

Looking for a Climate Signal in the US Nuclear Power Debate

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Abstract

Will concern about the likely effects of carbon emissions impact the willingness of people and organizations to accept the construction of new nuclear power plants in the United States? Analysts, environmental organizations, and the electric power industry agree that climate change has the potential to influence the ongoing debate about nuclear power, but no organization advocates a decisive shift from fossil fuels to nuclear power for electrical generation. Companies that own nuclear power plants also burn fossil fuels to generate electricity and therefore cannot be expected to support such a shift, and environmental organizations generally oppose the use of nuclear reactors to generate electricity. Emissions-trading programs offer contexts in which debates about the future role of nuclear power plants can occur. New Hampshire's decision to allocate allowances to emit oxides of nitrogen to the Seabrook nuclear plant serves as a useful case study. Participants in the Regional Greenhouse Gas Initiative process are considering possible emissions reduction strategies for the relatively nuclear-reliant Northeast. Twenty-seven of these people were interviewed for this project to understand how knowledgeable people are integrating knowledge about climate change with opinions about nuclear power. These interviews do document a climate signal in the debate about nuclear power, but they also show that concern about climate change has not resulted in substantial new support for the use of nuclear power to generate electricity.

Chapter 1: Introduction

Like wind turbines, photovoltaic panels, and hydroelectric dams, nuclear power plants generate electricity without the carbon dioxide emissions that result from burning fossil fuels (IPCC 2001). Concern about the effects of these emissions on the Earth's climate has strengthened the consensus that there is a general need to increase the amount of electricity generated from energy sources other than fossil fuels. This thesis is about a controversial question that follows naturally from these two relatively uncontroversial statements. Will this general need for non-carbon-emitting generation influence opinions and positions about the possible future construction of nuclear power plants in the United States?

It is important to consider this question because the threat posed by climate change is becoming more urgent, and people and organizations are beginning to seriously consider how to limit carbon emissions in the coming decades. One option is to extract energy from sources other than fossil fuels, and nuclear power plants are currently the most widely deployed carbon-free energy source in the United States. Because all of the one hundred nuclear plants that provide about one fifth of our electricity are scheduled to be decommissioned before 2050, even people and organizations opposed to the expanded use of nuclear power may experience pressure to consider new nuclear reactors to replace the current fleet so that other technologies can be used exclusively to offset fossil fuel consumption. On the other hand, history suggests that some will oppose any construction

of new nuclear plants, and no reactor has been ordered and subsequently completed in the United States for several decades.

The future construction of nuclear power plants depends on the alignment of a large number of interlinked political and economic forces; this thesis does not disentangle these forces but instead evaluates whether and how concern about the effects of carbon pollution is leading to changes in opinions and positions about nuclear power. Such changes would be of practical interest because planners would like to be able characterize plausible energy futures as they consider possible responses to climate change, and they currently do not know how people and organizations will react if other relevant forces lead to proposals to construct nuclear power plants. It is also of theoretical interest because it has the potential to yield insight into how people and organizations weigh qualitatively different risks such as those posed by climate change and those posed by nuclear power plants.

Chapter two of this thesis reviews relevant current literature. While reports from a number of expert panels have asserted that concern about climate change should motivate careful reconsideration of the future of nuclear power, there is little explicit support for the construction of new reactors as a response to climate change. The technical literature that could inform such support is vast and technically robust, but many authors caution against expecting to find smooth connections between technically based arguments and changes in opinions, positions, and policies. Surveys of public opinion show no consensus about new nuclear power plants, and statements from prominent politicians and references in the popular press show how some political actors are beginning to integrate climate concerns into positions and opinions about the future of nuclear power.

To my knowledge, this research represents the first substantive attempt to characterize the relationship between concern about climate change and opinions about nuclear power

Subsequent chapters of this thesis describe the results of my efforts to look closely at individuals, organizations, and policies for clues about the likely structure of future debates about nuclear power in the context of climate change. While there is ample evidence of a climate signal in debates about the future of nuclear power, these chapters show that significant obstacles impede the translation of climate concerns into the acceptance of hypothetical new nuclear power plants in the United States. These obstacles include aspects of the structure of relevant organizations, characteristics of specific policy instruments that may be used to address climate change, perceived economic and technical problems with nuclear technology, and enthusiasm about other non-nuclear carbon-free technologies for electrical generation. For these reasons it is presently impossible to predict whether concern about climate change will ever drive increased acceptance of new nuclear power plants for electricity generation.

On the other hand, this research may serve as a complement to the huge amounts of technical data about nuclear power and climate change that are available from institutions such as the United States Department of Energy and the Intergovernmental Panel on Climate Change. A primary purpose for the creation of information about energy and the environment is to support the development of effective policy, but the continued production of technical data has certainly not yet led to the development of effective climate policy in the United States. A better understanding of people and organizations that are actually considering climate-related questions may help to facilitate progress. It is my hope that this thesis can make a contribution toward this goal by

describing important aspects of the debate about nuclear power in the context of climate change.

I began the research that led me to these conclusions by carefully studying the debate about a controversial decision to explicitly include a nuclear power plant in a program to limit air emissions in New Hampshire. While the program does not address carbon emissions, participants in the debate and other analysts expressed the opinion that the decision was significant partly because of the potential to set precedent for future efforts to address climate change. No comprehensive program to limit carbon emissions has yet been implemented, so this case remains important. It shows how various actors reacted to a specific proposal of a type that could ultimately be made as part of a program to regulate carbon emissions, and, because there is already a specific regulatory structure in place, it offers a tractable context in which to consider the difficult analytical problem of how nuclear reactors can be treated by future carbon-based cap-and-trade programs.

Two types of organizations participated actively in the debate described above and can therefore be expected to play significant roles in future debates about nuclear power in the context of climate change: companies that own nuclear power plants and environmental organizations. Reactor owners make up a self-described “nuclear industry,” and extensive data analysis was conducted to illustrate the degree to which these companies are reliant on nuclear power and other fuels, especially coal, to produce electricity. Annual statements were also studied for clues about how expectations of climate change may influence decisions about the future use of nuclear power. My study of environmental organizations began with a broad survey of web sites and other public

sources for references to nuclear power. As my research progressed, my focus narrowed to include only references to climate change from organizations that participated in the debates described in other parts of this thesis. These two types of organizations were selected partly because they are influential and active in debates about nuclear power and partly to assess whether conflicts about nuclear power can meaningfully be characterized as conflicts between “environmentalists” and the “nuclear industry.”

For the final and most substantial phase of my research I studied the Regional Greenhouse Gas Initiative process, which included public meetings during which people, representing stakeholder organizations, discussed the design and implementation of a cap-and-trade regulation for carbon emissions from electric power plants in the northeastern United States. I began by documenting the degree to which the region relies on nuclear power for energy production. Next I searched public comments from environmental organizations, energy companies, and others for references to nuclear power. Finally interviews with participants were conducted, transcribed, and analyzed to develop a more nuanced description of how knowledgeable people actually think about the possibility that concern about climate change may eventually lead to the construction of new nuclear reactors in the United States. This research yielded important new insights, and it also contributed greatly to the degree to which I am able to confidently describe some of the more obvious aspects of the debate.

The results of my research are presented in five chapters. Chapter three documents the use of the term “nuclear industry” and shows that many companies that own nuclear power plants also own coal-fired power plants and therefore cannot be

expected to support strong climate policies of the type that could stimulate the construction of new reactors. Chapter four shows that environmental organizations generally do not support the construction of new nuclear power plants as a response to climate change, and also provides examples of how these organizations connect, or do not connect, positions about nuclear power with positions about climate change. Chapter five describes the controversial and potentially precedent-setting decision by the state of New Hampshire to allocate permits to emit smog-forming pollution to a nuclear power plant. Chapter six introduces and describes relevant aspects of the Regional Greenhouse Gas Initiative (RGGI), a multi-state effort to control carbon emissions from fossil-fueled electric power plants with a cap and trade regulatory system. Chapter seven draws on interviews with RGGI participants to document ways in which well-informed and concerned citizens may integrate concern about climate change into existing attitudes about nuclear power plants. A short final chapter draws together conclusions from various parts of the thesis and recommends further research in several areas.

Chapter 2: Literature Review

This chapter reviews literature that may be useful for understanding opinions and positions about nuclear power in the context of climate change. The chapter begins with a very short introduction to relevant technical literature in the areas of climate change, nuclear power, and alternative energy sources. The second section presents examples that show how various expert panels and prominent environmentalists have acknowledged and begun to address the connection between nuclear power and climate change. The work of several social scientists who argue that the direct study of people and organizations is crucial for understanding controversies about science and technology is discussed next. The chapter concludes with examples that show how public debates are addressing the issue and uses specific examples to support the assertion that concern about climate change is beginning to play a role in discussions about the future use of nuclear power plants to generate electricity in the United States.

Technical notes on climate change, nuclear power, and alternative energy sources

The available scientific literature about climate change is vast and technical, but there are several essentially scientific conclusions that drive debates over climate change, including the debate about nuclear power (Houghton 1997): (1) Human activity is altering the composition of the atmosphere in significant and measurable ways. This, in itself, may bother some people; (2) There is a vast and diverse body of evidence that the Earth's climate has begun to change, and this change has been linked, only somewhat less

conclusively, to changes in the chemical composition of Earth's atmosphere; (3)

Although the most likely future is one in which Earth's climate responds by becoming progressively warmer, there is much uncertainty about the overall amount and rate of warming, and about the distribution of change across the globe. Effects on people are likely to depend on the rapidity of the change and the ability of people to adapt; (4) The economic and political systems of the Earth are intimately linked to the production of atmospheric pollution, particularly carbon dioxide, and therefore, if the problem is to be addressed, the burden must necessarily fall mostly on economic and political actors. These actors may include scientists but science and its complement, technology, cannot solve the problem independently. These four conclusions must also inform attempts to weigh the risks of new nuclear power plants in the context of increasing concern about climate change.

The available literature about nuclear power is also vast, technical, and controversial. Particularly useful summaries include *The Future of Nuclear Power: An Interdisciplinary MIT Study* (Deutch, Moniz, et al. 2003) and *Megawatts and Megatons: The Future of Nuclear Power and Nuclear Weapons* (Garwin and Charpak 2002); both of these sources support the following summary of the major issues that surround nuclear reactor technology. Risks imposed on society by nuclear power plants stem largely from the fact that reactors produce, and reactor sites store, large and constantly increasing amounts of very highly radioactive used fuel. This fuel could melt inside the reactor core, it could be accidentally released into the environment soon or long after having been removed from the reactor, or it could be diverted for use in weapons production. Elaborate and constantly improving plans for safe operation and on-site used fuel storage

are in place, and the operating record of nuclear plants has been excellent for at least the past 25 years. On the other hand, many continue to question whether nuclear power plants can ever be adequately guarded against both accidents and outside attacks, and efforts to permanently isolate used fuel have yet to progress beyond preliminary planning stages. New reactor designs may represent improvement over existing reactors, but there is little reason to expect that these concerns will ever be fully addressed. Complex sub-debates continue about the link between nuclear power and nuclear weapons (see *Nuclear Power and the Spread of Nuclear Weapons: Can We Have One Without the Other?* Levanthal *et al.* 2002) and the link between radiation and cancer (see *Radiation Standards: Scientific Basis Inconclusive, and EPA and NRC Disagreement Continues*; GAO 2000). A some what more extensive introduction to technical issues related to nuclear power is included as Appendix E.

There is little question that renewable resources, especially wind power and solar power, have the technical potential to facilitate needed emissions reductions without the construction of new nuclear reactors. In many cases solar panels covering rooftops can collect enough energy to meet the demands of the people inside, and wind turbines, deployed widely, could supply the energy needed for other uses (Berinstein 2001). A variety of other renewable energy sources can also contribute (Herzog 2001), and carbon sequestration technology may even allow for the continued extraction of energy from fossil fuels without carbon pollution (Houghton 1997). The fact that the wind and sun do not necessarily provide energy when it is demanded could eventually present a technical challenge, but the wide deployment of energy storage systems, such as those based on hydrogen fuel, could solve this problem and even eventually facilitate the use of wind

and solar energy for transportation (Berinstein 2001). Conservation, both in the form of technical improvements in energy efficiency and as simple reductions in consumption, also has the potential to render some of this infrastructure unnecessary. On the other hand, financial considerations, regulatory obstacles, and the need to locate huge numbers of suitable sites for grid-connected renewable energy installations impede swift realization of this technical potential, and fossil fuels and nuclear power continue to provide energy for more than ninety percent of US electricity generation (Cheney 2001). Short descriptions of a range of energy technologies are included in Appendix F.

Nuclear power, climate change, and energy policy

The technical potential for the increased use of nuclear power to play a role in addressing the problem of carbon emissions has been described by a number of experts and panels:

- The Intergovernmental Panel on Climate Change reported in 2001 that, according to its analysis of the available literature, nuclear power “is an effective mitigation option, especially by way of investments in the lifetime extension of existing plants (IPCC 2001).”
- The National Commission on Energy Policy concluded in 2004 that “the crucial challenge of capping and ultimately reducing U.S. and world greenhouse gas emissions would be considerably more difficult without the contribution that expanding nuclear electricity generation could make to this task (Holdren, Reilly, Rowe, *et al.* 2004).”

- In the introduction to *Double or Quits: The Global Future of Civil Nuclear Energy*, Malcolm C. Grimston and Peter Beck assert that increasing the use nuclear power is one of four options that “will be available to meet both growing world demand and greenhouse gas emission constraints” and argue that “given the enormous uncertainties that lie ahead in the energy field, on both supply and demand sides, it is quite possible that some combination of all four will be needed (Grimston and Beck 2002).”
- *The Future of Nuclear Power: An MIT Interdisciplinary Study* offered climate change as the primary justification for an exploration of the potential to triple worldwide nuclear energy production by 2050 (Deutch *et al.* 2003).
- Vaclav Smil concludes his *Energy at the Crossroads: Global Perspectives and Uncertainties* with a chapter on “Possible Futures,” in which he writes: “The energy intensity of the global economy will continue to fall but the quality of the supplied energy will rise as a larger share of it will be consumed as electricity and natural gas. More electricity will be generated by conversions of renewable flows but, in accord with historically long transition times, the shift from today’s predominantly fossil-fuel-based system to one dominated by conversions of direct and indirect solar flows will not be completed before 2050. The greatest uncertainties concern the future contributions of nuclear generation. Even in the short run (until 2020) it is not certain if it will retain an important, albeit diminished, share of aggregate electricity supply, or if it will shrink

to less than 10% of the total output. Its long run fortunes are anybody's guess (Smil 2003).”

- Writing in *Science* magazine in 2004, Stephen Pacala and Robert Socolow of Princeton University asserted that “humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century” and listed a doubling of worldwide nuclear generating capacity as one of fifteen “strategies available to reduce . . . carbon emissions from 2004 to 2054 by 25 GtC (Pacala and Socolow 2004).”

All of these sources assert the technical possibility that the construction of new nuclear power plants may play a role in future efforts to control greenhouse gas emissions, and they all suggest another point that is even more relevant to the current project: Within a broad spectrum of possibilities that ranges from rapid phase-out to substantial expansion, the future of nuclear power is uncertain and not technically constrained. Economic and political forces will determine the future, directly or indirectly. While technical considerations will inform decisions and support arguments, they will not, by themselves, be decisive. The next two paragraphs show how two respected environmentalists have attempted to integrate the information presented above.

Gustave Speth is Dean of the Yale School of Forestry and Environmental Studies and a Professor in the Practice of Environmental Policy and Sustainable Development. In his 2004 book Red Sky at Morning: America and the Crises of the Global Environment, Speth writes: “For such crucial issues as deforestation, climate change, and loss of

diversity, we have already run out of time: appropriate responses are long overdue.” He goes on, in a later chapter, to explain, in the context of climate change, that “Societies will have to shift from extraordinarily wasteful use of energy to extraordinarily efficient, precise energy use . . . Societies will also have to move from a mix of fuels that is carbon intensive (relying heavily on coal and oil) to one with very low emissions of carbon . . . there are several possible paths forward: (1) shift to natural gas . . . (2) shift to renewable energy sources . . . and (3) shift to nuclear power, fission and fusion. [Carbon sequestration] is beginning to receive considerable attention from scientists and engineers. . . My view is that prospective climate change is so risky and carbon dioxide stabilization so demanding that virtually all these approaches will be required in some form or other in the decades ahead.” Nearly 200 pages later, a footnote adds that “the environmental and security issues that face any revival of the nuclear option remain formidable” and cites three references, one on waste, one on safety, and one on proliferation (Speth 2004).

Widely respected energy expert and Harvard Professor John Holdren directs the Woods Hole Research Center. He is trained in plasma physics and has a long record of involvement in nuclear issues with an emphasis on weapons control and proliferation. During Bill Clinton’s second presidential term, Holdren chaired the Energy Panel of the President’s Committee on Science and Technology (PCAST). A 1999 report, unanimously approved by panel members, recommended “developing and promoting cleaner energy supply technologies, particularly biomass, wind, solar, and other renewable energy sources, more efficient fossil fuel systems, technologies to capture and store carbon, and nuclear fission and fusion” (OSTP 1999). A recommendation by a

similar panel in 1997, also chaired by Holdren, called, as a response to climate change, for increased funding for research related to nuclear power and other energy production technologies (PCAST 1997). In 2004, Holdren went further and told an audience in a lecture about the risks of climate change at the Carnegie Institution in Washington: “The Cheney Commission’s national energy policy document, for all the uproar that has blown up around the process of producing it, has many good points. . . [including] . . . generally sensible recommendations about nuclear energy” (Holdren 2004). The referenced National Energy Policy, issued in 2001, states that “existing and new technologies offer us the opportunity to expand nuclear generation” (Cheney 2001). Holdren also served on an MIT panel that recommended a broad package of incentives for the construction of new nuclear power plants in 2003 (Deutch, Moniz *et al.* 2003).

While neither of these authors explicitly calls for the construction of new nuclear power plants as a response to climate change at this time, they do imply that opposition to nuclear power does not flow inevitably from the objective consideration of relevant facts and therefore may be open to re-evaluation in the context of concern about climate change. The potential for such re-evaluation is the subject of this thesis; the next section presents the work of several social scientists who have studied processes by which such a re-evaluation could occur.

Risk, society, and decision making

In the first chapter of *Human Choice and Climate Change*, (1998) Sheila Jasanoff and Brian Wynne discuss “Science and Decisionmaking.” They explain that, as recently as 1990, “scientists and policymakers generally accepted that planetary changes could

best be understood, and mastered, by identifying a collection of causal forces, both natural and social; by predicting their effects; by aggregating them through large-scale quantitative techniques of modeling and assessment; and, finally, by using assessments as inputs to policy” but assert that these “initial assumptions about how to study and respond to climate change have proved inadequate.” Many other authors have concluded that decision-making about technology and the environment can be studied more productively when people and organizations are understood to play a more central role than scientific conclusions or technological demonstrations. Examples that do not directly address nuclear power or climate change include Sylvia Tesh’s (2000) *Uncertain Hazards: Environmental Activists and Scientific Proof*, which describes how organizations that form to address specific environmental concerns can generate and apply scientific knowledge in valid, useful, and underappreciated ways; Frank Fischer’s (2000) *Citizens, Experts, and the Environment: The Politics of Local Knowledge*, which looks beyond organizations at the question of how and why the participation of individual citizens can and should be sought when complex questions of environmental policy are under consideration; Deborah Stone’s (2002) *The Art of Political Decisions Making*, which describes a people-centered model of social choice in which differing conceptions of the public and private interest interact in the theater of politics, broadly defined, to influence the course of history; and Sheila Jasanoff’s (1990) *The Fifth Branch: Science Advisors and Policymakers*, which carefully documents the degree to which, even when experts consider technical questions, decision-making processes cannot be understood without a thorough understanding of sociological considerations.

One thing that these authors have in common is that they all argue that choices about technological futures are often much less constrained by scientific facts than they may seem to be at first glance. Two related assumptions that will be familiar to observers of conflicts about technology and the environment are questioned and ultimately discarded: (1) Political controversies about technology normally result when at least one participant is not well informed or lacks analytical ability; (2) When political conflicts do result from a lack of information or analytical ability, they can often be understood as conflicts between well-informed expert analysts and a relatively ignorant subset of the general public. My consideration of the debate about nuclear power in the context of climate change is informed by widely accepted knowledge about science and technology, but, in the tradition described above, I assume that this information will not be decisive and study people, institutions, and policies for clues that show how opinions and positions about nuclear power may change, or not change, in response to accumulating information and increasing concern about climate change.

The question of how societies consider specific consequences, or “side effects” of technologies like nuclear or coal-fired electric power plants is the central concern of political sociologist Ulrich Beck. Four pages into Part I of his *Risk Society: Toward a New Modernity*, Beck explains that “by risks I mean above all radioactivity, which completely evades human perceptive abilities, but also toxins and pollutants. . . They induce systematic and often *irreversible* harm, generally remain *invisible*, are based on *casual interpretations*, and thus only exist in terms of the (scientific or anti-scientific) *knowledge* about them” (Beck, 1992, p. 23, italics in original). Beck relies heavily on the

example of nuclear power to support his assertion that side effects resulting from technological development are beginning to exert a powerful influence on the organization, or disorganization, of modern societies, and he makes at least two relevant points: The first is that continued production of knowledge about possible events such as reactor meltdowns leads to justified skepticism about technologies such as nuclear power. His point here is that, even before the accidents at Three Mile Island and Chernobyl, scientists had invented the idea, or risk, of a future nuclear meltdown. The second is that even when scientists produce knowledge that they consider to be reassuring, they create new risks: to assert that something is unlikely is to assert that it is possible. In Beck's view, it is specifically because the numerical probability of events such as reactor meltdowns is fundamentally undeterminable that the contemplation, by scientists, of possible Chernobyl-type event can be decisive. To support his argument that nuclear power plants have this characteristic of indeterminate risk, he asserts that governments insure privately owned nuclear power because quantitative descriptions of likelihoods and potential consequences of accidents do not seem to be available to the degree that private insurance companies require. Even modern society's most expert risk analysts cannot meaningfully characterize the risks posed by nuclear power plants and therefore, in Beck's view, society should be generally skeptical about assertions that technological risks are acceptable. Nuclear risks are caused entirely by human activity, and their socially constructed nature is of fundamental importance: The same people and social-scientific processes that create technological risks as adverse consequences in hypothetical futures also create the physical objects on which concepts of technological risk are constructed.

Beck seems to be less concerned with climate change, possibly because, although it is certainly a “side effect” of technology, the potential effects may be easier to characterize, even if this is only because they are more certain and less indeterminate. But he does consider the link between climate change and nuclear power. According to Beck (Beck 1992, p. 31)

There occurs, so to speak, an overproduction of risks, which sometimes relativize, sometimes supplement and sometimes outdo one another. One hazardous product might be defended by dramatizing the risks of the others (for example, the dramatization of climatic consequences ‘minimizes’ the risk of nuclear energy). Every interested party attempts to defend itself with risk definitions, and in this way to ward off risks that could affect its pocketbook. The endangering of the soil, plants, air, water, and animals occupies a special place in the struggle of all against all for the most beneficial risk definition, to the extent that it expresses the common good and the vote of those who themselves have neither vote nor voice (perhaps only a passive franchise for grass and earthworms will bring humanity to its senses).

This passage highlights the significance of the observation that risks are social constructions for debates about nuclear power: While there is no reason to expect climate change will decrease the numerical probability that a particular nuclear reactor will release radiation into the environment, concern about climate change may well affect the production and construction of the risks posed by nuclear reactors. Beck’s use of the evocative image of “grass and earthworms” in this context is consistent with his

argument that the problem faced by our evolving risk society is the general overproduction of technological risk and not the failure to meaningfully compare risks; the possibility that grasslands may be more threatened by climate-induced desertification than they are by radiation from nuclear power plants does not seem to concern him at all.

Consider the following illustration of the dynamics that Beck describes: The authors of *The Future of Nuclear Power: An Interdisciplinary MIT Study* intended to justify a substantial expansion in the use of nuclear power to facilitate reductions in greenhouse gas emissions when they wrote (Deutch, Moniz *et al.* 2003):

We believe the safety standard for the global growth scenario should maintain today's standard of less than one serious release of radioactivity accident for 50 years from all fuel cycle activity. This standard implies a ten-fold reduction in the expected frequency of serious reactor core accidents, from 10^{-4} /reactor year to 10^{-5} /reactor year. This reactor safety standard should be possible to achieve in new light water reactor plants that make use of advanced safety designs. International adherence to such a standard is important, because an accident in any country will influence public attitudes everywhere.

In Beck's *Risk Society*, documents like the lengthy and careful MIT study lead naturally to public skepticism about nuclear power, even in the context of climate change, because they create what Beck calls "risks" that "only exist in terms of the (scientific or anti-scientific) *knowledge* about them (Beck 1992, p. 23).

Significantly, even the MIT study does not argue that its numerical estimates can be relied upon to ensure acceptance; they are concerned that "an accident in any country

will influence public attitudes everywhere.” In other words, one reason to avoid accidents is that they will determine how future risk definitions are constructed and, possibly, impede efforts to forge a societal consensus in which “dramatization of climatic consequences ‘minimizes’ the risk of nuclear energy (Beck 1992, p. 31).” Beck would almost certainly view the MIT study as an artifact of the increasingly obsolete “industrial society” in which an orderly and powerful structure could be relied upon to convince citizens that widespread benefits accruing from technological development will reliably outweigh localized and quantifiable side effects. When he looks forward toward the developing Risk Society he sees a much different situation: Governments and experts are no longer able to construct the concept of risk in this broadly reassuring way because they have become preoccupied with the side effects of technology, such as, for example, nuclear waste. Viewed through Beck’s theoretical lens, nuclear power plants presently cannot compete with other options such as wind, solar power, and even fossil fuels for public trust because their technological complexity ensures that they must always depend on experts and large institutions to assert and ensure that they do not pose unacceptable risks.

The question of how people reach conclusions about the risks of specific technologies like nuclear or coal-fired electric power plants is the central concern of psychologist Paul Slovic, whose psychological studies of risk perception have attempted to shed light on the well-documented but still poorly understood observation that different people perceive risks very differently. Slovic is clearly concerned by his observation that “the fear and revulsion evoked in the general public by the thought of a

nuclear waste repository stand in contrast to the confidence that most technical analysts and engineers have in their ability to dispose of radioactive materials safely,” (Slovic 2000, p. 281) and he has conducted a number of studies that attempt explain why contrasts of this type persist. He studies specific risks and concludes that better communication may help to counter public skepticism, so his concept of public opinion is more orderly than Beck’s, and one author has criticized him for assuming that “the [Environmental Protection] agency’s task is to reduce citizen protests, not to reduce environmental pollutants” (Tesh 2000, p. 84). But his work is useful in this context because he concludes that:

There is a logic to public perceptions and behaviors that has become apparent through research. For example the acceptance afforded X-rays and prescription drugs suggests that acceptance of risk is conditioned by perceptions of direct benefits and by trust in the managers of the technology, in this case the medical and pharmaceutical professions. The managers of nuclear power and non-medical chemical technologies are clearly less trusted and the benefits of these technologies are not highly appreciated, hence their risks are less acceptable (Slovic, 2000, p. 269).

While climate change will not alter the characteristics of nuclear power plants that drive public skepticism, the ability to generate electricity without the emission of greenhouse gases may well come to be seen as beneficial by many people. If so, Slovic’s research suggests that public willingness to accept the risks of nuclear power could increase if growing concern about climate change leads to greater appreciation for the need to reduce carbon emissions. Significantly, it also suggests that signals that nuclear risks are

tolerable, if they came from environmentalists who are trusted by the public, could do much to dispel public skepticism.

My research, which includes interviews with people who are very well informed about climate change and electric power plants, does not offer strong support for Slovic's suggestion that increased awareness of the potential clean air benefits of nuclear power plants will make people more willing to accept nuclear risks. However, a substantial number of the people who were interviewed took the complex view that new nuclear power plants might not actually facilitate beneficial emissions reductions because they would compete mostly with other non-emitting technologies, such as solar and wind power. Therefore Slovic may be correct to suspect that "the benefits of [nuclear power plants] are not highly appreciated." Slovic, who studies people, and Beck, who studies societies, provide complementary theoretical bases for my assumption that mounting evidence of climate change may eventually cause increased willingness to accept the risks posed by the construction of new nuclear power plants in the United States.

Public opinion, politicians and the popular press

The previously mentioned MIT report on the future of nuclear power included the observation that "There is a surprising lack of survey data in the public domain that would allow us to understand why people oppose and support specific power sources," and commissioned a survey to supply some of the missing information. (Deutch, Moniz *et al.* 2003) One question asked respondents for opinions how about how future demand for new power plants should be met, given specific fuel choices. Near half responded that nuclear power should be used less or not at all and only about one quarter indicated a

preference for increased reliance on nuclear power in the future. There was even less support for coal and oil, and only for solar and wind power were substantial increases supported by a large majority of respondents. Nearly half evaluated the chance of a serious accident at a US nuclear power plant in the next decade to be “very likely” or “almost certain,” and nearly two-thirds disagreed with the statement that “nuclear waste can be stored safely for many years.” Some respondents were provided with different information about some questions than others, and, while information about costs was found to influence opinions about nuclear power, the study concluded that “information about global warming again had no effect on public attitudes toward alternative energy sources” including nuclear power. This evidence suggests that the public remains quite skeptical about nuclear power.

Most other available US survey data was collected during the first eight months of 2001, soon after California experienced a well-publicized energy crisis and the Bush Administration’s National Energy Policy called for construction of new power plants, including nuclear reactors; all of the examples included in the following paragraph are from *Polling the Nations* (Polling the Nations 2004). A Gallup poll conducted in March of 2001 showed the public to be split nearly evenly between support and opposition for the construction of new nuclear power plants, and seven other similar polls conducted by national news organizations found levels of opposition that ranged between forty and sixty percent. A few other questions which specified that new plants would be located in the respondent’s community or only questioned Californians elicited substantially more negative responses. It is reasonable to speculate that concerns about the capacity to generate sufficient electricity may have driven public acceptance of nuclear power to an

artificially high level, and polling data provided by the industry-funded Nuclear Energy Institute does provide some evidence that public acceptance of nuclear power reached an all-time high in 2001. On the other hand, the possibility that public opinion about nuclear power may have been influenced by concerns about energy supplies does suggest that opposition may not be so firm as to be immune to the influence of news about increasingly severe global warming. Also relevant is the fact that two other surveys, though not well correlated geographically with this study, do suggest that public awareness of the technical potential for nuclear power plants to facilitate reductions in air pollution may be low: When Europeans were asked by *Euro barometer* in 2002 if “an advantage of nuclear power is that it produces less greenhouse gases,” only 31% expressed agreement and 45% responded “don’t know.” And when the League of Conservation Voters asked residents of Georgia, USA to rate nuclear power plants on a scale of 1 to 5, “where one means something is not a source of air pollution and five means something is a major source of air pollution” the most common response, chosen by 36% of respondents, was 5.

Successive Vice Presidents of the United States have commented on the possibility that concern about climate change will eventually lead to the construction of new nuclear power plants. In early 2001, after having been assigned the task of crafting a national energy policy, Dick Cheney argued "If we're serious about environmental protection, then we must seriously question the wisdom of backing away from what is, as a matter of record, a safe, clean, and very plentiful energy source” (Cheney 2001). While Cheney is widely considered to be unsupportive of environmental protection, Senator

John McCain, who has sponsored legislation to limit carbon emissions but has no record of opposition to nuclear power, told the radio program *Living on Earth* (2005) “You can’t be serious about reducing greenhouse gas emissions unless you factor nuclear power into the equation.” These comments suggest a caution that should be kept in mind when reading this thesis: Even if the general political environment seems to have become more open to the construction of new nuclear power plants, it may simply be that some people and groups that have always supported the use of nuclear energy have gained political influence and been able to use concern about climate change to support unchanged pro-nuclear positions. Such a shift in power between people and organizations with unchanged opinions and positions would be significant, but it is not the main subject of this thesis.

In *Earth in the Balance: Ecology and the Human Spirit*, Al Gore describes a general concern about the accumulation of technological risks that echoes Beck’s work to some degree and also explicitly considers the question of whether climate risks should drive increased acceptance of nuclear power. In the first part of his book, titled “Balance at Risk,” Gore writes:

The strategic nature of the threat now posed by human civilization to the global environment and the strategic nature of the threat to human civilization now posed by changes in the global environment present us with a similar set of challenges and false hopes. Some argue that a new ultimate technology, whether nuclear power or genetic engineering, will solve the problem. Others hold that only a drastic reduction of our reliance on technology can improve the conditions of life – a simplistic

notion at best. But the real solution will be found by reinventing and finally healing the relationship between civilization and the earth (Gore, 1992, p. 35).

That Gore does not consider nuclear power to be a significant “healing” technology is stated much later:

In my own view, the present generation of nuclear technology, light water-pressurized reactors, seems now rather obviously at a technological dead end. The research and development of alternative approaches should focus on [safety and waste]. In any event, the proportion of world energy use that could practically be derived is fairly small and is likely to remain so. It is a mistake, therefore, to argue that nuclear power holds the key to solving global warming (Gore, 1992, p. 328).

In the years since 1992, information about climate change has steadily accumulated, hundreds of light water reactors have operated worldwide without safety or waste-related disasters, and several new but not fundamentally different designs for light water reactors have been certified by the Nuclear Regulatory Commission. Perhaps Gore and others like him have become less skeptical about the risks of nuclear power because of growing concern about climate change. This possibility is the main subject of this thesis.

In April 2005, one of the people interviewed for this project alluded to this possibility when he predicted: “If there’s climate catastrophes that folks arguably understand to be climate change . . . those are the kinds of dynamics that will keep

consideration of new nuclear power in the game.” About three months later, and less than two months before Hurricane Katrina flooded New Orleans, *Newsweek* published an interview with Eileen Claussen of the Pew Center on Global Climate Change. She was asked: “What will the effects be here in the United States?” Her response began: “As the sea level rises, some areas, particularly in Louisiana, could be submerged because of their low-lying coastal plains. There will be more floods.” About a month after the hurricanes, the *New York Times* editorialized: “The recent hurricanes left behind a revived debate about global warming. While some environmentalists point to the wreckage as a kind of retribution for America's failure to control greenhouse gas emissions, right-wing talk show hosts repeat, over and over, that even if global warming did exist, there is no proof it had anything to do with Rita and Katrina. In a way, they're all right.” Regardless of the status of the scientific debate about connections between greenhouse gas emissions and specific effects such as hurricanes, it is becoming increasingly difficult for organizations, political actors, and even right-wing talk show hosts to ignore climate change as scientific and political reality.

On the other end of the political spectrum, environmentalists are finding a corresponding possibility more and more difficult to ignore: The need to produce electricity without greenhouse gas emissions may eventually spur the construction of new nuclear power plants. For example, in the same week that Hurricane Katrina dominated headlines, *Business Week* reported: “While the government must still solve the problems of waste and security, says Steve Cochran of Environment Defense, ‘given the challenge of climate change, the world needs to be open to every low carbon initiative – including nuclear power.’” Six weeks later, in *Newsweek*, Frances Beineke of the Natural

Resources Defense Council was asked to comment on assertions that environmentalists should rethink opposition to nuclear power in light of climate risks. She responded:

We've looked at nuclear, but we continue to think it has serious problems. One is economic. If nuclear power could compete in the marketplace without major subsidies from Congress it would be an interesting thing to look at. But that's not what the industry is proposing. And the waste problem is not solved. We haven't figured out what to do with the waste. Until they do that and compete economically, we don't think it's a major part of the equation.

What are we to make of these statements of potential non-opposition? Are they different from the adamantly anti-nuclear Sierra Club's longstanding official opposition to the construction of new nuclear power plants "pending . . . resolution of the significant safety problems inherent in reactor operation, disposal of spent fuels, and possible diversion of nuclear materials capable of use in weapons manufacture" (Sierra 1974). In fact there is at least one significant difference, which is that the recent statements from representatives of Environmental Defense and the Natural Resources Defense Council acknowledge a connection between climate change and nuclear power. In other words, they begin to lay intellectual groundwork on which a significant reconsideration of nuclear power could be assembled if a new reactor was proposed in the context of a strong climate policy.

