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The Perils of a Half-Built Bridge: Risk Perception, Shifting Majorities, and the Nuclear Power Debate

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Much of the risk perception literature relies on the important but unstated assumption that manipulating public opinion to conform to scientific assessments of risk could help the public and, in turn, policymakers make better decisions about whether and how to regulate.[1] *This Article argues that the assumption fails in the context of certain "multilayered" risks, or risks that pose tiered policy choices, for which the question is not just whether to regulate, but how to respond to derivative risks arising from the first set of regulatory changes. Examining the debate about the role of nuclear power in the United States' response to climate change, the Article observes that first- and second-tier risks often differ in character, or require different types of regulatory solutions (market-based versus command-and-control). Due to these variations, the public may hold starkly different views about regulation of each tier, and those views may be differently "sticky"—that is, differently susceptible to persuasion.*

In the context of the nuclear power debate, this tiering of opinion has perverse implications. The first-tier risks of nuclear power are those associated with individual reactors, including the risks of accident or terrorist attack; the

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1. *See, e.g.*, Dan M. Kahan, Paul Slovic, Donald Braman & John Gastil, *Fear of Democracy: A Cultural Evaluation of Sunstein on Risk*, 119 HARV. L. REV. 1071, 1072 (2006) [hereinafter Kahan et al., *Fear of Democracy*] ("Risk perception scholars are not of one mind about the prospects for making public opinion conform to the best available scientific information on risk. But no one who aspires to devise procedures that make democratic policymaking responsive to such information can hope to succeed without availing herself of the insights this field has to offer.").

second-tier risks are those associated with mining, transport, processing, storage, and disposal of radioactive materials. Recent work asserts that despite entrenched public fear of nuclear power, it may be possible to induce people to support construction of low-emissions reactors as a strategy for mitigating climate change. But even if policymakers could employ the risk education strategies discussed in the literature to shift public opinion in favor of nuclear reactor development, there is no reason to think such strategies would be equally effective at changing attitudes toward the second-tier risks of radioactive materials and the command-and-control regulations necessary to address those risks. To the contrary, many people would likely continue to oppose certain types of government action on these derivative problems, even assuming complete success of the hypothetical first-tier education strategy and resulting support for expansion of nuclear facilities. As a result, the United States could find itself with a thriving nuclear power sector, but without the political will to address the grave collateral risks.

These observations lead to two conclusions, one related to the nuclear power example, and one to risk regulation more broadly. First, differently sticky public attitudes toward first- and second-tier nuclear risks and their regulatory solutions may defeat any effort to respond to climate change via an increase in U.S. reliance on nuclear power. Second, efforts to change public risk perceptions may not advance a regulatory agenda, and may even prove counterproductive. Specifically, where multiple risk layers exist, a successful first-tier education effort and consequent policy changes could create or expose second-tier risks that defy regulatory solution, leaving policymakers stranded at the abrupt and unexpected end of a half-built bridge. Depending on the gravity of the second-tier risks, this regulatory dead end could be one that neither policymakers nor the public would have chosen beforehand.

INTRODUCTION

In the last few decades, social scientists and behavioral economists have made considerable progress in understanding how ordinary people perceive environmental and health risks, and why their perceptions differ from expert assessments.[2] To date, much of the research has focused on how biases and mental rules of thumb (or "heuristics") influence lay perception of risk. For example, studies suggest that people underestimate risks they assume voluntarily,[3] and risks associated with beneficial activities.[4] In contrast, they overestimate risks imposed involuntarily,[5] and risks associated with activities of which they normatively disapprove.[6] Also, unsurprisingly, people fear risks associated with vividly documented catastrophes far more than equally significant risks that have not recently made the front pages.[7]

Most scholars now agree about the effects of these biases and heuristics,[8] but there is ongoing debate over whether such mental shortcuts are best understood as limits—"bounds"—on individuals' capacity to reason,[9] or

2. *See generally* Ann Bostrom, *Risk Perceptions: "Experts" vs. "Lay People"*, 8 DUKE ENVTL. L. & POL'Y F. 101 (1997) (discussing "discrepancies between expert assessments and lay perceptions of risk"); U.S. EPA, UNFINISHED BUSINESS: A COMPARATIVE ASSESSMENT OF ENVIRONMENTAL PROBLEMS (1987) (noting the discrepancy between expert and lay assessments of the risk of indoor radon).

3. *See, e.g.*, Paul Slovic, Howard Kunreuther & Gilbert F. White, *Decision Processes, Rationality and Adjustment to Natural Hazards*, *in* THE PERCEPTION OF RISK 26, 26 (Paul Slovic ed., 2000) ("the public seems willing to accept voluntary risks roughly 1000 times greater than involuntary risks at a given level of benefit"); Lisa Heinzerling, *Political Science*, 62 U. CHI. L. REV. 449, 470–72 (1995) (reviewing STEPHEN BREYER, BREAKING THE VICIOUS CIRCLE (1993)).

4. *See, e.g.*, Melissa L. Finucane, Ali Alhakami, Paul Slovic, & Stephen M. Johnson, *The Affect Heuristic in Judgments of Risks and Benefits*, *in* THE PERCEPTION OF RISK, *supra* note 3, 413, 415–16; *see also* Cass R. Sunstein, *The Laws of Fear*, 115 HARV. L. REV. 1119, 1137 (2002) (reviewing THE PERCEPTION OF RISK, *supra* note 3).

5. *See, e.g.*, Slovic et al., *supra* note 3; Heinzerling, *supra* note 3.

