuclear power, so the industry needed to take on that role itself.
5. In general, poor communication with the public and media characterized the first decades of nuclear power. Too often, the industry used scientific and technical jargon without defining its terms, and so created suspicion and distrust instead of confidence in the new technology.

D. Yucca Mountain as an Illustration of the Debate

The Department of Energy (DOE) is attempting to construct a storage facility for used commercial fuel and Department of Defense (DOD) nuclear waste that has been turned into glass at Yucca Mountain in Nevada.[17] The project is being vigorously opposed.[18] The design standards for the storage facility are tied up in court.[19] The standard for radiation dose from leakage after 10,000 years—even assuming it occurs—is one-third of the current annual background dose in South Dakota.[20] This demonstrates that it is a political struggle, not one based on scientific problems or insufficiencies.

IV. ANALYSIS OF THE DEBATE

A. The Opponents

The Opponents' statements are political. "Unsafe," "uneconomical," and "unnecessary" are personal value judgments. These statements do not arise from scientific or engineering analysis. There are no algorithms that produce these results. Scientific formulas provide the same answer for everyone given the same data and proper manipulation.

Value judgments arise from within the individual. Congress makes the majority value judgments in our political system—called National Policy. Based on still valid scientific information, Congress decided long ago that

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17. Office of Civilian Radioactive Waste Management, http://www.ocrwm.doe.gov/ymp/about/waste_explained.html (last visited April 22, 2006). DOE selected the site in Nevada after preliminary surveys of several possible locations throughout the country and a detailed survey at Yucca Mountain. The detailed survey comprised a U-shaped tunnel in and out of the solid volcanic rock mountain to access the proposed places for disposal, and a thorough geological study. *Id.* The disposal places will be inside chambers off of the tunnel. The defense waste will be the liquid and sludge from weapons production, turned into solid glass and canned. *Id.* Commercial waste will be used fuel from power plants, which is solid ceramic stored in metal tubes in special containers. The author visited the site in 1994 and 2004.

18. *See* Eureka County, Nevada Nuclear Waste Office, Litigation—Yucca Mountain Lawsuits, http://www.yuccamountain.org (last visited April 22, 2006) (providing a summary and discussion of the lawsuits involved). The State of Nevada is the principal opponent of the Yucca Mountain facility. Nevada's Senior Senator, Mr. Harry Reid, is a strong voice in Congress in opposition. One of the main objections is the radiation exposure standard for possible leakage of metal and solid fuel that may dissolve in water that may leach into the disposal places after 10,000 years, which may cause one to speculate as to whether or not the objections are scientific or based on something else.

19. *Id.*

20. Special to the PVT, *Yucca Mountain: Radiation Standards Explained*, PAHRUMP VALLEY TIMES, Aug. 31, 2005, *available at* http://www.pahrumpvalleytimes.com/2005/08/31/new/yucca.html. This article discusses the EPA standards for Yucca Mountain for 0-10,000 years and 10,000 to 1,000,000 years. *Id.* It also discusses the average exposure from radiation in different locations: Florida 131 mrem/year; South Dakota 963 mrem/year; U.S. average 360 mrem/year. *Id.*

nuclear power should be used,[21] and has yet to change that decision, despite efforts of the minority that still opposes nuclear power.

In our political system, a minority can continue to assert its viewpoint for as long as it chooses. Occasionally, after years or decades, the majority opinion does change, and this is precisely what the opponents hope to obtain.

Rather than say they have a different value judgment, the Opponents attack nuclear power on scientific and technical grounds, since this is the "chink in the armor" left open by the licensing process.[22] The Opponents do not perform independent scientific and engineering research, but examine that of the industry, available through the licensing process. They pick what they think are weak points and challenge them in every possible venue.[23] What the Opponents ignore is that the scientific approach takes a

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21. In passing the original Atomic Energy Act, Congress accepted nuclear power for land-based electricity generation.