Conclusion

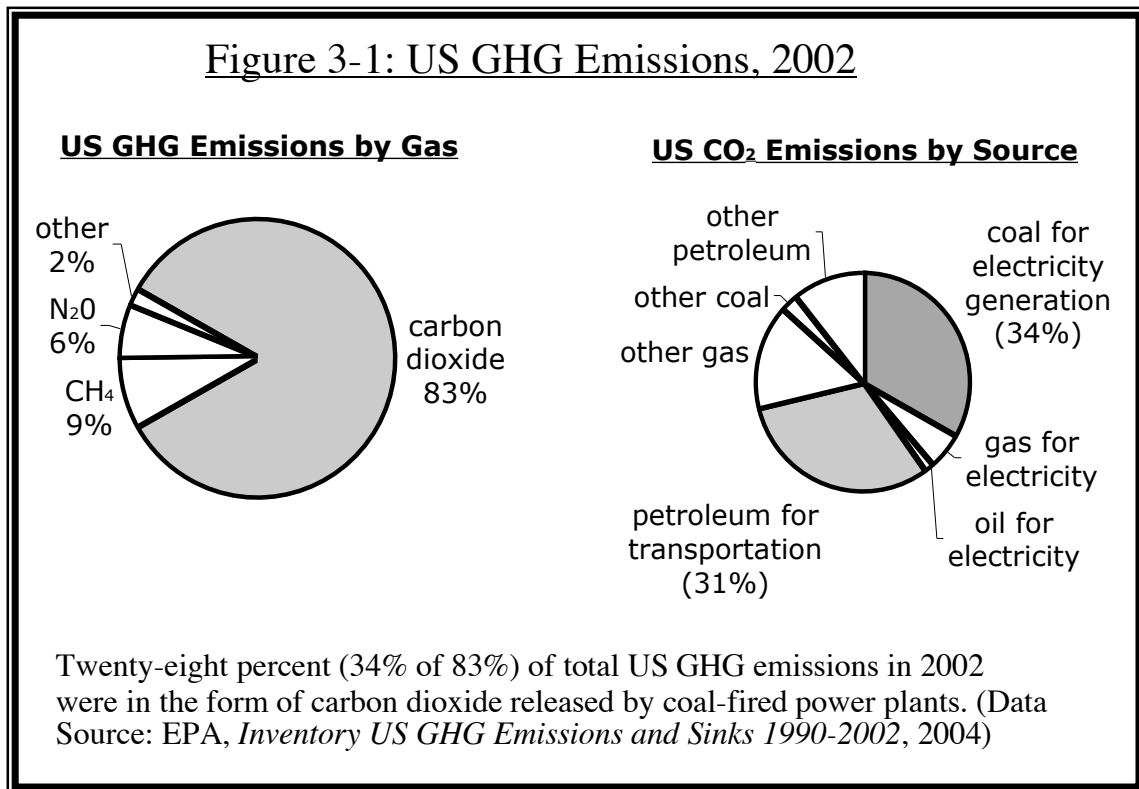
Daniel Sarewitz, writing in *Environmental Science and Policy*, has used the examples of climate change and nuclear waste to show that "political controversies with

technical underpinnings are not resolved by technical means (Sarewitz 2004).” Sarewitz’s argument is, essentially, that science is so good at producing information that efforts to resolve controversy through targeted research very often produce bodies of knowledge that are sufficiently diverse to strengthen a range of potentially conflicting arguments. Even the most casual or opinionated observer of controversies about nuclear power will have noticed this dynamic, and the fact that Sarewitz uses nuclear waste and climate change to illustrate his observation suggests the difficulty of the current task, which is to explore how people and organizations integrate information about the two topics. I agree with Sarewitz when he suggests that “progress in addressing environmental controversies will need to come primarily from advances in the political process, rather than scientific research” and that “the abandonment of a political quest for definitive, predictive knowledge ought to encourage, or at least be compatible with, more modest, iterative, incremental approaches to decision making that can facilitate consensus and action.” While I leave it to others to recommend specific advances in the political process, I do hope that the following description of how people and organizations are attempting to integrate concerns about climate change with opinions and positions about nuclear power can serve as a useful resource for those who seek to engage in the sort of careful and patient decision making process advocated by Sarewitz.

Chapter 3: The US Nuclear Industry, Global Climate Change, and Coal

Descriptions of controversies about nuclear power often refer to a set of companies called the “nuclear industry.” However, because the owners of nuclear power plants also use fossil fuels including coal to generate electricity, the phrase “nuclear industry” should be used with caution. The promotion of nuclear power, often assumed to be in the interest of the “nuclear industry,” may conflict with the interest that many owners of nuclear power plants have in preserving the competitive position of their other generating plants. This chapter will show that the coal industry, if correspondingly defined to consist of the owners of coal-fired power plants, is not significantly different from the nuclear industry. The connection between nuclear power and coal is significant because, while nuclear power plants do not emit greenhouse gases as they generate electricity, coal-fired power plants are the single most significant source of carbon dioxide emissions in the United States, as shown in the figure 3-1. This chapter documents the use of the term “nuclear industry,” uses data on ownership and emissions from electric power plants to document the composition of the US nuclear industry, and draws on annual reports to analyze reactions of individual companies to climate change. A separate section about the industry-funded Nuclear Energy Institute is also included.

Figure 3-1: US GHG Emissions, 2002



Use of the term “nuclear industry”

The phrase “nuclear industry” is used by environmentalists, newspaper reporters, and other analysts and advocates. The industry “argues,” shows “reluctance,” and can be “skittish” or fail to “take seriously” a problem; it can be “revived.” The following examples illustrate typical usages of the phrase:

The future of the nuclear industry will depend on the credibility and commitment of the industry and its regulators to nuclear safety. That future could see many existing plants retired prematurely, or see many licenses

extended, and even perhaps see new nuclear plants. (David Lockbaum, Union of Concerned Scientists, testimony before US House 2000)

When the nuclear industry gives, members of Congress act, notes Public Citizen, which charts the record of politicians on key nuclear issues. (Karl Grossman “Nuclear Phoenix” E: The Environmental Magazine 2001)

I think the nuclear industry itself is going to be skittish if there is not some resolution to the high level waste issue. (Shirley Jackson, former Nuclear Regulatory Commission “chairman,” interview with Numarck Associates 1999)

Although most environmentalists won't admit it, the [nuclear] industry has a point about the deadly effects of today's dominant source of electricity production, coal. (Mark Hertsgaard, “Three Mile Island” The Nation 2004)

George Bush, in his eagerness to revive the nuclear power industry, is altogether too willing to script the American energy future as a disaster movie. (Carl Pope, “The Harrison Ford Solution” Sierra 2004)

The nuclear industry argues that the relentless external pressure for zero discharges and exposures, even when there is little or no technical case for it, has damaged nuclear economics (Grimston and Beck Double or Quits, 2002)

The nuclear industry's reluctance to take seriously the 24,000 cancer deaths that we expect as a result of Chernobyl is reminiscent of the tobacco firms in

their ludicrous and deceptive charade . . . (Garwin and Charpak Megawatts and Megatons, 2002)

The nuclear energy industry is committed to the construction of new nuclear plants when the business conditions are appropriate. (Marvin Fertel of Nuclear Energy Institute, testimony before US Senate 2004)

To some extent, the term is probably used to simplify communication or even possibly to capitalize on opinions about aspects of industries in general, such as their role in producing useful products or their focus on profits at the expense of other goals. It is clear, however, that the phrase “nuclear industry” is often used in a way that implies the existence of a homogenous group that advocates coherently for the continued and expanded use of nuclear energy to produce electricity.

Even more relevant for the current study is the fact that the nuclear industry is often seen to be a group that “hopes” to play a major role in solving what is widely acknowledged to be one of the most important problems facing the human citizens of planet Earth: climate change caused by the emission of greenhouse gases. Two illustrative statements follow:

The nuclear industry is hoping that concern over climate change will result in support for nuclear power. (Wenonah Hauter of Public Citizen, interview with Numarck Associates 1999)

The nuclear power industry hopes concern over global warming may help spur a revival. (Kenneth Chang, “As Earth Warms, the Hottest Issue is Energy” New York Times 2003)

Certainly there are many individuals within the nuclear industry that do hope for such a revival, both because they fear global warming and because they expect to benefit from increased use of nuclear power. But, as a former chair of the Nuclear Regulatory Commission has pointed out:

The nuclear industry is reluctant to advance the case because generating companies also rely on fossil-fuel plants (primarily using carbon-intensive coal) for electricity production. This sector thus has a strong disincentive to use global warming as a justification for nuclear power because of the implication of that argument for other components of the companies' supply portfolios. (Richard Meserve, "Global Warming and Nuclear Power" Science 2004)

The next section of this chapter describes the supply portfolios of companies that make up the US nuclear power industry.

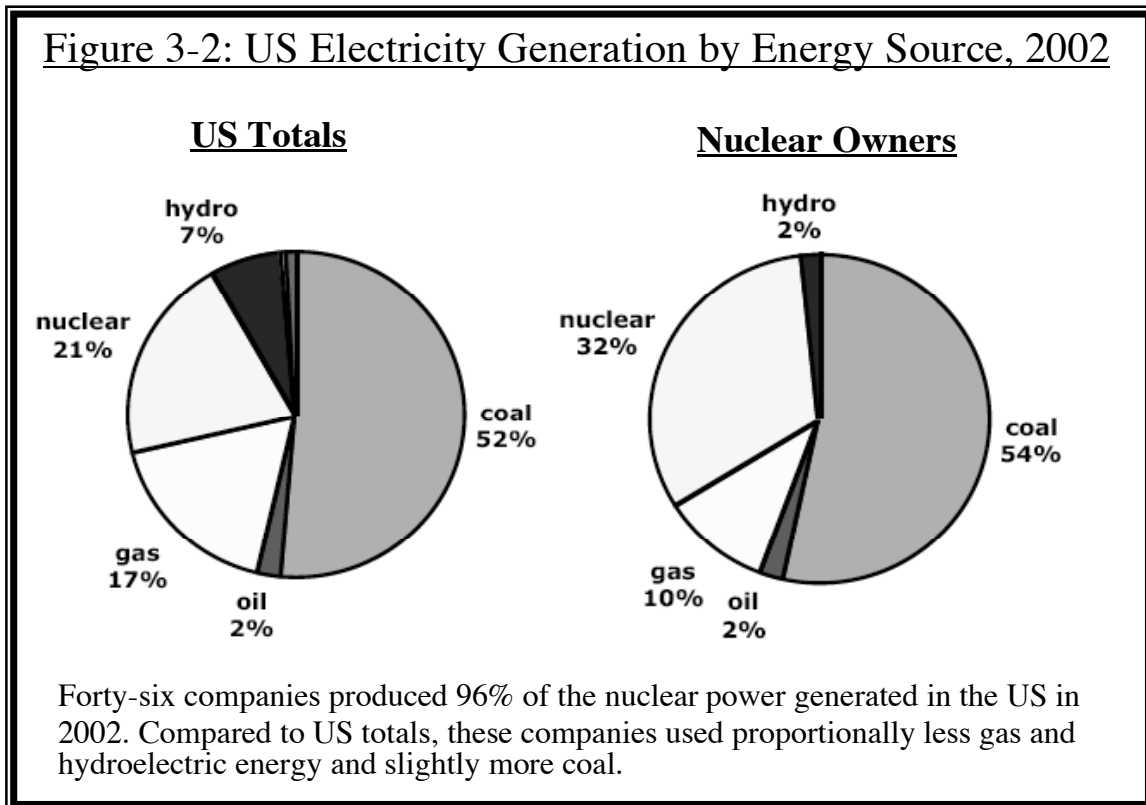
Users of the term "nuclear industry" rarely define the term, but the above examples illustrate that the existence of a group of plant owners that work together to promote the utilization of nuclear power to generate electricity is often implied. Broader definitions of the "nuclear industry" could include, for example, equipment suppliers or even law firms, but such definitions would be impossible to meaningfully bound and would not be any more consistent with the usage in the statements surveyed above. The point here is that there is an assumption that a coherent "nuclear industry" exists, and that this "nuclear industry" can be expected to strongly favor policies that encourage increased use of nuclear power as a solution to the problem of global warming. Even in the face of rapidly mounting evidence of the reality of global climate change, the 2004

version of the Energy Information Administration's Annual Energy Outlook forecasts the construction of many new coal-fired power plants and few nuclear plants over the coming two decades; it is tempting to expect the "nuclear industry" to view such a future as a potential missed opportunity and to muster its formidable financial resources to ensure that nuclear power is favored over "clean coal" and even object to assertions that substantial reductions in carbon emissions are virtually unattainable. In this model, the "coal industry" would be expected to favor very different policies than the "nuclear industry"; coal is the most carbon intensive fuel and any successful policy to reduce carbon pollution will necessarily discourage the continued use of existing coal-fired electric power plants. The remainder of this chapter will document the degree to which such expectations are inconsistent with the actual structure of the US nuclear power industry. For the remainder of this chapter, the term "nuclear industry" will be used to refer to the group of companies that own nuclear power plants in the United States.

Ownership of US nuclear power plants

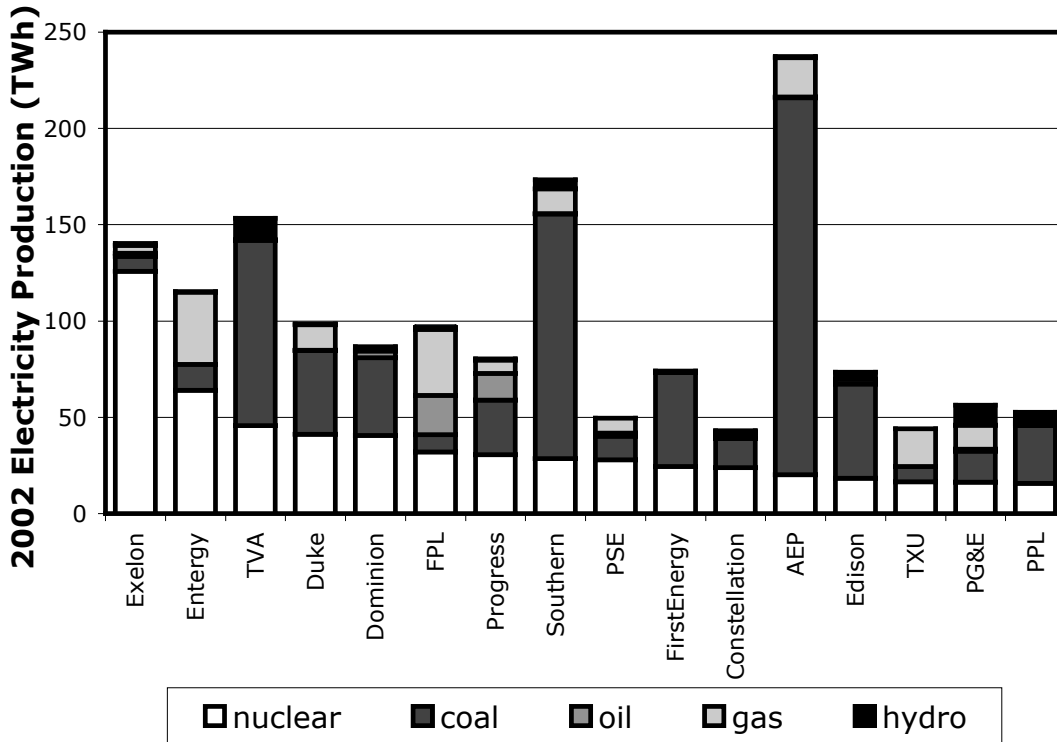
Data compiled by the Natural Resources Defense Council (NRDC), the Coalition for Environmentally Responsible Economics (CERES), and the Public Service Enterprise Group (PSEG), and released in their *Benchmarking Air Emissions of the 100 Largest Electric Power Producers in the United States – 2002*, facilitate consideration of this question and provide all source data for the following graphs and paragraphs (CERES 2004). It turns out that reality is complex: As shown in figure 3-2, there is substantial overlap between the coal and nuclear industries, and, perhaps more significantly, the group of companies that operate nuclear power plants generate about 50% more

electricity using coal than they do using nuclear power and are more heavily reliant on coal than the electrical generation industry as a whole. Although it is true that a substantial tax applied to carbon emissions could ultimately stimulate the construction of new nuclear power plants by driving up the price of coal-fired electricity, it is equally true that such a tax on carbon emissions would cost the nuclear industry more than a tax on nuclear generation of equal value per kWh because it would be applied to the coal plants that they own and operate. In its current configuration, the nuclear industry cannot be expected to favor policies that encourage the increased use of nuclear power as a solution to problems created by burning coal.



The nuclear industry is actually even more complex. Owners of nuclear power plants use energy sources other than nuclear power and coal to generate electricity, and different owners of nuclear power plants use different combinations of energy sources. Figure 3-3 summarizes the relevant data for the top 16 nuclear owners and shows that substantial diversity exists within the so-called nuclear industry. Many companies use large and increasing amounts of natural gas, which burns substantially more cleanly than coal but exists in smaller amounts than either coal or uranium (Smil 2003). Hydroelectric power provides more emissions-free electricity than any source other than nuclear power, but few suitable sites remain for new dams in the continental United States (Cheney 2001). Other renewable energy sources such as wind, solar, geothermal, and biomass now generate very small but rapidly increasing percentages of the US total. The positions of individual companies on climate change policy might be expected to correspond to the prominence of these different sources in their generation portfolios; this hypothesis will be tested later in this chapter.

Figure 3-3: Energy Sources for Top Nuclear Generators

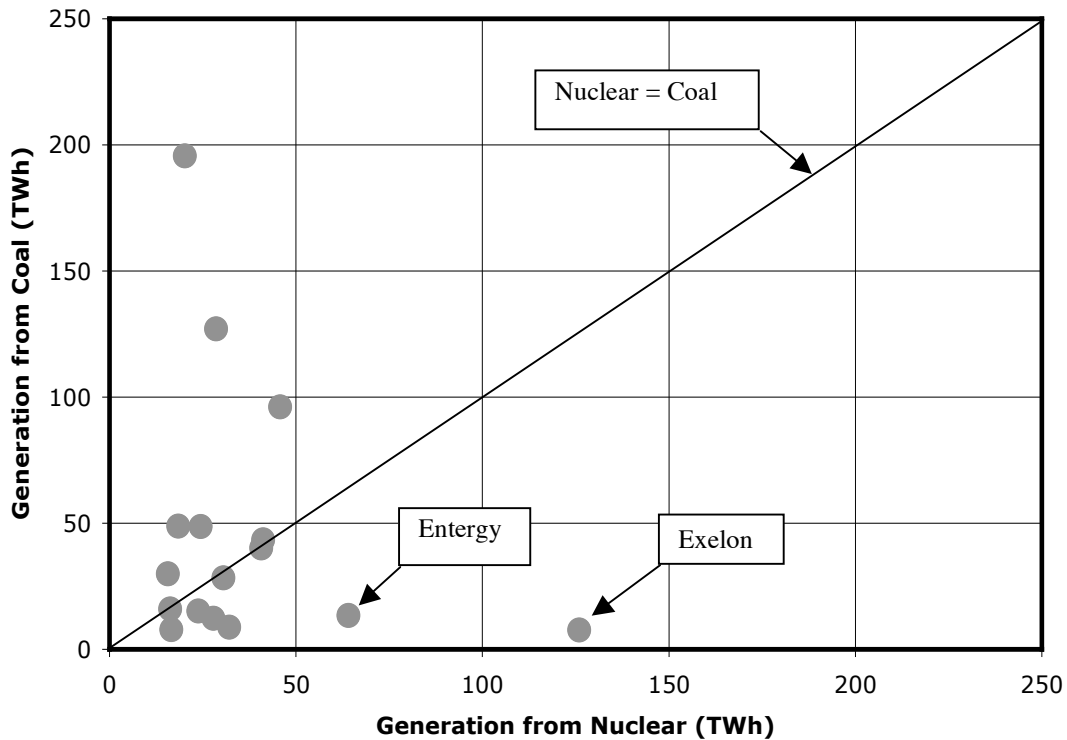


Sixteen companies accounted for 74% of nuclear generation in 2002. Overall, these companies produced 42% of US electricity and 37% of CO₂ emissions from US electricity production. Their reliance on coal ranged from 5% for Exelon to 82% for AEP.

A narrow focus on coal and nuclear power can help to simplify the picture and is justified by the prominence of these two energy sources in two important dimensions. First, burning coal produces about 80% of total carbon emissions from electrical generation, and second, nuclear power accounts for about 70% of emissions-free electrical generation. Figure 3-4 shows the degree to which the top 16 nuclear owners vary in their reliance on coal. Perhaps significantly, although many of these companies

rely substantially on both fuels, two companies, Exelon and Entergy, are exceptional in that they rely heavily on nuclear power and use very little coal. These two companies produce about 25% of all nuclear-generated electricity and might be expected to provide strong support for policies that favor nuclear power over coal. Exelon in particular produces nearly twice as much electricity from nuclear power plants as its nearest competitor, Entergy, and uses less coal than any of the other top 16 nuclear generators. Also notable are the dominance of coal in the portfolios of Southern Company and American Electric Power and the presence of six of the top ten coal generators in the nuclear industry. To the extent that it is defined by ownership of nuclear power plants, the nuclear industry is characterized more by its reliance on a diversity of energy sources than by decisive investment nuclear power.

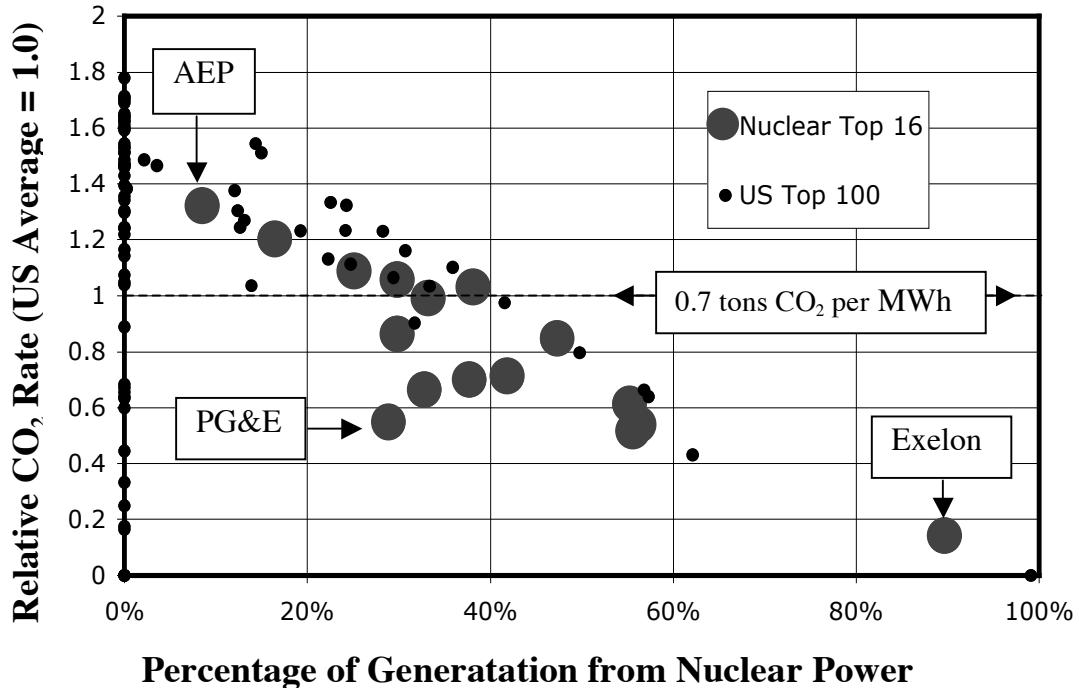
Figure 3-4: Nuclear vs. Coal for Top 16 Nuclear Companies



Two companies, Exelon and Entergy, are exceptional in that they generate a large amount of electricity from nuclear power while using little coal. Many of the top 16 nuclear generators rely more heavily on coal than they do on nuclear power plants.

Does the nuclear industry burn so much coal that it emits carbon dioxide at a higher per-kWh rate than the electricity industry as whole? Figure 3-5 shows that it does not. While the nuclear industry may rely heavily on coal, the fact that nuclear power plants do not emit any carbon dioxide ensures that, for both the top 16 nuclear generators and the top 100 electrical generators, greater reliance on nuclear power is correlated with lower carbon dioxide emissions rates. This correlation also illustrates the potential for new nuclear power plants to play a role in efforts to combat global climate change.

Figure 3-5: Nuclear Reliance vs. CO₂ Emissions Rate for US Power Plant Owners



Each point on the graph represents one company. The graph shows that greater reliance on nuclear power is correlated with lower CO₂ emissions rates. (“Relative CO₂ Rate” is the ratio of emissions to total electricity generated, divided by the industry average of 0.7 tons per megawatt-hour. For example, compared to the average for all US electricity generation, Exelon emits only about 17% as much CO₂ for each MWh of electricity produced; AEP emits 32% more.)

Annual reports and political contributions of individual companies

The substantial overlap between the group of companies that own nuclear power plants and the group that owns coal plants greatly complicates the political and economic context in which the nuclear industry must consider possible responses to climate change. Even the Nuclear Energy Institute, which represents the interests of nuclear power plant

owners before Congress, crafts advertising campaigns, and speaks to the media on behalf on the industry, is constrained by the degree to which member companies may not support policies that favor nuclear power over coal. On the other hand, diversity within the industry might be expected to drive a divergence in policy preferences, especially between, for example, Exelon and American Electric Power. The annual reports of individual companies and records of campaign contributions to the political parties, which are reviewed in the following section, contain data that has the potential to reveal such a divergence.

Of the top 16 nuclear generators, only the US government-owned Tennessee Valley Authority is not a publicly traded company that produces annual reports for investors. The other 15 annual reports are available for download on the companies' web sites; to collect the data analyzed in the next section, all of the 2003 reports were searched for key terms including *nuclear*, *climate*, *carbon*, *greenhouse*, and *warming*. Of the 15 annual reports, only those of Edison, Duke, and Constellation contained no references of any kind to carbon emissions. On the other hand, only Exelon, FirstEnergy, and FPL explicitly referenced nuclear power's contribution to lowering carbon emissions, and only FPL made a distinction between nuclear power and natural gas. Excerpts from these three reports and Entergy's follow:

The day may soon come when policy makers will conclude that climate change is a real threat, and it is imperative that we act now to ensure that lower carbon alternative fuels, including natural gas, nuclear, and sustainable renewables, are available to meet the future energy needs of our economy (Exelon)

Clean burning natural gas accounted for 34 percent of the power provided by FPL. Greenhouse gas emissions-free nuclear was the fuel source for 21 percent.

The CO2 emissions per kilowatt-hour of electricity generated by FirstEnergy is lower than many regional competitors due to FirstEnergy's diversified generation sources which includes the low or non-CO2 emitting gas-fired and nuclear generators.

Entergy's commitment to addressing global warming and our investment in clean generation technologies were significant factors in meeting the stringent criteria for listing on the Dow Jones Sustainability Index for a second year.

Although it is probably significant that heavily nuclear Exelon's report includes the most emphatic reference to climate change as, at the least, a potential regulatory reality, the other two companies that referenced nuclear power's contribution to lowering carbon emissions are not exceptional in their reliance on nuclear power. Only Exelon, Entergy, and FPL used the term "nuclear industry" in their 2003 annual reports.

There are a variety of other references to climate change in the reports: Southern Company proposes the increased use of natural gas as a potential compliance strategy; TXU and PPL claim to have made significant reductions in relevant emissions; FPL and PG&E announce their participation in voluntary greenhouse gas emissions reductions programs administered by the Environmental Protection Agency; PG&E claims to have a relatively low rate of carbon emissions; and AEP describes participation in the Chicago Climate Exchange. Perhaps more significantly for the current study, TXU, PPL, Entergy,

AEP, FirstEnergy, Southern Company, Progress, and Dominion all mention carbon-related regulatory uncertainty, and several companies allude explicitly to the risk that compliance costs could be high. Three examples follow:

We [AEP] recognize that our reliance upon coal brings with it important environmental responsibilities. . . . the environmental compliance requirements ahead of us may seem daunting to some

TXU Corp. continues to assess the financial and operational risks posed by future regulatory or policy changes pertaining to greenhouse gas emissions and multiple emissions, but because these proposals are in the formative stages, TXU Corp. is unable to predict their future impacts on the financial condition and operations of TXU Corp.

We [FirstEnergy] cannot currently estimate the financial impact of climate change policies although the potential restrictions on carbon dioxide (CO₂) emissions could require significant capital and other expenditures.

Although these statements do not explicitly address the viability of nuclear power as a substitute for fossil fuels, they do suggest that some companies are concerned about potential regulatory costs that would presumably not affect the nuclear-generated portion of their electricity production. FirstEnergy's reference to capital costs may be particularly significant; although it is almost certainly not intended as a reference to the construction of a new nuclear power plant, it is true that such a construction plan would be an example of a capital expenditure that could help the company to function under restrictions on carbon dioxide emissions. Figure 3-6 summarizes coverage of global warming in the

nuclear industry’s annual reports. While there is ample evidence of the potential significance of the issue for the companies, the available data do not suggest any clear division between heavily nuclear-reliant companies and those with greater emissions from coal.

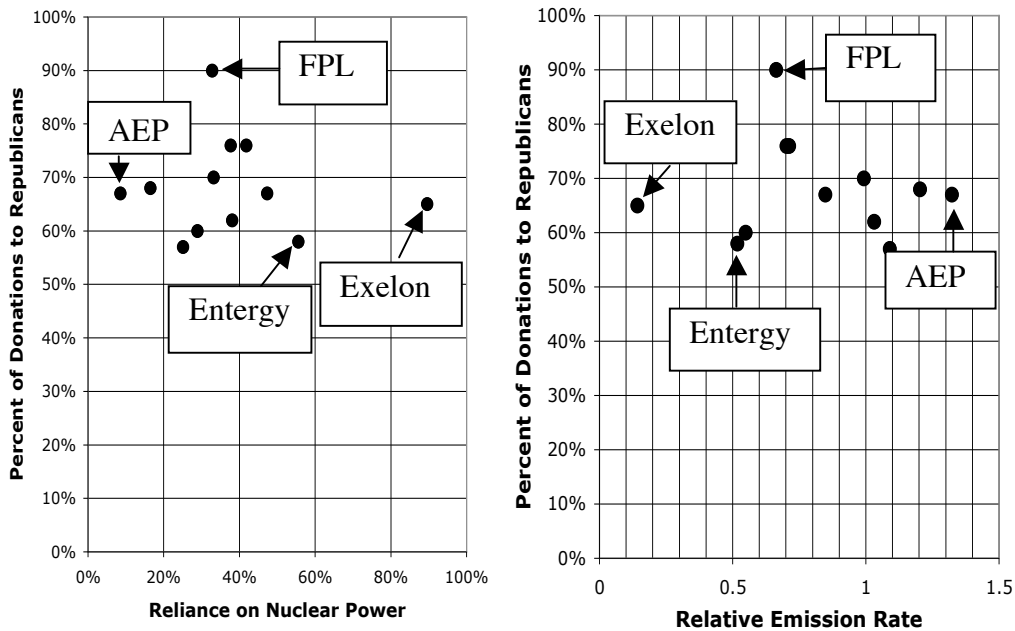
Figure 3-6: Nuclear Power and Climate Change in 2003 Annual Reports

<u>Company</u>	<u>Percent of 2002 generation from nuclear power</u>	<u>Reference to climate change</u>	<u>Climate-related reference to nuclear power</u>
Exelon	90%	X	X
PSEG	56%	X	
Entergy	56%	X	
Constellation	55%		
Dominion	47%	X	
Duke	42%		
Progress	38%	X	
TXU	38%	X	
FirstEnergy	33%	X	X
FPL	33%		X
TVA	30%		
PPL	30%	X	
PG&E	29%	X	
Edison	25%		
Southern	16%	X	
AEP	9%	X	

Most of the top 16 nuclear generators included references to carbon pollution, greenhouse gases, or climate change in their 2003 annual reports. Only three reports contained references to nuclear power in this context. (All reports contained numerous other references to nuclear power plants, and most referred only to impacts of potential regulations rather than actual changes in climate).

While companies inform their investors of current strategies to prepare for a possible future in which carbon constraints become a regulatory reality, they also work to influence the degree to which the government translates increasingly conclusive scientific evidence into forceful environmental policy. The Center for Responsive Politics operates a web site that provides data about campaign contributions, including the data used in the following section of this paper. Specifically, 13 of the top 16 nuclear owners were among the 20 top contributors in the *Electric Utilities* category, which contributed a total of 21.5 million dollars during the 2002 election cycle. Of this total, 66% went to individuals or political action committees associated with the Republican Party, with the remaining 34% to Democrats. According to the same source, Republicans received 89% of the \$3.7 million donated by the coal mining industry and 77% of the \$470,000 donated by the Nuclear Energy Institute. Figure 3-7 illustrates that there is little correlation between either reliance on nuclear power or emissions rate and donation patterns. This may be because, while the Democrats are generally more supportive of the sort of strict limits on carbon pollution that could eventually stimulate the production of new nuclear power plants, they are also typically less friendly to the energy industry in general, and nuclear power in particular, than Republicans. For example, recent Congressional votes in favor of continued movement toward designating Yucca Mountain as an eventual storage site for used nuclear fuel and against comprehensive national regulations on carbon emissions were overwhelmingly cast by Republicans.

Figure 3-7: Political Contributions, Reliance on Nuclear Power, and Emissions Rates for top Nuclear Companies



During the 2002 congressional campaign, all of the top 16 nuclear generators donated more to Republican candidates and PACs than to Democrats, but the above two graphs show that there is no evidence that donations to Republicans were related to either reliance on nuclear power or CO₂ emissions rates. (Each company is represented by one point on each of the above two graphs. “Percent of Donations to Republicans” is the percentage of a company’s political contributions for the 2002 congressional election cycle that went to Republican candidates or PACs, as reported by the Center for Responsive Politics. Reliance on Nuclear Power is the percentage of a company’s total electricity production coming from nuclear power plants; Relative Emission Rate is defined in figure 3-5.)

The Nuclear Energy Institute and climate change policy

According to Congressional testimony by senior vice president Marvin Fertel of the Nuclear Energy Institute, the Institute “is responsible for developing policy for the United States nuclear industry. NEI’s 270 corporate and other members include every United

States energy company that operates a nuclear plant.” On May 20, 2004, Fertel testified before the Clean Air, Climate Change, and Nuclear Safety Subcommittee of the US Senate’s Environment and Public Works Committee. Most of the testimony involved technical aspects relating to safety and security at existing US nuclear plants, but a small portion was devoted to the role of nuclear power as “an essential component of our nation’s clean air goals.” Three excerpts follow:

Nuclear energy also is an environmental imperative for reducing greenhouse gases.

Expanding nuclear energy production through continued efficiency gains and building new nuclear plants would further enhance the role of nuclear energy in our environmental goals.

The industry has been working for several years on regulatory, financial and legislative initiatives that encourage investment in new nuclear plants.

NEI policy supports the construction of new nuclear power plants in the United States.

Four days after Fertel called for the construction of new nuclear plants in the US, renowned environmentalist James Lovelock, writing in the British newspaper *The Independent*, forcefully advocated the construction of new nuclear power plants as the only realistic defense against potentially catastrophic global warming (Lovelock 2004). Clearly the nuclear industry is likely to welcome Lovelock’s calls for the construction of new nuclear power plants, but can Lovelock expect support from the financially powerful NEI in his efforts to stimulate the implementation of policies to force significant and timely greenhouse gas reductions?

Probably not; the prospects for this type of relationship are clearly constrained by the nuclear industry's reliance on coal. The May 20th testimony was actually Fertel's second appearance before a Senate Committee on behalf of the nuclear industry in 2004. On March 4, he testified before the Subcommittee on Energy of the Energy and Natural Resources Committee on the subject of new nuclear power plants. At least ten different sentences in his written testimony either argue explicitly for the construction of new nuclear power plants or describe specific benefits that such construction would bring. However, seven of these ten sentences are also accompanied by arguments for the construction of new coal-fired power plants. Three examples follow:

Our country is not investing enough in new baseload coal and nuclear plants.

We strongly encourage the passage of energy policy legislation to provide broad-based stimulus for investment in new energy infrastructure, including new nuclear plant construction, deployment of clean coal technologies, new electricity transmission and other energy sources.

Regulatory uncertainty and perceived risks over the licensing process for new nuclear power plants could inhibit capital investment in new nuclear facilities. In the coal industry, uncertainty over environmental requirements, including possible future limitations on criteria pollutants and carbon dioxide, has slowed capital investment in new coal-fired generating capacity or in upgrading existing capacity. Public policy must recognize the impact of these uncertainties and develop mechanisms to address them.

The construction of new coal-fired power plants is inconsistent with efforts to reduce

greenhouse gas emissions. Lovelock’s editorial also states that “we can not continue drawing energy from fossil fuels,” but the NEI explicitly advocates the construction of new fossil fuel-fired power plants. Because of its reliance on coal, the nuclear industry may not be in a position to support efforts to reduce greenhouse gas emissions, even if they have the potential to stimulate substantial investments in new nuclear power plants.

Conclusion

The “nuclear industry” consists of a group of companies that own nuclear power plants. However, these companies also own coal-fired power plants and rely heavily on coal to produce the electricity that they sell. This reliance on coal greatly constrains the degree that they can be expected to advocate for nuclear power as a substitute for coal. For this group of companies, the most profitable future is one in which lax regulation of carbon pollution allows the production costs for coal-fired electricity to stay low enough that the construction of new nuclear power plants is unlikely to be profitable. However, there are companies within the nuclear industry, including Entergy and especially Exelon, that are much less constrained by their reliance on coal. The potential for implementation of policies intended to severely restrict the use of coal and stimulate a search for large-scale alternatives may eventually lead to open support for such policies from these companies and others. The data reviewed for this paper, however, provide little evidence that significant divisions currently exist among nuclear owners over policies related to global climate change and nuclear power. Although nuclear power plants currently account for the majority of greenhouse gas emission-free electricity generation in the US, this analysis suggests that the group of companies that own these plants, often called the

“nuclear industry,” cannot be expected to support efforts to reduce emissions, even through policies that have the potential to stimulate the construction of new nuclear power plants.

Chapter 4: Environmental Organizations, Global Climate Change, and Nuclear Power

It is well known that environmental organizations have traditionally opposed the use of nuclear power plants to generate electricity. For example, at least three of the organizations discussed in this chapter, the Union of Concerned Scientists, the Natural Resources Defense Council, and the Sierra Club, have opposed the expanded use of nuclear power for three decades (Walker 2004). However, increasingly persuasive evidence that the use of fossil fuels is contributing to global climate change has accumulated since these positions were formulated. The purpose of this chapter is to examine the possibility that this evidence may eventually cause a decrease in the degree to which environmental organizations oppose the construction of new nuclear power plants as one alternative to reliance on fossil fuels. Relevant statements about climate change and nuclear power from a range of groups are collected and analyzed, and responses to several specific proposals are described.