6. *See, e.g.*, Cass R. Sunstein, *Misfearing: A Reply*, 119 HARV. L. REV. 1110, 1119 (2006) [hereinafter Sunstein, *Misfearing*].

7. CASS R. SUNSTEIN, LAWS OF FEAR: BEYOND THE PRECAUTIONARY PRINCIPLE 36–39 (2005) [hereinafter SUNSTEIN, LAWS OF FEAR].

8. An alternative view presumes that people assess risks more rationally, by weighing costs and benefits. *See* W. KIP VISCUSI, RISK BY CHOICE: REGULATING HEALTH AND SAFETY IN THE WORKPLACE 37 (1983).

9. *See* Sunstein, *Misfearing*, *supra* note 6, at 1111–12 ("People should be regarded as boundedly rational weighers.").

instead as reflections of their cultural identities.[10] The former view, termed "bounded rationality," conceives of individuals as rational evaluators of risk whose estimations are skewed by perceptual and cognitive biases, but not (in the first instance, at least) by their cultural predispositions.[11] They view the world, if you will, through tinted glasses, rationally perceiving what they see, but failing to notice the color alteration. In contrast, advocates of the "cultural cognition" model assert that individuals' "worldviews," or political and cultural belief systems, "permeate all of the mechanisms through which [they] apprehend risk, including their emotional appraisals of putatively dangerous activities, their comprehension and retention of empirical information, and their disposition to trust competing sources of risk information."[12] According to this model, two aspects of worldview primarily influence lay perception of risk: the extent to which a person is hierarchical, or inclined to defer to the judgment of government leaders, and the extent to which he or she prioritizes individual rather than collective goals.

Armed with this basic (if still disputed) understanding of the cognitive shortcuts and cultural predispositions that drive public attitudes about risk, policymakers are now positioned to address a more forward-looking set of questions, all of which fall under a single broad heading: should government respond to arguably misplaced public fear, and if so, how? For example, should policymakers "respond to public concerns, simply because they are public concerns," (the "populist" view) or, at the opposite extreme, should government regulate only those hazards that have a significant actual likelihood of causing serious—or at least expensive—harm to public health or welfare (the "technocratic" view).[13] Or is there a middle ground? Can regulators devise strategies to bring the public's perceptions closer in line with the experts' calculations, and then regulate whatever risks the public continues to fear?

Many authors advocate this last approach, suggesting broad and largely one-size-fits-all strategies for reshaping lay perceptions of risk.[14] This Article contends, however, that taking the important step from theories that identify and characterize risk perception biases to prescriptions for public education strategies and regulatory responses requires a deep and nuanced understanding of the specific risks at issue. Failure to hone the education and regulatory prescription to the particular risk at issue could produce unexpected outcomes with costs that outweigh any anticipated benefit.

10. Kahan et al., *Fear of Democracy*, *supra* note 1, at 1072 (reviewing SUNSTEIN, LAWS OF FEAR, *supra* note 7, and arguing that the book ignores "one of the most important recent advances in the science of risk perception"—the way that "cultural worldviews permeate all of the mechanisms through which individuals apprehend risk").

11. Sunstein, *Misfearing*, *supra* note 6, at 1111.

12. Kahan et al., *Fear of Democracy*, *supra* note 1, at 1072.

13. SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 126.

14. *See, e.g.*, Dan M. Kahan & Donald Braman, *Cultural Cognition and Public Policy*, 24 YALE L. & POL'Y REV. 149, 168–69 (2006) [hereinafter Kahan & Braman, *Cultural Cognition*] (discussing MARY DOUGLAS & AARON WILDAVSKY, RISK AND CULTURE (1982), and other work by Douglas).

To make this point, this Article considers the potential outcomes of using public education strategies informed by cognitive psychology to address a high-profile contemporary issue[15]—whether the United States should promote nuclear power as a substantial part of the country's response to climate change. There is sharp debate about the advisability of this approach to climate change mitigation. Nuclear industry proponents claim that, in light of increasing scientific certainty that climate change poses a real and substantial threat to human health and welfare, the United States should promote rapid and significant growth of the nuclear sector. They point out that nuclear plants do not burn fuel and therefore emit no combustion byproducts like carbon dioxide, the greenhouse gas most responsible for climate change.[16] Indeed, even if one takes into account the greenhouse gas emissions associated with uranium mining, transport, processing, storage, and disposal, most analysts agree that nuclear energy has advantages over traditional energy sources like coal and natural gas, and is environmentally competitive with alternatives like wind power.[17] Industry opponents, on the other hand, argue that nuclear facilities are not cost-effective, and that the dangers of nuclear power—including safety risks, proliferation risks, and radioactive waste generation—outweigh any putative climate change benefits.[18]

This much of the debate has been widely reported, but one further point bears emphasis here. As discussed in Part II below, scientists who have evaluated the so-called "nuclear option" have concluded that making nuclear power a nonnegligible part of our climate change strategy would require

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15. *See, e.g.*, *Nuclear Power: The Shape of Things to Come*, ECONOMIST, July 9, 2005, at Special Report 2; Stephen L. Teichler & Charles W. Whitney, *Nuclear Power is Coming Back to Life: While Obstacles Remain, the Industry Sees a Brighter Future*, LEGAL TIMES, June 12, 2006, at 28; Mike Stuckey, *New nuclear power 'wave'—or just a ripple?*, MSNBC, Jan. 23, 2007, http://www.msnbc.msn.com/id/16272910/.

