VERMONT YANKEE NUCLEAR POWER PLANT

LICENSE RENEWAL

CONSIDERATIONS

Prepared for:

**THE WINDHAM COUNTY
REGIONAL COMMISSION**

Windham County, Vermont

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Executive Summary

Planning ought to consider "What is our fair share" of societies' burdens, as well as what is "best for us." Not In My Back Yard (NIMBY) by everyone results in nothing more being built anywhere.

Considerations in the license renewal of the Vermont Yankee plant include its 35 year record to date and the expected Political, Environmental, and Economic and Power effects and events. The impacts of the plant will be minimal. Shutting down the plant may contribute to the problems of New England's dependence on natural gas, which might lead to regional rolling blackouts.

Political intervention is expected to be a constant. An educational program to help alleviate the mental health effect of those afraid of the plant should be considered.

A Planning Basis for Vermont Yankee includes all reasonably expected technologies and events. License renewal is expected. Planning for needed generation beyond Vermont Yankee should begin within the next few years.

Introduction

The Windham County Regional Commission is charged with assisting towns in planning. As part of its process the Commission is charged with reviewing applications to the State Public Service Board for certificates of Public Good. Entergy Vermont Yankee Corporation has submitted information to the Commission that it intends to apply to the Public Service Board for a Certificate to continue the operation of its Vermont Yankee Nuclear Power Plant. Entergy Vermont Yankee's application to the US Nuclear Regulatory Commission for a renewal of its license to operate the plant is currently under review. The plant was originally licensed to operate for forty years and began operation in 1972. The license expires in 2012. A twenty year renewal is sought. The Commission's Energy Committee is reviewing the application and will submit comments to the Public Service Board.

These Considerations have been formulated by a Nuclear Engineer whose entire career has been in nuclear power and electric power plants, and who has had a parallel career in public outreach and politics. He served a year as a Congressional Fellow in 2001, on the Energy Subcommittee of the House Committee on Science.

The Considerations are a combined scientific, engineering and political reality evaluation.

Philosophy for Planning

Shall towns who are members of the Commission plan on only what is "best for the town?" Or is part of their consideration "What is our fair share of societies' burdens?" Facilities and activities that have undesirable or less desirable impacts need to go somewhere. These facilities are needed by the state/country/world as a whole. When these facilities or activities are placed, it is reasonable and legitimate to insist that impacts be mitigated to the extent reasonable, and the impacts be compensated in some way. A common example is the impact of children of those on military bases attending public schools in surrounding towns. The federal facilities don't pay state or local taxes, so the federal government pays for the children's education in the schools. The usual practice throughout the country, to compensate localities for the impact of facilities like power plants and factories, is to allow them to keep all the property taxes from the facility, even though the impact may reach beyond the town and county lines, or even cross state lines.

An unforeseen result of the environmental movement seems to have been to motivate some citizens to say "Not In My Backyard" (NIMBY) to practically every proposal. Practiced by everyone, NIMBY leads to no new facilities anywhere. A static economy and infrastructure with a growing population and economy is of course impossible.

CONSIDERATIONS

Political Impact

Until the Vermont Yankee site has been returned to “Greenfield” conditions, those opposed to the plant will be intervening in the process and raising issues. This is their right in our democracy. Shutting down Vermont Yankee today will not make the political turmoil go away. This is perfectly clear based on the results of the Yankee (Rowe, MA) plant decommissioning. Some evaluate this as a benefit, some as a negative impact. In any case, it will be a constant.

This will continue to be a difficult problem because there is a collision of “two different worlds.” One world looks at risk compared to perfection, and the other compares risks among alternatives. One seems to assume radiation comes only from nuclear power plants, and the other assumes the scientific view, that we live in a sea of natural radiation, and choose to add bit more to benefit society.

Environmental Impact

The plant has been in operation for 35 years, with an Environmental Monitoring program as part of its license. The program began before construction to develop baseline data. Plant discharges are monitored as required. This history should be a sufficient basis on which to base a judgment on the impact of a license renewal. Other activities which affect the environment have been happening at the same time.