22. *See* U.S. Nuclear Regulatory Commission Backgrounder on Nuclear Power Plant Licensing Process, htpp://www.nrc.gov/reading-rm/doc-collections/fact-sheets/licensing-process-bg.html (discussing the original and amended licensing process under Domestic Licensing of Production and Utilization Facilities, 10 C.F.R. §§ 50.20–.23, 50.30 (2005) and Early Site Permit; Standard Design Certifications: and Combined Licenses for Nuclear Power Plants 10 C.F.R. §§ 52.1–52.103 (2005)) (last visited Apr. 22, 2006). Under the original scheme, licensing involves a two-stage process: a construction permit and an operating license. A public hearing, with staff review must be held before an issuance of a construction permit; a public hearing is not required to obtain an operating license. Under the newer combined licensing process, an applicant can apply for a construction permit and operating license in one application. However, the Nuclear Regulatory Commission will only authorize operation of the permit after confirming that the applicant completed proper inspection, tests, and analysis, thereby meeting the acceptable criteria. During the public hearing, recognized Interveners have the right to call and cross-examine witnesses, much like a trial. When each system in a plant is examined in isolation for weaknesses, some may be found. The overall design of plants takes credit for the total effect of all systems together functioning to create very high odds against an accident that will adversely affect the public and environment. The overall design also accepts that accidents and events that will not affect the public will have odds against them that are not so high, and will possibly occur more often.

As the licensing hearings for each plant proceeded, the owners adopted the approach of creating design fixes for just about every objection. This of course added expense, caused delay, and increased complexity, particularly when a plant was under construction. The opponents want to stop nuclear power, so delay and expense furthered their objective. The tactics continued, and when interest rates were high, led to the canceling of Seabrook Unit 2 and the bankruptcy of the Public Service Company of New Hampshire.

Now the licensing process includes a pre-approved standard design created to match a certain environmental envelope, located on a pre-approved site that has an environmental envelope consistent with the plant design. Interveners may participate in the pre-approval process. 10 C.F.R. § 52.54 (2005).

23. Opposition has been in the NRC administrative process and in court. It has included local and national groups, and state and local governmental bodies. In 1986, the Governor of Massachusetts refused to allow state employee participation in the federally mandated Emergency Plan for the Seabrook plants in New Hampshire. (The ten-mile Emergency Planning zone extends into Massachusetts). This delayed the plant starting for four years. Massachusetts took the case to the Supreme Court, but it refused to hear it. The Supreme Court wrote a ruling in the Calvert Cliffs plant challenge that changed the licensing process. The Court ruled that the lead federal licensing agency must insure that the requirements of all other agencies are met. The Union of Concerned Scientists, Public Interest Research Group, Conservation Law Foundation, and in New England, the Clamshell

step beyond considering and analyzing the results of all possible scenarios, and makes a judgment about the likelihood of occurrence of disastrous events. Reflection reveals that all life involves judgments about odds: Is it safe enough to go to work today? Snowing? How badly? Wait a while? For example, an obvious consensus on the odds of a large accident is the location of airports in or near cities around the world. Planes have crashed into cities, but rarely. No one says it cannot happen again. Likewise, no advocate of nuclear power has ever said severe accidents can never happen. But they judge the odds against severe accidents to be so great that very infrequent accidents make nuclear power's use acceptable when compared to its alternatives.

On this basis, Congress, the scientific and engineering community, and the nuclear industry itself disagree with the Opponents. The former believe that radiation and radioactivity are safe enough. They judge that nuclear power plants and the fuel cycle are economical, necessary, and safe enough from terrorist attacks.[24]

With regard to economics and sustainability, the Opponents claim that nuclear power requires a "hard path" philosophy.[25] A "hard path" philosophy is founded on the principles that bigger is better, central control is preferred, and the environment is unlimited.[26] The belief that nuclear power requires a "hard path" philosophy appears to be a misunderstanding of the historical antecedents of the whole technology behind nuclear power, as well as the electric power system. The U.S. was entrenched in the "hard path" before nuclear power was introduced, using the environment as if it were limitless. This incorrect association continues, as illustrated by a recent report from Great Britain's Sustainable Development Commission.[27]

Alliance, and New England Coalition (who still actively opposing Vermont Yankee) are some of the groups. *See* Vermont Yankee Nuclear Power Corporation v. Natural Resources Defense Council, Inc. et al., 435 U.S. 519 (1978).