16. *See, e.g.*, John Tierney, *No Nukes, No More*, N.Y. TIMES, May 17, 2005, at A1; G. Pascal Zachary, *The Case For Nuclear Power: Economists, Environmentalists And Energy Consumers Find Incentives To Start Building New Plants*, S.F. CHRON., Feb. 5, 2006, at E1; *IAE: Build more nuclear power plants*, MARKETPLACE, Nov. 7, 2006, http://marketplace.publicradio.org/shows/2006/11/07/PM200611074.html; Peter Schwartz & Spencer Reiss, *Nuclear Now! How Clean, Green Atomic Energy Can Stop Global Warming*, WIRED, Feb. 2005, http://www.wired.com/wired/archive/13.02/nuclear.html.

17. Institute for Energy & Environmental Research, Summary, Insurmountable Risks 2 (2006), http://www.ieer.org/reports/insurmountablerisks/summary.pdf (summarizing BRICE SMITH, INSURMOUNTABLE RISKS: THE DANGER OF USING NUCLEAR POWER TO COMBAT GLOBAL CLIMATE CHANGE (2006): "Compared to the other major energy sources used around the world to generate base load electricity . . . nuclear power plants emit far lower levels of greenhouse gases even when mining, enrichment, and fuel fabrication are taken into consideration."); *see also* John L.R. Proops, Philip W. Gay, Stefan Speck & Thomas Schröder, *The Lifetime Pollution Implications Of Various Types Of Electricity Generation. An Input-Output Analysis*, 24 ENERGY POL'Y 229, 236 (1996).

18. *See, e.g.*, HELEN CALDICOTT, NUCLEAR POWER IS NOT THE ANSWER (2006); Thomas B. Cochran, Christopher E. Paine, Geoffrey Fettus & Robert S. Norris, Position Paper: Commercial Nuclear Power (Oct. 2005), http://www.nrdc.org/nuclear/power/power.pdf; Institute for Energy & Environmental Research, *supra* note 17, at 4–21 (discussing nuclear power's economic and safety and environmental costs).

construction of about ten large U.S. nuclear facilities every year, and a corresponding expansion of uranium exploration, mining, transport, processing, storage, and disposal operations. Thus, the policy question we currently face—and the only question this Article considers—is not whether individual power companies could or should build an additional nuclear power plant or two,[19] but whether the country should amend its regulatory regimes to promote historically unprecedented expansion of the sector as a response to climate change.

In the current political environment, a large-scale national commitment to nuclear power would be virtually impossible.[20] Thus, the immediate subsidiary question is whether policymakers could increase public acceptance of nuclear energy by educating people about the risks of climate change and nuclear power's greenhouse gas advantages compared to traditional energy sources,[21] and if so, whether attempting to influence public opinion is advisable.

To investigate this question, the Article considers two alternative risk education strategies, one that aims to overcome identified "bounds" on lay people's assessments of risk, and another designed to take into account and reconcile divergent cultural worldviews. Both strategies have the same hypothetical goal: to convince the public that the risks of nuclear power are preferable to (or less significant than) those of climate change, and therefore that the United States should embrace regulatory changes that streamline development of new nuclear facilities to meet our ever-growing energy needs.[22]

19. That is, the sweeping policy choice is not whether, for individual companies, the marginal benefits of constructing one, two, or ten new nuclear plants over the next few decades exceed the marginal costs of that approach, but whether we should, as a nation, turn to nuclear power as a significant part of our climate strategy—and make the regulatory changes that such a sweeping shift in energy policy would entail. Although the discussion in this Article has implications for the former choice, the Article itself is directed only at the latter.

20. *See, e.g.*, DAVID REINER ET AL., AN INTERNATIONAL COMPARISON OF PUBLIC ATTITUDES TOWARDS CARBON CAPTURE AND STORAGE TECHNOLOGIES 6 (2006), *available at* http://sequestration.mit.edu/pdf/GHGT8_Reiner.pdf (citing poll results that suggest far less than half of the U.S. public thinks nuclear power should be "use[d] to address global warming"); Eugene A. Rosa, *Public Acceptance of Nuclear Power: Déjà vu All Over Again?*, PHYSICS & SOC'Y (American Physical Soc'y/Forum on Physics & Soc'y, College Park, Md.), Apr. 2001, at 20, http://units.aps.org/units/fps/newsletters/2001/april/aptoc.pdf (discussing poll results from 1999) ("Past accidents, misrepresentations by the nuclear industry . . . and a growing mistrust of many institutions, especially institutions associated with nuclear power, such as the DOE, have made the public apprehensive about the technology. And all signs indicate that this apprehension runs deep. On the other hand, Americans support the idea of leaving the nuclear option open, perhaps as a trump card against future energy shortages or as the only demonstrated energy alternative for dealing with global warming. In summary, while the public may support this technology in the future; there is little basis to say that the future is now.").

21. The relatively new suggestion of "debiasing through law" offers another potential approach, *see generally* Christine Jolls, *Behavioral Law and Economics* (Yale Law School, Public Law Working Paper No. 130, 2006), http://ssrn.com/abstract=959177 (summarizing the approach), though it is not immediately obvious how one could employ such a strategy in the specific context of nuclear power.

22. Importantly, this Article does not advocate nuclear power and avoids taking a position on the actual sizes of the nuclear and climate change risks because this hypothetical exercise has important implications whatever one's views about the relative safety of nuclear technology.

Would an education campaign based on either a bounded rationality or cultural cognition model succeed? The risk perception literature suggests two possible answers to this question, neither of which is encouraging for proponents of nuclear sector expansion.