Environmental organizations advocating a decisive shift away from fossil fuels as a response to climate change are, arguably, faced with a dilemma: Should the need for alternative non-fossil energy sources motivate a reconsideration of long-held positions opposing the construction of new nuclear power plants? In considering this question, it is useful to specify three possible descriptions of the current situation that could conceivably be supported by available data: (1) The risks posed by nuclear power plants

are so great that there is virtually no possibility that any combination of increasingly severe climate change and continually increasing carbon emissions will cause positions to change in the future; (2) At this time, environmental organizations are confident that other technologies and strategies can reduce carbon emissions with sufficient rapidity to render new nuclear power plants unnecessary, but, in principle, the possibility exists that dissatisfaction with the results of other strategies could, at some time in the future, lead to changed positions on the construction of new reactors; (3) Within environmental organizations, attitudes about nuclear power plants have already begun to evolve in response to climate change. The evidence that was reviewed for this chapter provides virtually no support for conclusion (3), and some organizations have openly announced, and others have clearly implied, that they have reached conclusion (1). But for some groups, the possibility that conclusion (2) best describes the current situation cannot be excluded.

In order to document the positions that environmental organizations have taken on relevant issues, web sites of these organizations were searched for references to climate change and nuclear power; the results of this search form the basis for all generalizations included in this chapter. The remainder of the chapter contains several distinct sections. The first places positions about nuclear power in historical context and explains why environmental organizations have the potential to play especially important roles in debates about nuclear power and climate change. The second section describes my data collection process and summarizes the results of my research, focusing exclusively on organizations that indicated their interest in relevant issues by their direct participation in the policy debates described in chapters five and six. The third examines several

examples in which groups have taken positions on specific issues related to nuclear power plants for clues as to whether positions were influenced by concern about climate change. General conclusions are described in a short final section.

History and Importance of Environmental Organizations

Because environmental organizations have taken many positions on a wide range of issues, generalizations are difficult. It is, however, probably fair to say that at least four positions related to energy policy are held by most organizations and have remained dominant for more than two decades: (1) Efforts should be made to reduce the consumption of energy and, especially, the use of petroleum and coal to produce energy. (2) The use of renewable energy sources, especially wind and solar power, should be increased. (3) Nuclear power plants are uniquely undesirable because they are unsafe and produce waste that is extremely dangerous. (4) When fossil fuels or nuclear power are used to produce energy, available technologies that limit environmental impacts should be deployed as widely as possible. Obviously there are also differences between groups and the study of these differences could be extremely worthwhile, but the general pattern is clear to any casual observer and will be the subject of this paper.

In the decades since these positions were initially formulated, climate change has emerged as a formidable new challenge, and, while three of these positions are well aligned with efforts to combat climate change, opposition to nuclear power is not. In 2002 nuclear power plants accounted for 73% of all greenhouse-gas emissions free electricity production in the US (CERES 2004), and, viewed very narrowly from the perspective of climate change, they are as good as wind turbines or solar panels in the

sense that their use is associated with the emission of similarly small amounts of greenhouse gases (IPCC 2001). While this narrow view obviously ignores the fact that they remain a uniquely dangerous source of long-lived radioactive material, it does show that nuclear power plants have the technical potential to play a role in facilitating reductions in carbon emissions and therefore provide an important environmental benefit. While history suggests that most environmental organizations are unlikely to ever advocate for the construction of new reactors in any context, this same history also means that efforts to stop such construction would be seriously weakened if they received anything other than emphatic support from these reliably anti-nuclear organizations.

The work of environmental organizations has the potential to be even more influential in the debate about new nuclear power plants as a potential solution to climate change than for some other environmental problems. This is because, although the general outlines of the debate are relatively simple, supporting details are not obvious. While, for example, some causes and effects of oil spills are obvious to even the most casual observer and the fact that emissions from smokestacks and tailpipes can cause localized air pollution is not difficult to understand, the links between causes and potential effects are less easily established in the cases of both nuclear power and climate change. Environmental organizations are important partly because they employ and include experts who can understand and interpret these links so that they can be used to formulate policy. And some public opinion research even suggests that the public trusts information received from environmental organizations more than it trusts scientists that work for either the government or industry (Smith 2002). For these reasons, any change in the established opposition of these groups to the use of nuclear power would have the

potential to influence people, other organizations, and the development of policies to address the growing threat of climate change.

Positions of Environmental Organizations

The purpose of this chapter is to describe and analyze positions taken by environmental organizations on new nuclear power plants in the context of climate change policy. A broad sample of environmental organizations was identified to serve this purpose, and the data collected show that enough similarities exist to support significant generalizations and that enough groups are included to repeatedly illustrate important themes. All of the data was collected from the web sites of well-known environmental organizations that provide information about both climate change and nuclear power. Each site was thoroughly searched for references to nuclear power using both search functions available on the sites and Google. Most groups have a page or a number of pages devoted entirely to the issue of global warming, and many have similar coverage of nuclear power. These pages were also studied. A detailed survey of available comments, with specific citations, is included in Appendix A to this thesis; the following table lists representative excerpts from groups that participated directly in the debates described in chapters five and six of this thesis. Direct quotations are in italics.

<u>Table 4-1: Environmental Organizations and Nuclear Power</u>	
Conservation Law Foundation	<i>Increasing the use or output of nuclear power is an unacceptable strategy for reducing electricity sector greenhouse gas emissions.</i>
Environmental Defense	<i>Like coal, nuclear power causes some of the most serious environmental impacts, albeit indirectly. ED advocates a switch “from fossil fuels and nuclear power to renewable energy.”</i>
Sierra Club	<i>George Bush, in his eagerness to revive the nuclear power industry, is altogether too willing to script the American energy future as a disaster movie.</i>
Natural Resources Defense Council	<i>NRDC does not anticipate that new nuclear power plants will be built in the foreseeable future because new nuclear power plants are unable to compete with a host of cleaner, cheaper, and less risky technologies. NRDC does not support the construction of new nuclear power plants.</i>
Redefining Progress	<i>The Ecological Footprint of nuclear power is more controversial. . . Nuclear power does not generate carbon dioxide emissions . . . but . . . it does create wastes that must be dealt with over many thousands of years.</i>
Union of Concerned Scientists	<i>A recent report lists specific conditions under which construction could be acceptable, but these conditions would be difficult to meet. A call to <i>Modernize America's Electricity System</i> does not mention nuclear power.</i>
US PIRG	<i>Our reliance on coal, oil and nuclear power imperils the world's climate, fouls the environment, harms human health, and results in the proliferation of nuclear materials.</i>
Comments of environmental organizations obtained from group web sites in 2004.	

Some important themes appear repeatedly both in the above excerpts and in the other available material. All groups describe or allude to the well-known problems of safety, waste, and proliferation, and many focus their coverage of these issues through the lens of terrorism and allude to the attacks that occurred in the US on September 11, 2001.

Almost all groups explicitly object to government subsidies that could encourage the construction of new nuclear power plants, in some cases asserting that such subsidies would likely divert funds that could otherwise support the development of cleaner energy sources. The Price-Anderson Act, through which the federal government shields reactor owners from full liability for major accidents, is repeatedly cited as evidence that nuclear power plants are not safe enough to survive in a fully market-based economy. Many advocate explicitly for a shift in funding away from nuclear power and toward these alternatives. Comments that allude in any way to the technical possibility that nuclear power plants could become an important part of efforts to mitigate climate change are quite rare.

One way in which an organization can acknowledge a link between nuclear power and the potential for future reductions in carbon emissions is by simply including information about nuclear power in materials that also reference climate change. Environmental Defense seems to take this approach, although the intention is almost certainly to discourage the consideration of nuclear power as an alternative. Redefining Progress and Natural Resources Defense Council confront the dilemma more directly: each acknowledges, within discussions of climate change, the emissions-free nature of nuclear power generation, and then explains drawbacks of nuclear power. Probably the most well developed position among these organizations is that of the Conservation Law Foundation, which opposes, in a specific policy statement, mitigation of climate change through the increased use of nuclear power. Other groups approach the question more indirectly or not at all. The Sierra Club and the Union of Concerned Scientists both cover climate change and nuclear power only as completely separate issues. Except for the

Union of Concerned Scientists, these groups all clearly oppose the use of nuclear power and indicate no willingness to reconsider their positions in light of increasingly severe climate change.

Environmental organizations remain overwhelmingly skeptical about nuclear power. The vast majority of information about nuclear power on the groups' web sites describes dangers to human beings, potential environmental impacts, and economic costs of nuclear power, and no group provides any reason to expect that it would actually accept proposals to build new nuclear power plants even in the context of a comprehensive plan to combat climate change. However, several groups do acknowledge a link between the issues and a smaller number even allow, albeit implicitly, for readers to attempt to weigh disadvantages of nuclear power against potential impacts of climate change.

Three Specific Examples

This section describes three examples in which environmental organizations have chosen to comment on specific questions about the future use of nuclear power. In two cases multiple groups have collaborated. These examples are important because, while the more general comments described above often treat nuclear power and climate change as completely separate issues, the task of formulating opinions on specific issues presumably requires the integration of a range of relevant data.

The first example is a 1998 letter to President Clinton that is available only on the Public Citizen web site. The letter, signed by the Sierra Club, US Public Interest Research Group, and others, states that the groups “strongly oppose proposals to use

nuclear power as an approach for lessening [greenhouse gas] emissions” (Public Citizen 1998). The letter explains that “Nuclear power creates more problems than it solves including contributions to greenhouse gas emissions when considering the complete fuel cycle of nuclear power.” Three of four sections deal with costs, subsidies, and economics; but the second section, titled “An Unacceptable Trade Off” concludes that “proposing to exchange global warming for global glowing is inconceivable to us.” Specifically, the letter opposes the funding of research into new nuclear power technology that was proposed as part of a comprehensive study of twenty first century energy policy prepared in 1997 by the President’s Committee of Advisors on Science and Technology under the leadership of respected energy expert John Holdren. Although the letter is certainly significant in that it specifically opposes the use of nuclear power to combat climate change, it is somewhat dated and not widely available and is therefore unlikely to strongly influence members of, or set a precedent that would constrain decisions by, the environmental organizations that participated.

The second example is a more current collaboration between groups that belong to the Climate Action Network (CAN), including Environmental Defense, the Natural Resources Defense Council, US Public Interest Research Group, the Sierra Club, the Union of Concerned Scientists, and others (CAN 2004). The Climate Action Network’s comments on the Joint Implementation and Clean Development Mechanism provisions of the Kyoto protocol oppose the inclusion of nuclear power plants in these flexibility mechanisms, which would allow participating countries, under certain conditions, to fund the construction of emissions-free generating stations in other countries and receive credit for having made corresponding emissions reductions. The stated positions are that “All

nuclear, coal, and large hydro projects should be excluded from the [Clean Development Mechanism] because of environmental concerns and incompatibility with sustainability goals” and “Nuclear projects must be explicitly excluded from Joint Implementation because of severe and repeatedly demonstrated environmental and social risks and impacts” (CAN 2001; CAN 2004). Although the statements certainly imply a general opposition to nuclear power, it may also be significant that they appear in the context of opposition to a program that would subsidize the construction of new nuclear power plants, and therefore, if read narrowly, may indicate opposition to a specific type of subsidy rather than general opposition to construction of new nuclear power plants in the context of climate change policy.

In attempting to characterize the likely course of future debates about specific proposals for new nuclear power plants, it is worthwhile to consider the possibility that, partly because fear of nuclear reactor technology is often expressed in terms of three components (safety, waste, and weapons proliferation), it may be possible to design future power plants to minimize these specific risks. The Sierra Club’s official position, for example, is to oppose the further use of nuclear power “pending” the solution to specific problems. Because opposition to nuclear power among environmental organizations in the United States originally evolved in tandem with currently deployed technology, it is extremely difficult to disentangle generalized opposition from specific complaints that could, in theory at least, be addressed in future designs. It could be that, for some people and environmental organizations, technology that is merely different will facilitate reconsideration of long-held positions and opinions about the viability of

nuclear power. Specifically, as historically anti-nuclear environmental organizations become increasingly concerned about climate change, a tight coupling between anti-nuclear feelings and specific aspects of current reactor technology could facilitate consideration of significantly different reactor designs. The specific test case described below is the third example discussed in this section.

There was, under development in South Africa for potential future commercial power generation, a reactor that is fundamentally different from those currently used to generate electricity in the US. Several environmental organizations commented on the possibility that this new type of reactor, called a pebble bed modular reactor (PBMR), could be deployed in this country. While current US reactors use rod-shaped fuel assemblies, the PBMR would use spherical fuel elements (Kneif 1992), and the reactors would be modular in the sense that each would generate electricity at about one tenth the rate of many current US reactors and several could be deployed at a single site (Deutch, Moniz *et al.* 2003). While interest in PBMR technology decreased after US investor Exelon dropped out of the South African project in 2002, the proposal stimulated much discussion about the advantages and disadvantages of specific design features (NIRS 2002). One important characteristic of the PBMR proposal is that the fuel elements are designed and configured within the reactor core in such a way as to preclude melting even after a complete loss of coolant (DOE 2001). For this reason, the design calls for a containment structure that is less massive and robust, and therefore probably less expensive, than those currently used for US reactors (UCS 2001). However, especially since September 11, 2001, containment structures have increasingly been viewed as necessary defenses against attacks even absent fears about meltdowns. The PBMR's

small size could also make it fundamentally less dangerous, more economically competitive, and easier to integrate into existing power grids.

News that Exelon was studying the PBMR technology for possible deployment in the US elicited commentary from at least six environmental organizations despite the fact that the proposed site is in South Africa and construction had not yet begun. These comments, summarized in Appendix A, were generally skeptical. The three most thorough reviews came from the Natural Resources Defense Council, Environmental Defense, and the Union of Concerned Scientists, and they were similar. While Natural Resources Defense Council cautioned that “safety and proliferation risks have not been subjected to a thorough licensing review (Lashof 2001),” they did describe the design as potentially “safer.” Environmental Defense and the Union of Concerned Scientists were both more skeptical, citing potentially serious consequences if the plant were to catch fire (Environmental Defense 2002, Union of Concerned Scientists 2001). Even given a specific design and worsening climate change, no group expressed anything close to the interest and enthusiasm that exist for other non-emitting methods of electricity production. It is also important to realize that the PBMR is both technologically exceptional and unbuilt; other nuclear power plants planned or under construction in Finland, Japan, and Taiwan are not fundamentally different from the existing plants about which most environmental organizations have already expressed strongly negative opinions (DOE 2001).

To the extent that environmental organizations chose to comment on the possible construction of the PBMR, most used their expertise to identify potential problems and therefore, presumably, signal their opposition to future construction in the US, although

the responses do seem to show a willingness to consider the possibility that new technology could offer advantages. Although no comments provide any direct support for the hypothesis that concern about climate change may increase the willingness of some groups to re-evaluate the merits of any proposed new nuclear power plant, it is not unreasonable to speculate that some of the less negative comments were informed by realization of the need for more emissions-free sources of electricity generation to combat climate change.

Conclusion

Although the general opposition of environmental groups to the use of nuclear power is obvious and not in question, it is not possible to predict with certainty, for any particular group or for environmental organizations in general, how increasing concern about climate change may influence reactions to proposals to build new reactors in the future. Two significant observations can, however, be made based on presently available information: (1) Information about climate change does not seem to have changed the fact that, in general, environmental organizations remain opposed to future increases in the use of nuclear power, and several groups have indicated direct opposition to the inclusion of nuclear power in efforts to reduce carbon pollution; and (2) While other groups have left some room for future flexibility, either by explicitly acknowledging nuclear power's status as an emissions-free energy source or by not addressing the question at all, there little evidence to suggest that any group will accept the construction of new nuclear power plants, even in the context of a comprehensive plan to address climate change, in the foreseeable future.

Chapter 5: A New Hampshire Case Study

Chapters one and two of this thesis argue that it is reasonable to look for a climate signal in debates about the future of nuclear power, and chapters three and four examine two types of organizations that can be expected to play important roles these debates. An obvious next step is to examine a specific policy debate, and chapters six and seven serve this purpose to a large degree in the context of the Regional Greenhouse Gas Initiative (RGGI). However, RGGI has not yet progressed beyond initial planning stages, so the case considered in this chapter offers an important analytical opportunity to closely study controversy about a specific and relevant policy decision. While this chapter is not explicitly about climate policy, it does illustrate how a debate about emissions regulations can turn into a debate about nuclear power and therefore provides a useful context for relevant policy analysis. The chapter begins by describing the a rule change that will allow the state of New Hampshire to allocate emissions permits to a nuclear power plant. Subsequent sections analyze the options that were available to New Hampshire and describe how environmental organizations and the nuclear industry reacted to the final decision. Finally it is argued that this case is important because future controversies about nuclear power and climate change are likely to be conducted in the context of similar debates about specific provisions of regulations that govern the trading of emissions permits. While this case study does not directly address climate change, it does offer both a useful policy lens through which to consider likely future controversies and valuable evidence of a climate signal in a current debate about nuclear power.

The controversial rule change

The New Hampshire Department of Environmental Services (DES) controls NO_x emissions from power plants within the state by requiring polluters to own permits called allowances, each of which represents the right to emit one ton of NO_x pollution. In 1994, New Hampshire agreed with other northeastern states to implement a trading program to reduce the NO_x emissions from power plants that lead to the formation of harmful ozone smog. Since 1999 NO_x polluters have been required to own marketable allowances equivalent to their NO_x emissions (OTC 2003). This requirement facilitates the monitoring and control of pollution, and the fact that the allowances are marketable provides an incentive to reduce pollution because unused allowances may be sold. Each year, a specific number of allowances are allocated, or provided at no cost, to market participants in New Hampshire according to rules that will be described in more detail below. The rules were changed in 2003 so that non-emitting sources, explicitly defined to include nuclear power plants, are now eligible to receive NO_x allowances from a pool previously reserved for renewable energy and efficiency projects. These allowances, which are only available for actual increases in electrical generation, may then be sold to NO_x polluters. The Seabrook nuclear power plant, which is the only such plant in the state, has announced plans to complete an eligible “uprate,” or incremental increase in generation capacity. When the project is completed in 2005, the plant will be able to generate more electricity than it has in previous years and will receive a quantity of allowances corresponding to the increase (Newbury 2004). An excerpt from the text of the new rule and an explanation from a state official follow:

From New Hampshire Code of Administrative Rules:

Env-A 3207.02 Statewide Total Allowances.

(b)(2) Project sponsors of any of the following types of projects shall be eligible for the receipt of NO_x allowances from the energy efficiency and renewable energy set-aside allocation:

- a. End-use efficiency projects;
- b. Non-emitting generating systems; and
- c. Renewable energy projects;

Env-A 3203.41 “Non-emitting generating systems” means devices for generating electricity, including but not limited to hydroelectric, nuclear, geothermal, wind, or solar power, that do not combust fossil fuel or emit NO_x emissions and have a nameplate capacity of 15 MW or greater commencing or increasing operation after December 31, 1990. Source. #7897, eff 5-24-03

Joseph Fontaine, Trading Programs Manager, State of New Hampshire
Department of Environmental Services (Fontaine 2003):

“Satisfying future electricity demand growth with new non-emitting generation, such as nuclear energy, may avoid upwind emissions increases from fossil fuel power generation. The New Hampshire Department of Environmental Services has revised its NO_x Budget

Trading Program and now allows nuclear power plant uprate projects to be eligible to receive NOx allowances from a set-aside account for incremental new power generation increases that displace future fossil generation.”

The remainder of this paper will examine the debate that surrounded this rule change. First, two sections provide contextual information about issues related to the Seabrook nuclear power plant and emissions trading. Next, the controversy surrounding the rule change and the written testimony submitted to DES is described in detail. Finally, two important conclusions are presented: (1) Both supporters and opponents of nuclear power agree that current decisions have the potential to set important precedents for the inclusion of nuclear power in efforts to mitigate global climate change, but many influential environmental organizations that have traditionally opposed nuclear power adamantly oppose such inclusion. (2) Supporters and opponents of nuclear power claim to agree that nuclear power plants should not be subsidized but disagree about what constitutes a subsidy. Therefore, to the extent that subsidies for generators that do not emit greenhouse gases becomes a favored mitigation strategy, the inclusion of nuclear power plants is likely to be especially politically problematic.

Context: the Seabrook nuclear power plant and New Hampshire

The Seabrook nuclear power plant has been selling electricity onto New England’s power grid since 1990. The reactor, which is the largest in New England, has

the capacity to produce electricity at a rate of nearly 1200 MW and generates about 7% of the electricity used in New England (EIA 2003). As of 2002, Seabrook accounted for 34% of electrical generation capacity in New Hampshire and nearly 60% of actual electrical output, compared to 23% for coal, 7% for hydroelectric, and 6% for other renewables, including biomass (EIA 2002). (Nuclear power plants usually operate nearly continuously; plants that burn natural gas or, to a lesser extent, coal adjust output to meet varying demand and therefore account for a greater percentage of capacity than actual generation.) As the nuclear fission reaction that produces heat occurs within fuel rods enriched with fissionable uranium, they gradually turn into extremely radioactive waste at a rate of about 20-30 metric tons per year. Current regulations allow for all of the waste produced to remain at the reactor site for as long as 100 years, first in a pool of water and then in dry casks (CRS 2003). Plans exist that would allow for the retention of the waste at the site for much longer periods, although the presently favored alternative is to eventually dispose of it at a remote underground location (DOE 2002),

The increase in generating capacity, or uprate, planned for the Seabrook plant will increase the plant's output by approximately 70 MW (Newbury 2004). Such uprates are not unusual and typically involve improvements to the systems that generate electricity from steam, such as turbines and generators, although they may also result in greater nuclear fuel use (NRC 2004). Seabrook's uprate will increase the rate of waste production by "about four fuel assemblies additional beyond the 80 to 84 that are normally replaced during refueling," or about 5 percent (Legendre 2003).

On the website of Seabrook's majority owner, FPL Energy, visitors learn about the hundreds of thousands of people who have visited Seabrook station since 1978 to

learn about the “thriving ecosystem that surrounds the plant” at the “Science and Nature Center” (FPL 2004). Unmentioned are the tens of thousands of other people who visited the site to protest the construction and operation of the plant over two decades.

Opposition to the construction of a nuclear power plant at Seabrook began in 1969 and organized around plans to dump warm cooling water directly into the portion of the surrounding ecosystem called the Hampton River, a concern that eventually led to the construction, at great expense, of tunnels to carry the water to the open ocean. As late as 1989, surrounding towns were actively protesting that evacuation plans were hopelessly inadequate, an objection that resonated among residents who had sat in traffic jams during voluntary evacuations of the local beach occasioned by the arrival of summer thunderstorms (Randall 2002).

Site-specific opposition to nuclear power plants, based on concern about localized environmental impacts or evacuation planning, continues to characterize such conflicts and may have been a factor in the decision to decommission the nearby Maine Yankee plant. Seabrook, however, attracted a degree of concerted opposition virtually unrivaled in the anti-nuclear movement. Beginning in 1976 and 1977, members of the Clamshell Alliance began to be arrested by the hundreds during regular non-violent protests, with the last such incident occurring in 1989. Opposition to Seabrook became probably the most hard-fought battle in a much larger national campaign against nuclear power which continues to occupy concerned citizens to this day and arguably contributed to the bankruptcy of the original plant owner and the cancellation of plans to build a second reactor at the site. The plant did not begin to generate electricity until 1990, more than twenty years after it was first proposed (Garza 1990).

In January 1990, Paul Gunter, co-founder of the Clamshell Alliance and veteran Seabrook protester, wrote: “With the cancellation of plans for hundreds of United States nuclear power plants over the past decade, Seabrook is the last of an industrial generation. The nuclear industry now hopes to win back public trust and confidence with smaller, standardized designs for "inherently safe reactors." Seabrook can become either a milestone or a tombstone for that industry plan” (Gunter 1990). Interestingly, the recent rule change may represent another industry milestone for Seabrook, a point not lost on Mr. Gunter. In testimony submitted on behalf of the Reactor Watchdog Project of the Nuclear Information and Resource Service (NIRS) in 2003, he wrote “NIRS is most concerned with the national precedent that the New Hampshire action would set for eventually subsidizing the existing 103 operating reactors with not only NOx but carbon dioxide allowances, thus fueling speculations for renewed nuclear power plant construction and expanded nuclear fuel production” (Gunter 2003).

Context: emissions trading in New Hampshire and nuclear power

The Ozone Transport Commission’s NOx emissions trading program was authorized by the federal Clean Air Act of 1990. The purpose is to facilitate economically efficient reductions in NOx emissions from regulated sources located in the northeastern states with the biggest ozone problems (OTC 2003). Certain aspects necessary to facilitate trading have been agreed upon by all participating states, while other aspects, including some aspects of the allocation of allowances, were to be determined by individual states for sources operating within their borders (ETEI 1999). Since the implementation of the cap and trade system, NOx emissions from included sources have

been significantly reduced within the region (OTC 2003). Because of the success of the program, it has been suggested that study of the US NO_x market may provide useful guidance for designers of future greenhouse gas emission allowance trading schemes (Huetteman 2002). Specifically, because the system requires the coordination of numerous plans administered by individual states, it may be a useful model for other regional efforts to reduce greenhouse gas emissions such as the Regional Greenhouse Gas Initiative, discussed in chapter 5.

In 2003 the OTC system is scheduled to be replaced by the EPA's SIP Call plan, which includes a larger number of states but does not include New Hampshire. The reason for this change is largely geographical: NO_x emissions from power plants are typically transported significant distances downwind before contributing to the formation of ozone smog. The SIP Call regime includes several upwind states with power plants that contribute significantly to the smog problem in downwind states. Researchers have attempted to evaluate the degree to which the OTC program may have switched some electricity production entirely out of the region. This could occur if some production were shifted to coal-fired plants in the Midwest which had then sent both electricity and NO_x pollution back into the region, decreasing the effectiveness of the program. But there is no evidence that this has occurred on any significant scale (OTC 2003).

The OTC program has been successful in the sense that NO_x emissions from power plants in the region declined by 60% even while electricity consumption increased (OTC 2003). Regulated NO_x polluters are required to provide evidence that they own allowances corresponding to their emissions, and emissions are monitored by sensors in smokestacks. But because of the complexity of electrical markets and because privately

owned power companies are not obligated to reveal financial details of transactions, much less the reasoning behind business decisions, it is difficult to establish causal connections between the program's implementation and specific NOx reductions.

A 2003 evaluation of the program compared electrical production in the region in 1997-1998 with production in 2000-2001. The study showed that nuclear generation increased from 28% to 35% of the regional total and concluded: "Increases in OTC nuclear generation appear to offset increases in regional demand and account for much of the decrease in fossil generation (OTC 2003, p. 9-10)." The OTC market structure does not specify acceptable means by which emissions reductions are achieved within states, but it does increase the production costs for emitting sources to the extent that they may need to purchase allowances to pollute, or, at the least, they may lose the opportunity to sell their allowances when they pollute. As long as the quantity of allowances corresponds to an amount of pollution lower than what would be produced in the absence of the program, there will be some upward pressure on the production costs for polluters that will not affect costs for producers that do not emit NOx pollution, such as nuclear power plants. NOx polluters will therefore be placed at a competitive disadvantage, and this effect could facilitate a shift of some generation from fossil plants to nuclear plants. The total number of allowances issued by the state of New Hampshire was 5219 for years 1999 – 2002, 3739 for 2003 – 2005, and 3000 for 2006 and subsequent years. Each allowance gives the owner the right to emit one ton of NOx pollution during one year, although unused allowances may be banked for use in future years, subject to restrictions on the total number of banked allowances that may be used in any future year (NHDES 2003).

Context: issues related to the allocation of allowances

One of the more difficult design questions that must be addressed when constructing emissions markets concerns the allocation of allowances, and, as was mentioned previously, this is one aspect of program development that has been left to individual states (ETEI 1999). However, EPA guidance documents do suggest two possibilities: (1) Traditionally, and in the first sample rules provided by EPA, allowances have been allocated to polluters in proportion to total fuel or thermal inputs for some baseline year. In other words, a specific number of allowances has been issued to a source for each unit of fuel used, so sources that burn fuel more cleanly have been rewarded because they have been able to sell allowances that were allocated based on fuel use but not needed because the fuel was burned with lower emissions. (2) In an alternative system, which has been adopted by New Hampshire, allowances are allocated based on electrical or thermal output. This allows sources that have been fuel-efficient (in the sense that they have used less fuel per unit of power production) to receive allowances in proportion to their (high) energy output in the baseline year rather than their (low) fuel consumption (EPA 2000). In either system the emission of pollutants in the present triggers the requirement to own allowances, and the fact that unused allowances may be sold and additional required allowances must be purchased provides the incentive to reduce emissions

Beginning in 2006, the first year in which Seabrook will receive allowances, the New Hampshire plan will become even more complex in that new allocations will be determined each year based on energy output data from the previous two years (NHDES

2003). The appropriateness of such output-based allocations has been questioned on the basis that energy production is naturally rewarded by the market, and the potential effects of allocations like the one that is to be implemented in New Hampshire are extremely difficult to predict and may prove to be economically inefficient (EPA 2000; Fischer 2003). It is also true that controversy over allowance allocations could be avoided if the available allowances were auctioned by the state rather than given away for free. However, because of political constraints against the direct imposition of costs on businesses, free allocations have been used for existing emissions trading programs in the United States

However, because it routinely produces more than half of New Hampshire's electrical output, had Seabrook been included directly in this output-based allocation scheme when the original OTC regime expired in 2003, it would have received a correspondingly large and valuable fraction of the available allowances each year. Partly for this reason, it was decided that this method should be used only for allocations to NO_x emitters and not applied to the nuclear plant. (Miura 2003; Fontaine 2004). The alternative would have amounted to a substantial transfer of wealth to Seabrook from its local fossil-fuel fired competitors, because they would have needed to purchase allowances from Seabrook or make much larger cuts in their NO_x emissions. In any case, it probably would not have had much impact on the plant's operation: In 1999, EPA produced a paper that suggested that the allocation of allowances to nuclear power plants would be unlikely to seriously impact the economics of nuclear power, although it could slow the decommissioning of some of the more marginal nuclear plants (EPA 1999).

But this move to output-based allocations may have been a factor in the decision to include nuclear power plants in New Hampshire's allocation scheme in another way. In 2000, EPA collaborated with stakeholders to publish a paper that provides guidance to state regulators considering the implementation of output-based allocation schemes. Nuclear power plants are included in a list of sources to which allowances may be allocated, and the paper includes sample rule language similar to that eventually adopted in New Hampshire. The state, which was represented by two environmental regulators on the workgroup that produced the guidelines, was one of only five state governments that contributed members (EPA 2000). Because it created a context in which allowance were allocated for electrical production, the adoption of output-based allocations for fossil fuel-fired plants may have increased pressure to allocate at least some allowances to Seabrook.

Ultimately, the decision was made to allocate allowances to Seabrook from a so-called "set-aside" account that had previously been reserved for other uses. According to EPA, "a regulating authority can distribute the set-aside allowances for purposes such as an incentive for certain technologies, as a way to address equity issues, or as a reserve for new units." New Hampshire's regulations stipulate that 600 of the annual total of 3000 allowances be included in such an account (EPA 2003). Allowances from the state's "multi-purpose set-aside account" may be allocated in the following five ways, in priority order: (1) They may be allocated to new sources; (2) They may be allocated to "end-use efficiency projects, non-emitting generating systems, or renewable energy projects," as described earlier in this paper; They may also be (3) banked; (4) auctioned; or (5) retired (NHDES 2003). Of the approximately 600 allowances placed in the account in each of

the past several years, each year a very small number have been allocated to proposed renewable projects, 100 have been retired, and the rest have been banked for future use by new sources (Fontaine 2004). Seabrook is expected to receive about 200 each year, and the opportunity to sell these allowances represents a likely financial benefit of approximately one million dollars annually. (ANS 2003; Newbury 2004).

Because of the complexity of the allocation rules for the set-aside account, and because of the discretion left to the state in administering the account, it is virtually impossible to determine the likely consequences of the rule change. For example, while one result would clearly be to increase the total allowed amount of NO_x pollution in the year of allocation, the next option down the priority list is to bank them so that they could be used to facilitate the entry of a new fossil fuel-fired generator into the New Hampshire market at some future date. As Seabrook is expected to produce electricity worth hundreds of millions of dollars annually and receive less than ten percent of the total quantity of allocated allowances, the overall impact on both the operation of the program and the financial health of Seabrook is likely to be small.

Comments received by New Hampshire Department of Environmental Services

Prior to the adoption of the rule, there were two public hearings and a period during which public comments were accepted for consideration. These comments are significant both for their relevance to the specific question that they address and for the possibility that they may shed some light onto the more important question that is a central focus of this thesis: How will interested parties position themselves in a possible future debate about the expanded use of nuclear power to combat global climate change.

This section will describe and analyze comments that were submitted by organizations and companies in detail.

Before looking at the actual comments, it is worth considering the constraints under which the commenters operate. Environmental groups traditionally oppose nuclear power as described in chapter 4, and this tradition would certainly provide a powerful brake on any impulse to accept nuclear power for its clean air benefits. And, in a dynamic documented in chapter 3, FPL Energy, the owner of Seabrook, also owns fossil fuel-fired power plants in New England and is, according to the company web site, the owner of a “world-leading wind portfolio” (FPL 2003). So a precedent that favors uranium over fossil fuels may not benefit FPL energy, and the company’s enthusiasm for the argument that nuclear plants should be treated like wind farms would likely be tempered by concern that such a connection could dampen enthusiasm for the subsidies enjoyed by the company’s wind generators. As is documented in chapter 3, this cross-ownership problem is typical of the nuclear power industry and strongly constrains positions taken by the Nuclear Energy Institute and its member companies.

According to information provided by DES, of the comments submitted by individual members of the public, fifteen expressed opposition and one approved of the proposed change; no further analysis of the opinions expressed by these individuals will be made in this paper. Nine groups signed a detailed letter, dated January 21, 2003 and hereafter referenced as the “January 21st letter,” opposing the change: NH Public Interest Research Group, Clean Water Action, Natural Resources Defense Council, Appalachian Mountain Club, Nuclear Information and Resource Service, Environment Northeast, Clean Air – Cool Planet, Conservation Law Foundation, and Campaign for Ratepayer

Rights. Several of these groups and others also expressed opposition independently from the January 21st letter. Two companies that generate electricity in NH in competition with Seabrook also submitted written testimony: Public Service of New Hampshire, which owns both fossil-fired and hydro-electric plants, explicitly opposed the addition of non-emitting plants to a list that already included renewables such as small scale hydropower. Newington Energy, which operates only one large gas-fired plant in NH, expressed support for the program in general without explicitly addressing the inclusion of non-emitting sources. The Environmental Compliance Supervisor for the Seabrook nuclear power plant made statements at both hearings in support of the change on behalf of FPL Energy Seabrook, the owner of the plant. On March 10, 2003, two weeks after the second hearing, the Nuclear Energy Institute submitted a 30-page point-by point rebuttal to the January 21st letter and expressed support for the rule change.

Comments: unacceptability of nuclear power

The premise of this thesis is that groups concerned about global warming may decide to accept some compensating increase in the use of nuclear power in exchange for a decrease in carbon dioxide pollution. Two opponents implied that, at least in the case of NOx pollution, such comparative thinking is not possible:

“The acid test of any emissions trading scheme is whether it can provide equal or greater environmental benefits at less cost . . . Because fossil and nuclear power plants produce fundamentally different types of . . . environmental harm, there is simply no meaningful way to compare the relative harm. .”

(January 21st letter)

“That increased generation at Seabrook “may” decrease the generation by Coal plants in New England . . . fails to provide any reasonable basis for this subsidy.” – (Conservation Law Foundation, February 18)

Repeated references to concerns about the safe operation of nuclear plants and dissatisfaction with plans for waste storage suggest that these concerns form the fundamental basis for opposition to the possibility that NH’s NOx trading plan could benefit Seabrook. They will not be further analyzed here because they have been thoroughly analyzed over the past three decades and the data presented here and in chapter 4 provide no evidence that they have changed in any significant way.

Comments: allowance allocations and subsidies

The comments provide some evidence that the participants attempted to predict the actual effects of the change on emissions levels, but, given the complex and uncertain nature of the plan described in the previous section, it is not surprising that there were few direct assertions about such impacts. Opponents repeatedly asserted that the inclusion of Seabrook in the program would serve no useful purpose and occasionally implied that it would make the program less effective by diverting allowances from other uses. Supporters merely asserted that inclusion of non-emitters like Seabrook would be fair and consistent with the overall goals of the program and did not argue forcefully that a failure to include them would have any adverse consequences. Both sides seemed to agree that it would be inappropriate for the government to provide subsidies to Seabrook.

In fact, one criticism offered repeatedly by opponents was that the plan constitutes an inappropriate “subsidy,” and supporters chose to argue that the granting of allowances would not be a subsidy rather than claim that Seabrook is deserving of a subsidy because of its status as a non-emitter. The reality is that the granting of allowances is in some ways similar to other subsidies and in some ways different. The state creates allowances, gives them value by requiring that polluters own them, and then gives them, free of charge, to various generators of electricity. This constitutes a subsidy for the recipients of the allowances in that the government chooses to provide something of value to certain market participants. On the other hand, assuming that the state provides a sufficiently small number of allowances that polluters decide to buy allowances, the money comes not from the government but from buyers and sellers of electricity generated by fossil fuel-fired power plants. The comments below reflect this controversy; except for the statement by FPL that the program would not be funded by “electric utility customers,” which was not repeated at the subsequent session, none is demonstrably incorrect.

“[DES] has proposed that the state subsidize Seabrook Station, in the form of pollution allowances.” – various groups (1/21 letter)

“This is not a subsidy in any sense of the word” and “economic value will be derived from the electricity utility marketplace and not the state, the taxpayers, or the electric utility customers.” FPL (2/18)

“Seabrook is already the recipient of massive subsidies . . . enough is enough.”