Radiological Impact

Data from the Yankee (Rowe) plant’s Environmental reports show a continual decrease in the radioactivity downstream from the plant during the plant’s life. The opponents approach is to attribute all negative changes to the plant, without scientifically demonstrating the cause-effect link. Using their approach, it could be concluded that the Yankee plant was cleaning up the river. In fact the decrease was the natural result of stopping the input of radioactive particles by stopping the atmospheric testing of nuclear weapons (1963) after the plant began operation (1960). Vermont Yankee’s data should show the same trend. The BEIR 7 Report still shows that a small portion of everyone’s exposure is due to “Fallout.”

Recently the press has reported foreign studies of childhood Leukemia in the vicinity of a few nuclear power plants. According to the reports the studies only have two elements: 1. the plant is there, and 2. something bad happened. Medical Science does not yet know the initiating cause of this terrible disease, so attributing it to the radiation from a nearby plant, which exists in the much larger sea of natural radiation in which we all exist, is not scientific. If health effects specific to certain radioactive isotopes were occurring, concluding that a plant was the cause requires two things. The plant must be shown to be releasing the isotope, and that it is reaching those affected in sufficient concentration to create the health effects occurring. Only this scientific approach will prove that a plant or other source is the cause.

Radiological Impact (continued)

Opponents of the plant cite variations in cancer statistics in Windham County as caused by the plant. These assertions are political, not scientific since they are of the type mentioned. The plant is there. Something bad happened. Therefore the plant caused it.

There is over a century of experience with natural and man-made radiation. Research has been continuous. The first International Standards were adopted in 1928.

River Impact

Locally, the Environmental Monitoring program for the plant documents the effects on the river. It is sometimes forgotten that the Connecticut River was known as the world's most beautifully landscaped sewer. The Clean Water act of the 1960's has been having its effect as pollution sources have been removed over the decades. A Fish Ladder was installed around the Vernon Dam. These examples illustrate that that multiple changes to the river have been and are taking place simultaneously.

In the hearings on the plant's request to raise the discharge temperature to the river from the Cooling Towers in the summer by one degree, the press reported that it was stated that a certain fish population down river from the dam had decreased. There was no linkage to the plant reported in the press. Was fishing increased? Again, this is a case of blaming everything on the plant.

The monitoring data and experience should be sufficient to judge that the plant may continue in operation beyond the current license. Additional monitoring might or might not be needed.

Changes to the mode of operation of the plant's cooling system are possible, if necessary. Design changes to the Cooling Tower system are also physically possible.

Life Cycle Effects on the Planet

The Commission is currently having the plant respond to questions about CO2 releases to the air from fuel enrichment and the entire manufacturing and decommissioning process of the plant. There are some impacts. Mining/drilling, transportation and manufacturing are common to many energy sources. No mention was made of the entire life cycle impacts of wind, solar, geothermal and hydro energy sources. Studies of the life cycle impacts of all energy sources have been done and documented in past decades. The fact that these studies are not mentioned by those raising the objection may tell more about the objectors than about the plant.

In any case, considering adverse environmental impacts of the life cycle of any technology as a measure of performance is a "red herring". It concedes that the impacts of those processes will not be mitigated. For example, manufacturing of concrete (kilning) is one of the planet's significant CO2 sources. This will certainly need to be corrected.

Plant Accidents Affecting the Public

Such events are possible, but so very unlikely that Congress judged that nuclear power is a good alternative to burning coal for electric power production. Possible accident sequences all unfold over many hours, allowing more than adequate time for Operator (those at the plant and those called in) intervention to break the sequences. Should an accident sequence be moving toward a significant release of radioactivity from the plant, a precautionary evacuation would be recommend to the Governor, in time to allow people to leave ahead of the projected release. An accident sequence might be broken after an evacuation was ordered, or after a release had begun. Attempts to stop and reverse the accident sequence would not stop.

The accident at the Three Mile Island Unit 2 plant is the correct example to use to evaluate the class of accidents that could affect the public. At that plant the fuel core was melting, but stopped by Operator action. There was no significant release. At that time Emergency Plans were not yet required, so there was public chaos, and panic by some people. The traumatic mental effects of this event still affect some.

Having the plant requires having the Emergency Plan, most of which is paid for by the plant. Were there no plant an Emergency Plan is still required for other hazards in the county. The river, railroad, highways, and severe weather all require a FEMA approved plan. The plan needed because of the plant has put the region ahead of many others. Many consider this a positive benefit of the plant!