First, the education strategies might simply fail. As discussed below, nuclear power generation embodies many of the traits that engender an instinctive or affective negative response. As a result, subjects of an education campaign aimed at overcoming cognitive bounds on risk perception might hold tight to their instinctive fears of nuclear technology in spite of their increased analytical understanding of the consequences of a warming planet. Similarly, any attempt to find a policy middle ground that appeals to people of divergent worldviews might also fail, because the same cultural worldviews that (according to the model) predispose one to fear climate change also predispose one to fear nuclear power, while the technologically optimistic views that predispose one to dismiss the dangers of nuclear energy also predispose one to question the seriousness of the climate risk.[23] Therefore, rather than overcoming cultural predispositions that influence lay perceptions of the two risks, any effort to build a coalition across worldviews could instead drive opposing groups to their respective corners.

This first outcome—outright failure—conveys a simple lesson: in deciding what to do about risks that the public fears (perhaps irrationally), regulators must consider whether those fears are amenable to persuasion. For risks that trigger few of our innate or cultural biases, the most democratic and cost-effective approach may be to design education strategies to bring public perceptions in line with expert opinion, and then to regulate only as much as the experts advise. For risks that trigger many biases, however, there is reason to suppose any such education effort would fail, leaving regulators to confront the difficult question posed above—how and how much to regulate in the face of contrary public opinion.[24]

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23. *See supra* note 13 and accompanying text.

24. This Article does not attempt to answer this question. In particular, it avoids entering the debate among those who advocate strict adherence to experts' assessments of which risks are "real," *see, e.g.*, STEVEN G. BREYER, BREAKING THE VICIOUS CIRCLE 55 (1993) ("I assume a kind of 'general will'—a public that 'really' wants an overall result" (greater risk reduction at present cost or equal risk reduction at lower cost) "that differs from its substance-specific preferences revealed on particular occasions"), those who acknowledge that even misplaced public fears may exact a cost sufficient to justify regulation, *see, e.g.*, FRANK ACKERMAN & LISA HEINZERLING, PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING 135–36 (2004); Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law*, 112 YALE L.J. 61, 103–04 (2002), and those who would give great weight to the many value judgments implicit in public perceptions of risk, *see, e.g.*, ACKERMAN & HEINZERLING, *supra*, at 136, 151 ("When people worry about risks that are unfamiliar, unknown, and potentially catastrophic, they are expressing, in part, a distaste for a special kind of uncertainty: one in which the worst-case harmful potential of a hazard is unknown and unlimited. . . . The context of risk, the fairness of burdens and benefits—all these characteristics, which are all-important in real decisions, are priceless. They cannot be forgotten in making effective public policy, but they cannot be remembered with a number."); Paul Slovic, *Trust, Emotion, Sex, Politics and Science: Surveying the Risk-assessment Battlefield*, *in* THE PERCEPTION OF RISK, *supra* note 3, at 390, 392 [hereinafter Slovic,

The more interesting possible outcome of the hypothetical nuclear power education strategies is not failure, but partial success. Subjects could learn to accept some first-tier nuclear power regulations, for example regulations that promote development of new reactors at existing facilities, or regulations that provide tax incentives and liability coverage for development of altogether new facilities.[25] These first-tier regulations would allow the nuclear sector to grow, but would simultaneously augment derivative risks like safety, proliferation, and radioactive waste. Each of these derivative risks would then require its own regulatory solutions, such as stricter guidelines for terrorism-resistant plant construction, or streamlined procedures for siting and licensing of waste facilities.

Individuals who support the first-tier market-stimulus regulations might feel differently about these equally necessary second-tier command-and-control regulations. This shift in attitude could result in two ways. First, people who came to see the advantages of nuclear power could prove to have stickier views toward secondary issues like radioactive waste storage and disposal. Whether one subscribes to the bounded rationality or cultural cognition school of risk perception, there is no *a priori* reason to assume that on learning to accept new nuclear power facilities, the public would also inevitably surrender its fear of and opposition to new waste facilities. The public's stickier attitudes toward waste issues could well have a perverse effect. Public fear of waste facilities could engender strong opposition to waste facility siting and development and, ultimately, a *less* satisfactory public response to the waste problem than to the first-order issues related to new power facility construction and operation.

The second possible shift in public attitudes would result only under the cultural cognition model. Proponents of that model argue that one way to overcome public biases is to devise policies that have "cross-cultural" appeal—that is, policies that will garner the support of a coalition of people of diverse cultural worldviews.[26] Again, however, the same coalition may not support both market-based regulations to stimulate the nuclear industry and command-and-control regulations to ensure safe handling and disposal of radioactive materials. In fact, as discussed below, any coalition that supports the former would likely prove unstable when confronted with the latter. Again, the results could well be perverse. The coalition that supports market-based nuclear power incentives could break down when confronted with proposals for top-down regulatory mandates governing plant operation, radioactive material handling, and waste storage and disposal, thereby allowing new plants to come online well before any programs are in place to address their second-tier effects.

Trust, Emotion, Sex] ("[M]any of the public's reactions to risk . . . can be attributed to a sensitivity to the technical, social and psychological qualities of hazards that are not well-modeled in technical risk assessments.");

25. *See* Kahan et al., *Fear of Democracy*, *supra* note 1, at 1097 (suggesting that market solutions soften some cultural cognition barriers to recognition and regulation of environmental problems).