- Sierra Club (2/18)

“This program does not provide a subsidy, or any kind of monetary assistance from the government to a commercial enterprise . . . economic value . . . will come. . . not from the state or the taxpayers.” - FPL (2/28)

“By any definition of the term, this is a subsidy to FPL Seabrook.” - CLF (2/28)

“Providing . . . non-emitting generation . . . NOx allowances is, therefore, not a subsidy, but an appropriate incentive that serves the public interest and the state’s economic interests.” - NEI (3/10)

In some ways, the debate about “subsidies” is largely semantic and might therefore seem like an insignificant sideline in the search for insight into the larger debate about nuclear power and climate change. But it is not irrelevant. If it does turn out to be politically impossible to impose costs on carbon polluters, it may be that a potentially useful alternative would be to subsidize potential competitors until they can compete with carbon polluters, as is currently done for power from new wind generators in the form of a production tax credit (MIT 2003). Commenting groups objected to “subsidies” but not, in general, to the possibility that the allowance program could result in an overall increase in the price of electricity that, because Seabrook’s operating costs would not be affected, would make the nuclear plant more profitable. Given this political landscape, strategies that fight global warming by imposing costs on carbon polluters may be more likely to result in the construction of new nuclear power plants than those that directly subsidize non-emitters because they are less likely to provoke explicitly anti-nuclear opposition. Allowance trading programs that include set-asides for non-emitters fall somewhere in between and are therefore most likely to provoke battles over the inclusion

of nuclear power.

Comments: nuclear power and global climate change

FPL Energy did not assert that the present decision had anything to do with global climate change. Although the NEI did not mention global climate change explicitly, their letter did point out that “nuclear plants release no . . . carbon dioxide” and submit several tables comparing life-cycle carbon dioxide emissions of various energy sources without explaining the relevance of the tables. The environmental groups, on the other hand, expressed concern that the decision could set a precedent for future plans to address climate change:

The decision . . . will almost certainly have far-reaching consequences, including opening the door for Seabrook to receive carbon dioxide allowances . . . – letter, 1/21

Credits will be . . . an important incentive for an emerging renewable energy industry . . . Development of these sources would represent a major step toward solving . . . global climate change. The proposed rule [may] set a precedent for taking money away from renewable developers. . . – Clean Air Cool Planet

The fact that the rule change in question had nothing explicitly to do with global warming may have discouraged full expression of these concerns in formal comments, so it is worth also considering statements made to the news media outside of the process:

“ . . . allowing Seabrook to participate in pollution credits trading sets a terrible precedent for the nation . . . Lawmakers in Washington as well as

other states will be considering proposals to provide pollution subsidies to the nuclear power industry, both to address smog as well as global warming pollutants.” Sierra Club press release, citing opinions expressed by Doug Bogen of Clean Water Action, 5/20/2003.

“PSR [Physicians for Social Responsibility] believes that the health costs and risk to public safety associated with nuclear power far outweigh any benefits it may provide in reducing air pollution and the greenhouse gases associated with climate change” (Physicians for Social Responsibility 2004)

These comments suggest that these groups that oppose nuclear power anticipate the possibility that a similar battle over the explicit inclusion of nuclear power plants in efforts to combat global warming is likely to occur in the future and have decided to oppose such plans. Although it is less clear from these comments that they would oppose nuclear plant construction that could result from policies that impose costs on polluters, there is also no indication that they would not oppose such plans whatever the context.

Analysis: rationale for allocating allowances to nuclear plants

New Hampshire’s trading program includes two related mechanisms that place power plants that produce more NO_x pollution at a competitive disadvantage with respect to those that produce less. The first is that NO_x emitters are required to own allowances corresponding to the amount of their emissions. The second, which is the focus of the current controversy, is that facilities that produce additional electricity without additional

NOx pollution can receive allowances, which they may sell to polluters. Controversy arose because of a proposal to change the rules that specify which facilities will receive these allowances to include the additional electrical output that will result from the planned uprate at Seabrook nuclear power plant.

Because emissions trading programs are typically linked to specific pollutants, there is no obvious way to explicitly include non-polluters, and there is really no clear need to do so if the number of available allowances is sufficiently small that potential polluters are influenced by the costs of obtaining allowances, and, equally importantly, the opportunity costs associated with keeping them. Such programs should, in theory, benefit all producers of electricity that do not emit the regulated pollutant because they can benefit from higher prices that result from the increased production costs imposed on competitors that pollute. Absent specific requirements that nuclear plants buy allowances for pollutants that they do not emit, it will be very difficult to exclude existing plants from benefiting from emissions trading programs that are effective at reducing air pollution to levels substantially below those that would occur without the program.

Newly constructed plants would also receive this benefit when they began to operate under such a system, and potential investors in such plants would certainly consider this possibility to the extent that they could be confident that it would still be available upon completion. In this way an effective emissions trading scheme could provide a stimulus for the construction of new nuclear power plants, and it may therefore be instructive to note that opponents in New Hampshire contested the inclusion of Seabrook in the program but did not explicitly cite this more indirect market benefit. Opposition to a plan that would simply regulate air pollution seems unlikely to come

from opponents of nuclear power even given this potential to stimulate the construction of new nuclear power plants. However, the fact that proposals to build new nuclear plants could be stimulated by policies designed to combat air pollution should not be expected to dampen opposition to new nuclear plants, even to the degree that such opposition is likely to come from people that also strongly oppose air pollution.

The rule in question in New Hampshire deals with a somewhat more difficult problem with the design of allowance trading schemes. The political process may constrain the degree to which producers of electricity are forced to bear additional costs for producing an unchanging amount of pollution. This concern may be addressed, most importantly in the early stages of implementation, by allocating free allowances to existing polluters. But non-polluting generators may object that if the state is giving away something of value in an effort to reduce pollution, surely it should not be given only to polluters. Designers of allowance markets in which some or all allowances are provided for free are likely to be sympathetic to concerns that their plans favor polluters and seek a solution. New Hampshire's allocation of some allowances to non-polluters, which can then be sold for profit to polluters that simultaneously incur a cost, is designed to address this problem. The controversy arises from the fact that this plan amounts to a relatively transparent transfer of wealth to non-polluters, including nuclear power plants, and therefore provides both the opportunity for nuclear opponents to fight a politically relatively easy battle against "subsidies" and a simple basis by which Seabrook can be excluded from the benefits available to other non-polluters: objectors can easily be satisfied by the elimination of nuclear plants from the list of possible recipients of allowances from the set-aside account. Although in this case opponents of nuclear power

plants were not successful in blocking their inclusion, both sides indicated that, to the extent that Seabrook's uprate will be "subsidized," the change is especially problematic politically.

Once the decision has been made to use some free allowance allocations to provide incentives for the development of new non-emitting sources, the argument that allowances should be granted for incremental additions to the output of nuclear power plants becomes relatively straightforward. The purpose of the program is to control NO_x pollution while facilitating the production of electricity. One aspect of the proposed method is to provide incentives for the creation of new NO_x-free generating capacity because it has the potential to facilitate either the decreased use of NO_x-emitting generators, the increased production of electricity without a corresponding increase in NO_x pollution, or both of these outcomes. Regardless of the overall merits of this plan, supporters of Seabrook's inclusion argue that it would be inconsistent to exclude nuclear power from the program based on concerns that have no clear relationship to the problem of NO_x pollution. The appealing simplicity of this argument must, however, be weighed against the implication that it is inherently undesirable to guard against unintended consequences or even attempt to encourage a preferred solution to a specific problem. While nuclear power does have the potential to play a role in the mitigation of air pollution, any implication that opposition to nuclear power is somehow logically incompatible with opposition to air pollution is simply not correct.

There is a related and perhaps more compelling way to frame the case for inclusion of nuclear power that deals explicitly with this question of tactics: It is possible that the exclusion of nuclear power could make the program less effective at addressing

its goal. Nuclear power plants are presently the largest source of NO_x-free electricity generation in the region, and upgrades to nuclear power plants have, in recent years, provided substantial increases in NO_x-free electricity production in other states. Even if other technologies are environmentally preferable to nuclear power, they may have less potential to quickly displace large amounts of fossil fuel consumption.

Analysis: arguments against the allocation of allowances to nuclear plants

One line of counter-argument is essentially economic and closely parallels the above argument. A reason to provide free allowances to new NO_x-free sources is that it may help to address specific ways in which technologies other than nuclear power, especially solar and wind power, may already be at a competitive disadvantage with respect to more traditional methods of power generation. The three major obstacles are issues of economic scale (each new wind or solar facility is likely to generate less electricity than most existing power plants), lack of subsidies from other sources (federal subsidies historically have provided very substantial support for both fossil-fuel and nuclear generators, especially if indirect subsidies are included), and the need to subsidize new technologies (for which functional markets may not yet exist). In all three of these respects, nuclear power plants are more similar to typical NO_x polluters than to the other candidates for allowances from the set-aside account and it is therefore, according to critics of the recent rule change, reasonable to exclude them.

A somewhat less compelling aspect of this economic argument follows from the assertion that, because Seabrook will probably make the planned upgrades even without the allocated allowances, including Seabrook serves no useful purpose. While this

objection is reasonable in the case of Seabrook, it is also true that the program would be seriously limited if it were necessary to conclude that a project was economically marginal enough that it could not proceed without financial assistance before it was to receive allowance allocations; potential developers of, for example, wind farms would, if subjected to the standard suggested by this argument, be required to convince the state that the project could not be built without allowances from the set-aside account. Such a determination for every project would be bureaucratically difficult, would introduce an element of uncertainty not otherwise present in the system, and could impose a perverse incentive on the participants to threaten not to complete projects for which allocations were in question. But, to the extent that the Seabrook uprate represents an isolated case in which the policy choice is very unlikely to have any influence on the actual outcome, it is probably factually true that the rule change serves no useful purpose.

The other counter-argument is quite different and much more difficult to analyze. Nuclear power plants pose risks that are essentially dissimilar to those posed by air pollution. Fossil fuel-fired power plants certainly release air pollutants that produce a variety of immediate adverse effects in the present such as asthma and acid rain and are expected to cause potentially dangerous climate change in the future. But nuclear power plants have the potential to release dangerous amounts of radiation at any time and constantly create waste that could contaminate the groundwater of unknowing victims in the far future. Opponents of nuclear power may argue that these risks are great enough to preclude any consideration of them as a solution to any other problem, regardless of the characteristics of the problem. While it is conceivable that such concerns could be addressed by technological improvements, they provide a foundation for opposition to

any form of support for nuclear power plants, regardless of the potential to address other problems.

Analysis: relationship to Kyoto protocol negotiations

This controversy is quite similar to one that arose over the Clean Development Mechanism of the Kyoto protocol. Although in that case nuclear power plants were explicitly excluded from a program designed to encourage carbon-free electricity production, some comments about their inclusion in New Hampshire's program indicate a belief that no firm precedent has been established. For example, Marvin Fertel of the Nuclear Energy Institute, an industry group discussed in chapter 3, described the recent rule change in New Hampshire as setting a "bold precedent" for the inclusion of nuclear power plants in programs that address air pollution (ANS 2003), while Josh Irwin of the New Hampshire Public Interest Research Group commented that "in the bigger picture, that is what we're debating here: nuclear power's role in the future" (Gorenstein 2003). FPL Group, the owner of the Seabrook plant, has also committed, under EPA's Climate Leaders Program, to voluntarily reduce its per kWh greenhouse gas emissions rate by 2008 and intends to use the planned uprate for which it expects to receive NOx allowances in New Hampshire to help it meet this goal (FPL 2004). Though the New Hampshire controversy is in many ways minor compared to the debate over the Kyoto protocol, it also has particular importance because of the United States' status as the world's most significant greenhouse gas polluter and largest producer of nuclear power.

Conclusions

Emissions markets are increasingly accepted by environmental groups as potentially valuable mechanisms for forcing emissions reductions, but the need to define boundaries for these programs poses a number of difficult questions that will send policymakers to the political process for guidance. The evolution of markets such as New Hampshire's NO_x market will likely provide a template if the trading of carbon dioxide emissions allowances ultimately becomes a widespread response to concerns about global warming. For this reason, it is worthwhile to study this controversy for clues about the inclusion of nuclear power in future strategies to address global climate change. Moreover, it is significant that the policy change by the New Hampshire state government, which occurred despite the opposition of these groups, does suggest that emissions trading programs have the potential to become a mechanism by which nuclear power plants can become a part of efforts to address air pollution, including greenhouse gases. This case provides little evidence of an evolution of attitudes about nuclear power because of concern about global climate change. However, it does mark the arrival of a new battleground, which is the structure of markets for emissions allowances, and the comments of these groups do indicate that they expect to face similarly difficult and potentially unsuccessful battles in the context of attempts to control emissions of greenhouse gases.

Chapter 6: The Regional Greenhouse Gas Initiative and Emissions Reductions: The Potential Role of Nuclear Power Plants

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by states in the Northeast to create a cap-and-trade system that will limit emissions of carbon dioxide from power plants in the region. At least three regional characteristics are likely to facilitate acceptance of the plan. (1) A degree of commitment to addressing the problem of climate change already exists within the region and is apparent in the variety of goals, processes, and policies that are currently in place in the Northeastern states. (2) Power plants, particularly those fueled by coal, are known to be major sources of carbon pollution in the region. (3) A regional cap and trade regime already limits the degree to which nitrogen oxides from power plants pollute the region's air, as discussed in chapter 4. The initiative will be supported by a regional organization which will be located in New York City.

The current process was initiated in April of 2003, when the governor of New York sent letters to 11 northeastern governors inviting them to participate in the design of a regional cap-and-trade program to limit carbon dioxide emissions from the electricity production sector. The governors of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, Delaware, and New Jersey agreed to formally participate, and Maryland and Pennsylvania observe. An action plan, adopted by participants in August 2003, specifies that agreement on a model rule that can be considered for promulgation

by individual state governments should be achieved by April 2005. A Staff Working Group consists of representatives of state governments and has primary responsibility for the process.

A Stakeholder Group includes representatives from energy companies, environmental groups, and other interested parties and is charged with facilitating debate and providing feedback to the Staff Working Group, and a Resource Panel provides expert advice. According to the RGGI web site, the “members of the Stakeholder Group were carefully selected by the RGGI states to represent a wide range of interests and geographies in the RGGI region, while remaining a manageable size to allow for the individuals involved to engage and discuss issues around one table, together with about 15 state representatives.” Selection of the Stakeholder Group was a complex and iterative process during which the concerns of a variety of potentially interested parties were considered. When the selection process was complete, invitations to be formally included as stakeholders were issued to a group of organizations that was judged by state regulators to be appropriately representative of the various interests from which they sought input. Open meetings of the Stakeholder Group occur regularly, and presentations, summaries, and other documents are available on the RGGI web site and provide a valuable window into the process. The web site also contains material not directly associated with the stakeholder process and is the source for virtually all information included in this paper.

Two distinct and significant factors are likely to force serious consideration of the future of nuclear power in the region by RGGI participants: First, as will be detailed later in this chapter, nuclear power plants currently produce nearly one-third of the electricity

generated in the RGGI region and nearly two-thirds of the total generated without fossil fuels (CERES 2004). Second, companies that own nuclear power plants are very well represented in the stakeholder process. Therefore, although some RGGI participants, such as environmental organizations, are clearly skeptical about nuclear power, and although RGGI is under no mandate to explicitly consider the future of nuclear power in the region, the nuclear issue will be difficult to avoid. The purpose of this chapter is to describe and analyze the role of nuclear power in the RGGI deliberations.

The chapter begins with a list of participating organizations. The first four sections provide contextual information about the current role of nuclear power in the region, stakeholders that own nuclear power plants (discussed in more detail in chapter 3), and stakeholders that represent environmental organizations (discussed in chapter 2). Three subsequent sections look much more explicitly at the RGGI negotiations: Details of market design and potential implications for nuclear power are analyzed, documents from the RGGI web site are surveyed for references to nuclear power, and these references are summarized and analyzed. The chapter concludes with a discussion of possible outcomes of the RGGI negotiations and potential implications for the future of nuclear power in the RGGI region.

RGGI Member Organizations

Names of organizations appear below exactly as they appear on the RGGI web site, with some added information, such as the meaning of some acronyms, included in parentheses. Stakeholders with acknowledged interests in nuclear power, such as the seven that own power plants and the six environmental organizations, are clearly

indicated and are discussed in detail below. For brief descriptions of Stakeholders and Resource Panel Members, see the *glossary of RGGI participants*, Appendix C of this thesis.

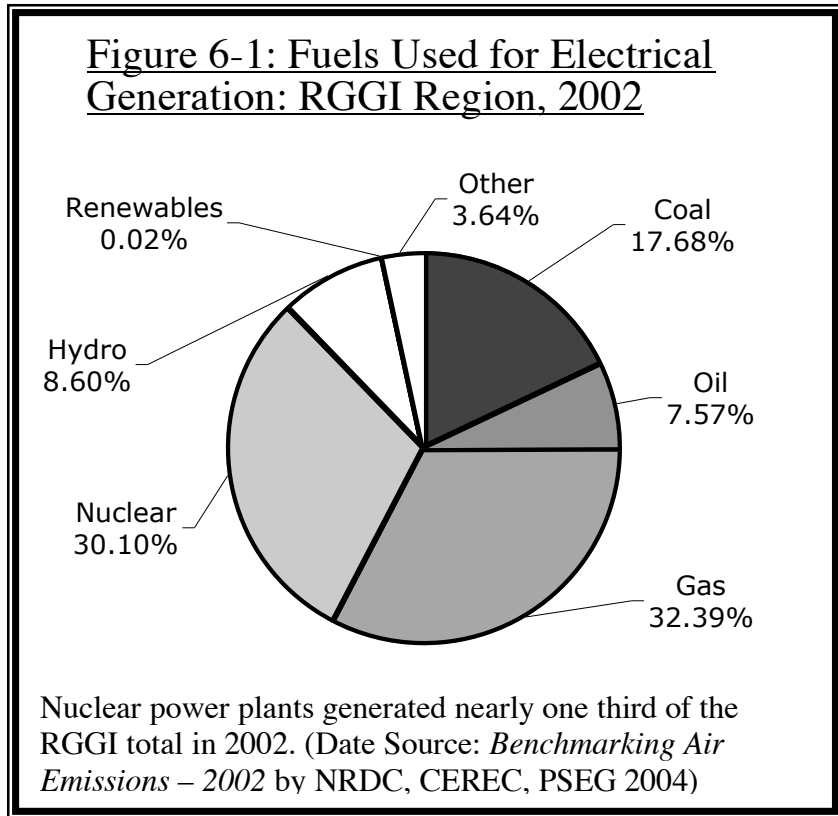
- Stakeholder Member Organizations: (Followed, in some cases, with either PO, power plant owners, or EO, for environmental organizations): ACEEE (American Council for an Energy-Efficient Economy), AES (PO), Conservation Law Foundation (EO), Constellation (PO), Dominion (PO), Environmental Defense (EO), Entergy (PO), Environment Northeast (EO), International Paper, Keyspan (PO), Maine Public Advocate, National Energy and Gas Transmission Group (PO), National Grid Triasco, Northeast Greenhouse Coalition, Natural Resource Defense Council (EO), Northeast Utilities (PO), NY Coalition, Pennsylvania Consumer Advocate, Pace Law Center, PIRG (Public Interest Research Group; EO), PSEG (PO), The NE Council, UCS (Union of Concerned Scientists; EO), United Technologies Corporation
- Resource Panel Organizations: RAP (Regulatory Assistance Project), Natsource, NESCAUM (Northeast States for Coordinated Air Use Management), PJM Interconnection, World Resources Institute, Pew Center, ISO-NE (Independent System Operator – New England), NYISO (New York Independent System Operator), RFF (Resources for the Future)

- Staff Working Group Organizations: Connecticut Department of Environmental Protection, Delaware Department of Natural Resources and Environmental Control, Eastern Canadian Provinces, Massachusetts Department of Environmental Protection, Massachusetts Division of Energy Resources, Massachusetts Office for Commonwealth Development, Maryland Department of the Environment, Maryland Energy Administration, Maine Department of Environmental Protection, Maine Public Utilities Commission, New Brunswick (Canada), New Hampshire Public Utilities Commission, New Hampshire Department of Environmental Services, New Jersey Bureau of Public Utilities, New Jersey Department of Environmental Protection, New York Department of Environmental Conservation, New York Public Service Commission, New York State Energy Research and Development Authority, Vermont Department of Environmental Conservation, Vermont Public Service Board

Context: nuclear power in the RGGI region

The RGGI region relies heavily on nuclear power plants to generate electricity, as shown in figure 6-1 below. While nuclear power plants produce about 20% of the electricity generated in the United States, the percentage is closer to 30% in the RGGI region. Facilities that can generate electricity without the emission of carbon dioxide are obviously of particular interest in the context of RGGI, and, among these sources, nuclear plants currently play an even more significant role. In 2002, nuclear plants in the RGGI region produced more than three times as much electricity as their closest non-emitting

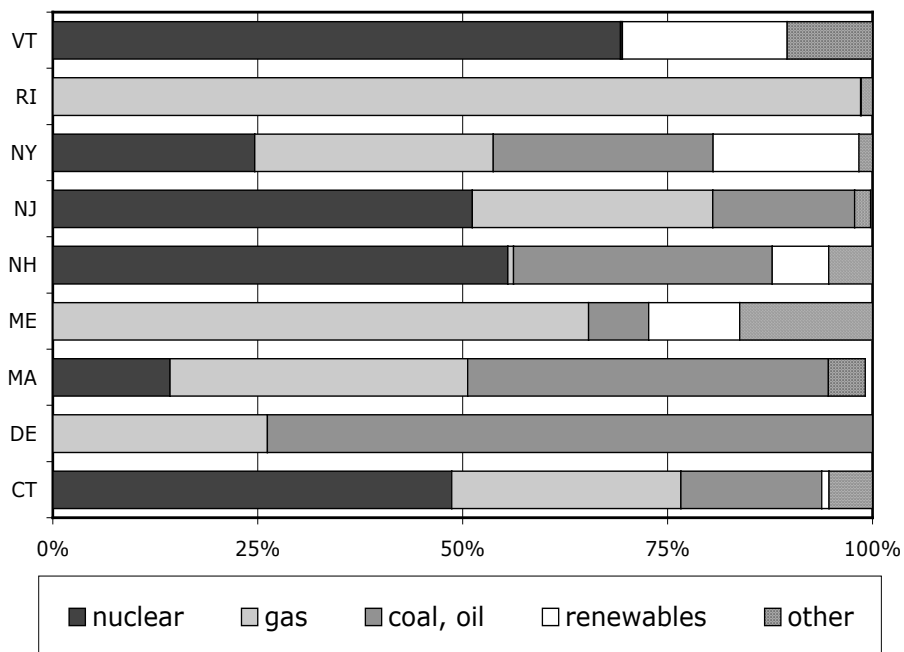
competitors, large hydro-electric plants, and more than one thousand times the combined output of the region's grid-connected wind and solar facilities.



RGGI states differ markedly in the degree to which nuclear power plants are used to generate electricity. These differences are important because, although RGGI does represent a cooperative effort by participating states, specific deliberations about nuclear power may take the form of negotiations between these states. The trading of carbon allowances that will occur if RGGI is implemented will involve transfers of substantial amounts of wealth, and many of these trades and transfers will cross state lines. Specific design features that will necessarily be considered by RGGI, such as the possible allocation of free emission allowances to generators, will have financial consequences for power plant owners that will differ depending on the energy source utilized. To the extent

that RGGI participants represent state governments, they may favor policies that that bring financial benefits to generators that operate within their borders. Or they may even fear the possibility that RGGI could impede efforts to retire in-state nuclear plants if it were to provide financial incentives to keep them operating. Whatever the specific consideration, RGGI participants that represent the governments of Vermont, New Jersey, New Hampshire, and Connecticut are likely to be sensitive to issues surrounding nuclear power in ways that other participants are not, as illustrated in figure 6-2.

**Figure 6-2: Electricity Generation in RGGI States:
By Fuel Use, 2002**



RGGI states differ markedly in the degree to which nuclear power plants are used to generate electricity; of nine states, three do not have any nuclear plants while in three others, the majority of generation came from nuclear plants. (Date Source: *Benchmarking Air Emissions – 2002* by NRDC, CEREC, PSEG 2004)

Nuclear power plants are larger, on average, than fossil fuel-fired plants and are, therefore, relatively small in number. The table below lists all fifteen nuclear power plants that currently operate in the RGGI region and includes relevant statistics. Comparison with the previous table shows that, in two states, New Hampshire and Vermont, the majority of electricity is generated by a single nuclear reactor. The situation is similar in Connecticut and, to a lesser extent, New Jersey. It is reasonable to suppose that negotiators from these three states are thinking very specifically about these particular facilities. Inspection of this data shows that no similar situation exists for any single non-nuclear facility (Three gas-fired power plants operate in Rhode Island). This relatively simple situation is also likely to facilitate interaction between the owners of these plants and state negotiators, especially to the extent that these companies are also RGGI stakeholders. The large size of nuclear power plants means that even RGGI participants that are not inclined to see nuclear power as an important issue for RGGI in general may be forced to confront questions about specific nuclear power plants.

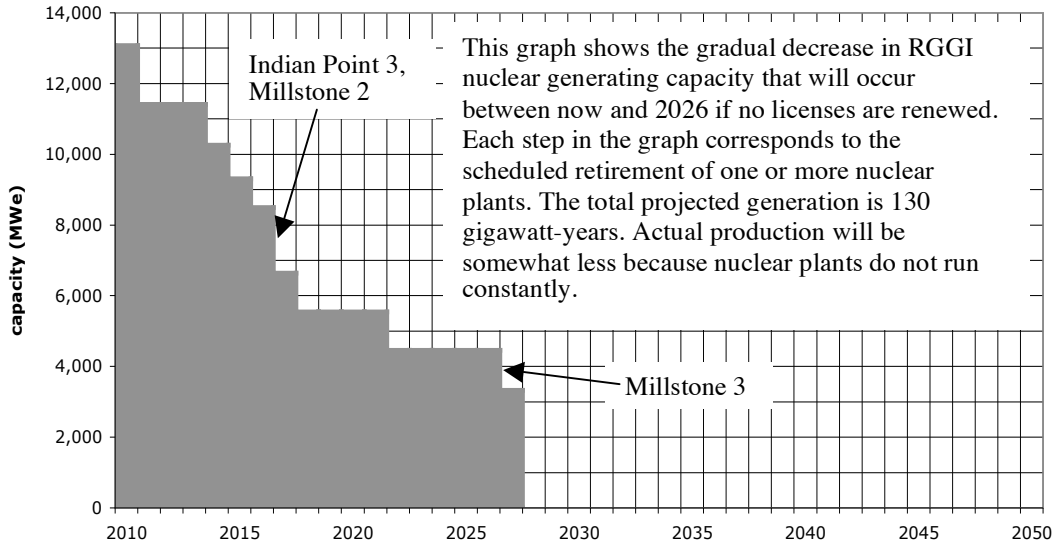
Table 6-1: Existing Nuclear Power Plants in the RGGI Region					
state	Owner	Name	output capacity (MW)	current license expires	Pending 20-year license extension and uprate applications.
NY	Entergy	Fitzpatrick	813	2014	
NY	Constellation	Ginna	480	2009	
NY	Entergy	Indian Point 2	951	2013	
NY	Entergy	Indian Point 3	979	2015	Has applied for 50 MW uprate
NY	Constellation	Nine Mile Point 1	565	2009	Has applied for license renewal
NY	Constellation	Nine Mile Point 2	1120	2026	Has applied for license renewal
NJ	PSEG	Hope Creek	1049	2026	Informed NRC of intent to renew
NJ	Exelon	Oyster Creek	619	2009	
NJ	PSEG	Salem 1	1096	2016	Informed NRC of intent to renew
NJ	PSEG	Salem 2	1092	2020	Informed NRC of intent to renew
CT	Dominion	Millstone 2	871	2015	Has applied for license renewal
CT	Dominion	Millstone 3	1130	2025	Has applied for license renewal
MA	Entergy	Pilgrim 1	653	2012	Informed NRC of intent to renew
NH	FPL	Seabrook 1	1155	2026	Has applied for 60 MW uprate
VT	Entergy	Vermont Yankee 1	496	2012	Has applied for 100 MW uprate
Fifteen nuclear power plants currently operate in the RGGI Region. (Data source: NRC)					

It is anticipated that all fifteen nuclear power plants will be retired over the next four decades, but there is much uncertainty about how much electricity they will produce before then. By 2026, all current licenses will have expired, but owners have already begun to apply to the Nuclear Regulatory Commission for 20-year extensions like those that have already been granted to some nuclear plants outside the RGGI region (NRC 2005). Potential and current applications for uprates, or license amendments that allow for increases in generation capacity, also contribute to uncertainty about the future of nuclear power plants that currently operate in the RGGI region. Details are listed in table

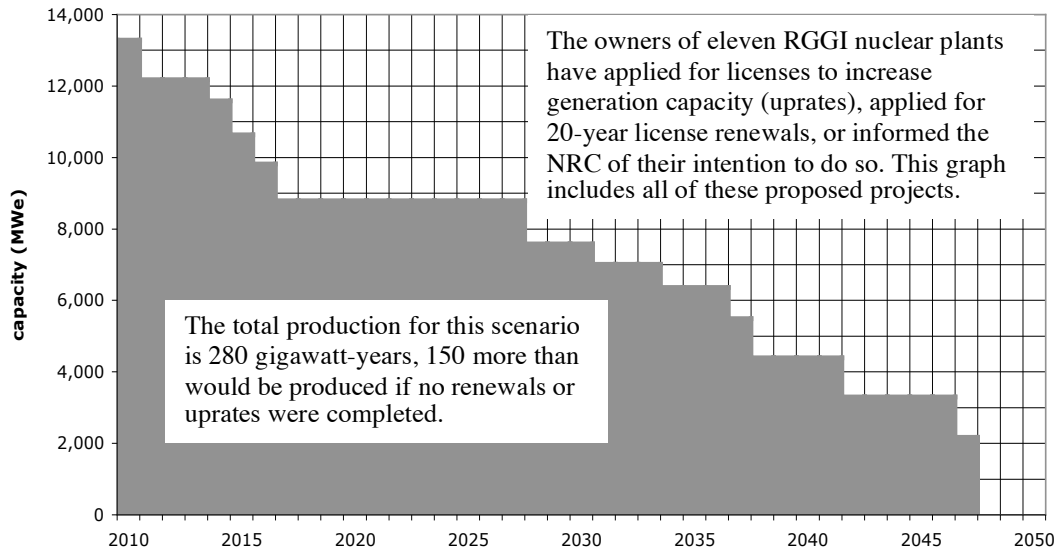
6-1 and illustrated graphically in figure 3-3, which shows that license changes under current consideration will have a very significant impact on total anticipated future production from the region's nuclear plants. Owners do not apply for license changes unless they anticipate that they can utilize their new license profitably, so RGGI has the potential to influence the degree to which these plants continue to operate through the next several decades. And because these fifteen power plants account for nearly one third of regional electricity production and do not contribute significantly to carbon emissions, their early closure would make the task of maintaining electricity production while reducing carbon emissions even more difficult than it would otherwise be.

Figure 6-3: Decommissioning of Existing Nuclear Plants

**Projected Generation of Existing RGGI Nuclear Plants:
Without License Extensions and Uprates**



**Projected Generation of Existing RGGI Nuclear Plants:
Including License Extensions and Uprates**



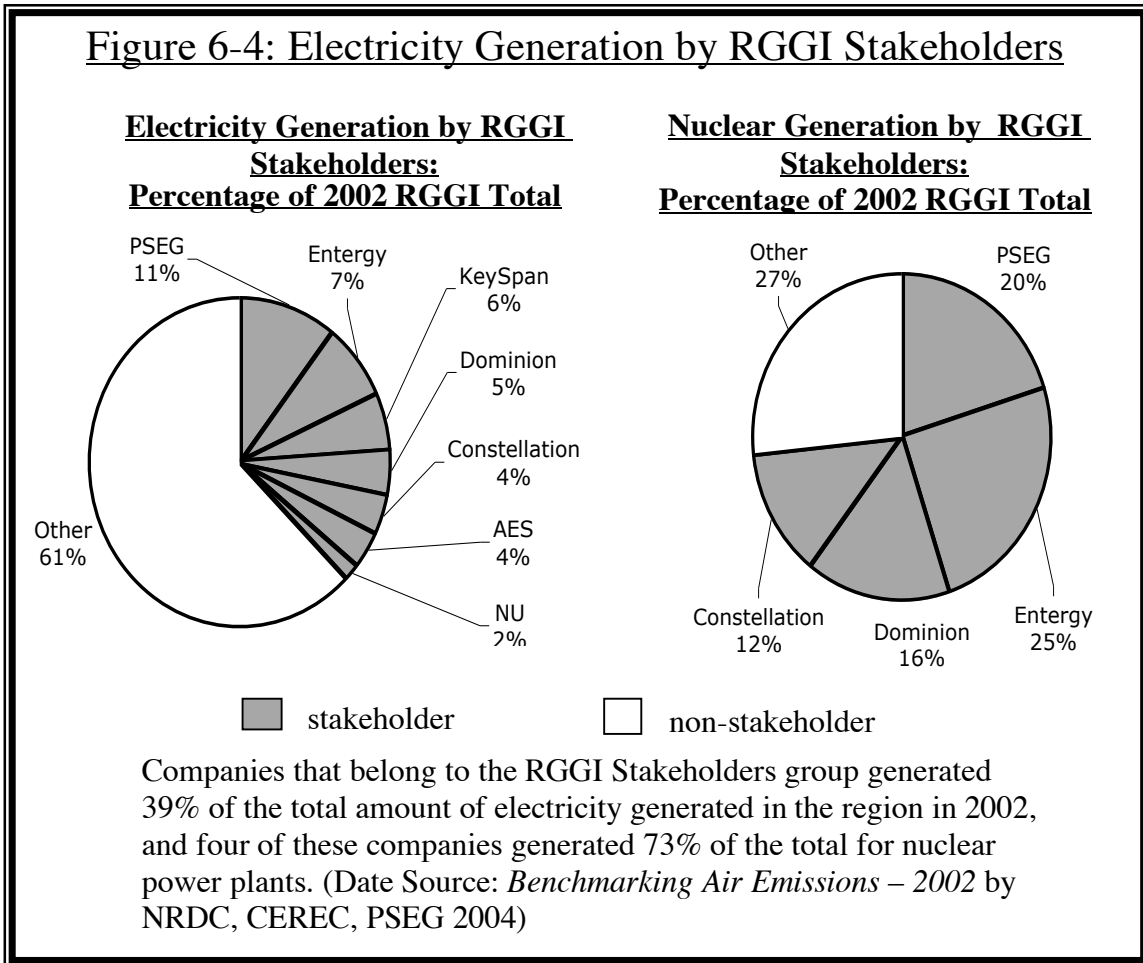
These graphs illustrate the loss of nuclear generating capacity that will occur in the RGGI region between 2010 and 2050 as existing nuclear plants are retired. Each rectangle formed by the gridlines represents one gigawatt-year of electricity production, which is approximately equal to the annual output of one large nuclear plant. For comparison, the unbuilt Cape Wind project may produce as much as 7 gigawatt-years during this 40-year period.

Perhaps even more important than the difference between the two graphs in the above figure is their similarity: RGGI planners must realize that, as they attempt to wean the region away from the use fossil fuels for electricity generation, they will almost certainly be confronted with the gradual loss of all of these nuclear power plants. To reduce carbon emissions while eliminating the only currently significant alternative will be a very substantial challenge, and it is difficult to anticipate a future in which the following question is not asked repeatedly: Why not replace retired nuclear plants with new nuclear plants so that more widely favored emissions mitigation strategies, such as conservation or the increased use of renewable energy, can be exclusively devoted to decreasing fossil fuel use? Others will certainly go further and argue that the region must become more reliant on nuclear power if RGGI is to be successful. Although it will be possible for RGGI to avoid explicitly dealing with nuclear plants in the rules that it creates, the outcome of the RGGI negotiations is likely to send relevant political and economic signals to owners and potential owners of nuclear power plants. Even if these signals are weak, they will be substantially amplified by the simple fact that nuclear power plants are currently the dominant alternative to fossil fuels for electricity generation.