Mental Health Effects

There are some people who profess to be afraid of the plant. I believe their fear is genuine. How much this may affect their mental and physical health is hard to judge. Some opponents say they are among the fearful. Educational measures to address their fears might be considered as part of continuing operation of the plant.

Economics and Power

The plant pays local and state taxes and provides jobs, and will for a long time. The amount of taxes and jobs will depend on the activity – operating, decommissioning, or just spent fuel storage.

The plant now provides power below market cost. The Vermont Electric Plan seems clear that future prices will not go down for the foreseeable future, because the region is using natural gas for a significant part of its electric power.

When Vermont Yankee is not operating power is supplied from “the grid,” mostly from natural gas generation.

What is not mentioned are the limits on the New England natural gas supply for a growing economy and a growing electrical demand. New pipelines and new LNG terminals will be needed to increase supply, but NIMBY rules. Transmission line capacity connecting to the regions is limited too. New England appears to be backing into regional rolling blackouts in the future.

Economics and Power (continued)

In this situation, shutting down a large generating source within the region and within Vermont does not seem very prudent, either for the state or New England.

Replacing gasoline with electricity will add an additional burden to the electric power supply system. This will happen with "plug in hybrid" cars, which will penetrate the market rapidly based on the price of gasoline and greenhouse gas regulations. When these cars are discussed, no mention is made of how the power to supply the cars will be generated. It makes little sense to generate electric power for the batteries in hybrid cars by burning natural gas or coal in the long run. Some of this will be needed to help the cars penetrate the market.

Shortly after plug-in hybrid cars with Internal Combustion engines run on gas/ethanol have entered the market, hydrogen fuel cell cars will appear. These have been built and tested, so the technology is proven. Engineering for manufacturing, price and market needs is in progress. These cars will be like the plug in hybrids, but with a fuel cell instead of the internal combustion engine. Missing in many discussions of the "hydrogen economy" is the fact that hydrogen can and is being made locally in the area needed, using electricity. Every existing convenience store with gas and other pumps can add a "hydrogen pump." Whether they will or not will depend on cost. This will add an additional load to the electric power generation needs.

Energy conservation and efficiency can and eventually will provide a large reduction in projected energy use. It is logical that this is so, since a great deal of our older infrastructure was designed and built on the belief that energy was and would be cheap, and the environment was a free sewer. The record to date proves that the savings are there. Achieving these savings will continue to be a slow process. The slowness may be understood by examining the situation of the average homeowner. The homeowner may want to improve building efficiency, but needs to know what to do, how to do it, and to finance it. The Vermont Electric Efficiency Utility overcomes these obstacles. The proposed all-fuels efficiency utility is needed.

continued

Planning Basis for Vermont Yankee

The most likely events are:

- The license is renewed for 20 years. Plants of the same product line have had licenses renewed, and there is a financial incentive for Entergy to solve any problems encountered in the renewal process.

- The used fuel will remain on the site beyond the Decommissioning period. It will eventually be removed for recycling, and due to political pressure.

- The site will continue to be needed as a tie point in the transmission grid, and according to a note in the Commission's meeting minutes, plans are already being made to do so.

- Political opposition will be continuous.

- New generation in Vermont will be desirable, as opposed to relying on outside sources. This will be true even with a renewed an increased supply from Hydro Quebec.

- Wind generation will expand well beyond that currently planned and envisioned.

- Distributed generation will be built using sustainably harvested local wood. There are no other local fuel sources for distributed generation.

- Solar electric power with batteries in homes, and local hydrogen generation and storage, plus storage in plug-in fuel cell cars, will eventually provide a significant part of peaking power.

- Net, time of day metering, coupled with Dispatcher controlled demand management of loads, will significantly trim peak electric demand.

- Large amounts of base load generation will be needed.

- Beginning planning for new generation beyond the end of Vermont Yankee's life in 2032 in the next few years will appear prudent, considering the time it now takes to license and build new generation.

END

Radioactive Waste Disposal

Nature's Way vs. Government's Way

Bernard L. Cohen
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Perhaps the principal reservation cited against using nuclear power for generating electricity is the problem of disposing of the highly radioactive waste (radwaste) in the spent fuel after it is removed from reactors. The widely recognized solution for that problem is to bury it deep underground -- a commonly considered depth is 2000 ft. How safe would that be?