24. Congress decided nuclear power was and is safe enough by passing the original Atomic Energy Act and maintaining support for it through all the opportunities to change their decision in succeeding Congresses. *See* Atomic Energy Act of 1946, Pub. L. No. 79-585, § 1(a), 68 Stat. 921 (amended 1954) (indicating the amendments throughout the years have not changed Congress' initial decision concerning the safety of nuclear power). In 2001, the author was present when Congress quickly examined the country's entire infrastructure after the attack of September 11. Nuclear power was not even considered, since the robust design of the plants against external hazards is known. Congress found that the public water supply system was vulnerable, and passed legislation to further protect it.

25. The term is from Amory Lovins's book SOFT ENERGY PATHS, which is very influential. AMORY LOVINS, SOFT ENERGY PATHS: TOWARD A DURABLE PEACE 25 (1977). A hard path philosophy believes that bigger is better and the more central control, the better. *Id.* A soft path philosophy believes in environmental sustainability, efficiency, conservation, local control, and care for human values.

26. *See id.* at 23 (describing the Soft Path's virtues). By implication, the hard path is the opposite.

27. "[There are 5] major disadvantages to nuclear power: . . . 4. Undermining Energy Efficiency- a new nuclear programme would give out the wrong signal to consumers and businesses, implying that a major technological fix is all that's required, weakening the urgent action needed on energy efficiency." Sustainable Development Commission, http://www.sd-commission.org.uk/pages/060306.html (last

Conclusions about philosophies should be re-examined periodically in the light of ongoing experience. The last forty-plus years of experience prove that nuclear power does not require a "hard path" philosophy.[28] Nuclear power coexists with alternatives such as wind and solar power. Several large power companies own both nuclear power plants and wind farms.[29]

Society's use of a "hard path" was the result of its past belief in a limitless environment. Buildings and homes used to be designed and built to minimize capital cost, with the assumption that heating and cooling costs would remain constant when adjusted for inflation, and the time horizon for the costs was short, rather than the life of the structure. This resulted in buildings with a minimum amount of insulation. Building codes now specify much more insulation. The air was used as an infinite sewer, since there were no discharge limits prior to the Clean Air Act. Many industries grew in size and specialization until it seemed that bigger was always better. In actuality the free market was forcing economies of scale, still moving prices down and capability up; computers are an example.

B. The Advocates

Advocates have responded to technical challenges with design fixes.[30] Opponents have responded with more challenges, raising the bar for the

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visited March 31, 2006). The Commission discusses the report entitled *Is Nuclear the Answer?* by Jonathan Porritt, Chairman of the Sustainable Development Commission. *Id.* This statement implies that nuclear power will provide so much energy, at least for a while, that consumers will not want to, or have to, be efficient and conserve. This is at the core of the environmentalist and anti-nuclear position—that nuclear power prevents conservation and efficiency.

28. *C.f.* LOVINS, *supra* note 24, at 59 ("Though soft and hard paths are not *technically* incompatible—reactors and solar collectors could in principle coexist—the two paths are antagonistic in other and more important ways that, though qualitative and judgmental, are real and unavoidable.") (emphasis original).

29. *See, e.g.*, Entergy Corporation website, http://www.entergy.com/content/operations_information/generation.pdf (listing utilities owned by various power companies) (last visited Apr. 22, 2006); Nebraska Public Power District, http://www.nppd.com (discussing the installation of thirty-six wind turbines by the NPPD) (last visited Apr. 22, 2006).

30. Fire Protection Program for Nuclear Power Facilities Operating Prior to January 1, 1979, 10 C.F.R. pt. 50 app. R (2005). The prolonged wrangle over these regulations represents the most striking example of how technical challenges have been met with design fixes. Concerns stem from a fire at the Brown's Ferry 1 plant (1975), which became serious when the operators failed to act due to poor training. There was a fire in a wall through which control circuits for all the emergency cooling pumps passed. They were all disabled and reactor core overheating, which would cause damage and could lead to a meltdown and a situation similar to the accident at Three Mile Island 1 (1979) was prevented only by the use of non-emergency pumps. Discussions, arguments, interventions, and plant changes are still ongoing. *See also* Neil H. Lewis, *Interpreting the Oracle: Licensing Modifications, Economics, Safety, Politics, and the Future of Nuclear Power in the United States*, 16 ALB. L.J. SCI. & TECH. 27, 45–50 (2006) (discussing the economics costs and impacts of Brown's Ferry and Three Mile Island).