Context: RGGI Stakeholders from the electric power industry

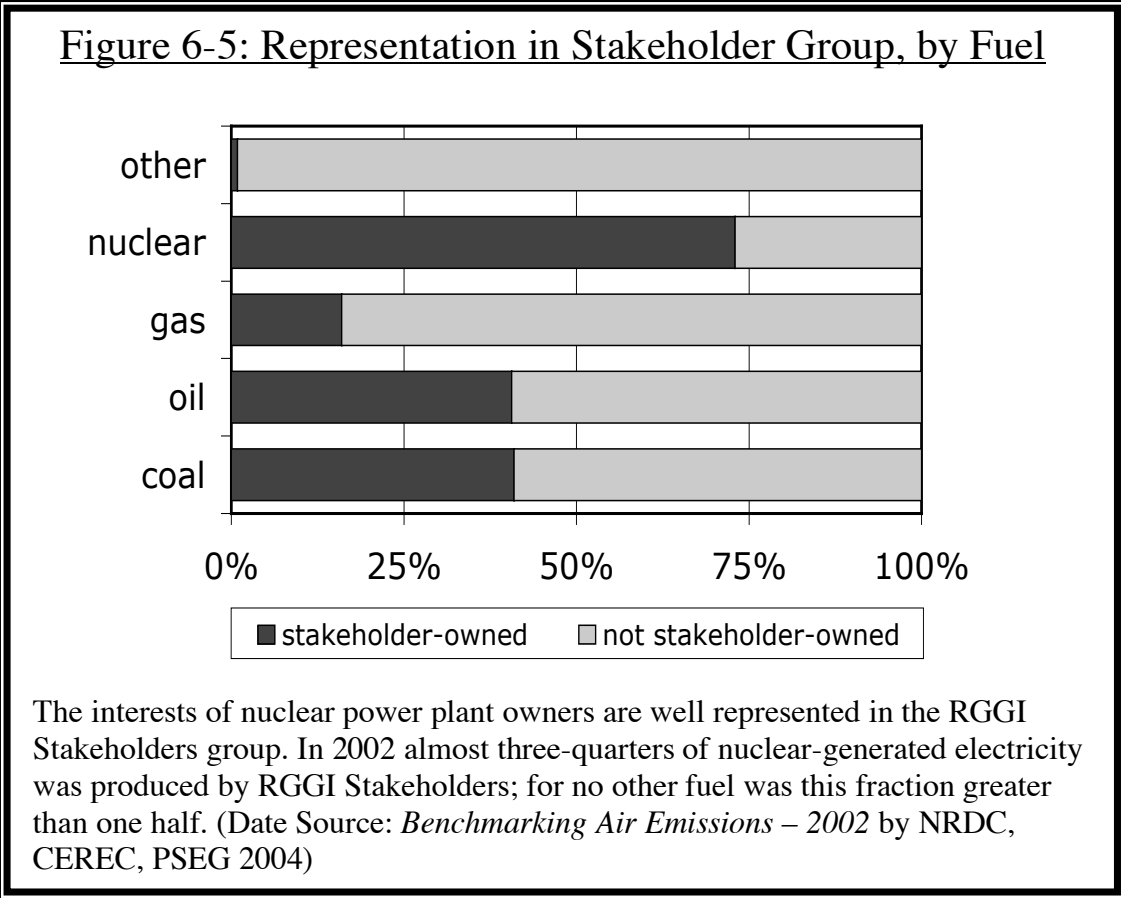
Seven RGGI stakeholders own plants that generate electricity in the region, and four of these companies own nuclear power plants. While power plants owned by RGGI stakeholder companies generated less than half of the electricity produced in the region in

2002, they accounted for nearly three quarters of regional nuclear-powered electricity generation. This data is illustrated in figure 6-4.



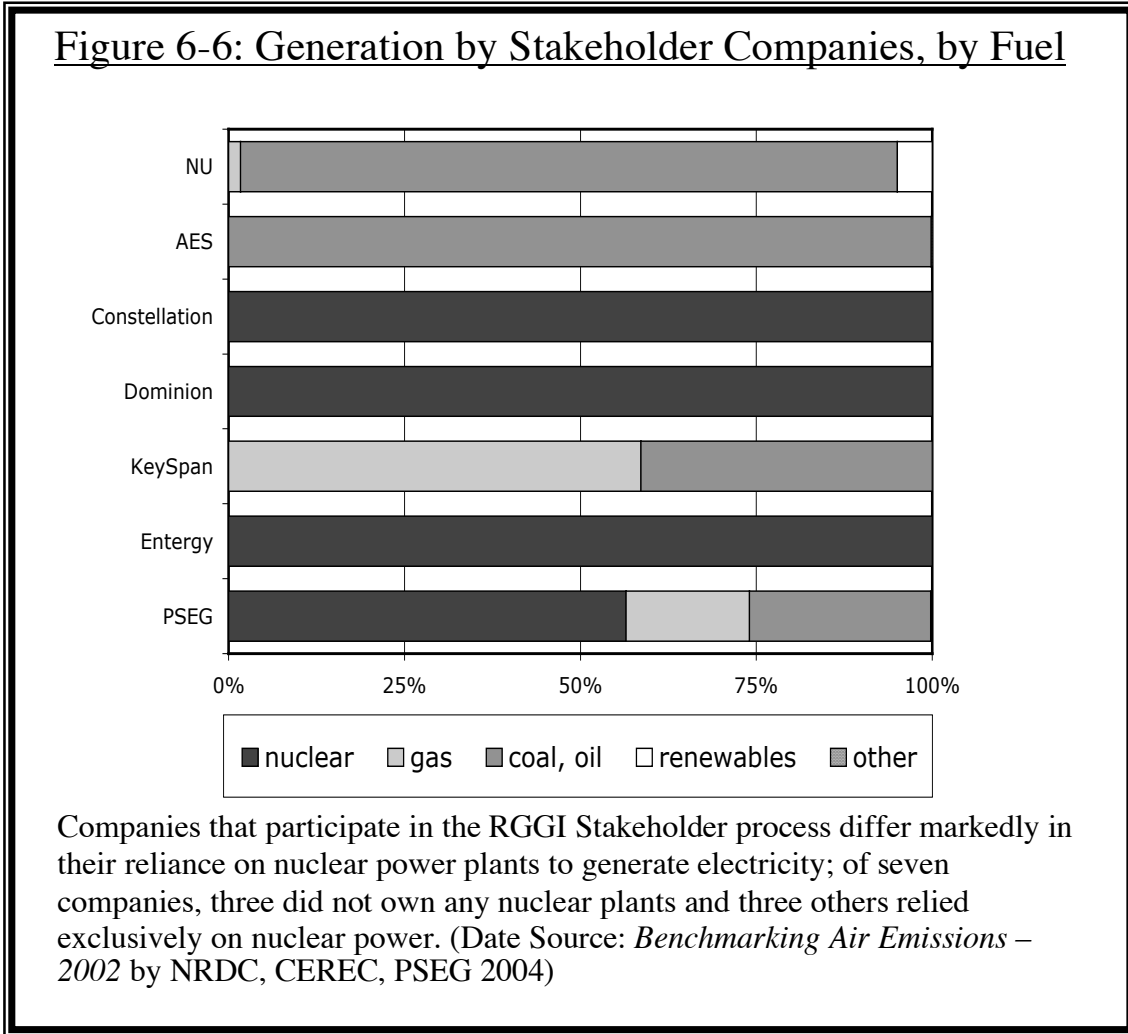
One significant observation, which is suggested by figure 6-4 and confirmed by figure 6-5, is that the interests of the owners of nuclear power plants are well represented in RGGI compared with the interests of the owners of power plants that use other energy sources. One possible explanation is that only nuclear power plants are so consistently large that they are always owned by companies with the resources to participate in a complex negotiation like RGGI. But whatever the explanation, the participation of nuclear plant owners in RGGI probably ensures that, at the least, policies that strongly

disfavor nuclear power will need to be defended against competent and powerful negotiators who will work to ensure that such anti-nuclear policies do not become part of the rules that are finally implemented.



A significant fact about the companies that own nuclear power plants in the United States as a whole, documented in chapter 3, is that they are not particularly heavily invested in nuclear power compared to other energy sources. While it is true that companies that own nuclear power plants in the RGGI region also own fossil-fuel plants in other parts of the country, the situation is quite different when one considers only their regional generation assets, as is shown in the figure below. It is reasonable to expect

Constellation, Dominion, Entergy, and, to a lesser extent, PSEG to be quite focused on their nuclear power plants as they participate in the RGGI negotiations.



It may, however, also be relevant that Entergy, Constellation, and Dominion all rely heavily on fossil fuels to generate electricity outside the RGGI region, so, to the extent that they are concerned that RGGI may prove precedent-setting, they may be less enthusiastic about policies that favor nuclear power over fossil fuels than would otherwise be expected. None of other four stakeholder generators owns nuclear plants

outside the RGGI region. More detailed information about ownership of nuclear plants can be found in chapter 3.

Analysis: Nuclear power and the details of RGGI design

The purpose of RGGI is to cause a decrease in the amount of carbon dioxide pollution emitted by power plants in the region. A cap and trade program will be designed to create incentives for market participants to take actions consistent with the achievement of this purpose. Although the strength of cap and trade programs is thought to come mostly from the fact that they do not specify the method through which mandated emissions limits are to be achieved, it is worthwhile to consider the possibilities. There are essentially four distinct ways in which carbon pollution from power plants in the region can be reduced: (1) Import electricity from outside the region. (2) Use less electricity. (3) Capture and sequester carbon before it becomes pollution. (4) Utilize technologies that generate electricity with little or no carbon pollution. The first possibility would probably be counter-productive because adjoining regions from which additional electricity could easily be imported rely heavily on coal, so, in a chain of events known as leakage, one result of increased importation could be increased emissions outside the RGGI region. Though much more could be written about the second and third possibilities, it is sufficient for the current analysis to point out that few expect the combination of conservation and sequestration to eliminate the need to pursue the last item in the list: The construction and preferential utilization of new power plants with lower carbon emissions, including less centralized wind and solar-powered facilities, will almost certainly be needed if RGGI is to cause substantial reductions in carbon

pollution. Because of the fact that nuclear power plants are presently the largest non-emitting producers of electricity in the RGGI region, it is difficult to dismiss the possibility that concerted efforts to rapidly and significantly reduce carbon pollution could eventually spur proposals to construct new nuclear power plants.

My survey of available documents, summarized in appendix B of this thesis, reveals little direct evidence that many RGGI participants have openly discussed the possible construction of new nuclear power plants in the context of the RGGI negotiations. Participants have mentioned nuclear power repeatedly, as will be documented below, but comments have generally revolved around two questions: (1) Will existing plants receive uprates, allowing them to produce more electricity? (2) Will the operating licenses of existing plants be extended beyond the 40-year periods authorized by most current licenses? While some license extensions and uprates have already been approved and more are anticipated in the near future, there are, at present, no specific plans to build new nuclear power plants anywhere in the United States. It is worth consideration, however, that extensions and uprates share some significant consequences with new construction. Both would result in the creation of greater amounts of nuclear waste, and both would increase the likelihood of a significant accident at a nuclear power plant, although license extensions or uprates could be more risky than new construction if new designs are safer than old ones or even if plants become less safe as they age or increase output. While it may seem reasonable to expect debates about uprates and license extensions to provide insight into future debates about new construction, there is little to support this expectation in the available documents,

and the interviews described in chapter 7 suggest that people do not consider their opinions about existing plants to be tightly linked to their opinions about possible new plants.

RGGI participants are under no mandate to form or express opinions about nuclear power, but the regulatory structure that they create will have financial impacts on producers of electricity that will vary depending on the method of electricity production. The central economic reality is that a cap and trade system will likely be designed to increase the marginal costs of producing electricity by burning fossil fuels, especially coal, relative to production costs for non-emitters. Non-fossil competitors may be able raise prices without losing market share. The higher electricity prices will have two effects: consumption will be lower than it would have been, and the production of electricity from power plants that use technologies not subject to the cap will increase. This second effect will occur regardless of the way in which the program is implemented, and the incentives created will affect wind farms and nuclear power plants alike, although some environmental organizations have argued that something must be included in the program design to preclude the possibility that any benefit will accrue to nuclear power plants. (See data labeled **Incentives and wealth**, in Appendix B, for evidence that these issues are being considered by RGGI.) There are, however, two specific design aspects about which positions taken are likely to be driven, at least to some degree, by opinions about nuclear power.

The first is the question of how the allowances created by the program are to be allocated. Chapter 5 introduces the issues discussed in the next few paragraphs in some detail, but a few points are probably sufficient at this time: (1) While economic analysis

suggests that allowances should simply be auctioned by governments to polluters, such a pure auction is thought to be unlikely to occur because of the costs that would be imposed on polluters and, by extension, their customers. (2) Allowances could be allocated to power plants based on anticipated fuel use or electrical output. An output-based allocation system could explicitly include non-emitting producers such as nuclear power plants and wind turbines. (3) Because allowances are worth money and governments are likely to give them away for free, potential recipients can be expected to argue for generous allocations to themselves. (See data labeled Allocations, in Appendix B, and chapter 5)

It is important to realize that the question of allocations is mostly about wealth distribution and not carbon pollution. Because allocated allowances are marketable, it is anticipated that under any allocation scheme they will eventually be sold to the polluter that can use them most profitably. Therefore, the specific choice of allocation scheme is not likely to have a significant impact on the degree to which any particular generation technology, including nuclear power, is selected over other options. On the other hand, one should not underestimate the degree to which any allocation scheme may be controversial. The implications for wealth distribution become clear upon consideration of the fact that any recipient of allowances can choose to sell them. The owner of a coal-fired power plant, for example, may find that it is more profitable to sell allocated allowances than to use them. Different allocation schemes may distribute valuable allowances among states, companies, consumers, and other entities and groups in very different ways, and some allocation method must be chosen from among the various possibilities.

It should be noted that, if RGGI were to decide to use annually updated, output-based allocations, some of these generalizations would be less applicable. In this type of system, which remains largely untested, a fixed number of allowances would be divided each year among generators or emitters in proportion to electricity production in the recent past. The resulting output subsidy would encourage production by generators with low carbon emissions as they seek to earn allowances to sell in future years. However, this same subsidy would also stimulate production of electricity and, therefore, lead to lower electricity prices than would exist in other allocation schemes. This lowering of prices would tend to undermine the effectiveness of the program because it would stimulate increased energy consumption, but such a system could be favored by political actors who are under pressure to avoid increases in the price of electricity. Another argument that has been made for updated, output-based allocations is that, by providing an incentive to increase production in the region, it may help to prevent a shift in generation to neighboring states not subject to the cap. If such a system were to be adopted by RGGI, then, partly because falling electricity prices could result, a decision to include or exclude nuclear plants in the allocation scheme could have implications for the future of the region's nuclear plants.

One of the considerations that may inform preferences for or against a particular allocation scheme is the way in which it treats nuclear power plants or some other preferred technology. Some environmentalists may feel strongly, for example, that it isn't fair for the government to give valuable allowances to the owners of coal-fired power plants but not the owners of wind farms. Those with favorable opinions about nuclear power may apply the same argument to nuclear power plants, frustrating

environmentalists that favor wind power and oppose nuclear power. These arguments would be particularly consequential if updated, output-based allocations were used. Whatever the technical merits of the particular allocation schemes under consideration, details of the final design of the program may reflect opinions about nuclear power even more than they reflect opinions about allowance allocations. And understanding such opinions is the major purpose of this project.

The second significant design feature is offsets, which are allowances that polluters obtain by causing reductions in carbon dioxide pollution through methods other than reducing emissions at their own facilities. Examples could include planting trees to absorb carbon dioxide or funding the construction of wind turbines. Although RGGI will not include a provision for offsets in the original model rule, negotiations are already underway to design an offset program for later implementation. Conceivably, increased production of nuclear power could generate offsets for polluters. (See data labeled **Offsets**, in Appendix B)

Another significant way in which the nuclear question has appeared in RGGI deliberations is in the efforts to model the likely outcomes of the implementation of a carbon cap. A major purpose of the modeling currently being undertaken by RGGI is to facilitate the specification of a realistic total cap by characterizing likely economic impacts. The results of these modeling runs are quite sensitive to assumptions about the future of existing nuclear power plants, which is not surprising considering the significant contributions currently made by these power plants. A decision to extend the operating life of a large nuclear power plant in the region by twenty years would increase the expected amount of available emission-free generation capacity over the period in

question very substantially and therefore lessen the expected economic impact of any imposed carbon cap. (See data labeled **Modeling**, in Appendix B)

Analysis: RGGI participants and attitudes toward nuclear power

Some important generalizations about particular categories of participants are possible based on the available comments. In general, environmental organizations are very skeptical about nuclear power in the context of RGGI, and the owners of nuclear power plants have not argued forcefully for the allocation of allowances to themselves. Members of the Staff Working Group and Resource Panel have repeatedly identified nuclear power as a significant issue, and they may be seeking input from the stakeholder group to help the decide how to proceed. The following paragraphs analyze these generalizations in more detail.

Perhaps unsurprisingly, virtually all references to nuclear power from environmental organizations reflect or imply opposition or, at the very least, skepticism about the possibility that the increased use of nuclear power will play a significant role in the achievement of RGGI's carbon emission goals. And several comments from environmental organizations go even further and assert that RGGI should avoid creating incentives to increase the use of nuclear power or accepting such increases even if they facilitate reductions from other sources. However, given the fact that RGGI is designing a market-based system intended to stimulate increased electricity production from non-emitting sources, such an exclusion could be quite difficult to achieve, and no specific

mechanism has been proposed by any participant. Not all environmental groups have expressed concerns that RGGI will favor nuclear power plants, and few groups have made explicit comments about the desirability of relicensing existing nuclear plants.

Representatives from the energy industry and even the nuclear power industry have not expressed strong opinions about nuclear power, and there is some indication of a division among electricity producers that could be driven partly by reliance on nuclear power. At one meeting, a representative of the heavily coal-reliant non-stakeholder American Electric Power argued for an allocation scheme that would exclude nuclear power plants while a presentation from heavily nuclear-reliant stakeholder PSEG enthusiastically described the potential benefits of an allocation scheme that would provide explicit financial benefits for increased production from nuclear power plants. The Nuclear Energy Institute (NEI), which represents a group of companies that own and operate nuclear power plants, has advocated for the explicit inclusion of both potential increased production and possible early retirements in RGGI's economic models.

Significantly, the degree to which owners of nuclear plants are likely to support policies that favor the use of nuclear power over fossil fuels is clearly constrained by the fact that several stakeholder companies own both types of plants; this issue is thoroughly documented in chapter 3 of this thesis. The NEI, whose members currently generate more electricity with coal-fired power plants than with nuclear plants, is similarly constrained. It is therefore possible that, in some cases, there is more than one motivation for policy recommendation made by NEI on behalf of its members. For example, NEI has strongly urged RGGI modelers to evaluate the potential effects of a failure to relicense all existing nuclear plants. While the stated purpose is to encourage recognition of the significant role

that these plants play, such a modeling exercise would also force planners to explicitly contemplate a context in which the loss of existing non-emitting nuclear generation capacity would make RGGI substantially more difficult to implement successfully. Recognition would be one result, but another possible result is that less stringent caps would be proposed to allow for anticipated retirements, benefiting the owners of coal-fired power plants, which are, in some cases, the same companies. This cross-ownership is less apparent when only regional holdings are considered, but all RGGI participants must be cognizant of the potential that RGGI may set precedents for an eventual national program, and both Constellation and Dominion burn substantial quantities of coal outside the RGGI region.

Representatives of state agencies that form the Staff Working Group and experts that make up the Resource Panel have repeatedly proposed nuclear power as a topic for discussion. The Staff Working Group has identified decisions about modeling, allocations, and offsets that must be made, and Resource Panel members have attempted to describe some of the likely impacts of these decisions. Significantly, these participants have remained silent on a central question: Are nuclear power plants an acceptable substitute for fossil fuel-fired plants? The nature of their comments does indicate, at least, that they do not see any fundamental reason that nuclear plants cannot play a role.

Conclusions

Of perhaps 100 documents available on the RGGI web site, there were thirty-five mostly passing references to nuclear power. Therefore, although this chapter does show that the RGGI process is considering issues related to nuclear power, it would be wrong

to conclude that the nuclear power question plays any central role in the process. On the other hand, it certainly plays some role, and important decisions that could be precedent-setting will have to be made. If RGGI decides to include some sort of provision that explicitly excludes nuclear power plants from benefits that will accrue to other non-emitters, or if nuclear plants are given some sort of explicit subsidy as through the allocation of allowances, the implications for the future of nuclear power as a potential solution to global climate change will be clear, though certainly not decisive: Explicit inclusion could provide an important signal that policymakers see nuclear power as, at least, one among many potential solutions to the problem of climate change, and explicit exclusion would provide the opposite signal, perhaps even more strongly. If, however, as appears more likely, RGGI concentrates on carbon pollution and does not explicitly exclude or include nuclear power plants, less can be said. Although a scheme that would require substantial reduction by 2020 would provide financial incentives that could eventually encourage proposals to construct new nuclear power plants, no useful political guidance would be provided. But even an outcome favorable to nuclear power plants would be no more than a small first step because it would provide very little information about likely reactions from generally skeptical stakeholders to future proposals for the construction of new nuclear power plants. The creation of an implicit economic incentive to construct new nuclear power plants would not preclude eventual political opposition to such construction.

One of the primary reasons that the RGGI process is considered to be important is that it has the potential to eventually serve as a template for a similar national program. Decisions made in the RGGI states about the explicit inclusion or exclusion of existing

and potential nuclear power plants have the potential to be reproduced in such a program if RGGI is successfully implemented. Incentives to build new nuclear power plants, either in the form of higher wholesale electricity prices for all producers or in the more explicit form of allowance allocations or offset credits, could eventually make new reactors economically viable both inside and outside the RGGI region. But site-based opposition to new nuclear power plants may be less likely to block construction in less densely populated or more politically conservative areas of the country, so a national program modeled on RGGI would greatly increase the possibility that RGGI-type incentives will eventually lead to the construction of new nuclear plants. Stakeholders and other participants are aware of this possibility but do not seem to have come to any coherent agreement on the issue, except to the extent that environmental groups seem united in the opinion that explicit subsidies for nuclear power plants should not be included in the program.

Chapter 7: Preferences and Opinions about the Future of Nuclear Power among Regional Greenhouse Gas Initiative Participants

Introduction

This chapter describes current thinking about the future of nuclear power among participants in the RGGI process, introduced in chapter 5 of this thesis. Excerpts from transcribed confidential interviews with members of this group are analyzed below, and at least one significant conclusion emerges: New information about climate change may not translate easily into acceptance of new nuclear power plants because, for many people, climate concerns also drive increased interest in all non-nuclear energy sources including, perhaps surprisingly, coal. Another significant finding is that, even though concerns about nuclear waste are widespread within the group, very few people expressed opposition to renewal of the operating licenses of existing nuclear plants. A number of excerpts in which individual people explain how concern about climate change has impacted their thinking about nuclear power are also included.

To some extent this work is motivated by, and intended to extend, the analysis of public opinion that was included in *The Future of Nuclear Power*, a widely-read 2002 report by a group of scientists and policy experts from Harvard and MIT that considered a potential expansion of the use of nuclear power in the context of climate change. The report cited “a surprising lack of survey data in the public domain that would allow us to understand why people oppose and support specific power sources” as motivation for

conducting their own public opinion survey, the results of which lead them to conclude that “surprisingly, concern about global warming, in our survey, does not predict preferences about future use of nuclear power.” The public that was surveyed, according to the report’s conclusions, “has yet to connect the way we generate power to carbon emissions and global warming.” This chapter focuses on a group of people that fully understand these connections, and it offers a coherent explanation for the fact that many of these people are both concerned about global warming and uninterested in planning for a future expansion in the use of nuclear power.

The chapter begins with a description of the specific methods that were used to recruit study subjects and schedule, conduct, transcribe, and analyze interviews. This list is followed by some general observations regarding attitudes and expectations described during interviews about the future of nuclear power in the RGGI region. The sections that follow are more narrowly focused on the description and analysis of what interviewees said about the future of nuclear power. The chapter concludes with further analysis and conclusions about likely responses to future proposals for the construction of new nuclear power plants in the RGGI region.

Methodology

To collect the data a cross section of participants in the Regional Greenhouse Gas Initiative (RGGI) process were asked, in confidential interviews, to discuss their opinions about the future of nuclear power. The RGGI process was selected primarily because it includes a group of well-informed citizens who are engaged in ongoing discussions about the climate problem in a region with a relatively high concentration of nuclear power

plants. After the completion of several pilot interviews in early 2005, an initial email request was sent to approximately eighty RGGI participants identified on the RGGI web site, and twenty-seven of them, including a wide cross-section of representatives from environmental organizations, energy companies, think tanks, state governments and others, agreed to be interviewed. More detail about who participated is included in table 7-1.

<u>Table 7-1: Research Subjects, by Category</u>					
	Organizations	People	Interviews	People Quoted	Quotes
Stakeholders	24	33	14	14	24
Stakeholder - Environmental	6	9	4	4	8
Stakeholders – Industry	10	15	5	5	10
Resource Panel	9	15	6	4	9
Staff Working Group	20	34	7	4	8
Totals	53	82	27	22	41
<p>Quotes included in this paper are drawn from 27 interviews with RGGI participants. The RGGI website includes contact information for Stakeholders and Resource Panelists; meeting summaries include the names and agencies of Staff Working Group members. Nearly all of these people were contacted. The first two columns include all listed RGGI participants, the third includes all of the people interviewed, and the last two include only excerpts that are included in this paper. More information about the RGGI process is included in chapter 5; participating groups are discussed in chapters 2 and 3 and appendixes A, B, and C. Stakeholders are categorized as <i>Environmental</i> if they explicitly advocate environmental protection and <i>Industry</i> if they represent companies that generate or distribute electricity. In no case was more than one person from an organization interviewed.</p>					

Most interviews were in-person conversations that lasted between forty minutes and one hour; five were conducted by telephone. Each interview began with the following hypothetical question:

Picture a future, perhaps only a few years away, in which the Regional Greenhouse Gas Initiative's model rule has been successfully implemented in all participating states. Power plant emissions are falling as market forces select efficient solutions. The regional economy becomes more energy-efficient and the use of renewable energy increases markedly. And a large energy company proposes the construction of a new nuclear power plant in the region, asserting that the new reactor will help to facilitate even greater reductions in carbon pollution. Thinking of yourself, as a private citizen, how would you react to such a proposal? Why?

Follow-up questions were used to elicit opinions about issues related to nuclear technology, alternative energy sources, and climate change, always with the goal of understanding how these people assemble this diverse information to form opinions about the specific question at hand. People were also asked about their organizations and, especially, to describe internal discussions, but it is important for the reader to keep in mind that this paper is about personal opinions and preferences, not organizational positions. Most were also asked whether they expected the construction new nuclear power plants within the next few decades. A full list of questions is included in appendix D.

As transcripts were created, excerpts that addressed important themes were selected and copied into a spreadsheet to facilitate coding, sorting, and

analysis. In most cases I was able to create transcripts and select excerpts before more than a few additional interviews were conducted, so interviews and transcript analysis were conducted with awareness of themes and questions that had been raised in previous interviews, and sorting criteria were added or removed from the spreadsheet throughout the project. Specific passages were initially extracted from transcripts for further analysis in the ever-growing spreadsheet because they were judged to unambiguously represent opinions about important topics. Eventually thirty-eight excerpts from twenty-two different interviews were selected for inclusion in this chapter. These final selections were carefully reviewed to ensure that meanings are rigorously preserved in excerpts that have been removed from contexts, and that the confidentiality of study participants is not violated.

Each excerpt is followed by a parenthetical reference to the group that the interviewee represents in the RGGI process and a unique number to allow for the identification of cases in which two or more excerpts are from the same interview. This identifying information is included mostly to illustrate the degree to which opinions were held across people and groups. While readers may be tempted to attempt further analyze the degree to which included quotes come from members of specific groups, the following qualifications argue against such efforts: (1) For every group, most of the people that I contacted chose not to participate. (2) Although I did ask some questions about organizations, interviewees were generally asked to respond as independent citizens and not group members. (3) Excerpts were selected for inclusion in this paper because they were judged to

represent coherent and significant viewpoints and not because they were representative of the group identity of the quoted person.

What They Think: General Observations

The main purpose of this project has been to elicit and carefully describe opinions and preferences held by RGGI participants about the future of nuclear power and climate change. This preliminary section provides a more general description of some recurrent themes that draws broadly on more than twenty hours spent with RGGI participants in which people described much more than just their own personal opinions and preferences about nuclear power. While approximate fractions are given to indicate the degree of support for various attitudes among interviewees, little significance should be attributed to these fractions because of the degree to which participants were self-selected.

- Many described at least some way in which concern about climate change has impacted their thinking about the future use of nuclear power. While an even larger fraction described suspicions that others were having this experience, most of these people seemed unable to recall specific cases in which this suspected evolution in thinking was known to have occurred. Questions about the future of nuclear power seem to have played a very minor role in the RGGI discussions. This is particularly true of the possibility that new reactors will be built in the RGGI region.

- Nearly half of the study participants stated that they would oppose the construction of a new nuclear power plant in the region given the current combination of nuclear technology, climate science, and available alternatives. All but a few of these opponents were open to the idea that changes in one or more of these areas, especially nuclear technology, could overcome this opposition, but many were quite skeptical that such changes would ever occur. Concern about waste disposal was the most commonly cited obstacle. A small but concerned minority mentioned the risk of weapons proliferation.
- Nearly half expressed some openness to a proposal for new construction in the near future, but only about half of these people thought that they would actually be supportive. The remainder thought that they might be willing to accept a proposal, but many of these people were very concerned that new construction could make it more difficult to deploy even more preferable alternatives like renewable energy and increased energy efficiency. Only a couple of the decided nuclear power supporters were among those that expected new construction in the region.
- Concern that investment in new nuclear plants would compete with more environmentally preferable solutions was very widespread. Very few people seemed to think that there was any plausible policy scenario under which new nuclear plants would be built without this competition being a problem. The expectation that new nuclear power plants will be very expensive seemed to play a role here because people perceived that much progress could be made in the

areas of renewable energy and efficiency if equivalent funds were made available for those purposes.

- Most were supportive, and virtually none were strongly opposed to, applications for the re-licensing of existing nuclear power plants in the RGGI region, and many cited concern about the implications for regional emissions, including carbon, if nuclear plants were shut down. Re-licensing was also widely acknowledged to be a low-cost option.
- Few predicted a decisive turn away from coal for electrical generation as a response to climate change. Many cited the abundance of domestic supplies, the political landscape, and plans for low- and non-emitting coal plants as powerful forces behind the continuation of our reliance on coal for electrical generation.
- When people were asked how they arrived at their opinions, very few described any explicit consideration of the what, when, where, or probability of various adverse consequences of either the creation of carbon dioxide or the fissioning of uranium atoms in electric power plants. Instead, people seemed almost entirely focused on the need to achieve certain specific goals, like the containment of nuclear waste or the reduction of carbon emissions by a certain percentage, and not to consider uncertainties about, for example, cancer or sea level rise, that would remain under particular policy scenarios. The fact that terrorism was almost unmentioned is perhaps the most revealing illustration of this phenomenon.
- Many mentioned the comments of the representative of the Nuclear Energy Institute (NEI). Her efforts to encourage more explicit consideration of the

importance of the region's existing nuclear plants were judged by many to be reasonable and even constructive, but most agreed that they had little impact on attitudes toward nuclear power among RGGI participants. More than one person from the electric power industry confirmed, off tape, that the policies advocated by the NEI are strongly constrained by the need to avoid adverse financial consequences for burning coal because, as is documented in chapter 3, the NEI is funded by a group of electric utilities that relies more heavily on coal than nuclear power to generate electricity. Few interviewees seemed aware of this constraint, and nobody suggested any specific implications.

- About one quarter expect that new nuclear power plants will be built in the RGGI region in the next few decades, while most expect that one or more plants will be built in the United States outside the region. Very high anticipated costs and site-based opposition were the most often mentioned obstacles, and many of the people that expect construction outside the region anticipate nothing more than the construction of a small number of plants with very substantial financial support from the federal government. Nobody predicted or advocated a large-scale shift from fossil fuels to nuclear power on any time scale.

All of the people interviewed acknowledged the need to discuss the future of nuclear power in the context of climate change. In many cases it was very difficult, however, to obtain a specific response to the hypothetical that clearly follows from the assumption that concern about climate change will influence future debates about nuclear power:

What happens if new construction is actually proposed? The next sections build on the

above observations but focus much more explicitly on how the people interviewed expect that they would arrive at a decision about such a proposal.

In Their Own Words: Climate Change, Nuclear Power, and New Nuclear Power Plants

A significant minority of the people who were interviewed indicated, without qualification, that they would support a proposal to build a new nuclear power plant in the RGGI region. Some of these people represent companies that generate electricity, and almost all acknowledged that they would probably support the use of nuclear power even if they were unconcerned about climate change. One person who described having “written off nuclear power for a twenty-five year period” because he had come to view political and economic obstacles to the construction of new nuclear power plants as insurmountable did describe the thinking that is the central subject of this paper. Note that, within each section of this paper, each italicized paragraph contains words from a different interview, and that words which are not italicized are my own.

I think it would be a great idea . . . we're not going to solve climate change without some assistance in terms of new technologies in the production of power or taking off and dusting off the technologies that are there. And nuclear seems to be the thing that makes some sense in terms of the near future in terms of climate change. . . . we need to reduce our greenhouse emissions so much I mean we're just scratching on the surface with this getting back to 1990 levels . . . the New England governors and Eastern

Canadian Premiers . . . were convinced that we need a 75 percent reduction in terms of greenhouse gases . . . in 2050 and the question is how are we going to get there. (#23 – Staff Working Group)

Almost all of the people that I interviewed indicated that they could be at least open to consideration of a proposal for a new nuclear power plant at some time in the future. For these people acceptance would depend on a variety of factors that will be discussed in other sections of this chapter; the purpose of the following excerpts is to illustrate that, for some of the people who were interviewed, climate change does enter into their thinking.

Before I got involved in RGGI I would probably be totally opposed but realizing, because they're non-emitting and they're important for that respect, and again if I was convinced, if someone could convince me that it's safe, the waste, another issue, I wouldn't be opposed to it. (#26 – Staff Working Group)

It doesn't sound like the climate change piece has made a big impact on your thinking about nuclear power. *Well it does give me pause. I guess I'm among those who are willing to suspend judgment in the longer term . . . it's got too many virtues to completely dismiss and yet it's got such massive issues to resolve. (#28 – Stakeholder)*

Nuclear was absolutely the worst twenty years ago in my mind but now because of the better management of nuclear power plants and the context of climate change it's competing almost equally in my mind for what I'll call traditional coal. (#8 – Stakeholder: Industry)

Fifteen years from now, then I'd be more amenable to it because I'd think maybe we've done about as much as we can with some of these other alternatives now what the hell are we going to do. So short term I'd probably be against it but long term . . . twenty years from now then I'd say let's talk. (#24 – Stakeholder)

These responses indicate that people are working to integrate concerns about climate change into their thinking about nuclear power, that changes have occurred in people's thinking, and that people anticipate further evolution of their own opinions. But they also illustrate a marked skepticism about the future role of new nuclear power plants. One skeptical participant observed:

Climate catastrophes that folks arguably understand to be climate change. . . are the kinds of dynamics that will keep consideration of new nuclear power in the game. (#14 – Resource Panel)

Perhaps significantly, the RGGI participants that I interviewed seemed not to be speaking to each other about nuclear power and climate change very much. When they were asked if they thought that concern about climate change was influencing other peoples' attitudes toward nuclear power, many responded affirmatively. But when they were asked whether they had personally observed any specific cases of this transition, even outside of the RGGI process, many conceded that they had not, or, perhaps even more tellingly, described newspaper articles or mentioned one of the very small number of previously skeptical public figures who have begun to advocate for the increased use of nuclear power to combat climate change. A few indicated that, at least at the institutional level, a tacit decision has been made not to discuss the issue in any context because of the potential that such discussions could be divisive or simply distract from more productive work.

The small minority of people who seemed the most confident that they would never support the construction of a new nuclear power plant all represented environmental organizations. Even the most emphatic of these acknowledged the challenge that climate change poses for those who oppose nuclear power:

We have to figure out how to solve global warming without increasing the amount of nuclear power. In fact I'd go further. We have to figure out how to solve global warming as we phase out nuclear power. Now some will argue that means that the cuts in the other pieces will need to be deeper as a result and my answer to that is yeah, that's right. (#9 – Stakeholder: Environmental)

The interviews with RGGI participants leave no doubt that people are thinking about the relationship between nuclear power and climate change.

While the people interviewed are aware of, and interested in, the connection between climate change and nuclear power, it is certainly also true that these interviews revealed no wholesale change in attitudes. Viewed narrowly from within the context of RGGI's emissions reduction goals, existing and new nuclear power plants can only really be viewed as potentially valuable parts of the solution, so why are most of the people that acknowledge a change in their own thinking so cautious? One reason is that substantial reductions of other pollutants have been achieved without the construction of new nuclear power plants. But there are other reasons for caution, which are described in the following sections. After a discussion of the related issue of applications to extend operating licenses of existing plants, these reasons will be discussed in three categories: attitudes about nuclear technology, attitudes about other non-emitting technologies for generating electricity, and attitudes about the future of coal.