It is universally agreed that the principal danger is that this buried radwaste will be contacted and dissolved by groundwater, transported in this solution as it works its way toward the surface, and eventually ingested by people with potable water, that used for drinking and preparing food -- 40% of our potable water is derived from groundwater. Once inside the body, where it may remain for many years, the radioactive materials continually expose body organs to radiation which can cause cancer.

The details of estimating the radiation dose to various body organs from ingesting a given quantity of each radioactive species are well worked out and published by the International Commission on Radiological Protection (ICRP), and the cancer risk from these radiation doses is estimated in publications by the National Academy of Sciences Committee on Biological Effects of Ionizing Radiation (BEIR) and the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR). Using these we can estimate the number of fatal cancers that would be caused if all of the buried radwaste from U.S. nuclear power plants were converted into digestible form and fed to people. We define this as the number of cancer doses, CD, in that radwaste. (This assumes that there are enough people involved so that none of the toxicity is wasted by feeding more than a fraction of one CD to any one individual.)

The number of CD in the ground from buried radwaste will depend on how many nuclear power plants we continually operate and on when we convert to chemical reprocessing of radwaste. Calculations are presented in my recent papers published in Health Physics Journal*. With reasonable assumptions, it is concluded that over the next several thousand years there will be something like 2 trillion CD buried, presumably 2000 ft below various locations throughout the contiguous 48 U.S. states.

How many cancers will this cause and how acceptable is the situation from the standpoint of public health? This depends on details of how the waste is buried, and there are two approaches to that operation -- there is Nature's way, and Government's way.

Nature's Way

One option is to convert the radwaste into rock-like materials and assume that nature will treat this radwaste-rock as it treats other rocks -- we call this "Nature's way". What do we know about how nature treats radioactive rocks?

Each ton of rock in the ground contains an average of 1.7 grams of Uranium and 5.8 grams of Thorium. Both of these elements emit radiation, and in the process are converted to other elements, most importantly Radium, which also emits radiation. The quantities of these naturally occurring materials in the top 2000 ft of U.S. rock -- that is, closer to the surface (and hence more potentially dangerous) than the buried radwaste -- comes to 30 trillion CD, 15 times the number of CD in the radwaste below it.

In the normal course of events, Nature allows some of this Uranium, Thorium, Radium, etc. to be dissolved out by groundwater and eventually to be ingested by people with potable water, exposing their body organs to radiation. From measurements on human corpses, we know how much of these naturally radioactive materials is in our bodies, and the radiation dose to which they expose us. From that dose, using BEIR and UNSCEAR publications, we can estimate the number of cancer deaths per year caused by this radiation. Chemical analyses of foods and water supplies tells us what fraction of these materials is derived from potable water rather than from food -- materials in food were picked up by plant roots in the top few feet of soil that is normally watered by rain or river water irrigation soaking down from above. The conclusion is that ingestion of these naturally radioactive materials with potable water causes about 68 cancer deaths per year in the U.S.

Since only 40% of our potable water is derived from groundwater, our estimate of the number of deaths from groundwater-derived natural radioactivity is reduced to 40% of 68, or 29. As these deaths are caused by the 30 trillion CD in the ground, this is about one death per year per CD. A more detailed analysis provides an estimate individually for each of the 8 naturally radioactive materials involved; the average of the 8 results is 1.3 deaths per year per trillion CD in the ground.

Nature's Way ***continued*:**

Applying these results to the 2 trillion CD in the buried radwaste from nuclear power plants gives us an estimate of about 2 deaths per year expected from the latter. However there are several reasons why this is an over-estimate:

- The nuclear power radwastes will be buried at 2000 ft depth whereas the natural radioactivity we are considering is at depths between there and the surface through which the average groundwater flow is 7 times larger than at 2000 ft, so the above result should be divided by 7.

- There is a substantial time delay in travel from deep underground to near the surface for materials dissolved in ground water -- these materials are temporarily filtered out by the rock though which the water passes, causing travel times to be many thousands (or even millions) of years -- during which large fractions of the radioactivity in the radwaste decay away.

- The holes in which the radwaste-rock would be emplaced would be backfilled with a special clay (bentonite) that swell up when wet to block further water intrusion, and if the waste is eventually contacted and dissolved, this clay efficiently filters escaping radioactive materials out of groundwater, greatly extending its travel time.