next fix. And so the game continues.[31] Advocates agree that sustainability is our goal, but have never acknowledged the relevant history that explains why our whole economy was on a hard path. The nuclear industry adopted the approach that good performance will convince the public of the value of nuclear power. Industry has recognized that communication with the public is of great importance, and is continuing its effort to correspond effectively. Overall, the Advocates have examined past mistakes and tried to correct them.[32]

V. FUTURE PATHS

Sustainability is an accepted goal.[33] The need to contend with global warming, while providing an adequate lifestyle for a growing population, is recognized. The reality of reaching the peak of world oil production, to be followed by the peak of natural gas production, is acknowledged.

There is no agreement on time tables: how soon peak oil and gas will occur; how quickly global warming action must be taken; and how long we have to achieve adequate lifestyles. There are over 440 electric power reactors in operation worldwide, with many more under construction or planned by many countries.[34] A few countries have outlawed nuclear power, and a few are phasing it out.[35] Several countries are expanding their use of coal, apparently to fill the gap; i.e., to maintain and grow their economies while phasing in nuclear, wind, and solar power. [36]

In conclusion, although many paths are possible, the most realistic consideration of the future suggests that scientific facts, engineering possibilities, and economic and political necessities will prevail. Coal, nuclear, wind, and solar power will continue to grow, with much of the growth replacing oil and gas energy. Efficiency, conservation, and

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31. The latest example is the Yucca Mountain dispute.

32. *E.g.*, Institute for Nuclear Power Operations, http://www.eh.doe.gov/inpo/index.html (following the accident at Three Mile Island 2 in 1979 the industry voluntarily founded the Institute for Nuclear Power Operations (INPO) to be its self-critic.) (last visited Apr. 22, 2006); World Association of Nuclear Operators, http://www.wano.org.uk/WANO_Documents/What_is_Wano.asp (following the disaster at Chernobyl 4 the world industry founded the World Association of Nuclear Operators (WANO) to be its self-critic.) (last visited Apr. 22, 2006).

33. PE Author, *Obligation Earth*, PE THE MAGAZINE FOR PROFESSIONAL ENGINEERS, Apr. 2006, at 25. Sustainable development is now part of the code of Ethics for Professional Engineers.

34. *See* World Nuclear Association, Information and Issue Briefs for March 31, 2006, http://www.world-nuclear.org/info/reactors.html (providing a table of World Nuclear Power Reactors 2004–06 and Uranium Requirements) (last visited Apr. 22, 2006).

35. *See id.* (including figures for Germany and Sweden in the table).

36. For just the U.S. data, *see* Energy Information Administration, Official Energy Statistics from the U.S. Government, Overview (2006), *available at* http://www.eia.doe.gov/oiaf/aeo/pdf/overview.pdf (noting forecasts of all the use of all fuels) (last visited Apr. 22, 2006).

environmental cleanup and restoration will continue to expand. Cars and trucks will be converted to biodiesel, alcohol, and hydrogen. Solar energy will replace all the building heating possible, and the remaining heating will be obtained from biodiesel or biogas. There will be widespread hydrogen production, which is greenhouse gas free when nuclear power is utilized.

Far down the road, electricity from microwaves beamed down from satellites is likely to take over a large portion of our energy supply. Solar and wind power and some hydropower will supply the rest. Coal, oil, and gas will have been phased out. Nuclear power may begin to phase out as soon as the mid-twenty-second century, although there is enough fuel for at least a thousand years.[37] With so many paths possible, it will be an interesting journey. It is a journey on which we must be proactive, rather than waiting for skyrocketing prices to force us into action.

37. *See* World Nuclear Association, http://www.world-nuclear.org/info/info.htm (The world uranium resource is listed at fifty years with the present type of reactors, and sixty times that with Breeder reactor technology, which has always been assumed and is in use now. In addition, the thorium resource, which can be converted (bred) to Uranium 233, which is a reactor fuel, is listed as three times that of uranium. Thorium breeding has been proven.) (last visited May 12, 2006).