26. Kahan & Braman, *Cultural Cognition*, *supra* note 14.

The likely consequences of risk education strategies based on the bounded rationality and cultural cognition theories indicate two broad conclusions. First, pragmatically, an honest appraisal of the immense financial and regulatory investment that would be necessary to make nuclear power a significant *and safe* part of the United States' climate change strategy suggests that we cannot get there from here. Either the entrenched public fear of nuclear power will prove resistant to even the best education strategies, or worse, those strategies will engender support for only the first round of necessary regulatory reforms, not the entire suite of reforms necessary to ensure safe growth of the sector. Thus, absent an unusual willingness on the part of political leaders to buck public will, these scenarios suggest that the nuclear industry will either remain moribund, or thrive but evade comprehensive regulation.

Second, for multilayered risks like nuclear power, one potential cost of any initial regulatory effort is the development or augmentation of derivative risks that require their own round of regulation. The public may prove to have stickier attitudes toward these derivative risks than toward the principal risks, undercutting the effectiveness of the initial risk education strategy. Alternatively, the derivative risks may require different forms of regulatory solutions, thereby destabilizing the (loose) coalition that supported the first round of regulation.[27]

The remainder of this Article puts flesh on these bones. Part II outlines the principal approaches to risk perception discussed in the literature. Part III introduces the nuclear power debate and explores the potential outcomes of hypothetical risk education strategies based on the bounded rationality and cultural cognition models. Finally, Part IV extrapolates from this exercise to the broader problem of public attitudes toward layered risks.

I. MODELS OF PUBLIC RISK PERCEPTION

A. Background

Every day, we confront serious risks and make behavioral or policy choices that affect the magnitude of those risks. On both the individual and public policy levels, some of those choices are easier to make than others. Individual drivers, for example, readily choose to obey (most) red lights, thereby reducing the probability of serious accidents. And policymakers readily

27. Indeed, Madison all but predicted this latter dynamic in Federalist 10, when he advocated a large republic as a means of limiting the power of unruly factions. "To state the Madisonian proposition . . . broadly, the danger of a stable coalition increases as the size of the political unit decreases because the areas of disagreement become fewer and the divisions in the population consequently become more fundamental and permanent." Note, *City Government in the State Courts*, 78 HARV. L. REV. 1596, 1597 (1965). This insight, salutary in the context of factional rebellion, poses a thorny problem for sensible, stepwise regulation of multilayered risks facing large polities.

choose to require manhole covers, thereby reducing the probability of fatal falls.

But what of the harder choices—those that require significant individual or public expenditures, and those that involve risk tradeoffs? Many individuals may have a harder time deciding whether it is "worth it" to sell their old car and purchase a new one that meets the latest safety standards, or to get a vaccine that provides some long-term protection but poses a risk of immediate infection or other side effects. And policymakers, too, may be uncertain whether to require incorporation of an expensive safety device in new cars, or to require that all schoolchildren receive a particular live-culture vaccine.

Since the 1970s, these and related questions have stimulated lively debates about whether and when government should regulate risks. Much of the discussion has addressed questions of scientific, economic, and political philosophy: When is it scientifically and economically "worthwhile" to regulate a risk? And what balance should regulators strike between public safety and individual liberty? Not surprisingly, perspectives on these issues vary widely. Along the economic to scientific philosophy spectrum, the views range from those who believe that government activities should be strictly cost-justified[28] to those who question the use of any form of cost-benefit analysis,[29] advocating instead a general "precautionary principle."[30] The political philosophy spectrum, on the other hand, extends from those who would limit government intervention[31] to those who champion a strong, even paternalistic role for regulators.[32]

In the last few decades, advances in behavioral psychology have complicated matters by identifying a third issue for debate. Theorists exploring the cognitive shortcuts and cultural predispositions that influence public perceptions of risk have observed that policymakers must decide whether to adopt a "populist" approach and "respond to public concerns, simply because they are public concerns,"[33] or, at the opposite extreme, take a "technocratic"

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28. *E.g.*, W. Kip Viscusi, *Monetizing the Benefits of Risk and Environmental Regulation*, 33 FORDHAM URBAN L.J. 1003, 1004–05 (2006) ("Because no risk or environmental benefit warrants an infinite expenditure, the practical policy issue is what level of monetary cost is justified to obtain the benefit.").

29. *E.g.*, ACKERMAN & HEINZERLING, *supra* note 24, at 9 ("To say that life, health, and nature are priceless is not to say that we should spend an infinite amount of money to protect them. Rather, it is to say that translating life, health, and nature into dollars is not a fruitful way of deciding how much protection to give them. A different way of thinking and deciding about them is required.").

30. *See, e.g.*, SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 15–18 (summarizing the history of the principle and discussing its "widespread international support").

31. *E.g.*, W. Kip Viscusi, *Constructive Cigarette Regulation*, 47 DUKE L.J. 1095, 1101–02 (1998) ("The mere existence of a large risk, however, is not a legitimate rationale for government regulation... In a world of rational choice, with full information, there would be no rationale . . . for interfering with [individual] decisions.").

32. *E.g.*, Christine Jolls, Cass R. Sunstein, & Richard Thaler, *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471, 1541 (1996) (describing how bounded rationality may shape a "skepticism about antipaternalism," though not offering "an affirmative defense of paternalism").

33. SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 126.

approach, and ignore public sentiment, responding to fear only "if and to the extent that it is anchored in reality."[34]

This Article explores the possible consequences of taking an intermediate approach, using advances in behavioral psychology to design public education strategies that influence lay perception of risk.[35] In particular, the Article considers the implications for such an education strategy of situations in which the at-risk public responds differently to principle and derivative layers of a multilayered risk.