- The medical cure rate for cancer is improving at a rate of about one percent per year so the great majority of the cancers predicted in our calculation, occurring thousands (or more) of years in the future, will probably be easily cured.

- Our calculation is based on <u>average</u> conditions in the ground throughout the U.S. whereas radwaste repositories will be built at sites carefully selected by the best experts in geology and hydrology to provide maximum security.

- It would be very easy to detect any substantial amount of escaping radioactivity from these sites if it should occur, so measures could be taken to greatly reduce human exposures.

Our final conclusion is, then, that if we took advantage of Nature's way, converting the radwaste into rocks and burying them in the natural habitat of rocks, deep underground, this buried radwaste would cause far less than one death per year in the U.S.

Nature's Way ***(continued)*****:**

There are other completely independent ways of arriving at this conclusion presented in my other scientific publications**.For example, from analysis of water carried by our rivers into the oceans, we know that, on average, 12 millionths of a foot of rock thickness under U.S. is being dissolved away each year, and from hydrology studies we know that about 1/12,000 of this is derived from one foot of depth at 2000 feet below the surface. Thus, 1/12,000 of 12 millionth, one billionth of a foot of depth is dissolved out of one foot of depth each year, so an average atom in this rock has one chance in a billion per year of being dissolved into groundwater.

We know the amount of potable water ingested by U.S citizens each year, and dividing this by the total annual U.S. groundwater flow tells us that an average atom dissolved in groundwater has one chance in 2000 of being ingested by a human. Thus an atom of buried radwaste rock has one chance in 2000-billion -- one chance in 2 trillion -- per year of entering a human stomach. Applying this to the yearly contribution from each of the radioactive components in buried radwaste as they decay away with time gives us a result agreeing with the our previous conclusion from Uranium, Thorium, etc. These studies include estimated contributions from groundwater entering rivers that are used for potable water, from people eating fish who inhabited those rivers, and from using groundwater to irrigate food crops, but these have only minor effects on the conclusion.

All of the estimates described here have been published in widely read scientific journals, and none of them has been challenged, or even criticized in the scientific literature. It thus seems clear that if we were to utilize Nature's way of managing radwaste, converting it into rocks and burying them deep underground, we could expect something less than one cancer death per year in U.S. to result. This surely compares very favorably with the many thousands of deaths per year being caused right now by the wastes, principally air pollution, from generating the same amount of electricity by burning fossil fuels. Following Nature's way would be a simple and very acceptable solution to the issue of radwaste disposal.

Government's Way

For the problem of radwaste burial, the U.S. government approaches safety issues mainly through three agencies. Nuclear Regulatory Commission (NRC) sets up licensing procedures for repositories, these must be approved by Environmental Protection Agency (EPA), and Department of Energy (DOE) designs repositories and applies to NRC for a license to build and operate them. All of this is subject to substantial interactions with the public including government financing for activities of opposition organizations and their legal appeals to Federal courts. The entire process involves roles for the President, the Secretary of Energy, the government of the host state, and final approval by Congress. Obviously, these procedures introduce extensive political activity.

The principal licensing requirement set up by this system is that DOE must demonstrate with high confidence that at no time in the next million years will any single individual member of the public be exposed to a stipulated radiation dose (15 millirem) in any one year. This dose would give him a risk (assuming there is no progress in curing cancer from now until that time) equal to 2% of the average American's present risk of being killed in an accident in any one year.

There is no stipulation on how many other people are exposed to that or lower doses; or over what time period these exposures occur, so there is no consideration given to the total number of cancers caused. Isn't that what we should be concerned about? With the present licensing requirement, nuclear bomb testing in the atmosphere could be licensed as no one person has received even one-half of the stipulated doses, but that practice was abandoned in 1962 because it was estimated to be killing thousands of people every year.

This licensing process precludes any direct use of Nature's way. The calculations described above for Nature's way utilize data averaged over the entire U.S. Its result, less than one death per year, is equivalent to the consequences of sitting a large number of repositories at random locations throughout the U.S. But it does not predict the effects of a single repository at a specific site. I have proposed** that it is reasonable to assume that utilizing all the expert knowledge of geologists and hydrologists would select repository sites at least as secure as random selections. But Government agencies allow no place in the licensing procedures for such an assumption.