In Their Own Words: Nuclear Plant License Renewals and Climate Change

Somewhat surprisingly, almost all of the people interviewed, including many who were quite adamantly opposed to the hypothetical construction of new plants in the RGGI region, were generally supportive of the idea that applications for twenty-year extensions to operating licenses should be granted for existing nuclear power plants. Because of the tension between the largely waste-based opposition to the construction of new plants and

the willingness to accept the additional waste that would be created by re-licensed plants, and because the question is much less hypothetical, discussions of re-licensing elicited some interesting responses in which people struggled to directly weigh, or compare, competing concerns about nuclear power and climate change. In the following three excerpts, people with very strongly held misgivings about the creation of additional waste and corresponding opposition to the construction of new nuclear power plants describe having weighed climate change against their concerns about the continued operation of the existing fleet:

I ended up thinking . . . that shutting the plant down early was not a realistic option and, as I was thinking about that, the recognition that the continued operation of the plant is avoiding some carbon was a mild, I'd say it was a factor, I'll put it that way. (#32 – Resource Panel)

I think the climate change question does factor into my thinking on the re-licensing for sure, and, I mean I think the biggest issue I would have is safety and those plants that have even questionable safety issues I think should be looked at very carefully in terms of re-licensing. Those plants that run really well and have a decent short term on site storage solution you might consider for re-licensing . . . I think the other air quality benefits are as important as, I don't know which is more important, they factor in as well so you might have a similar discussion. (#10 – Stakeholder: Environmental)

I'm probably more agnostic than I would have been twenty years ago. Slightly less clear that it's an automatic non-starter the balance between climate damage and nuclear power damage seem like they are not quite equivalent trade offs. You're measuring at least apples and oranges. The nuclear power damages are likely to be fairly confined unless you have some kind of a global disaster, a Chernobyl kind of thing. . . . The waste stuff tends to be localized and the odds are good that even if you have a disaster, the disaster is confined. So you're comparing that against a climate change, somewhat unclear in terms of what kinds of damages but if you just look at people at risk from sea level rise you're looking in terms of ten to fifty million people. So you've got a very different scale for your damages and the climate ones appear slightly more certain in fact in my mind than the nuclear risks ones. If I take a look at the IAEA analyses on risks and probabilities you get about a one in ten billion chance of having some disaster that kills ten people. They're very small. And if you look at the climate change ones you've got, essentially a fifty percent probability that we'll have more than 550 parts per million concentration, so those are fundamentally different scales and therefore both hard to compare but equally hard to say this risk to fifty million should be weighed equally to this risk to ten. And it's in that context that I probably come out in favor of re-licensing. . . . If at the end of the day what we're doing is we're saying are the risks of nuclear power less significant in my mind than the risks of climate change the answer is yes, they are less

significant. (#30 – Resource Panel)

The third of these excerpts is notable mostly for the degree to which it is exceptional: Although many interview questions were designed to elicit this sort of detailed discussion of how an individual human being assembles information about nuclear power, climate change, and other issues to formulate an opinion, very few people described this sort of attempt at a comprehensive consideration of consequences, and virtually nobody else mentioned numerical probability of outcomes or even, for that matter, uncertainty. The first two excerpts above illustrate the more typical case in which, even when an interviewee acknowledged that climate concerns were affecting their opinions about nuclear power, I was unable to elicit clear explanations of how, or even whether, these concerns were weighed against others to arrive at a specific decision to, for example, accept the re-licensing of existing nuclear power plants. This could be partly because of the way the interviews were structured: because I wanted to know what people had already thought about, not what I could persuade them to think about, I did not generally challenge them with specific risks of nuclear power or climate change. But explanations that cited specific risks were rare enough to make me confident that the sort of explicit risk-weighing described above is not a common method by which people arrive at opinions about nuclear power and climate change.

If concern about climate change causes people to accept the continued operation of existing nuclear plants, will it eventually cause them to accept the construction of new nuclear power plants? Maybe, but the question is much more hypothetical, and the evidence indicates that there are some complex reasons to doubt that such a connection

can be assumed, at least for the near future. These reasons will be described in detail in the next two sections, but the following simpler explanation certainly captures one important aspect of the problem:

The decision I'm trying to make is am I going to keep this plant running or am I going to shut it down. And if I keep it running I'm going to create some more waste but I've already got a site full of waste and I don't have to go through the process of siting another plant of some other type, I don't have to figure out if I want to do fossil fuels that are going to add carbon emissions. . . . I think that if you do shut down an existing nuclear plant you're likely going to replace at least some of the power with fossil fuels so your carbon emissions are going to go up. You're sort of going in the wrong direction. . . I think if you sort of take climate change out of the equation, I think the decision to re-license an existing plant is easier than the decision to build a new plant because of a combination of cost, siting, issues that you've already got the thing there and whatever problems you've got you've bitten off and you're just sort of making incremental changes as opposed to something more, sort of a bigger deal. And so I think you bring in climate to either of those decisions so if you're already kind of, if the licensing thing was already a closer call then the climate consideration might push you over the edge of that decision more easily, whereas with the new plant if it wasn't that close a call the climate change consideration might make you more interested in building a new one but it might not make as big an impact on the decision. So I think it's more the

other issues, and then the climate issue is the same. (#31 – Resource Panel)

More than one person specifically described having learned, as part of the RGGI process, about increases in emissions of a variety of pollutants including carbon dioxide that occurred when several nuclear power plants in New England were shut down temporarily in the 1990s; this is the sort of movement “in the wrong direction” mentioned above and was clearly a concern for some. While the reasons that new plants would be a considered to be a “bigger deal” were often not entirely clear, especially given the strongly-held concerns about the continued accumulation of waste at existing sites, it was perfectly clear that they are, in fact, considered to be a much bigger deal and many were very careful to explain that it would be wrong to suggest that acceptance of re-licensing implies a general willingness to substitute nuclear risks for climate risks.

In Their Own Words: Waste and Nuclear Technology

Further evidence that RGGI participants do not seem to be weighing nuclear risks against climate risks can be found in attitudes toward nuclear power technology and waste disposal. Most of the people that I interviewed willingly indicated that their opinion about a proposal to build a new nuclear power plant would depend, to some degree, on specific design considerations related to reactor safety and nuclear waste. Many also implied that progress on the waste issue could eventually facilitate their own acceptance. On the other hand very few were willing to even consider the question that is the central topic of this project; that concern about climate change might eventually cause

them to become more willing to accept technologies that they would otherwise oppose. Part of the problem is, of course, that environmentalism in the RGGI region has historically been tightly coupled with opposition to nuclear power. According to one resource panelist:

Determination to do something about climate comes out of the region's traditional environmental sensitivity and leadership. And that does not resonate with existing nukes. (#14 – Resource Panel)

Whether new developments in nuclear technologies can ever broadly satisfy the environmental community is very much an open question, but my data does suggest that such progress has the potential to play a larger role than new information about climate change in facilitating the acceptance of new nuclear power plants, even for some people that are very concerned about climate change.

Concern about nuclear waste is very widespread. Only a small minority of the people who were interviewed seemed unconcerned about the continued creation of nuclear waste at operating nuclear power plants, and at least half indicated that their concern would be likely to cause them to be opposed to any proposal to build a new nuclear power plant in the RGGI region. Some were very skeptical that the problem could ever be resolved:

If this country is sort of vaguely democratic in any way. . . the empirical evidence suggests that you're just not going to be able to find another site every five years, you're not going to be able to get the local folk to accept it.

(#20 – Stakeholder: Environmental)

I would say the waste issue is number one in my mind. It's the generation of the waste, the storage of the waste, the eventual transportation of the waste and how it's going to be dealt with for tens of thousands of years. (#8 –

Stakeholder: Industry)

Others, however, seemed to view the problem as more political than technical. In other words, the likely consequences that concern these people are not explicitly related to possible contamination with radioactive material; they are also concerned about imposing a burden of responsibility on future generations, and many of them are quite open to the possibility that progress along already-proposed paths will ultimately lead them to accept or even favor the construction of new nuclear power plants.

As a younger person I was probably an anti nuke person. . Now I'm willing to admit that if you constrain carbon and you continue to increase your demand for electricity, the remaining resources are by definition going to have a leg up on carbon emitting resources . . . Do I feel better about them because of climate change and how they offer some sort of alternative to carbon. Not a

lot because they come with their baggage. You've got not only nuclear power plants but you've got waste dumps at every plant so what you're doing is sort of proliferating just very significant environmental waste, waste which has got negative environmental impacts and it's, I don't know if that trade off is worth it. . . . I like the idea of storing the waste and creating a central repository for it. . . . I think that would be significant to making nuclear power look more palatable. (#22 – Staff Working Group)

There's lots of questions associated with nuclear operations that would come into play in how I'd react to it, if they're talking about a new generation technology that has a waste management component associated with it I would be open to the proposal. (#8 – Stakeholder: Industry)

There's a waste disposal problem that is absolutely fundamental that needs to be addressed before the technology can be relied on to a greater extent. (#18 – Stakeholder)

I would probably react positively with only one caveat, one exception, which would be how to deal with the nuclear waste issues coming from the plant. If we take the case of an individual proposal for a new nuclear plant, if there was real progress being made toward shipping what we have out of New England toward Yucca Mountain then you might be less likely to be opposed? Correct.

. . . I think the government in ten years. . . . we'll have some national legislation in terms of greenhouse gas issues. . . . I'm hoping that at that point these various mixes of interests will say we need to do something now to solve this waste issue and to get the new nuclear plants licensed and get them built.

(#21 – Stakeholder – Industry)

The previous excerpt, especially, suggests an important and challenging dynamic that surrounds the waste issue and, to a lesser extent, the design of new nuclear power plants. People believe that acceptable solutions to problems in reactor design and waste disposal have been proposed and will ultimately make them more comfortable with future construction. On the other hand, their desire to see these solutions implemented may make them even more unlikely to accept new construction in the current technological environment, which they regard as inferior. Support for the development of these technological solutions was quite common among the RGGI participants interviewed, although direct subsidies to the nuclear power industry to support their deployment were much less popular.

The carbon dioxide that is created in fossil fuel-fired power plants and the radioactive isotopes that are created in nuclear power plants both have the potential to impact the lives of future generations. A few people discussed this similarity:

There is a real problem that's going to occur and a solution that's going to cost a lot more to us if we don't solve it on the climate. . . from what it does to our land

resources, what it does to farming, to agriculture, what it does to other populations, to potable water, I just think when you look at the whole piece, that's much greater risks than we're going to, from having a climate problem versus having a storage problem. (#12 – Stakeholder)

Even if we reduce our greenhouse gas emissions today, the climate forcing that's already in the atmosphere that will remain there for at least another hundred years if not longer and the ocean a thousand years. So you compare that with, OK, is a hundred years, well OK that's my grandkids, we can deal with that versus a hundred thousand years for nuclear waste and it's, I mean it is a matter of degrees. (#19 – Staff Working Group)

Even these people did not indicate that they had achieved any real clarity through this way of thinking, and nobody suggested that they were able to integrate issues of generational equity with concerns about specific effects that might occur with unknown probabilities. During one of the pilot interviews that I conducted while preparing to speak with RGGI participants I was told: “You’re balancing risks, right? If you believe the risks of climate change are getting severe then you’re going to have to accept some other risks in other ways.” My interviews offer little support for the hypothesis that such balancing of specific risks plays a significant role in people’s thinking about nuclear power and climate change.

We have seen in this and the previous section that many of the people who were interviewed are willing to accept the continued creation of nuclear waste at existing nuclear power plants but do not believe that they would be willing to accept a proposed new plant without demonstrable progress toward a satisfactory long-term solution to the problem of waste storage. There is undoubtedly some tension between these two positions, but a way to reconcile them was suggested above: Maybe concern about climate change will provide a motivation for the development of an improved system of waste disposal and maybe even better reactor designs. This could happen, but there is a significant obstacle that is unrelated to the specific technical challenges. While most expect and hope that concern about climate change will lead to the development of a wide range of new energy technologies, most would also prefer that explicit efforts to motivate such technological development be targeted toward non-nuclear options. As will be shown below, new nuclear technologies are not a preferred solution, and, in many cases, even people who are not opposed to the use of nuclear power and are optimistic about future developments in reactor technology and waste management would prefer to see resources directed toward other power generation technologies.

In Their Own Words: Renewable Energy and Efficiency as Alternatives

Many interviewees who expressed willingness to seriously consider a proposal for a new nuclear power plant were careful to be clear that new nuclear power plants were not their first choice as a response to climate change, and others who were more dismissive of the hypothetical nuclear proposal were even more anxious to convince me that investments in efficiency and renewable energy represent much more sensible and,

significantly, affordable responses to climate change. Ten examples are included to illustrate the degree to which this preference for other options was pervasive and robust among the RGGI participants who were interviewed, with the notable exception of those working in the electric power industry.

There are a package of non-emitting options that are not nuclear power that are not fossil. And I think the package is more attractive than the nuclear power plant. (#30 – Resource Panel)

I don't think that we gain anything by having a new fleet of nuclear plants be part of that package because I don't think we need it. . . people are becoming more familiar with all these other new technologies, people are building wind farms. . .

You need to have a package that includes not only the whole renewable portfolio standard issue and make sure that that is on track but also the efficiency . . . there's a lot more that can be done. . . so that, coupled with renewable will help put you on a glide path to replace some of those fossil units. (#13 – Stakeholder: Environmental)

I'd have to look at it in terms of the waste management issue, the technology, and probably whether such a development would undercut more sustainable new markets like wind and other forms of renewables. (#8 – Stakeholder:

Industry)

I'm certainly working towards solutions that hopefully will provide that type of generational transition so we will not require new nuclear facilities. (#19 – Staff Working Group)

Moving to a new generation of new plants is going too far and would be too great a distraction from what we ought to be doing and I've already given you that list.

Politically it's almost like public policy cannibalism, the bad idea eats up the good idea. . . .we put these mirages on the public policy table and we seduce ourselves into thinking that there's going to be water when we get there and meanwhile we've walked right past the distributed resources that would have supplied our needs. (#32 – Resource Panel)

In the short term I'm inclined to push against nuclear power plants for fear that they will be a quick and dirty solution I would tend to want to keep pressure on the whole system to exhaust the available opportunities such as renewable energy, such as energy efficiency. (#24 – Stakeholder)

Carbon dioxide is such an enormous issue that it requires some fundamental

change. But my preference would be to look at all the other things on the list before we ever got a nuclear plant. (#27 – Stakeholder)

I think that these are going to be incremental impacts, serious by nature but incremental over time, and that we have time to, we're going to have to take the time to transition our energy resources to less carbon intensive resources, and they may include an expansion of nuclear in the future if the technologies are enhanced, but hopefully it will be a massive increase in efficiency programs and renewables. (#8 – Stakeholder: Industry)

Several points are made in the above excerpts, most of which come from interviews with people who were not entirely sure that they would oppose a proposed new nuclear plant at some time in the future, especially given hypothetical improvements in technology and waste management. The first, illustrated most clearly in the last three examples, is that the possibility exists that, over time, impressive progress in the areas of renewable energy and efficiency could result in a softening of opposition to the construction of new nuclear power plants. A second is that many people who are not categorically opposed to nuclear power worked to make sure that I understood that nuclear power is much less preferable than renewable energy or efficiency. The third and most significant point is that many people perceive that, with regard to public perception and to the availability of both political and economic capital, nuclear power competes directly with renewable energy and efficiency.

The most significant conclusion that can be drawn from these interviews is that there are a variety of things that people would like to see happen in response to climate change, and, for the foreseeable future, the construction of new nuclear power plants is not one of them. Decreased opposition to specific proposals to build new nuclear power plants could result, but support is much less likely. The reason is simply that there are better options and the expansion of nuclear power could make their development less likely. To defend against this objection, I began all interviews by describing a hypothetical scenario in which a strong carbon policy was already stimulating conservation and the development of renewable energy, and I would occasionally even add the stipulation that the hypothetical proposal was for the construction of a new nuclear power plant on the site of an existing coal plant which would then have to be shut down. But this didn't seem to change opinions; often the answer was that there are better alternatives, even if that wasn't the specific question that I was asking. Analyses of specific mechanisms by which nuclear power competes with other alternatives may be perfectly valid and still miss a more general point: Any consideration of nuclear power, including the present project, has the potential to distract from efforts to proceed down more desirable paths. The point for now is that the idea that nuclear power competes with preferred alternatives seems to be conceptual and pervasive in the sense that it is independent of how specific policy choices may determine the degree to which such competition actually occurs. Even when specific policy concerns, such as the possibility that new nuclear power plants will compete directly with renewable energy in electricity markets, can plausibly be addressed with specific policy solutions, such as set-asides like those mandated in renewable portfolio standard requirements, hypothetical new nuclear

power plants are still viewed as substitutes for, rather than complements to, other mitigation strategies.

This concern about competition does offer a plausible explanation for the lack of opposition to re-licensing: For some, the argument seems to be about crafting an acceptable alternative to the existing system, and existing plants, almost by definition, do not compete for this role. One proponent of a “package” of preferable alternatives made this connection with applications for twenty-year license extensions explicitly:

I think the package doesn't come in at costs we . . . are willing to pay. We need to buy twenty years. (#30 – Resource Panel)

Many framed this competition argument in more explicitly economic terms. Although people were asked to consider a hypothetical future in which a new nuclear power plant was proposed in response to a price signal resulting from RGGI regulations, most respondents, including those in the electric power industry and the environmental organizations, expressed skepticism that any price signal resulting from RGGI would be sufficiently strong to support the construction of a new nuclear power plant for profit, both because they don't expect a strong price signal from RGGI and because they expect that a new nuclear power plant would be very expensive. So, to adjust my scenario to better conform with their expectations, people added hypothetical government subsidies for nuclear new power plants, which led to a substantial number of responses like the ones below:

I think it would come with a big hand attached to it sticking out towards the government looking for a subsidy. And then the argument is not should we go ahead with nuclear, it's if we are going to be putting substantial governmental funds into zero emissions should that, should those funds be going toward nuclear. (#20 – Stakeholder: Environmental)

I have enough faith in technology to believe that, if all of the great minds and resources that had been put into nuclear power over the last fifty years were put into other sustainable technologies that we can make that happen, and I think that's the attitude that we have to have about this given what we know to be the dangers of nuclear power. (#9 – Stakeholder: Environmental)

As much as I talk positive about nuclear, on the other hand they are going to make such a windfall in terms of a RGGI system that somehow we need to make sure that that money gets plowed back into some of the other alternative energy sources. (#23 – Staff Working Group)

This concern that the construction of new nuclear power plants will make it more difficult to implement the much-preferred solutions of renewable energy and efficiency were held across a wide variety of organizational affiliations and general attitudes toward nuclear power. The last excerpt above, for example, comes from an interviewee who is very

receptive to the idea that new nuclear power plants should be built to address the climate problem.

There was one small class of interviewees that showed no patience for the idea that new nuclear power plants should represent a last resort alternative to be used only after other non-emitting options were exhausted. At least two people representing companies that own nuclear reactors expressed particular skepticism about wind power, probably the most strongly preferred energy source among the other RGGI participants with whom I spoke:

Renewable is being held out by many environmentalists as sort of a panacea. I don't see that For your own personal preference you'd prefer to have a single reactor than have a large area covered with windmills. I think it's a waste of . . . money and land. (#17 – Stakeholder: Industry)

I think there's lots of opportunities for renewable energy. Unfortunately I think that the technology today . . . is overstated about it's importance. . . You just can't get much electricity out of them. A GE wind turbine with 250-foot blades, you get a couple of megawatts out of it and you line them up side by side, it's just not practical. (#25 – Stakeholder: Industry)

A third representative from the electric power industry explained:

The enviros hate nuclear . . . you listen to some of these people and, assume zero load growth, assume renewables are going to take care of everything. . .

(#7 – Stakeholder: Industry)

Concerns that unrealistic expectations for renewable energy may undermine efforts to develop realistic policy seem to be quite isolated within the electric power industry.

RGGI offers a context in which nuclear power plants are naturally grouped with electric generation sources like wind and solar power because they do not emit carbon. All of the people interviewed understand and accept this, and many of them are even quite open to the idea that RGGI and similar plans for carbon regulation may eventually stimulate the construction of new nuclear power plants. However, this section has shown that many people have a list, or package, of renewable generation options and efficiency improvements that they favor over nuclear power for a variety of reasons, and, even more importantly, these people tend to consider these options separately from nuclear power rather than simply integrate new nuclear power plants directly into the list, or package, because they do not emit carbon. For those who expect that new nuclear power plants will be very expensive, the description of this list often takes the form of a cost curve in which market forces should deploy renewable energy and efficiency first because they are cheaper, unless massive subsidies are used to stimulate new reactor construction. For these people, probably including a substantial majority of the people who were interviewed, such an outcome would be undesirable, largely because of their concern that more preferable alternatives could not compete with heavily subsidized nuclear reactors.

In Their Own Words: The Future of Coal

Interviewees were asked whether they thought that the use of coal would have to decrease in response to climate change. One response surprised me when I heard it, but turned out to represent a somewhat widely held view among the RGGI participants that I interviewed:

I have had this response with respect to coal more than I have had it with respect to nukes. . . Cleaner coal, maybe integrated coal gasification is going to provide more of a solution than nuclear power. . . if you can sequester carbon then IGCC's footprint is just miniscule compared to a new nuclear power plant. . . . You got, well you have to figure out coal because you have all this coal resource. . . I haven't had this huge insight with respect to nuclear power that I've had with respect to coal. . . if you can get those technologies out you most certainly will not need to decrease it you will actually increase it. (#22 – Staff Working Group)

Many, though certainly not all, expressed general skepticism that coal use can be radically reduced. The first two of the following four excerpts are from people that would oppose a proposal to build a new nuclear plant in the RGGI region, the third and fourth are from people who would support such a proposal:

Pulverized coal . . . is a technology of the past. Now it gets into a question what do you mean by coal, do you include gasification. . . that starts to be a more rational thing to discuss. . . they certainly haven't worked all the bugs out of carbon capture and sequestration, it's not a reasonable solution yet, but as with nuclear I'd leave the door open and frankly the likelihood of figuring out how to use coal in a manner that is consistent with carbon constraint, in a way that is acceptable in terms of other environmental factors, is probably a lot higher than solving nuclear's problems. (#20 – Stakeholder: Environmental)

If we're going to keep using coal how do we use it in the smartest way with the least environmental impact, so if we have coal IGCC plants and you have carbon capture and storage and you sequester that carbon geologically I can see a long-term future for coal without us destroying the planet. (#13 – Stakeholder: Environmental)

Coal has to be in the picture, it's the resource we have in this country. I think we're going to have to figure out how to burn it better. (#7 – Stakeholder: Industry)

We're never going to be out of the focus of coal in this country, there's just no way, it's never going to happen. It's just too bad that DOE won't really

promote the clean coal technologies that they've talked about for the last thirty years. . . they can make coal and the environment one but they just haven't. (#23 – Staff Working Group)

One person who argued that new nuclear plants would be undesirable, though not totally unacceptable, partly because they would compete with efficiency and other alternatives, offered a detailed explanation of his support for research into carbon sequestration as an alternative to nuclear technologies:

If I had the five billion dollars to spend or whatever we think the nuke is going to cost, I would spend it on carbon sequestration. . . . Because of the energy mix in the United States and our abundant coal resources and the politics of energy in the US, not to mention the politics of energy in China and India, the world is going to be burning a lot of coal over the rest of my lifetime and I don't see how we can transition past that any time soon and with the technologies that are reasonably available. And so I've, this is a change in view for me, over the past three years, instead of thinking we have to phase out coal, which I think is basically an impossible task over the next thirty years, I've come to embrace a strategy that would accept that we're going to be dependent on coal for a significant fraction of our central station supply and that what we need to do is more aggressively develop IGCC with sequestration. And because I think that's so essential I would rather spend my money on that technology than on the next nuclear plant. . . . the political

forces that are going to cause us to keep burning coal are incredibly powerful and there's no political force that's forcing us to build new nukes. . . I'm looking at the world, I'm trying to be really practical and I know I need to solve the coal problem. I don't have to solve the nuclear problem. (#32 – Resource Panel)

Many of the people who were interviewed seem to be more willing to cautiously integrate the possibility that carbon sequestration technology will facilitate the construction of a new generation of coal fired power plants into their thinking about strategies for reducing carbon emissions than they are to similarly change their thinking about nuclear plants. For many of these people, especially given the current nuclear waste disposal situation, new nuclear power plants really are at the bottom of the list of preferable solutions.

Analysis

All of these people were presented with a hypothetical situation in which a company responds to a significant carbon constraint with a proposal for a new nuclear power plant, “asserting that the new reactor will help to facilitate even greater reductions in carbon pollution.” They were then asked how they would react to such a proposal. Some said that they would probably be supportive and others said that they would probably be opposed, but many were not sure how they would react. How would they decide? It seems that the significant criteria

can be divided into three categories.

The first category is opinions about nuclear technology. Any progress at all toward disposal of the nuclear waste currently stored at reactor sites would soften opposition to new construction, and significant progress toward the realization of existing plans for storage in Yucca Mountain would likely be decisive for a number of people. Although one might be tempted to assume that people who support license renewals would be unlikely to oppose new construction based on concerns about waste, I was repeatedly told that this assumption would be incorrect. Signals about reactor technology were less clear, mostly because few people are familiar with existing unbuilt designs, but few expressed strong concerns about the operational safety of existing plants so it seems unlikely that details of reactor design will be decisive for many of these people.

The second category is preferences for other technology over nuclear power. Why, exactly, this should be relevant is a complex question, given that most of the people that I talked to did not seem to have strong preferences between the various other alternatives, which were described in many cases as complementary parts of a package rather than as competing with each other. But the important point is probably that, even for many of those who support further consideration of nuclear power, it is the least preferred alternative, and for some, all other technological alternatives are considered to be complementary, and even if nuclear power may eventually be accepted, it will never become part of this package of preferred solutions. For these people, including a majority of the people that were interviewed, it is very important that nuclear power not be used

as a substitute for a list of technologies that, for many people, even includes carbon sequestration. Confidence that other options are being fully explored, which could conceivably be facilitated by policies such as renewable portfolio standards, may help some people to be more comfortable with a proposal to build a new nuclear power plant than they would otherwise be.

The final category is concern about climate change, and the likely effect of this variable is much more difficult to describe. Although many reported the realization that climate change has impacted their thinking about nuclear power, these people often acknowledged that, even absent climate change, they would likely reach the same conclusions about any specific question because concerns about the other effects of air emissions have always pushed them in the same direction. Proponents are more confident and opponents may be less so, but concern about climate change is decisive for almost nobody; only a small minority reported that, other things being equal, they expected that increasingly severe climate change would make them more likely to accept a new nuclear power plant absent improvements in technology and especially waste storage.

When considering how my interviewees responded to the hypothetical question that I posed, it is worth considering who they are. While diverse in their opinions and knowledge about nuclear power and in the viewpoints of the organizations that they represent, this is a group of people that does share one characteristic: they all engage in policy analysis and strategic thinking for a living. What I was primarily looking for were clues as to how knowledgeable and concerned people would respond to a relatively bounded question of the type

citizens are sometimes expected to have opinions about: Would you support or oppose the construction of a new nuclear power plant? I had hypothesized that some people might respond by saying that concern about climate change would make them notably less likely to oppose, or more likely to support, such a proposal in the near future. I had also hypothesized that they might explain their reasoning in terms of nuclear power or climate change. This hypothesis turned out to be largely incorrect: very few people responded in these terms. In many cases they carefully and patiently explained that they couldn't really consider the question because of a fairly sophisticated policy objection: Other options exist that can meet near-term needs for non-emitting generation and no plausible policy instrument can stimulate the construction of new nuclear power plants without limiting the development of other more desirable options. Though certainly constructed from true statements, this argument might not be so persuasive in a broader public debate because it requires a thorough understanding of alternative policies and technologies.

Conclusions

For a significant number of the people that I interviewed, opinions about nuclear power are clearly linked to concerns about climate change. However, in almost all cases, this linkage has yet to have a noticeable effect on support, or even acceptance, of new nuclear power plants. Part of the reason for this is that many people are unsatisfied with current reactor technology and, especially, waste storage plans. But there is another reason, which has to do with preferences for

other technologies, including so-called clean coal. One way to make sense of what people said about the available alternatives is to understand that, at least for the next couple of decades, it seems likely to them that the potential supply of energy alternatives that can facilitate reductions in carbon pollution will be far greater than the demand for actual reductions. In other words, when confronted with the possibility of new reactors, a very common response was to explain that they are not needed because better alternatives exist in sufficient quantities. The RGGI process probably reinforced this perception because it included a modeling component which showed that all of the constraints under consideration could readily be met without the construction of new nuclear power plants or, for that matter, carbon sequestration or even reductions in electricity consumption. A more restrictive program could stimulate some of these developments, but nuclear power, as the least preferred and possibly most expensive option, is likely, in this view, not to be necessary to meet even more ambitious goals.

This response does suggest another question: is it possible that people will eventually become sufficiently satisfied with the degree to which other alternatives are being deployed that they will become more willing to accept the use of nuclear power as a last resort? I would say, cautiously, that progress in this direction is possible, but that the current trend is probably in the opposite direction. For example, many expressed frustration with the rate at which wind turbines are being deployed. We should concentrate on building wind farms, in this view, and a new nuclear power plants would represent unwanted competition. Many cannot conceive of a near term policy scenario in which they would not

view a new nuclear plant as something that was being done instead of more preferable alternatives. Rapid expansion of the use of renewable energy could, it seems to me, help to neutralize this objection to some degree for some people, especially if continually increasing concern about climate change leads to ever-stronger pressure to decrease carbon emissions as rapidly as possible. But, of course, for others, the same rapid expansion of renewable alternatives would simply support the assertion that new nuclear power plants are not needed.

Although I began my interviews with a hypothetical question, my goal was mostly to learn about thinking that had already been done about new nuclear power plants. The simple and far from unanimous answer is that, partly because of concerns about nuclear waste, partly because of optimism about alternative solutions, partly because of expectations that existing plants will continue to operate, and partly because they do not expect anyone to propose a new nuclear power plant in the RGGI region, there is little interest among RGGI participants in the possibility that new nuclear power plants will be built in the RGGI region in the next few decades. Most are not sure how they would respond to such an unexpected proposal; climate change could soften opposition but there is no reason to be confident that it would be a decisive factor for any but a small minority of the people to whom I spoke.

Chapter 8: Conclusions

There is no question that global climate change plays a role in debates about nuclear power in the United States. Proponents and opponents of the increased use of nuclear power agree that it is possible that future policy responses to global warming will eventually stimulate the construction of new reactors. A number of studies have reminded analysts that nuclear power plants provide electricity with very low greenhouse gas emissions, and a few have explicitly argued for the construction of new reactors as a favored emissions reduction strategy. On the other hand there seems to be little momentum toward such a project. The social scientists discussed in chapter two suggest that we should not be surprised when direct but explicitly technical arguments are not easily translated into policy, and this thesis describes some of the obstacles that exist in this case. Of course there are also very significant technical arguments against the use of nuclear power plants to generate electricity, and I have not attempted to evaluate the merits or importance of these arguments. The purpose here is to further understanding of how people and organizations are integrating growing concern about climate change with existing opinions about nuclear power plants; the following conclusions are supported by my research and have the potential to serve this purpose.

A diverse body of literature supports the hypothesis that concern about climate change has the potential to play an important role in future debates about proposed new nuclear power plants. (See chapter two.)

Environmental organizations and the industry-funded Nuclear Energy

Institute agree that efforts to limit carbon emissions will stimulate debate about nuclear power. (See chapters 3, 4, 5, and 6) Public communications in a variety of contexts allude explicitly to a linkage between climate change and debates about nuclear power. These debates will continually create new contexts in which people and companies may argue that nuclear power plants are environmentally preferable to coal-fired power plants. On the other hand such contexts have existed for two decades and there is no evidence that any environmental group or Nuclear Energy Institute participant has reached this conclusion.

The nuclear power industry is heavily reliant on coal to generate electricity and therefore cannot be expected to support regulations that favor nuclear power over coal combustion. (See especially chapter 3 and also chapters 5, 6, and 7.) Further research that compares companies with different degrees of investment in nuclear power plants has the potential to clarify links between industry structure and positions about nuclear power and climate change. Specific legislative proposals to cap carbon emissions from electric power plants may drive divisions between these companies and limit the degree to which they can continue to support common policies through their participation in the Nuclear Energy Institute. Companies such as Exelon and Entergy, with little investment in coal-fired power plants, may begin to argue explicitly for policies that encourage the use of nuclear power instead of coal. If the US government begins to show interest in strong policies to address climate change, then repetition of the research described in chapter three could reveal contrasting responses from different companies

that depend on the degree of their current and anticipated investment in nuclear power plants.

Environmental organizations that have participated in debates about air-emissions regulations do not support the construction of new nuclear power plants as a strategy to limit greenhouse gas emissions. (See especially chapter 4 and also chapters 5, 6, and 7 and appendix A.) Because their opposition to nuclear power predates knowledge about climate change, and because they argue that knowledge about climate change should cause a wide range of changes in behavior and policy, these groups are likely to experience pressure to revisit past decisions to oppose nuclear power. While the data presented in this thesis suggest that long-held positions in opposition to nuclear power have remained intact in every case, they do not preclude the possibility of further evolution. Any clear signal that these groups are willing to accept new nuclear power plants could be influential because current positions are so well-established, and because they have credibility as advocates for substantive responses to climate change.

The inclusion of direct subsidies for nuclear power plants in plans to limit carbon emissions will elicit particularly strong opposition from environmental organizations and others. Financial benefits that accrue to nuclear power plants simply because emissions regulations drive up the wholesale price of electricity will generally be tolerated. (See chapters 4, 5, 6, and 7) This conclusion has extremely significant implications for efforts to understand the likely structure of future debates about nuclear power in the context of climate change. Policies that rely on direct subsidies to stimulate the construction of non-emitting power plants offer both a mechanism and a rationale for the exclusion of nuclear power: Opponents can argue that

nuclear plants should simply be excluded from otherwise intact lists of subsidized technologies because they represent an established technology that has long been utilized by companies that have sufficient financial resources to fund new construction. Policies that impose direct costs on carbon polluters will place nuclear power plants at a competitive advantage compared to carbon emitters but offer neither a simple mechanism nor an inherent rationale for the explicit exclusion of nuclear power plants.

Climate change does not seem to be causing knowledgeable people to change previously held opinions about the construction of new nuclear power plants. This is partly true because of well-known issues of cost, safety, and especially waste. But the fact that climate change affects the way people think about all other energy options also limits the degree to which people accept the assertion that climate change should increase the degree to which people are willing to accept the construction of new nuclear power plants. (See chapter 7.) A substantial fraction of the people who were interviewed for this project were careful to explain to me that other solutions to climate change are much preferred over new nuclear power plants, and that they could not support inclusion of new nuclear power plants in near-term efforts to address climate change partly because nuclear power plants would compete with a set of preferred options that may prove to be sufficient. For some of these people it may be that climate change has made them even more strongly opposed to the construction of new nuclear power plants. This could occur if they expect new nuclear plants to compete for money and political support with other technologies that they consider to be more realistic and desirable responses to climate change, and it is even true, in some cases, of so-called clean coal technologies. Most people who believe that climate change should cause

opinions about nuclear power to evolve have never opposed nuclear power and have not observed such evolution in the opinions of others.

Specific risks do not play important roles in people’s descriptions of how they would evaluate a hypothetical proposal to build a new nuclear power plant. (See chapters 2 and 7) Further research that correlates perceptions of relevant risks with opinions about nuclear power could show important connections between risk perception and opinion formation that were not revealed by my research. However, the results of the interviews with knowledgeable people described in chapter 7 suggest that policies and organizations receive more explicit consideration than, for example, sea level rise or nuclear waste when people attempt to integrate knowledge about climate change and opinions about nuclear power. An important implication is that progress is more likely to be facilitated by consideration of a broad range of policy options than by careful but narrow attempts to fully specify likely consequences of either carbon pollution or the operation of nuclear power plants.

There are knowledgeable people who are willing to accept the continued operation of existing nuclear power plants but expect to oppose future proposals to construct new reactors. Some of these people acknowledge that concern about climate change partly explains their acceptance of existing reactors. (See chapter 7) Further study of the individuals who hold these opinions has the potential to yield more precise information about how people draw distinctions between acceptable and unacceptable responses to climate change. This observation also suggests that something other than analytical risk comparison drives opinion formation and that people may be thinking more about categories such a “existing” and “new” technology than they are

about the specific effects of particular technologies when they evaluate proposals to generate electricity at nuclear power plants.

Taken together these conclusions suggest that formidable obstacles are likely to impede acceptance of new nuclear power plants in the context of efforts to reduce carbon pollution. Debates about nuclear power are traditionally conceptualized as conflicts between “environmentalists” and the “nuclear industry,” and controversies about climate change are often discussed in similar terms. But close examination of these groups shows that neither is likely to advocate strongly for the replacement of existing coal-fired power plants with new nuclear power plants. Policies that impose costs on companies that emit carbon dioxide have the potential to be acceptable to both groups and increase the degree to which nuclear power plants can be operated profitably, but carbon policies of sufficient strength to stimulate the construction of new nuclear power plants have yet to find political favor. A related problem stems from the fact that some people may be willing to accept new nuclear plants only as a last resort: So little substantive effort has been made so far that even people who support the eventual construction of new reactors can often point to numerous other more preferable strategies that have not yet been implemented and should, in their view, be deployed first. Readers should also remember that this thesis does not fully address one important possibility: People who oppose the construction of new nuclear reactors because of fundamental concerns about waste, safety, or weapons proliferation may be inherently unreceptive to arguments that they should accept

nuclear risks to address other problems. On the other hand nothing in this thesis precludes the possibility that, as climate change worsens, people and organizations will become more willing to accept exactly that argument in the case of climate change.

There is a certain circularity implicit in the debate about how to address carbon dioxide pollution from generators of electricity. There is some agreement that the potential to reduce emissions quickly is limited by the lack of readily available alternatives. Another point of wide agreement is that efforts to mitigate carbon dioxide emissions from electrical generators should focus on the development of clean renewable resources such as wind and solar power. The relationship between these two points of agreement is complex, but one aspect of their interaction is that, to some degree, each provides a rationale for the other. We lack confidence in our ability to severely decrease our consumption of fossil fuels because we limit the list of alternatives that we consider, but our willingness to limit the list of alternatives that we consider may be, at least in part, a consequence of our perceived inability to severely limit our consumption of fossil fuels. What would we do if we really needed to stop burning fossil fuels now? Readers will probably have surmised that I will not object if this goal is achieved partly through the construction of new nuclear power plants. This thesis, however, does not explicitly argue for such a strategy or offer much evidence that new nuclear power plants would be more acceptable in the context of efforts to address climate change than in any other context.

It is my hope that it does, however, offer observations which can help to facilitate progress toward the important goal of achieving substantial reductions in the total amount

of carbon dioxide that is emitted from electric power plants in the United States. My concern here is that, regardless of opinions about nuclear power, consideration of the climate question is made more difficult by uncertainty about the future of nuclear power. This is of course partly true for the simple reason that nuclear power plants are currently the dominant source of emission-free electricity production. However, in my opinion, this dilemma persists for a more complex reason: The fact that the climate question includes an ongoing and angry sub-debate about the historically intractable nuclear question may deter people and organizations from comprehensive consideration of the climate question. If successful, this thesis will help others to understand current thinking about the nuclear question with more clarity and confidence, and, if I am correct about how these issues are connected, this understanding will serve my readers well as they attempt to consider the even more consequential question of how to best address climate change.