B. *Why Lay and Expert Opinions Differ*

1. *Overview*

Lay people and experts differ markedly in their estimation of both everyday and less familiar risks.[36] The attempt to explain these results began over three decades ago, when psychologists studying gambling preferences began to apply their findings to human risk perception.[37] In the intervening years, numerous studies have confirmed that public perception of risk is influenced by certain perceptual and analytic biases and mental rules of thumb, or heuristics.

For example, the "affect heuristic" describes the instinctive, or affective, reaction that leads people to underestimate the risks of beneficial activities (activities with which they have positive associations)[38] and overestimate risks

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34. *Id.*

35. It is worth noting, however, that having populist or technocratic leanings does not determine one's views on the scientific, economic and political issues that complicate risk regulation. A technocrat who firmly believes that government should respond only to "real" risks must still decide which type and level of response are scientifically and economically justified, and which are politically so. Thus, even if we could "mak[e] public opinion conform to the best available scientific information on risk," Kahan et al., *Fear of Democracy*, *supra* note 1, at 1072, numerous hard questions would remain.

36. BREYER, *supra* note 24, at 33; *see also* WORLD HEALTH ORGANIZATION, THE WORLD HEALTH REPORT 2002: REDUCING RISKS, PROMOTING HEALTHY LIFE 31 (2006), *available at* http://www.who.int/whr/2002/en/whr02_en.pdf ("By the early 1990s, particularly in North America and Europe, it became apparent that . . . risk had different meanings to different groups of people and that all risks had to be understood within the larger social, cultural and economic context. . . . In addition it became apparent that public perceptions of risks to health did not necessarily agree with those of the scientists, whose authority was increasingly being questioned by both the general public and politicians. Although there was considerable agreement between the public and scientists on many risk assessments, there were also some, such as nuclear power and pesticides, where there were large differences of opinion. . . . These differences of perception often led to intense public controversy. . . . By the mid-1990s . . . [it was] generally accepted that differences in perceptions of risk had to be understood and resolved.").

37. THE PERCEPTION OF RISK, *supra* note 3, at xxi.

38. *See, e.g.*, Paul Slovic, *Rational Actors and Rational Fools: The Influence of Affect on Judgment and Decision-Making*, 6 ROGER WILLIAMS U. L. REV. 163, 180 (2000) [hereinafter Slovic, *Rational Actors*]; Paul Slovic, Melissa L. Finucane, E. Peters, & D.G. MacGregor, *The Affect Heuristic*, *in* HEURISTICS AND BIASES: THE PSYCHOLOGY OF INTUITIVE JUDGMENT 397 (Thomas Gilovich, Dale Griffin & Daniel Kahneman eds., 2002).

imposed involuntarily.[39] The affect heuristic may help to explain why people tend to overestimate the magnitude of "dread" risks.[40] A particularly dread risk (that is, an uncontrollable risk, imposed involuntarily, with lethal consequences that are unfairly distributed across society) inspires strongly negative feelings that, in turn, lead individuals to assess the *level* of the risk as high.[41]

In a related phenomenon, many people overestimate the risks of activities of which they disapprove ("normative bias"[42]). Thus, those who vehemently oppose abortion may be more likely to believe the procedure poses dangers for pregnant women, while those who support abortion rights may discount any such evidence as the product of junk science.[43]

By contrast, the "availability heuristic"[44] has less to do with the characteristics of a risk than with how recently and in what manner it has been reported in the news. If people are able to call a specific incidence of a risk to mind, they tend to assume the risk itself is high.[45] If the remembered incidence was catastrophic, the effect is even more pronounced.[46] A 2006 food-borne *E. coli* scare[47] provides a good example. In its immediate aftermath, people were more likely to worry about eating fresh vegetables from the store than about the risk of driving to the store in the first place.

Social interactions reinforce the availability heuristic. As people tell stories about disasters, they often transmit not only objective information about the event but their own subjective fear. Thus, fears of "available" risks often prove contagious (the "cascade effect"[48]). Additionally, groups of like-minded people tend to sharpen and confirm each other's views about such risks, leading to "group polarization."[49] Finally, the cascade effect and group polarization have a predictable effect in the workplace, where employees' views about risk

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39. *See, e.g.*, Slovic, Kureuther & White, *supra* note 3; Heinzerling, *supra* note 3.

40. Paul Slovic, *What's Fear Got to Do with It? It's Affect We Need to Worry About*, 69 MO. L. REV. 971, 976 (2004) [hereinafter Slovic, *What's Fear Got to Do with It?*]; *see also, e.g.*, Finucane, *supra* note 4, at 415–16; Sunstein, *supra* note 4, at 1137. The affect heuristic helps to explain why "food additives, for example, tend to be seen as very high in risk and relatively low in benefit, whereas . . . antibiotics and x-rays tend to be seen as high in benefit and relatively low in risk." Slovic, *Rational Actors*, *supra* note 38, at 180.

41. Slovic, *What's Fear Got to Do with It?*, *supra* note 40, at 976.

42. Sunstein, *Misfearing*, *supra* note 6, at 1119.

43. *Id.* at 1118.

44. SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 36–39.

45. Christine Jolls & Cass R. Sunstein, *The Law of Implicit Bias*, 94 CAL. L. REV. 969, 981 (2006).

46. *See, e.g.*, Paula E. Berg, *When the Hazard is Human: Irrationality, Inequity, and Unintended Consequences in Federal Regulation of Contagion*, 75 WASH. U. L.Q. 1367, 1403–04 (1997) ("Studies of risk perception demonstrate that the media's tendency to focus on sensational, unusual, and catastrophic risks leads the public to overestimate the occurrence of these hazards.").