Government's Way ***(continued:)***

If the radwaste were simply converted into rocks and buried deep underground, licensing would require knowledge of, and future predictions for, all aspects of groundwater behavior at that site including effects of possible earthquakes and volcanic action in the vicinity, different future climates (10,000 years ago the Arizona desert was a rain forest and the Sahara desert was well watered), unpredictable geological land uplifting which often drastically alters river and groundwater flow patterns, intrusion by humans and lower life forms, etc. These are automatically taken into account in Nature's way because they are occurring in some U.S. locales now and hence contribute to the averages used in the calculations.

Aside from problems in predicting the future, we do not well understand the present details of Nature's way -- the interactions between factors involved in dissolution of rock by groundwater and its subsequent transport, such as the chemical composition and granular nature of the rock, the chemical composition of the groundwater, effects of cracks in the rock, etc.

The DOE solution to this problem is not to depend on Nature's way, but rather to install the waste in a large underground man-made storage chamber in which everything is designed so as to prevent, or at least greatly delay, contact with groundwater. It includes parts made of corrosion-resistant titanium, of other special corrosion-resistant metal alloys, of stainless steel, and of carbon steel, with devices for conducting away the heat from the radioactivity. The design includes provisions for preventing and/or mitigating effects of water dripping into this chamber, of falling rock, and of a large variety of other possible intrusions.

In summary, Government's way is to depend heavily on technology to prevent, or at least delay encounters with groundwater, in contrast to Nature's way in which radwaste rock is ordinarily exposed to groundwater from the time of burial. There is a problem here in that if and when encounters with groundwater do occur in Government's way, they are under rather different circumstances than contact with groundwater in Nature's way. Can we be confident that this does not severely compromise the results?

In order to satisfy the licensing requirement utilizing Government's way, it is necessary that everything be calculated for the specific site. Such calculations require that assumptions be made about processes that are not well understood and about the probabilities for various possible future disrupting circumstances.

Government's Way *(continued):*

That introduces a very serious problem in that these assumptions involve personal judgments. Such judgments can be debated, negotiated, and agreed upon by scientific experts trying to reach a consensus. But the political debate is dominated by non-experts who have never studied the thousands of pages of scientific input leading to these judgments. Many of them are committed to opposing any such consensus, motivated by politically useful slogans such as "we don't want our area to be the nation's garbage dump". Politics in Nevada, where the first repository is being planned, requires that any candidate for political office adopt that position, and that includes Senator Harry Reid who now directs the U.S. Senate and has vowed to do anything in his very considerable power to obstruct the process.

Needless to say, this licensing procedure requires a lot of time and a lot of money. More than 15 years and 5 Billion dollars has already been spent on the licensing of the proposed Nevada repository, and the end is hardly in sight. The opponents, including Senator Reid, argue that there is no urgency to making a final decision as the waste is now being safely stored at the various nuclear plants where it is generated.

However the lack of a decision is impeding the construction of new nuclear power plants. Some states, including California, legally prohibit such new construction until the radwaste problem is "solved", and some utility executives refuse to consider undertaking such construction fearing the political impacts of that "unsolved problem". Since nuclear power is the principal source we have for generating electricity without contributing to global warming, the current situation is a real obstacle to our future energy security. And it is all caused by irrational politics._______

* Understanding the toxicity of buried radioactive waste and its impact, Health Phys 89;355-358;2005 and 91:394-396;2006
** Probabilistic risk analysis for a high level waste repository, Risk Analysis 23:909- 915;2003

Risk Analysis of Buried Waste from Electricity Generation, Am Jour. Of Phys. 54, 38 (1986).

The Downside of Nuclear Power- By an Advocate

Howard C. Shaffer∗ - from the Vermont Journal of Environmental Law

Format enhanced for the Windham Regional Commission Testimony

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 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

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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).

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 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

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

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 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 nuclear reactors could be safely sited throughout the country.[11] Congress authorized power reactors, nuclear medicine, industrial isotope

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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," 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.

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 <u>sole</u> 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 <u>only</u> 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.

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 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 Trap Rock 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:

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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 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.

- 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.

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 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

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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.*

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

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 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]

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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 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 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.

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 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

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).

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.fs

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 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.

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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).
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).