Appendix A: Environmental Organizations

The following paragraphs describe, summarize, and excerpt information about nuclear power that was available on the web sites of prominent environmental organizations in August 2004. The comments are analyzed in chapter 4.

The **Audubon Society** (AS) surveys energy options in a page titled “Beyond Oil.” The article lists “pros” and “cons” of a variety of technologies, including nuclear power, and points out that nuclear power plants produce “virtually no atmospheric pollutants.” The article describes “improvements” that have been certified by the Nuclear Regulatory Commission for use in future construction and forecasts that “Several reactors that were left unfinished when demand slowed will likely be completed.” AS also commented explicitly on the proposed pebble bed modular reactor: “One company seeks licensing of reactors using new “pebble bed” technology, in which insulated grains of uranium too small to reach meltdown replace fuel rods. . . New modular construction would make for small units (inherently safer) and standardized design (less expensive to build). (Garelik 2001).”

The **Conservation Law Foundation** (CLF) has adopted, in its “Principles for Reducing Greenhouse Gas Emissions in New England,” a position that “increasing the use or output of nuclear power is an unacceptable strategy for reducing electricity sector greenhouse gas emissions.” Other principles recommend efficiency, conservation, and the increased use of renewable resources and provide specific numerical goals, including, for the electricity sector, the use of “clean renewable energy sources” to supply 10% of

electricity consumed in 2010 and 20% in 2020, and a 40% reduction in carbon dioxide emissions by an unspecified date (CLF 2003).

Greenpeace (GP) warns that “seemingly oblivious to the fact that terrorists are targeting nuclear power plants, the nuclear industry and its proponents are plotting a nuclear renaissance” and “the Nuclear Regulatory Commission is squandering its limited resources by entertaining the prospect of certifying even more reactor designs” (GP 2002). In its *Renewable Energy Platform* the group opposes subsidies for nuclear power plants and asserts that “the sun and wind potential in the U. S. is huge” (GP 2004). In April of 2004, the nuclear policy analyst for Greenpeace described existing designs for new reactors as “unsafe, uneconomic, and unnecessary” and described “continued support of nuclear power” as “unconscionable” (Riccio 2004). No comments on nuclear power in the context of climate change policy were available on the group’s web site.

In a 2002 fact sheet on “Electricity Generation and Pollution” that alludes to climate change, **Environmental Defense** (ED) poses the question, “What about nuclear power?” and answers that “like coal, nuclear power causes some of the most serious environmental impacts, albeit indirectly. . . Mining, processing and transporting nuclear fuel produce significant pollution, including air pollution.” and mentions hazards and waste storage as drawbacks. The sheet explains that electricity generation accounts for 40% of US carbon emissions but does not explain that the operation of nuclear power plants does not contribute significantly to this total (ED 2002). A longer report on energy policy details concerns that nuclear plants, including proposed future designs, make tempting targets for terrorists and repeatedly argues for a shift in government support “from fossil fuels and nuclear power to renewable energy” (ED 2002). A 2004 “White

Paper on Climate Action” produced by ED includes a “case study” of Entergy Corporation, which is described as “one of the nation’s leading electricity suppliers.” The study describes a corporate “Sustainable Forestry Initiative” and payments to farmers to support the use of “direct seeding” but makes no mention of the company’s status as the second leading producer of nuclear-generated electricity in the US (ED 2004). ED also commented explicitly on the proposed pebble bed modular reactor: “The President’s energy plan . . . advocates building more nuclear plants using a plant design called the Pebble Bed Modular Reactor. This kind of reactor would be constructed without the concrete “secondary containment” that shields most of the existing reactors from all but the most massive attacks. Although the design protects against melt-down accidents, the Pebble Bed Modular Reactor could still catch fire and spread radioactivity if it were attacked in other ways.” (ED 2002)

Friends of the Earth (FOE) has not explicitly addressed the question of nuclear power and climate change, but a critique of the proposed Energy Policy Act of 2003 explains that “handouts in the energy bill . . . support the nuclear power industry, while neglecting the long-term security and clean-up problems that nuclear power poses” (FOE 2003).

In a 2004 presentation on “The Future Role of Nuclear Power in the US,” the director of the **Natural Resources Defense Council’s** (NRDC) “nuclear program” explained that “nuclear power production does not result in significant greenhouse gas emissions and during normal operations the radioactivity emissions produce far fewer health effects than emissions from coal-fueled plants. Despite this one favorable comparison, nuclear power generation has its own set of unique problems -- proliferation,

reactor safety, and disposal of the nuclear waste. These problems need to be solved before expanding our commitment to nuclear power” (NRDC 2004). A 2001 Report went further: “NRDC does not anticipate that new nuclear power plants will be built in the foreseeable future because new nuclear power plants are unable to compete with a host of cleaner, cheaper, and less risky technologies. NRDC does not support the construction of new nuclear power plants because” of the risks of proliferation and accidents and because “the US has no operational geologic repository for the safe disposal of spent fuel” (Lashof 2001). Other documents on the group’s web site dismiss advanced nuclear technologies currently under investigation as potentially even more dangerous than existing nuclear plants, especially from a proliferation standpoint. Although a 2001 “Critique of the Bush Energy Plan” asserted that “There is no such thing as clean coal,” the “director of NRDC’s climate center” argued in 2004 congressional testimony on “Future Options For Generation of Electricity from Coal” that the existing “Clean Coal Power Initiative” should be altered to encourage the development of carbon sequestration technologies and that “status quo policy is likely to have adverse impacts on the coal industry by failing to create a business case for the technologies that are required to permit continued coal use in a carbon-constrained world” (NRDC 2001; NRDC 2004). According to the testimony, “Environmental advocates must acknowledge, like it or not, that the use of coal cannot be wished away.” The 2001 report also advocates a moderate increase in the use of natural gas. NRDC also commented explicitly on the proposed pebble bed modular reactor: “There are even safer designs on the drawing board . . . some in the nuclear industry are now touting a pebble-bed modular reactor as a much safer way to generate nuclear power. The pebble-bed modular reactor is still in the design

phase and its safety and proliferation risks have not been subjected to a thorough licensing review. In any case, no new nuclear reactors should be deployed unless they are demonstrated to be “inherently safe,” thereby obviating the need for Price-Anderson Act protection from liability (Lashof 2001).”

On a web page titled “Energy and Environmental Health,” **Physicians for Social Responsibility** (PSR) provides a concise but comprehensive list of the risks posed by both climate change and nuclear power. The first paragraph, on “Greenhouse Gases and Climate Change,” explains that the burning of fossil fuels contributes 85% of US greenhouse gas emissions and goes on to argue that “Resulting climate change is likely to manifest in a variety of health impacts, including increased respiratory distress, heat-related illness, and infectious disease outbreaks, as well as compromised water quality and quantity. Population displacement from sea level rise and extreme weather will likely compound these health effects in some regions. climate change could also contribute to global security concerns when resulting poverty, migration, and famine interact to create potentially volatile situations.” The next paragraph, about air pollution in general, is followed by a final paragraph on “Nuclear Power and Radioactive Waste” that begins: “Finally, although nuclear power plants do not produce the pollutants associated with fossil fuel use, they create large quantities of high- and low-level radioactive waste that poses a challenge in terms of management and disposal. U.S. nuclear reactors have created 77,000 tons of high-level radioactive waste, leaving the US with a toxic legacy that will last hundreds of thousands of years. Radioactive waste has the potential to contaminate expansive areas of land and to threaten the health of large numbers of people. Additionally, nuclear power plants are vulnerable to accidents and attack,

making them an environmental and public health risk.” The relationship between these two passages is not made clear, but it seems that PSR views both as dangers and does not intend for readers, fearful after reading the description climate change, to consider nuclear power as a possible solution.

Public Citizen (PC) runs the provocatively titled “Critical Mass Energy and Environment Program.” The group closely monitors and aggressively criticizes efforts to support nuclear energy by reporting on campaign contributions by the owners of nuclear power plants, analyzing the Department of Energy’s efforts to plan for the construction of new reactors, and opposing legislative proposals to subsidize the construction of New nuclear power plants (PC 2003; PC 2004). Climate change does not seem to be a central issue for PC, and it is dismissive of assertions that nuclear power and climate change are related issues. According to the group, “nuclear power is not capable of combating global warming because of the exorbitant cost of reactors and the long lead time needed to build them. Further, the steps needed to generate nuclear power . . . add carbon dioxide to the atmosphere” PC also commented explicitly on the proposed pebble bed modular reactor: “The industry is touting the pebble bed modular reactor as the cost-effective future of nuclear power, though the technology’s primary cost-saving measure appears to be the lack of a containment building, which of course would render such facilities even more vulnerable to assault (PC 2004).

Redefining Progress (RP) testified before congress in 2001 against subsidies for the “widely discredited nuclear power program” (RP 2001). Nuclear power poses a challenge for the organization’s popular “ecological footprint” model of environmental impacts, in which all activities, including energy use, are assigned a footprint with a

specific area. According to the web site, “The Ecological Footprint of nuclear power is more controversial. On the one hand, nuclear power does not generate carbon dioxide emissions, aside from the energy embodied in a nuclear plant's construction and maintenance. On the other hand, it does create wastes that must be dealt with over many thousands of years. Accidental contamination from nuclear energy, such as at Chernobyl, has made sizeable areas of productive land unfit for human use. In addition, there is a security concern, since radioactive material can be used for weaponry. Our current approximation of these variables gives each source an equal impact per energy unit. Taking nuclear energy out of the Footprint accounts would reduce the worldwide Footprint by less than four percent” (RP 2004).

Although the **Sierra Club** (SC) site is the only one that includes explicit “policies,” the relevant statement about nuclear power dates to 1974 and therefore far pre-dates serious concern about climate change. “The Sierra Club opposes licensing, construction, and operation of new nuclear reactors utilizing the fission process pending” the adoption of strong conservation policies, and “resolution” of problems related to safety, waste, and proliferation (SC 1974). In a 2004 editorial that made no mention of climate change and enumerated various risks posed by nuclear power plants, the club’s executive director wrote that “George Bush, in his eagerness to revive the nuclear power industry, is altogether too willing to script the American energy future as a disaster movie” (Pope 2004). The club’s web site proposes solutions including conservation, renewable energy and “converting [coal] plants to burn cleaner natural gas” (SC 2001).

The **Union of Concerned Scientists** (UCS) plays a somewhat unique role in that, while it employs a nuclear safety engineer who argues relentlessly for safety regulations

that are more rigorous and open, it also allows for the possibility that new nuclear plants may be built in the future by enumerating, in a recent report, specific conditions under which such construction could be acceptable, including the exclusion of new reactors from federally subsidized insurance, the construction of a working prototype before commercial deployment of a new reactor design, continuing study and refinement of approved reactor designs throughout construction and testing, and “meaningful” public participation in the approval process for reactor designs (Lochbaum 2004). But these conditions may be difficult to satisfy, and the group’s call to “Modernize America’s Electricity System” in response to concerns about the impacts of fossil fuel use does not mention nuclear power. UCS also commented explicitly on the proposed pebble bed modular reactor: “The pebble-bed reactor does offer certain safety advantages -- at least, on paper. Proponents claim that the pebble-bed reactor cannot experience the meltdown-type accident as occurred at Three Mile Island in 1979. Perhaps, but can the pebble-bed reactor . . . catch on fire . . . can plant workers . . . trigger an accident . . . can some unexpected component failure cause fuel damage . . . It appears from a preliminary design review that the proposed reactor achieves its economic advantages by replacing . . . containment structures . . . with a far less robust enclosure building (UCS 2001).”

US PIRG’s (PIRG) web site does mention nuclear power in the “clean energy agenda” included in its “global warming” web page but does not acknowledge any contrast between nuclear power and fossil fuels even in this context: “A rapid transition to energy efficiency and renewable energy sources will combat global warming, protect human health, create new jobs, protect habitat and wildlife, and ensure a secure, affordable energy future. In contrast, our reliance on coal, oil and nuclear power imperils

the world's climate, fouls the environment, harms human health, and results in the proliferation of nuclear materials” (PIRG 2004)

The **World Wildlife Fund** (WWF) has explicitly addressed the potential role of nuclear power in efforts to combat climate change and concluded in a position paper that “WWF does not believe that nuclear power is the solution to global warming. In fact, WWF has a vision for the future which phases out the use of fossil fuels and nuclear.” The paper goes on to explain that “WWF urges the increase of new renewable energies to 20% of the global primary energy consumption by 2020 and to around 100% by 2080” (WWF 2003). WWF explains in the position paper, in a 2000 report, and on a web page titled “Climate Change Solutions: Nuclear Power will not help” that nuclear power is not considered to be sustainable and is inherently risky, and that investments in efficiency, renewable energy, and even gas-fired cogeneration represent better alternatives (WWF 2000; WWF 2004).

Appendix B: RGGI comments

The following excerpts are all from documents that are available on the RGGI web site. Direct quotations are in quotation marks or italics. Oral comments are taken from meeting summaries available on the RGGI web site and may not be exact transcripts. Most comments are therefore labeled with one or more of four topics discussed in chapter 6: incentives and wealth (**I**), allocations (**A**), offsets (**O**), and modeling (**M**). The comments are in chronological order, with the most recent comments last.

An August 2003 paper originally prepared for the Center for Energy and Economic Development asserts that *New York already has reduced emissions below 1990 levels for independent reasons, including a shift away from oil towards natural gas and increases in nuclear generation and power inputs*. The study explicitly argues that new nuclear power plants are a relatively low-cost option if very deep cuts are implemented and contemplates construction at a rate of two or more plants each year beginning by 2017. Another central point is that, because states within the RGGI region differ greatly in their reliance on nuclear power, a decision to allocate, or not allocate, allowances to nuclear power plants could have important implications for how the program shifts wealth between the states.

A A model rule outline produced by the Staff Working Group dated December 12, 2003 poses, as a “policy issue” the following question: *What types*

of sources should receive allocations? Fossil only? Nuclear? Renewables?

(Allocations)

M A March 12, 2004 memo from the Northeast Regional Greenhouse Gas coalition states that *the manner in which nuclear relicensing and nuclear rerates are addressed is important and can have significant impacts on modeling results* and mentions already-completed modeling efforts that were restricted to the state of Connecticut as illustrative of the substantial impacts that may result from reliance on differing assumptions about the future of existing nuclear power plants. (Modeling)

O An April 12, 2004 draft discussion paper on offsets prepared by the Staff Working Group lists *potential offset projects* from three categories, including *direct emissions reductions, sequestration, and indirect emissions reductions (avoided emissions)* including *energy efficiency projects, renewable energy projects, and nuclear energy projects*. (Offsets)

A,I A May 1, 2004 “Concept Memo” about the possibility of allocating allowances to consumers rather than producers, submitted by the Regulatory Assistance Project, a RGGI Resource Panel member, suggests that nuclear power plants could be explicitly excluded from provisions that otherwise apply to non-emitting power sources. The paper points out that *if decision makers in a state wanted to avoid conferring the market value of unneeded carbon credits to purchasers of the power from, say, nuclear plant uprates . . . the allocation rules could mathematically treat those MWh differently* and (pages later) *what about impacts on zero-emissions resources that raise other economic or environmental*

concerns (e. g., nuclear power and large-scale hydro)? . . . Should special rules be created to limit credit implicitly given to those resources, should individual states have the flexibility to make those adjustments, or should neither be permitted?

(Allocations, Incentives and wealth)

M A May 15 2004 paper on modeling prepared by the Staff Working Group mentions nuclear retirements: *Each stage may include multiple scenarios and sensitivity runs, for variables such as higher gas prices, higher demand growth, technology cost and performance, transmission changes, nuclear retirements, etc.* The paper also explains the difference between a new modeling scenario and a sensitivity run: *Changing . . . technology assumptions (e.g., making a new nuclear technology available to the market) will . . . be new scenarios.* (Modeling)

M A May 17, 2004 memo from Environmental Northeast, the Union of Concerned Scientists, the Natural Resources Defense Council, and the National Association of State PIRGs on modeling makes several recommendations. *Fuel costs and storage costs should be included and a forecast made about how these costs will change with time; take into account the delay in development of long term storage and the need for more on-site storage – we will be looking into this issue and commenting further . . . Nuclear uprate costs should be based upon peer reviewed literature, not industry trade rags and should account for the costs of licensing and litigation; NEMS has specific assumptions about uprates. . . . New nuclear facilities should not be included.* (Modeling)

I,A,O A May 18 2004 “platform for action” from a number of New York state environmental organizations, including the American Lung Association of New

York State, the New York Public Interest Group, and the Sierra Club – Atlantic Chapter takes the position that *New York should refrain from creating new subsidies for nuclear power or utilizing increases in nuclear output (uprates) as an emission-reduction strategy.* (Incentives and wealth, Allocations, Offsets)

A question posed to stakeholders by the Staff Working Group at the May 20, 2004 Stakeholders meeting elicited the following comment from one stakeholder who expressed general skepticism about aggressive caps: *The Northeast has more nuclear generation (as a percentage of total generation) than the rest of the country and eventually these plants will stop generating. Nuclear plant retirement should be factored in to setting the cap.*

At the same May 20 meeting one stakeholder responded to a question about flexibility mechanisms by recommending that RGGI *include non-emitting generation (nuclear and renewables) in cap.*

I At the June 24, 2004 Stakeholder meeting a representative from Resources For the Future, a Resource Panel member, presented previously published research showing that different allocation methods could differentially impact the value of companies that differ in their reliance on coal, gas, and “nuclear and renewables.” (Incentives and wealth)

A,I At the June 24 meeting, the representative from Resources For the Future responded to a question about impacts on fuel diversity. *A key point, however, is that renewables and nuclear (non-emitting generation) stand to gain in any of these allocation schemes because the program raises the costs of their rivals and raises their revenues by raising electricity price. They do not have to receive a*

share of the allocations of emission allowances to benefit from the program.

(Allocations, Incentives and wealth)

O At the June 25 Stakeholder Workshop on GHG Offsets, a representative of NESCAUM, a Resources Panel member, listed “GHG demo projects reviewed in 2000”, including a nuclear rerate and wind power marketing by Exelon corporation. (Offsets)

M An August 6, 2004 letter from the Nuclear Energy Institute: *We strongly suggest that the RGGI modeling team include the following two assumptions regarding nuclear energy in the reference case: (1) All nuclear plants that have not already received a 20 year license renewal of their original 40 year licenses will apply for and receive license renewal; (2) Potential uprates at existing nuclear facilities be included in the list of new capacity options from which the model selects, based on economics, when new generating capacity is needed. We also strongly recommend that RGGI model one future scenario to investigate the outcome if nuclear power plants do not renew their licenses.* (Modeling)

O,A,I A lengthy September 2004 paper on offsets by the National Association of State PIRGS, which was reviewed prior to publication by representative of Environment Northeast, the Natural Resources Defense Council, and the Conservation Law Foundation includes an extensive discussion of nuclear power. The paper argues against offsets in general but takes a more broad position against nuclear power, recommending that *nuclear power projects and other environmentally damaging technologies not be eligible for offsets or otherwise obtain a market advantage for being zero-emitting in any cap-and-trade system.*

The paper devotes several paragraphs to the possibility that an offset program could provide “support for environmentally destructive practices” and warns that *the prospect of nuclear projects qualifying for carbon offsets is sufficiently real that the international agreement governing climate change mitigation projects in developing countries states that industrialized countries should not use credits generated from nuclear power projects toward compliance with their own emission targets.* According to the paper, *nuclear power poses environmental, health, and safety risks that are unacceptable.* The paper also describes a recent decision by the state of New Hampshire to allocate NOx allowance to Seabrook nuclear power plant: *By allowing Seabrook to receive NOx allowances, New Hampshire has effectively used the cap and trade program to subsidize nuclear power. This action sets a dangerous precedent, both for future regulation of conventional pollutants and for the treatment of nuclear power should offsets be included in any Northeast power-sector carbon dioxide cap-and-trade program.* (Offsets, Allocations, Incentives and wealth)

I A September 2004 “Sustainable Economics Issue Brief” by Redefining Progress argues forcefully that, because different states vary greatly in the degree to which in-state generators emit carbon or rely on nuclear power, any system that imposes large costs on carbon emitters but not nuclear power plants is fundamentally unfair: *We believe that carbon-only systems create economically and politically unacceptable regional disparities and other perverse incentives . . . columns 4 and 6 show revenues from what we consider to be an more realistic permitting system. This system includes an equalizing charge on electricity from*

nuclear power and large hydropower equal to the average permitting fee on fossil fuel-generated electricity. The referenced endnote: For instance, a carbon-only permitting system creates an incentive to switch to nuclear power, an alternative favored by relatively few environmentalists because nuclear power plants pose their own environmental risks and costs. These risks and costs are difficult to compare to those posed by fossil plants. (Incentives and wealth)

M A presentation by a representative of NYSERDA about modeling at the September 13 Stakeholder meeting reviewed financial assumptions about new nuclear power plants for inclusion in models and proposed sensitivity runs to explore the effects of different assumptions about nuclear relicensing on modeling outcomes. A Stakeholder or Resource Panelist commented that *it is important to address the cost of increased pollution control. Nuclear re-licensing and updating assumptions will likely impact this.* The representative of NYSERDA later said that *only two sensitivity runs were done in CT: with and without nuclear relicensing and nuclear upgrading; the impacts of these assumptions were more significant than fuel prices and demand forecast variations.* In response to the same presentation, an observer from the Nuclear Energy Institute stated that *Companies consider the book life of new nuclear plants to be 40 years, not 30, as you have assumed. Companies will only do so many upgrades in a given year due to capital constraints, so you may want to spread out upgrades by company. Also, NEI will be happy to provide RGGI with data to do a re-licensing run. Understanding how re-licensing affects economics of cap and trade program is important, and we advise doing sensitivity assuming no re-licensing. (Modeling)*

A,I In an October 14, 2004 workshop on allowance allocations, a representative of American Electric Power asserted, in a slide presentation, that *to the extent that electric prices increase, CO2 program increases profits for deregulated nuclear, hydro, and new gas*. He went on to argue that allocations to past polluters would be most fair and *prevent non-emitting units from getting an even greater windfall (such as would occur through an “output-based allocation.”* (Allocations, Incentives and wealth)

I At the October 14 workshop, a representative from Resources For the Future, a Resource Panel member, presented previously published research showing changes in the *Net Present Value of Existing Generation Assets*. The research shows that the owners of existing nuclear plants would benefit from any allocation scheme under consideration. (Incentives and wealth)

A At the October 14 Workshop on allocations, a representative from the Regulatory Assistance Project asserted that there is *no need to allocate to nuclear and large-scale hydro facilities because: Why sweeten their enhanced value windfall? No increased compliance costs. . Heavily subsidized already. .No desire to promote more. . These resources raise other environmental concerns.* (Allocations)

A At the October 14 Allocation Workshop, a representative of PSEG showed graphs of PSEG’s generating capacity in the RGGI region. Nuclear power plants account for 23% of the company’s generating capacity but 58% of its 2003 output. The presentation argues strongly for annually updated, output-based

emissions allocations that would *Embrace total energy portfolio including renewables and nuclear*. (Allocations)

M A presentation given at the November 12 Stakeholder meeting by consultant working to create a model that can be used to forecast likely impacts of RGGI included detailed assumptions about both existing and new nuclear power plants, including cost projections, and listed 2013 as the earliest possible date by which a new nuclear power plant could come online. (Modeling)

O An overview of possible offsets that was provided by a member of the Staff Working Group at the November 12 meeting did not mention nuclear power. The following three comments were made by stakeholders or observers: *I'd like to see nuclear uprates treated as an offset because air quality and GHG benefits. Treat nuclear power" equivalently" to other non-emitting resources. Nuclear uprates don't pass the "additionality" criteria if so economic, so shouldn't be eligible for offsets*. (Offsets)

M At the November 12 meeting, representatives of ICF consulting responded to specific questions about the economic models that will be used to evaluate potential impacts of RGGI. They stated that *License renewal was treated as a specific cost, not automatically assumed, but all units with retrofit or uprate options were assumed to exercise them due to their relative low cost*. In response to a question about the sensitivity of results to changes in the price of natural gas, they stated: *Given that new coal is not allowed in RGGI, and using EIA numbers for nuclear, it's a gas future for RGGI region. It would take a significant change to change that*. [The United States Energy Information Administration, or EIA,

recently produced an estimate of the likely cost of new nuclear power plants.]

(Modeling)

At a November 30 workshop on electricity markets, a representative of ISO-NE suggested that RGGI could impact energy facility siting decisions. He suggested that states might *only permit non-CO2 emitting resources to satisfy load growth, including efficiency and conservation; wind solar, and renewable biomass; and nuclear.*

I,O

A February 2005 letter from seven regional Public Interest Research Groups, The National Association of State PIRGS, Clean Water Action, and three other local environmental groups states that, *should offsets eventually be included . . . Nuclear power projects and other environmentally damaging technologies not be eligible for offsets or otherwise obtain a market advantage for being zero emitting in any cap-and trade system.* (Incentives and wealth, Offsets)

At the February 16, 2005 stakeholder meeting, a paper about lessons from the NOx trading program by Resource Panel member World Resources Institute was presented. According to a slide about leakage of emissions into other regions, *fossil generation in the OTC [Ozone Transport Commission, which includes most RGGI states] region declined decreased 0.5%, while nuclear increased 5%.*

M

A presentation about modeling the likely economic impacts of RGGI, given by ICF consulting at the February 16 meeting, contains a slide titled *What is the expected regional generation mix (without RGGI)?* This slide shows a slight increase in the amount electricity generated by nuclear power plants between 2006 and 2024. Other slides make clear that this *reference case* assumes that no

plants will be decommissioned and some uprates will be completed. A companion document from the same source includes more details and states that *nuclear relicensing is likely to have an impact on the cost of CO2 policy compliance in the RGGI region and on electric prices*. One Stakeholder or Resource Panelists questioned the assumption that all plants would be relicensed and commented that *some plants in New Jersey may not be allowed to re-license*. In later discussions about modeling at the same meeting, the leader of the Staff Working Group mentioned nuclear up-rates in a list of new capacity coming on line in the first few years of the program and one attendee commented: *what I heard this morning is that the model is calling . . . the maximum amount of nukes and no new coal in the RGGI region. This assumes that there are nuclear uprates . . .* (Modeling)

- O** An overview of possible offsets that was provided by a member of the Staff Working Group at the February 16 meeting did not mention nuclear power. (Offsets)

A March 9, 2005 memo titled *Comments on RGGI Modeling Runs to Date* from stakeholders Environment Northeast, National Association of State PIRGs, Natural Resources Defense Council, Conservation Law Foundation, and others states observes that *New York's unusually high emissions in 1990 . . . were heavily influenced by temporary nuclear outages*.

- M** A March 31, 2005 letter from Dominion recommended that *RGGI perform a sensitivity run to evaluate the impact if nuclear power plants do not renew their licenses* and also argued that *RGGI should remove the restriction in its modeling on the expansion of coal-fired facilities in New England*.

A At the April 6, 2005 Stakeholders meeting, a representative of the Nuclear Energy Institute stated that NEI would *like to see at a minimum some recognition by policy makers of non-emitting generation in the past and future. Specifically we would like to see the benefits of nuclear generators explained* and, following the presentation of a paper from Resources for the Future which showed how different allocation methodologies could impact the value of existing nuclear units, commented that *the reference case assumes that all nuclear units re-license. A handful may not be re-licensed. 15 units in RGGI states, only 1 re-licensed, 4 pending, and they are on an economic bubble and may not be re-licensed because of other factors. Devaluing the assets further may ensure they are not re-licensed.*

M In April 22, 2005 letter, the Nuclear Energy Institute *strongly suggests that a sensitivity run of ICF's IPM model be performed to analyze the impact of nuclear plant license expiration on the region's ability to meet a CO2 cap. . . The only responsible course of action for the RGGI Staff Working Group is to quantify the role of nuclear power before recommending policy and asking policy makers to agree on an electric sector cap-and-trade system. . . Specifically, policy makers seeking to force CO2 reductions from the electric sector should support nuclear energy initiatives, such as license renewal and uprates, and explicitly recognize the strategic role of nuclear power in mitigating the region's greenhouse gas emissions.* A May 2005 paper completed for NEI and submitted to RGGI, titled *The Role of Nuclear Energy in Reducing CO2 Emissions in the Northeastern*

United States, concludes that nuclear power plants must keep producing electricity and new nuclear power plants can ease CO2 reductions.

A A May 2005 submission from the Northeast Regional Greenhouse Gas Coalition recommends *further discussion regarding the treatment of incremental non- and net zero- CO2 emitting EGUs within the RGGI program (i.e., nuclear, wind, and other renewables, etc.) . . . and of allocating to new non-emitting sources such as wind, hydro and nuclear.* At the May 19, 2005 Stakeholder meeting, the representative of this coalition asked, *Will the system hold together – i.e. if a large nuclear plant goes down, how will that effect the system?*

M A June 17, 2005 letter from the Edison Electric Institute, described in the letter as *the association of U.S. shareholder-owned electric companies, international affiliates and industries worldwide*, includes comments on a variety of modeling issues but does not mention nuclear power

Appendix C: Glossary of RGGI participants

This glossary deciphers acronyms and, in many cases, provides additional relevant information about RGGI participants such as stated positions on nuclear power, climate change, or the Regional Greenhouse Gas Initiative. Except as noted, all information comes from the home pages of the various organizations or from annual reports available for download. All words in italics are direct quotations from materials obtained from the organizations' web sites, although sentences and phrases that appear together in this glossary did not necessarily appear in exactly the same order in the sources material. All companies that operate nuclear plants in the eleven-state RGGI region are also included even if they do not participate; information about the location and ownership of nuclear power plants is easily accessible on the web sites of both the Nuclear Regulatory Commission and the Nuclear Energy Institute.

ACEEE (The American Council for an Energy-Efficient Economy) *is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection. Analytical projects are carried out by staff and selected energy efficiency experts from universities, national laboratories, and the private sector.*

AES *is a leading global power company that owns 114 power plants and 17 distribution businesses in 27 countries. The company seeks to grow its diversified portfolio by developing and constructing new power plants and through selective acquisitions. AES*

does not own any nuclear power plants and is very heavily invested in coal-fired generation.

The **Conservation Law Foundation** (CLF's) *advocates use law, economics, and science to create innovative strategies to conserve natural resources, protect public health, and promote vital communities in New England.* The group recently produced a paper on potential effects of climate change titled *Heritage in Peril: New England and Global Warming*. According to a section of the group's 2001 newsletter titled *Nuclear Power: No Solution to Climate a Change*, *CLF is taking steps to ensure that deregulation forces all five of New England's nuclear plants to close.*

Constellation *is the nation's leading competitive supplier of electricity to large commercial and industrial customers.* The company is *one of the largest wholesale power sellers in the country*, and owns *a diversified fleet of power plants throughout the United States.* The company owns and operates two reactors (Calvert Cliffs 1 and 2) at a single sight in Maryland and three (Ginna, Nine Mile Point 1 and 2) at two sites in New York. These are Constellation's only nuclear power plants.

Dominion *is one of the nation's leading energy companies.* The company owns power plants, oil and gas reserves, and natural gas pipeline and storage systems. The company owns and operates two power reactors (Millstone 2 and 3) at a single site in Connecticut and four others located outside the eleven-state RGGI region.

EDF (Environmental Defense) *finds ways to help the environment that actually benefit the economy, such as using market incentives to achieve the greatest pollution reductions at the least cost. Focusing on the most serious environmental problems, it employs more Ph. D. scientists and economists in environmental advocacy than any similar group.* EDF has 400,000 members and 260 full-time employees.

Entergy is the second largest producer of electricity from nuclear power plants in the United States and also owns a large fleet of natural gas-fired power plants. The company owns and operates three power reactors (Indian Point 2 and 3, Fitzpatrick) at two sites in New York, one (Pilgrim 1) in Massachusetts, and one (Vermont Yankee) in Vermont. Entergy also owns five other power reactors in other US states.

Environment Northeast *addresses large-scale environmental problems that threaten regional ecosystems, human health or the management of regionally significant natural resources, primarily in a bioregional ecosystem including New England and eastern Canada. The group addresses these problems through policy analysis; collaborative problem solving efforts; and an advocacy program that promotes environmental sustainability.*

Exelon is the largest producer of electricity from nuclear power plants in the United States and operates five power reactors (Three Mile Island 1, Limerick 1 and 2, Peach

Bottom 1 and 2) at three sights in PA and one (Oyster Creek) in New Jersey, but does not officially participate in the RGGI process. Exelon is the only company that owns a nuclear power plant within the nine-state RGGI region that has not attended any of the stakeholder meetings, even as an observer. The company also owns eleven additional power reactors located in other US states.

FirstEnergy owns and operates two power reactors (Beaver Valley 1 and 2) at a single sight in Pennsylvania, but does not officially participate in the RGGI process. The company also owns another power reactor in Ohio.

FPL owns (88%) and operates one power reactor (Seabrook 1) in New Hampshire, but does not formally participate in the RGGI process. A representative of FPL has observed two RGGI stakeholder meetings. The company owns four power reactors located in other US states.

International Paper produces paper products and is *one of the world's largest private landowners*. The company's 2003 annual report does not allude to the possibility that forests may play a role in efforts to mitigate climate change, either as carbon sinks or as a fuel source.

ISO-NE (Independent System Operator – New England) *is the not-for-profit corporation responsible for the day-to-day reliable operation of New England's bulk power generation and transmission system.*

Keyspan is the *largest distributor of natural gas in the Northeast and the largest electric generator in New York State.* The company does not own nuclear power plants and the 2003 annual report makes no reference to climate change.

The **Maine Public Advocate** represents the interest of ratepayers within the jurisdiction of the Maine Public Utilities Commission. These interests include low rates and quality service.

The **National Energy and Gas Transmission Group** owns several non-nuclear power plants in the RGGI region. The company recently emerged from bankruptcy protection and expects to cease operations in 2005 after selling all of its assets.

National Grid Triasco *is one of the world's largest utilities, focused on delivering energy safely, reliably, and efficiently.* NGRID distributes *electricity in the northeastern US to approximately 3.3 million customers and gas in upstate New York to around 560,000 customers, and has a number of businesses operating in related areas.*

Natsource provides three types of services: *strategic advisory, brokerage, and asset management. Natsource Strategic Services Unit possesses significant climate policy expertise in the public and private sectors, and Natsource staff have written extensively on the greenhouse gas market, the impacts of trading system design on environmental and economic results and the role of technology in addressing climate change. Natsource has brokered emissions transactions of greenhouse gas emissions, sulfur dioxide, oxides of nitrogen, and renewable energy certificates with a net market value of over \$5,000,000,000. Natsource Asset Management Corp. is organizing the Greenhouse Gas-Credit Aggregation Pool for a group of buyers.*

The **Natural Resource Defense Council** *uses law, science, and the support of more than 1 million members and online activists to protect the planet's wildlife and wild places and the ensure a safe and healthy environment for all living things.*

The NE Council (New England Council) *is proud to be the voice of the larger business community as a stakeholder in the Regional Greenhouse Gas Initiative. Scientific evidence points toward the conclusion that greenhouse gas emissions should be avoided, reduced, or sequestered. The group advocates a geographically and technologically broad-based emissions reduction strategy.*

NESCAUM is the Northeast States for Coordinated Air Use Management, an association of air quality control divisions in the Northeast States. Member states include all nine

RGGI participants except Delaware. NESCAUM's purpose is to exchange technical information, and to promote cooperation and coordination of technical and policy issues regarding air quality control among the member states. NESCAUM is working to create the Regional Greenhouse Gas Registry, which will support RGGI.

The **Northeast Greenhouse Coalition** *participates in the development of regional climate change policies in the United States to develop a model for national action, promote coordination and standardization to maximize cost-effectiveness, and build linkages and reciprocity with international climate change programs especially the European Union's Emission Trading Scheme.* Members include BP America, Calpine Corporation, Consolidated Edison, Northeast Utilities, National Energy and Gas Transmission, Pfizer, Public Service Enterprise Group, United Technologies Corporation, and Waste Management. The group's position statement advocates a broad and transparent program.

Northeast Utilities (NU) is a *diversified energy company located in Connecticut with operations throughout the Northeast.* The company operations range from *delivering electricity and natural gas, to marketing energy commodities, to operating and maintaining power plant facilities.* NU sold interest in several nuclear plants during 2003 and no longer owns any operational nuclear generating capacity. The company's 2003 annual report does not reference climate change.

The **NY Coalition** is the New York Energy and Business Coalition, which includes the Business Council of New York State, the Energy Association of New York State, the Environmental Energy Alliance of New York, the Independent Power Producers of New York, the International Brotherhood of Electrical Workers, and the Utility Workers of America. Keyspan, National Grid, and Entergy are members of the Energy Association. The *Basic Position* of the Coalition is that the program must be adaptable, *must not jeopardize jobs or the economy*, the program should not *put the state at a competitive disadvantage*, and that power plants should *get full credit for emissions reductions since 1990*.

NYISO's (The New York Independent System Operator) *mission is to ensure the reliable, safe, and efficient operation of the State's major transmission system and to administer and open, competitive, and nondiscriminatory wholesale market for electricity in New York State*.

The **Pace Law Center** for Environmental Legal Studies operates the Energy Project, which uses *research, education and advocacy to promote sustainable energy as a means of reducing the global burden of pollution from electrical energy production*.