47. *See, e.g.*, Marian Burros, E. Coli Fears Inspire a Call for Oversight, N.Y. TIMES, Dec. 9, 2006, at B1.

48. SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 94–98.

49. *Id.* at 98–102.

often come to resemble those of their employer institutions ("affiliation bias"[50]).

2. The Bounded Rationality Model

Some theorists find these and similar biases and heuristics sufficient to explain most of what is observed about the selectivity—and occasional irrationality—of public fears. Professor Cass Sunstein, for example, identifies five factors that he deems "especially pertinent" to understanding differences in risk perception:[51] (1) the availability heuristic; (2) "probability neglect," which refers to the human tendency to worry about worst-case scenarios, no matter how improbable; (3) loss aversion, which leads people to disfavor a potential loss more than they favor an equal and opposite potential gain;[52] (4) widespread belief in the benevolence of nature; and (5) "system neglect," or the tendency to focus on the effects of a risk to the exclusion of other important regulatory considerations, like the direct costs of government intervention and the potential risk tradeoffs that might result from such intervention.[53]

Professor Sunstein contends that observed correlations between people's cultural framework and their perceptions of risk result from these and other bounds on rationality. These bounds (in particular the cascade effect and normative bias) lead individuals of similar cultural backgrounds to reach similar conclusions about risks.[54] According to this model, therefore, any cultural differences in risk perceptions are not the cause but the effect of perceptual shortcuts and biases.

Explaining this concept further, Sunstein divides the universe of risks into two categories: those that raise few political concerns (the risk of falling asleep at the wheel, or suffering a heart attack during exercise) and "hot risks," which are associated with culturally divisive issues (for example, risks associated with abortion or gun ownership).[55] To evaluate the former type of risk, he claims, individuals coolly assess the evidence, within the bounds of culturally-independent analytic shortcuts. For hot risks, on the other hand, heuristics and

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50. Nancy Kraus, Torbjorn Malmfors & Paul Slovic, *Intuitive Toxicology: Expert and Lay Judgments of Chemical Risks*, in THE PERCEPTION OF RISK, *supra* note 3, at 285, 311–313. Kraus and her co-authors observe, for example, that "[t]oxicologists working for industry see chemicals as more benign than do their counterparts in academia and government." *Id.* at 311. This observation does not, of course, answer the causation question. Contrary to the assumption in the text, it may be that individuals who are predisposed to fear chemicals choose to work for academic or governmental employers, and those who dismiss such fears find the chemical industry a more welcoming work environment. Once such affiliations are created, however, one would expect the cascade effect and group polarization to solidify them.

51. *See* SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 35–37.

52. For example, people charge more to relinquish a good they already have than they are willing to pay to acquire the same good in the first place. *Id.* at 41–43.

53. *Id.* at 35.

54. Sunstein, *Misfearing*, *supra* note 6, at 1118.

55. *Id.* at 1115.

biases like the cascade effect, group polarization, and normative bias[56] tend to bolster existing social or political divisions, leading people to favor the views held by others in their self-identified cohort.

Assuming this bounded rationality model explains much of what is observed about human risk perception, how might public education strategies be designed to foster support for a desired regulatory program?[57] Risk perception theorists and behavioral psychologists suggest various tactics for overcoming bounds on risk assessment.

First, any education strategy must address strict inaccuracies in public perceptions. To this end, Professor Paul Slovic emphasizes the importance of public trust in the individual who provides the risk information. In turn, the information provider must be sufficiently expert to understand and assess the validity of risk estimates and convey them sensitively to a potentially fearful public.[58]

The accessibility of risk education is also important. For example, people tend to understand comparisons better than numbers or probabilities, especially when the latter are small.[59] Thus, to educate someone about the risk of death from riding a motorcycle, it is less useful to present the absolute motorcycle fatality rate (2000 fatalities per year per 100,000 persons at risk) than to compare that rate to the risk of dying from smoking (300/100,000 fatalities per year), the risk of dying from a motor vehicle accident (24/100,000 fatalities per year), and the risk of being killed by lightning (0.05/100,000 fatalities per year).[60]

Another accessibility consideration stems from the recognition in the psychology literature that people tend to understand frequencies better than probabilities. For example, consider the following ways of presenting information about the reliability of a medical test: (1) "[A] test to detect a disease whose prevalence is [one in a thousand] has a false positive rate of [5%]," versus (2) "One out of a thousand Americans has a disease; fifty out of a thousand healthy people test positive."[61] In both examples, the probability that a person who tests positive actually has the disease is about one in fifty. But people understand that fact much more intuitively when presented with the second frequency-based statement.

A risk education campaign, however, will not easily shift perception of some risks, because some of the difference between lay and expert risk

56. *See* SUNSTEIN, LAWS OF FEAR, *supra* note 7 at 89–104.

57. For the moment, this analysis begs normative questions about the wisdom and morality of such a deliberate "reeducation" campaign. The conclusion of the Article, however, begins to answer the former question.

58. Paul Slovic, *Informing and Educating the Public about Risk*, *in* THE PERCEPTION OF RISK, *supra* note 3, at 182, 183 [hereinafter Slovic, *Informing and Educating*]; *accord* Slovic, *Trust, Emotion, Sex*, *supra* note 24, at 392.