The **Pennsylvania Consumer Advocate** *represents consumers when a utility company asks the PUC to raise customers' rates. The OCA tries to keep rate increases to only what the utility needs to provide safe and adequate service to customers*.

The **Pew Center on Global Climate Change** brings together business leaders, policy makers, scientists, and other experts to a complex and often controversial issue. The Center is producing first-rate analysis of key climate issues, working to keep policy makers informed, engaging the business community in the search for solutions, and reaching out to educate key audiences.

PIRG is the National Association of State Public Interest Research Groups, which helps the state PIRGs to *uncover threats to public health and well-being and fight to end them, using the time-tested tools of investigative research, media exposes, grassroots organizing, advocacy, and litigation.* Several state PIRGs in the RGGI region have formed the New England Climate Coalition to urge states to take action on climate change and *reject nuclear power and its radioactive pollution.*

PJM Interconnection ensures the reliability of the largest centrally dispatched control area in North America by coordinating the movement of electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia. PJM operates the largest competitive wholesale electricity market in the world, manages a sophisticated regional planning process for generation and transmission expansion to assure future electric reliability, and facilitates a collaborative stakeholder process.

PPL owns (90%) and operates two power reactors (Susquehanna 1 and 2) at a single sight in Pennsylvania, but does not officially participate in the RGGI process. A representative of PPL attended one RGGI stakeholder meeting as an observer.

PSEG maintains *one of the largest generation fleets in the Northeast, including a large base of low-cost nuclear and fossil generating stations.* Three of the company's nuclear units, located in New Jersey and Pennsylvania, *accounted for 57 percent of PSEG Power's electric generation in 2003 – producing an abundant amount of emissions-free electricity for the public.* *During the past five years, PSEG has reduced the rate of carbon dioxide emissions from its operations worldwide by about a third.* PSEG owns and operates one power reactor (Hope Creek 1) in New Jersey and two (Salem 1 and 2) at a single site in Delaware.

RAP (The Regulatory Assistance Project) *is a non-profit organization, formed in 1992 by experienced utility regulators, that provides research, analysis, and educational assistance to public officials on electric utility regulation. RAP is committed to fostering regulatory and market policies for the electric industry that encourage economic efficiency, protect environmental quality, assure system reliability, and allocate system benefits fairly to all customers.*

RFF is Resources for the Future. *As the premier independent institute dedicated exclusively to analyzing environmental, energy, and natural resource topics, RFF gathers*

under one roof a unique community of scholars conducting impartial research to enable policymakers to make sound choices.

UCS (The Union of Concerned Scientists) *is a non-profit partnership of scientists and citizens combining rigorous scientific analysis, innovative policy development, and effective citizen advocacy to achieve practical environmental solutions. UCS strives for a future that is free from the threats of global warming and nuclear war, and seeks a great change in humanity's stewardship of the earth.* Although not explicitly opposed to the use of nuclear power, the group advocates forcefully for improved safety at existing nuclear plants and *when Massachusetts policy makers indicated an interest in allowing power plants to offset some of their carbon dioxide emissions, UCS helped prevent investments in nuclear power from becoming an option for offsetting heat-trapping emissions.* UCS has 62,000 members and an annual budget of approximately nine million dollars.

United Technologies Corporation *is a global provider of high technology products and services to the building systems and aerospace industries.* The company's 2003 annual report does not mention nuclear power or climate change.

The **World Resources Institute** *provides the scientific and analytical underpinning so necessary to move people and their institutions, both public and private, to the difficult decisions that lead to change.* One of five stated goals is to *protect the global climate*

system from further harm due to emissions of greenhouse gases and help humanity and the natural world adapt to unavoidable climate change. And they know that harnessing the power of markets will ensure real, not cosmetic change.

Appendix D: Interview Questions

The following instrument was used to conduct interviews. All interviews began with exactly the same hypothetical question. Other questions were used as needed to ensure that important topics were covered in all interviews and were usually not asked in exactly the same words that appear below.

As you know, I'd like to talk to you about nuclear power and climate change. I am interested in both the general debate and specific aspects of the RGGI process. First I'll be asking about your own personal opinions, and then I'll ask about the organization that you represent in the RGGI negotiations. I'll begin with a broad, hypothetical question.

Picture a future, perhaps only a few years away, in which the Regional Greenhouse Gas Initiative's model rule has been successfully implemented in all participating states. Power plant emissions are falling as market forces select efficient solutions. The regional economy becomes more energy-efficient and the use of renewable energy increases markedly. And a large energy company proposes the construction of a new nuclear power plant in the region, asserting that the new reactor will help to facilitate even greater reductions in carbon pollution. Thinking of yourself, as a private citizen, how would you react to such a proposal? Why?

Additional questions for people that react positively (if needed):

- *Is that just because of climate change, or have you always supported the use of nuclear power? Has your opinion about nuclear power changed over time? Can you be specific? How? When? Why?*
- *Are you, personally, very concerned about climate change? Very briefly, what do you think should be done? Should we try to significantly decrease the use of coal for electrical generation? Soon?*
- *Do you believe that nuclear power plants are safe? What about the waste?*
- *Do you expect that the next generation of nuclear plants will be essentially similar to the current fleet, like those that are being built in Finland and Japan, or do you expect them to be entirely different, like, for example, the so-called pebble bed reactor? Do you see any of the designs currently under development as potentially significant improvements? What aspects impress you?*
- *Are you generally optimistic about renewable energy? Why? Which technologies seem the most promising to you?*
- *Do you, personally, favor policies that provide explicit financial benefits for nuclear power, such as the allocation of carbon allowances to the owners of nuclear power plants? Do you feel strongly about this? Why? What would be the purpose of allocating allowances to nuclear plants? What about production tax credits and other subsidies?*
- *Have you been generally satisfied with quality and quantity of the discussion about nuclear power within the RGGI Stakeholders group? What about the Resource*

Panel and Staff Working Group? Can you describe any specific discussions about nuclear power that you are thinking about?

- *Do you think that the RGGI process has influenced the way more skeptical participants think about nuclear power? Can you describe a specific example?*

Additional questions for people that react negatively (if needed):

- *Are there any circumstances under which you, personally, would consider accepting the construction of new nuclear power plants? Even if climate change continues to worsen? Has your opinion about nuclear power changed over time? Can you be specific? How? When? Why?*
- *Are you, personally, very concerned about climate change? Very briefly, what do you think should be done? Should we try to significantly decrease the use of coal for electrical generation? Soon?*
- *Why, exactly, do you oppose the increased use of nuclear power? Are nuclear power plants unsafe in your opinion? Are you concerned about waste?*
- *Do you, personally, think that the nuclear plants we have should be shut down? What about applications to extend licenses and increase production through uprates? Should they be granted? Why?*
- *What about some of the new designs that have been proposed? Do you believe that they might be more promising in terms of safety or waste?*
- *Do you, personally, think that the problem of carbon emissions can be addressed adequately without nuclear power? How? Are you generally optimistic about renewable energy? Why? Which technologies seem the most promising to you?*

- *Do you, personally, favor policies that explicitly exclude nuclear plants from economic advantages that might otherwise be available to non-emitting energy sources? How could this be accomplished?*
- *Have you been generally satisfied with quality and quantity of the discussion about nuclear power within the RGGI Stakeholders group? What about the Resource Panel and Staff Working Group? Can you describe any specific examples of specific discussions about nuclear power that you are thinking about?*
- *Has your participation in RGGI influenced the way you think about nuclear power? Can you be specific? Were any particular presentations or discussions influential?*
- *Do you think that the RGGI process has influenced the way others think about nuclear power? Can you describe a specific example?*

Additional questions for people that seem neutral or undecided (if needed):

- *Have you always been fairly neutral about nuclear power? Did you have an opinion when they were building the current generation of nuclear plants, like Seabrook? What has changed? Is there anything that might push you one way or the other in the future? Worsening climate change? A serious accident at a nuclear plant? New plant designs?*
- *Are you, personally, very concerned about climate change? Very briefly, what do you think should be done? Should we try to significantly decrease the use of coal for electrical generation? Soon?*

- *Has your participation in RGGI had any impact on your thinking about nuclear power?*
- *Do you, personally, have opinions about questions that are currently being considered by regulators? For example, should applications for uprates and license renewals be approved? What are the implications for regional carbon emissions? How should RGGI deal with nuclear plants? Should they receive allowances? Why? What about renewables like wind power?*
- *Are you concerned that RGGI's long term goals for carbon emissions reductions may be nearly impossible to meet without new nuclear power plants, given political and economic constraints?*
- *Are you generally optimistic about renewable energy? Why? Which technologies seem the most promising to you?*
- *Are you generally satisfied with the quality and quantity of the debate about this issue within the RGGI Stakeholders group? What about the Resource Panel and Staff Working Group? Can you give any specific examples?*
- *Do you think that the RGGI process has influenced the way other participants think about nuclear power? Are you sure about this? Can you provide examples or evidence?*

Additional questions for people that don't seem to buy the premise (if needed):

- *Let me try to be more specific about what I'm getting at. In the RGGI region, The Cape Wind developers want to do this huge construction project out in the ocean. Surely environmental groups are on board because there is a need for clean*

energy, not because they don't mind offshore construction. Nuclear power is relatively clean when you look at it from the air pollution standpoint, like wind power. My point is that RGGI could lead to more proposals for more power plants that don't emit carbon dioxide, maybe including nuclear plants. Don't you think so? Why not?

Additional question for state regulators only:

- *Have you taken any specific positions related to nuclear power on behalf of your organization in the RGGI negotiations? Which issues and why? How did you arrive at these positions?*
- *Has there been much discussion about nuclear power recently in your organization? Why? Would you be willing to describe some of these discussions? What issues come up? Have any particular events lead to discussions or meetings about nuclear power within your organization in the last few years? Have there been any differences of opinion over this issue? To what extent have these discussions been driven by concern about climate change?*

For people that do not want to talk about themselves (if needed):

OK, then lets go ahead and talk about the organization that you represent in the RGGI process.

For all participants:

So, just to be clear, is it fair to say that you, personally, would probably favor/be-willing-

to-accept/oppose a proposal to build a new nuclear plant in the RGGI region?

Now, what about the organization that you represent in the RGGI negotiations? Would they also favor/accept/oppose such a proposal to build a new nuclear plant in the RGGI region? Does your organization's position reflect the opinions that you've already expressed? Are you sure? How do you know? Have there been formal meetings or informal discussions? Are there any specific points on which you disagree with the positions taken by your organization?

For environmental and other non-profit organizations, including consulting experts (if needed):

- *Has there been much discussion about nuclear power recently in your organization? Why? Would you be willing to describe some of these discussions? What issues come up? What about climate change? Have any particular events lead to discussions or meetings about nuclear power within your organization? Have there been any differences of opinion over this issue? Are there questions about nuclear power that remain unresolved within your organization? How will they be resolved?*
- *I've noticed that the nuclear companies are quite well represented in the Stakeholders group. Do you see this as a problem, or as helpful? Can you give any examples of the role that these companies have played in the RGGI process?*
- *How was the Stakeholders group chosen? Was your organization generally pleased to be able to participate? Is RGGI a high priority for your organization?*

Have you and other staff members been able to devote sufficient time to RGGI in general? What about the nuclear power question?

For companies (if needed):

- *I've noticed that companies that own nuclear power plants are quite well represented in the Stakeholders group. Has this been a problem or has it been helpful? Was your company generally pleased to be able to participate? Did anybody suggest that you should choose not to participate? Why?*
- *Is there much discussion about climate change policy within your company? Can you describe any specific examples? Is RGGI considered to be significant? Why?*
- *Have you taken specific positions about, for example, the allocation of allowances to nuclear plants on behalf of your company? Is there a formal process by which such positions are adopted? Can you describe this process and how it worked in this case?*
- *To what extent is the possible implementation of regulatory schemes like RGGI influencing investment decisions in your company? Are you looking at new nuclear technologies? What about other low-emissions technologies such as renewables, geologic sequestration, or liquefied natural gas?*
- *What do you think are the biggest challenges for the nuclear industry if it hopes to expand? Safety? Waste Disposal? Are new reactors just too expensive? Do people in your company think that these challenges can be met?*

For companies that own nuclear plants (if needed):

- *Has your company applied for any uprates or license extensions? Are these at all dependent on RGGI or similar regulations for economic viability?*
- *Is your company hoping to build new nuclear plants sometime, or are you pretty much focused on getting the most out of the plants that you already have?*

For all participants

There is one other thing that I would like to know. Do you, personally, expect that new nuclear power plants will be built in the RGGI region in the next few decades? Why? Can you foresee any events that might change this outlook? Would these events change people's opinions, or just affect the political and economic balance? What about outside the RGGI region? Why?

Thank you, that's all the questions that I have. Would you like to make any additional comments?

Appendix E: A Short Technical Introduction to Nuclear Power

Nuclear Reactors and Nuclear Power Plants

It was discovered early in this century that large atomic nuclei occasionally decay, or break apart, spontaneously, and, within a few decades, it had been shown that nuclei of the isotope Uranium-235 can be caused to break apart, or be fissioned, into two smaller nuclei by bombardment with neutrons. The total mass of the pieces into which a uranium nucleus is broken when it is fissioned is less than the mass of the original nucleus, with the missing mass being converted into thermal energy according to the equation $E=mc^2$. Significantly, the fission reaction can be sustained as a chain reaction because neutrons are created that can fission other Uranium-235 atoms. If a sufficiently pure and large sample of Uranium-235 is rapidly assembled, the reaction will be very fast and an explosion will occur, but in a nuclear power plant, the less-than-five-percent Uranium-235 mixture is not even close to sufficient purity to cause an explosion. However, when it is carefully configured with other materials to create a nuclear reactor, it gives off large amounts of heat, and when the heat that is produced drives a steam turbine that is connected to generator, the entire arrangement is called a nuclear power plant.

There are at least two major problems, or challenges, associated with the design and operation of nuclear power plants. Most fundamental is the fact that many of the nuclei into which Uranium-235 is fissioned are very radioactive, so the solid rods that contain this fuel become gradually more dangerous to handle and store as the reactor operates. Plans must be made to carefully isolate these spent fuel rods from people and

the environment for many thousands of years until they become less radioactive.

Containment is made more difficult by the fact that, although no nuclear explosion is possible, the fission products present in an operating reactor core have the potential to give off enough heat to melt the fuel and possibly the structures that are designed to contain the fuel, facilitating release of dangerously radioactive fission products into the environment. Whether these challenges can be met satisfactorily is the subject of ongoing debate.

Estimating the risk of nuclear accidents

There is no dispute about the following facts: The operation of nuclear power plants creates new radioactive atoms in significant quantities, including new elements, like plutonium, that do not exist naturally on Earth. These radioactive atoms decay over periods of time that range from many thousands of years to tiny fractions of a second, and when they decay they give off radiation. Radiation, in amounts much smaller than those potentially released by the spent fuel produced by nuclear power plants, causes cancer through well-studied cellular mechanisms (Samet and others 1994). The problem, then, for users of nuclear power is to keep radioactive material isolated, both while it is housed at the reactor site and for the indefinite future.

This isolation continues to be accomplished successfully at nuclear power reactors in the United States and a variety of comprehensive plans for safe storage far into the future exist (Deutch *et al.* 2003). But the long time scales, large number of sites, and necessity of transportation make it likely that accidental releases of radiation will occur. Although it is possible to estimate the likelihood of these events from entirely technical

considerations using a process called probabilistic risk assessment, such projections are somewhat limited by the fact that they are derived by aggregating assessments about individual components, and both the individual assessments and the aggregation methods are quite uncertain and accessible to only a small number of experts. By analogy, it may be that, if you wanted to know if a pothole is likely to form in the street in front of your house, you could assemble a group of experts in areas including meteorology, materials science, hydrology, traffic patterns, and other disciplines to examine the physical and known performance characteristics of the asphalt and develop a defensible estimate of the probability that a pothole will form this winter. However, you might be more convinced by someone from the city department of road repair who looked at the question more like an epidemiologist and made a prediction based on the performance of other sections of asphalt with similar characteristics.

This observation suggests another, experience-based, approach to the consideration of safety and the storage of used. Experience with commercial nuclear power reactors in the United States includes about 2700 reactor years of operation and on-site waste storage and one major accident, (Deutch *et al.* 2003) albeit one that did not release a significant amount of radioactivity and for which no consistent evidence of resulting increased mortality exists (Kammen and Hassenzahl 1999; Talbot and others 2003). Dividing one accident by 2700 reactor years and multiplying by the 80-year lifetime of the average American yields a risk of 0.030 that a life lived near an American nuclear power plant will include an accident of the type that occurred at Three Mile Island. Inclusion of Chernobyl in this estimate would yield a different worldwide average risk, but that reactor lacked a containment building such as the one that limited damage at

Three Mile Island, among other important safety features, and its performance may therefore not be relevant (Garwin and Charpak 2002). In other words, to continue the analogy with epidemiological methods, some might argue that it is misleading to exclude the most sensitive reactor species from analysis while others would argue that because we have a large sample of similar reactors, we should exclude those that are different in obviously relevant ways. Current estimates obtained through probabilistic risk assessment estimate a frequency of core damage of one in 10,000 reactor years, and this is not inconsistent with the results derived above (Deutch *et al.* 2003). The vastly different health outcomes resulting from Chernobyl and Three Mile Island illustrate another limitation of this method of analysis: assigning health outcomes to particular core damage scenarios adds an even greater level of complexity and associated uncertainty.

Despite these limitations, one important point for the present discussion is that the continued safe operation of nuclear power plants lowers at least one type of estimate of the probability of one of the more feared types of nuclear accidents. Over the last two decades, research about global warming has greatly increased the degree to which producing electricity through the combustion of fossil fuels such as coal is known to entail serious risk, while experience with nuclear power has decreased the frequency with which we may expect nuclear accidents to occur in the future. This experience is one reason that it is appropriate to continually revisit previous conclusions that nuclear power poses risks that make it unacceptable as an alternative to fossil fuel combustion.

Nuclear power and nuclear weapons

While connections between the civilian nuclear power industry and nuclear weapons can be seen through economic, political, social, and environmental lenses, this short introduction will be limited to two narrow technical considerations. The first relates to fuel enrichment: The process by which the concentration of fissionable uranium-235 is slightly increased from the naturally-occurring level to produce reactor fuel can readily be adapted to produce material that can be made used to make nuclear bombs. The second relates to the so-called back end of the fuel cycle: plutonium, which can also be used to build nuclear bombs, is created in fuel rods in operating reactors and can be extracted and purified. These two considerations, enrichment and plutonium production, underlie concerns about nuclear activities in Iran and North Korea, respectively. While some people believe these considerations should strongly influence decisions about nuclear fuel cycles in the United States, for others they are almost completely irrelevant (Levanthal and others 2002).

Radiation and Cancer

Although it is possible for nuclear accidents to result in radiation exposures that lead to acute health endpoints, there is good reason to believe that the vast majority of the risk posed by nuclear power is associated with increased cancer incidence resulting from exposure to relatively low doses of radiation. The low doses discussed in this section are defined by two characteristics: Predicted effects are likely to be difficult or impossible to detect epidemiologically, and doses are typically lower than those arising from exposure to natural radiation sources. Even in the case of Chernobyl, all but a few hundred of the

thousands of deaths expected to result will constitute statistically insignificant additions to background cancer mortality rates (Garwin and Charpak 2002). Therefore, estimates of the expected disease responses to exposures resulting from nuclear fuel cycle accidents depend sensitively on interpretations of existing evidence of dose response relationships. And these interpretations do vary somewhat.

One widely used measure of the degree to which low doses of radiation cause cancer is the one adopted by the International Commission on Radiological Protection, which estimates that exposure to radiation causes additional cancer fatalities at a rate of 4×10^{-4} per rem of exposure (Cottingham and Greenwood 2001). The assumption that the relationship between dose and response is linear at low doses is based on two distinct lines of reasoning. The first is that, because data for high dose exposures that have happened in some mines and near the sites of atomic bomb explosions in Japan indicate a linear relationship between dose and response, it is reasonable to assume, in the absence of evidence to the contrary, that this relationship holds true at dose levels similar to those to which all humans are constantly and unavoidably exposed (GAO 2000). The second is that, because cancer originates in genetic mutations within cells and it is known that individual radiation tracks can cause such mutations, it is likely that a doubling of the number of additional radiation tracks will double the number of additional mutations and therefore the number of additional cancer cases expected (Garwin and Charpak 2002). Other reasons to accept this linear no threshold model as a basis for radiation regulation include the fact that it is widely used for other carcinogens and the fact that it is the mathematically simplest plausible model that does not conflict with available data.

However, the lack of definitive low dose data has led some to question the wide use of the linear no threshold model as a basis for regulation. A recent report by the General Accounting Office states explicitly that “U.S. regulatory standards to protect the public from the potential health risks of nuclear radiation lack a conclusively verified scientific basis, according to a consensus of recognized scientists” and illustrates three possible dose-response curves in addition to the widely used linear no threshold model (GAO 2000). In a scientifically and politically illustrative example, the Nuclear Energy Institute asserted, in support of efforts to encourage the allocation of NO_x allowances to Seabrook nuclear power plant, that “decades of scientific study shows that there are no negative effects on humans exposed to less than 10,000 millirems of radiation,” but added a qualifier as a footnote: “The mainstream scientific community has amassed decades of research on the health effects of radiation exposure, which support the conclusion that there are no discernable health effects from exposures below 10,000 millirems.” The problem is that, because of high background rates of cancer, significant effects may not be clearly discernable by epidemiological means. But the most recent comprehensive study of the issue by the National Academies of Science, released in draft form in the summer of 2005, concluded that “the current scientific evidence is consistent with the hypothesis that there is a linear, no-threshold dose-response relationship between exposure to ionizing radiation and the development of cancer in humans” (National Research Council 2005).

Two well known past nuclear accidents are particularly instructive cases for understanding this controversy. Estimates of the number of deaths caused by the accident at Chernobyl range from a few dozen to nearly a half million and debate over efforts to

detect statistically significant increases in cancer incidence continues in the area surrounding Three Mile Island (Garwin and Charpak 2002; Talbot and others 2003). Although in both cases the total amount of radiation that was released is not under active dispute, uncertainty about the geographic distribution of the radiation (Wing and others 1997) and the degree to which cancer would have occurred without the radiation drive disagreement (Gofman 1990). Given the standard expected low-dose response, Chernobyl is thought to have caused a few tens of thousands of deaths (Garwin and Charpak 2002) and Three Mile Island possibly zero (Kammen and Hassenzahl 1999). However, one recent analysis of the geographic distribution of cancer deaths in the area surrounding Three Mile Island has revealed a statistically significant correlation between relative radiation dose and the incidence of several types of cancer (Wing and others 1997), and one thorough re-analysis of the way in which data from Japan should be applied to populations with different background cancer rates yields a dose response curve that would assign several hundred thousand deaths to the Chernobyl accident (Gofman 1990). There is also recent evidence of a surprisingly large increase in the rate of curable thyroid cancer among children who were not given iodine tablets to prevent the accumulation of radioactive iodine in the thyroid as was recommended after the Chernobyl accident (Stone 2001). These controversies imply that regulation of future nuclear power plants will involve conflict over expected impacts and illustrate the potential for further study of the impacts of Chernobyl and Three Mile Island to yield useful data.

Another qualitatively interesting aspect of radiation risk is the existence and nature of exposure pathways other than those associated with the nuclear fuel cycle.

These exposures are both natural and human-made. Humans are exposed to annual doses of at least 25 millirem of radiation each year from outer space, about 17 millirem originates from radioactive decay occurring within the human body, and 30 millirem or several times more is received from the ground below (Cottingham and Greenwood 2001). And radon is thought to add a dose that averages about 100 millirem per year, although this number can be much lower or higher depending on both indoor and outdoor concentrations. Also, modern medical technology routinely exposes patients to doses in this range. The average annual radiation dose due to diagnostic procedures such as x-rays and CAT scans averages about 100 millirem in the United States, and radioactive implants used to treat prostate cancer can deliver doses in the range of one million millirem per week within the body (Garwin and Charpak 2002). Nuclear Regulatory Commission regulations impose annual limits for maximally exposed members of the public between 25 millirem and 100 millirem, and regulations under consideration for the proposed waste storage site at Yucca Mountain would limit exposures through drinking water contamination to 4 millirem per year (GAO 2000). EPA guidelines for indoor Radon exposure characterize reduction of the lifetime lung cancer risk for non-smokers below 0.001, which corresponds to an annual exposure of about 30 millirem, as “difficult” and do not recommend further remediation (EPA 2003). These examples are intended to illustrate the fact that, in the case of radiation and in contrast to most other regulated carcinogens, anticipated exposure levels due to regulated activities are comparable to, and often substantially lower than, those that accumulate naturally on earth.

The variability and ubiquity of natural radiation imply that, if small additional doses of radiation cause increased cancer incidence, it may be possible to quantify the relationship using ecological studies that look for correlations of increased cancer rates with high natural background rates. Similar efforts with air pollutants have occasionally been successful even though the fact that exposures are anthropogenic should make the elimination of confounding factors more difficult than for natural radiation. Efforts to link pollution with disease are complicated by the fact that exposure levels often correlate with variables, like population density and the degree of industrialization, that often themselves correlate with health endpoints of interest. Such confounding is somewhat less likely in the case of the natural radiation background, which is less inherently correlated with human activity and can be as much as several times the average value (Steck and others 1999; GAO 2000; Wang and others 2002). The results of such studies have provided some support for the continued use of the linear no threshold assumption but have not been decisive (Lubin and Boice 1997; Wang and others 2002). Although they have helped to more firmly establish an upper bound on the dose-response relationship, some argue that the failure to conclusively establish the existence of any low dose response makes the linear no threshold theory unscientific (Jaworowski 1999) while others point out that the possibility of responses substantially in excess of those predicted by the International Commission on Radiological Protection coefficient is also not definitively contradicted by available epidemiological evidence (Gofman 1990; Garwin and Charpak 2002). In this sense, of course, radiation toxicology is not unusual but instead reflects a broader controversy about regulation under uncertainty.

One aspect of the controversy over plans to store used nuclear fuel under Yucca Mountain in Nevada illustrates some important points about the interaction between science, regulation, and risk perception. The Nuclear Regulatory Commission has proposed an all-pathway exposure limit for the maximally exposed individual of 25 millirem per year while the Environmental Protection Agency prefers 15 millirem (GAO 2000; EPA 2001). This 10 millirem per year difference corresponds, using the standard rate of 4×10^{-7} cancers per millirem multiplied by 10 millirem times an 80 year human lifetime, to an increased individual lifetime risk of 3 in 10,000 for a maximally exposed individual. Some argue that this number is just as likely equal to zero (ANS 2001) while others argue that it is as much as 10 times larger (Gofman 1990). Regardless of the expected response, this increase in annual dose to the maximally exposed individual, and therefore risk of radiation induced cancer, is substantially less than that which would result from moving from Rhode Island to Denver, where there is less atmosphere to protect residents from cosmic rays. The costs associated with meeting the stricter standards throughout the one hundred centuries over which EPA regulations are intended to apply are substantial and could therefore impact the overall costs of nuclear power generation, making it a less economically competitive alternative to fossil fuels than it would otherwise be (GAO 2000). Radiation standards clearly also differ in the degree to which technology can maximize the possibility that they will met successfully. This will be especially true, for example, for standards relating to the transportation of nuclear waste.

These examples begin to suggest the complexity with which science and policy interact. Does migration to Denver imply that people are willing to accept sufficiently

small increases in radiation-induced cancer? How do we deal with the fact that the population that will be exposed to radiation near, for example, Yucca Mountain, includes mostly people that have not yet been born? Should we be concerned that overly strict radiation standards could lead to the abandonment of nuclear power for economic reasons, leaving us with a corresponding increase in greenhouse gases? These questions do not have definitive answers, but they are central, if often unstated, aspects of most controversies about the use of nuclear power.

Appendix F: Non-nuclear Energy Alternatives

Coal

Coal is domestically abundant, is likely to remain so for several centuries, and can be mined cheaply. In the US, coal is used almost exclusively as a fuel for electricity production. In coal-fired power plants, the heat released when the coal is burned is used to turn water into steam. The fact that this vaporization process can exert forces on objects that interfere with the associated expansion is well illustrated by the banging sound that one hears when the lid covering a pot of water is repeatedly lifted by the escaping steam; early steam engines included, essentially, a pot (or cylinder) with a lid (the piston) that was mounted to slide up and down within the pot and connected, with a shaft, to a wheel or other moveable part. Modern steam turbines, which are used in both coal-fired power plants and nuclear power plants, are similar, except that the expanding steam pushes on a moveable blade (the turbine) with a shape similar to that of the propeller of a boat or airplane. The turbine is connected to a generator, which generates electricity. In this way, approximately half of the electricity used in the US is produced from coal.

But there are environmentally significant side effects, stemming predominately from two aspects. The first is that modern surface-mining techniques in wide use in the US often completely destroy pre-existing landscapes and ecosystems. The second, and arguably more important, aspect is associated with the actual combustion process. Coal is chemically complex, and the chemical reactions that occur during the combustion process result in the release of a variety of pollutants into the atmosphere. These include oxides of sulfur and nitrogen, which are important causes of acid rain and ozone smog,

respectively. Mercury that was contained in the coal when it was mined is dispersed widely through the ecosystem and then re-accumulated in the tissues of carnivorous fishes that humans consume. And the combustion process combines carbon contained in the coal with oxygen in the atmosphere to make carbon dioxide, the most important greenhouse gas.

The recently popular phrase “clean coal” mostly makes sense because coal is so inherently dirty, not because modern coal-fired power plants are clean compared to any non-coal energy source. While there are known technologies that can eliminate much of the air pollution associated with the combustion of coal, many are either relatively untested, very expensive, or both. One technology, usually called carbon sequestration, even offers the possibility that the carbon dioxide that would otherwise be emitted by coal-fired power plants can be captured and placed in permanent underground storage.

Petroleum

Much of what is written above about the environmental impacts of coal is true, though substantially less so, of petroleum products, including heating oil and gasoline. The combustion process produces several important pollutants, and many argue that the extraction process does substantial damage to the local environment. In contrast with coal, oil is used mostly for transportation and therefore burned in internal combustion engines (without steam); only a small and decreasing amount is used for generating electricity. The ratio of known supplies to annual consumption is measured in decades not centuries.

Natural gas

Although natural gas, which contains mostly methane, is, like petroleum and coal, a fossil fuel, it is, by almost any measure, much cleaner. For example, it is so much cleaner than coal in terms of greenhouse gas pollution that switching from coal to natural gas for electricity generation is likely to be an important part of efforts to address global warming even though carbon dioxide is emitted when natural gas is burned. Recent widespread deployment of combined-cycle gas turbine technology, in which expanding gases produced by the combustion process push directly on a first (gas) turbine before the remaining heat is used to produce steam to push a second (steam) turbine, has substantially increased the efficiency with which natural gas can be used to produce electricity. Almost all power plants built in the US in the last decade use natural gas as their primary fuel, but optimism that natural gas can replace coal must be tempered by legitimate concerns over the adequacy of both short-term and long term supplies.

Hydroelectric power

At a hydroelectric power plant, water falls over the top of a dam onto a turbine, which spins a generator to produce electricity; this is the most widely used of the various renewable energy sources. Significantly, hydroelectric power plants do not directly produce air pollution, including greenhouse gases. But any substantial increase in the use of hydroelectric power in the US would face two formidable obstacles: many of the most useful rivers are already thoroughly dammed, and the flooding of land that must accompany the construction of a new dam would displace current occupants and elicit

vehement opposition from environmentalists to the destruction of both land-based and aquatic ecosystems that would necessarily result.

Solar energy

There are several thoroughly proven technologies for the capture and use of incoming solar energy. The simplest involves exposing water filled pipes, painted black and backed by reflectors to maximize collection, to sunlight. The warm or hot water thus produced is then used directly or piped through interior spaces to warm them. In a different type of solar collector, when sunlight hits photoelectric panels, individual photons cause individual electrons to be ejected from metallic surfaces with enough force to push them through an electric circuit in which they release the energy so obtained to a light bulb, battery, or other load. The fact that the deployment of these two technologies is not currently constrained by the availability of suitable sites is illustrated by the simple observation that most sunny rooftops do not house solar panels. This observation also suggests the nature of the constraint that does operate, which is cost: other energy sources in this list are substantially cheaper. In another variation, reflectors concentrate sunlight on a single focus, where the light is turned to heat which is used to boil water (or possibly heat a different working fluid), and the resulting steam is used to power a turbine like those used in coal-fired power plants. The fact that costs of these technologies, particularly photovoltaic panels, continue to decrease as the need for alternative energy sources becomes more acute suggests that significant increases in the use of solar energy can be expected in this century. It is possible that solar power will come to dominate our energy supply within the lifetime of some of today's children.

Wind power

The only conceptually important difference between the windmills that still decorate the countryside in northwestern Europe and modern wind turbines is that, in the modern version, the axle on which the blades are mounted spins an electric generator. Although the absolute percentage of US electricity consumption that is currently generated with wind turbines remains small, the technology has reached a level of deployment that clearly demonstrates the potential for truly large-scale generation at reasonable prices. A decisive turn toward wind power would require that large steel towers be built across thousands of square miles of land, but in many cases the land (or water, in the case of offshore wind farms) between the towers would be largely unaffected. Finding acceptable sites does pose a formidable challenge in some parts of the country, and difficulties associated with the fact that turbines spin only when winds blow may ultimately impose limits on the degree to which wind can become a dominant energy source. But there are no technical obstacles that preclude sustained and significant increases in the production of wind-generated electricity in the near future.

Biomass

Biomass fuels are plants that have recently been alive, including the dung of some herbivorous animals. While reliance on such biomass fuels is common in many parts of the world, it is very rare in the modern US. But some see the increased use of so-called energy crops, which could be burned instead of coal in power plants, as another potential way to decrease net carbon dioxide emissions. The somewhat convoluted but ultimately

persuasive argument made by advocates of the use of energy crops unfolds as follows: While burning plants does release carbon dioxide into the atmosphere, the process of growing the same plants removes the same amount of carbon dioxide from the atmosphere, therefore closing the cycle. The combination of growing crops and polluting power plants burning the same crops produces net emissions of zero. While this description of the relevant portion of the carbon cycle is accurate, it is also true that large amounts of land must be devoted to the production of the crops, and the crops would not remove other pollutants that would be released by the power plants. Although biomass represents a potentially sustainable energy source with net carbon emissions near zero, environmentally motivated constraints on both land use and air pollution are likely to limit the degree to which biomass becomes a significant energy source in modern economies such as the US.

Other energy sources

The heat produced within the Earth from tidal friction and radioactive decay is usually called geothermal energy, and this energy is used where it is readily available to heat water that is used for direct heating or converted to steam to drive turbines connected to generators. The mechanical energy moving through the oceans in the form of both waves and tides can be captured and used to generate electricity. And small water-powered turbines, submerged in otherwise free-flowing rivers, can generate electricity on practical scales with minimal environmental impacts. But none of these or any other similarly proven but rarely used technology is anticipated to play a truly significant role in efforts to mitigate global climate change.

As has been the case for decades, a true wild card in this discussion of future energy sources is nuclear fusion. The invention of the atomic bomb in the US during the Second World War led directly to the development of two related technologies. The first is the commercial nuclear power plant, which relies on the type of nuclear reaction (fission) that powered the first nuclear explosions. The second is the hydrogen bomb, which relies on a different type of nuclear reaction (fusion) to release even more impressive quantities of energy. While nobody has yet figured out how to create a controlled fusion reaction that produces more energy than it consumes, it is also true that nobody has identified any compelling theoretical reason to be confident that the problem will remain unsolved forever. It is anticipated that fusion reactors, if they are ever invented, will be superior to fission reactors from the perspectives of safety and waste production. The energy of nuclear fusion, which also powers the sun, could revolutionize energy production on Earth before the end of this century, or it could remain in the undiscovered future for millennia. Nobody knows.

Carbon sequestration

It may not be necessary to stop burning fossil fuels to stop carbon dioxide pollution. A variety of pollutants are already scrubbed from the smokestacks of coal-fired power plants, and technology exists that allows carbon dioxide to be added to this list. The gas could then be stored permanently in, for example, depleted oil or gas wells, or at the bottom of the ocean. This process has, however, yet to be demonstrated on a large scale at a power plant and is expected to be expensive at best and potentially impractical for a variety of reasons, most related to the problem of permanent isolation of the carbon

dioxide from the atmosphere. Although this technology holds some promise, there is little reason to expect that it will greatly lessen the need to find alternative energy sources to replace fossil fuels.

Hydrogen

Cars can be powered by hydrogen in the same way that light bulbs can be powered by electricity. The important point is that, like electricity, hydrogen gas can be a useful energy carrier but is not an energy source. Nevertheless, the potential importance of hydrogen for efforts to replace fossil fuels, especially coal and oil, should not be underestimated for the following reason: While coal and oil are easily stored (in tanks or even, in the case of coal, big piles) and transported, wind and solar energy must be converted to some other form if it is to be used at times or locations other than those at which it is collected. Electricity can transport the energy over short and medium distances relatively efficiently, but it does not solve the time problem. Electrical energy generated by wind turbines or produced by photovoltaic cells can, however, be readily converted for storage and transportation as chemical potential energy in hydrogen gas, which can then be burned in much the same way as natural gas. (Connect wires to the terminals of a standard 9-V battery and place the other end of both wires in a cup of salt water. Bubbles of hydrogen gas will form at the end of one of the wires; the process is called electrolysis.) The possible use of nuclear reactors for the production of hydrogen gas is also under active study. Electricity is not an energy source and must therefore be manufactured, but it is an absolutely essential part of modern energy systems; hydrogen gas has the potential to play a complementary and similarly important role in the future.

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