59. Slovic, *Informing and Educating*, *supra note* 58, at 187.

60. *Id.*

61. *See* STEVEN PINKER, HOW THE MIND WORKS 344, 348 (1997).

assessments stems not from analytic mistakes but from biases that lead people to fear certain kinds of risk more than other, comparably sized risks, depending on affective factors like "uncertainty, controllability, catastrophic potential, equity and threat to future generations."[62] Thus, an education effort that simply compares, say, the risk of living near a nuclear power plant to that of driving a car will not resonate with the public, as it "fails to give adequate consideration to... important differences in the nature" of these hazards—differences that *do* resonate.[63] In short, changing the public's risk perception requires a "two-way process" in which "[e]ach side, expert and public,... respect[s] the insights and intelligence of the other."[64]

Recognizing this fact, producer and journalism professor Jon Palfreman argues that "journalists should expand their narrative horizons: to include not just the facts about the risk in question but also how people feel about the risk and why. In essence, they should report two dimensions of the risk story—the physical narrative... and the psychological subtext."[65] In the specific context of climate change, for example, Palfreman suggests that journalists might be better able to interest the public in global climate change if they emphasize its implications for future generations—"the 'legacy' concept" that proved successful with nuclear power awareness.[66] "If we all have available an image of our grandchildren struggling with irreversible climate change," he claims, "the problem seems less abstract and more pressing."[67]

This summary is incomplete but provides some sense of the necessary ingredients of an education strategy that aims to overcome (or, more accurately, account for) bounds on strictly rational risk assessment: trust in the educator, accessible presentation of the facts, and framing that is sensitive to the specific risk characteristics that underlie much public fear. In the discussion below, references to a "bounded rationality campaign" to convince the public to accept nuclear power as a solution to climate change refer to a hypothetical campaign that perfectly incorporates these and other important insights about the biases and heuristics that influence lay perceptions.

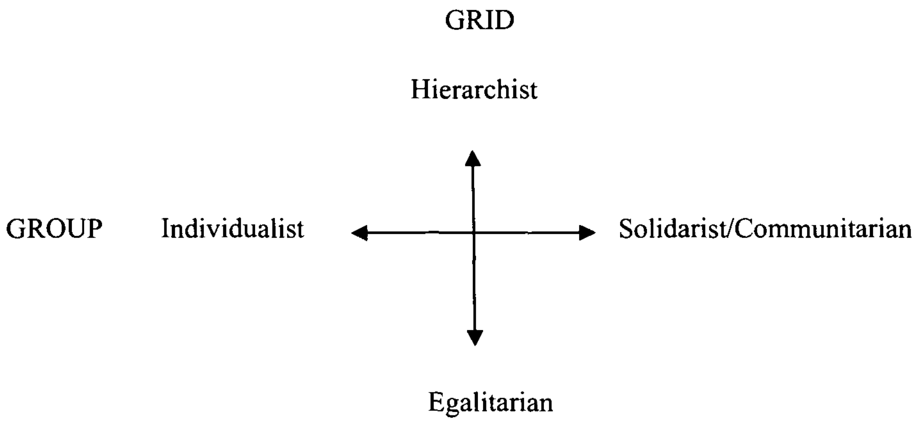
3. *The Cultural Cognition Model*

The cultural cognition model offers an alternative explanation for some of the observed shortcomings in public risk perception, and it may therefore call for an alternative (hypothetical) educational approach. Without rejecting bounded rationality, the cultural cognition model argues that "worldviews

62. Paul Slovic, *Informing and Educating*, *supra* note 58, at 190.
63. *Id.* at 190–91.
64. *Id.*
65. Jon Palfreman, *A Tale of Two Fears: Exploring Media Depictions of Nuclear Power and Global Warming*, 23 REV. POL'Y RES. 23, 38 (2006).
66. *Id.* at 38.
67. *Id.* at 38–39.

permeate all of the mechanisms through which individuals apprehend risk,"—including the biases and heuristics discussed above.[68] Authors in this area identify two possible worldview axes and assert that individuals "conform their beliefs about risk" to their coordinates in this two-dimensional space—that is, effectively, "to their visions of an ideal society."[69]

As illustrated below, the two axes are "grid" (hierarchical to egalitarian) and "group" (individualist to solidarist/communitarian).[70]



According to this model, strict hierarchists distrust reports of environmental risk, because they are inclined to believe government officials are competent,[71] and they "perceive warnings of imminent environmental catastrophe as threatening" that competence.[72] Strict individualists, too, reject claims of environmental risk because they believe in the functioning of unregulated markets.[73] Strict egalitarians and solidarists, on the other hand, are predisposed to favor regulation of environmental risks, because such regulation checks the commercial activities that produce social inequalities (anathema to egalitarians) and legitimize greed (ditto to solidarists).[74]

Can these cultural predispositions be overcome? Proponents of the cultural cognition model believe so:

> Nothing in our account implies either that there is no truth of the matter on disputed empirical policy issues or that the public cannot be made receptive to that truth. Like at least some other cognitive biases, cultural cognition can be counteracted. . . . [F]actual disputes over gun control, the death

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68. Kahan et al., *Fear of Democracy*, *supra* note 1, at 1072.

69. *Id.*

70. Kahan & Braman, *Cultural Cognition*, *supra* note 14, at 153–54.

71. Ellen Peters & Paul Slovic, *The Role of Affect and Worldviews as Orienting Dispositions in the Perception and Acceptance of Nuclear Power*, 26 J. APPLIED SOCIAL PSYCHOL. 1427, 1430 (1996).

72. Kahan et al., *Fear of Democracy*, *supra* note 1, at 1073–74.

73. *Id.* at 1084.

74. Kahan & Braman, *Cultural Cognition*, *supra* note 14, at 154.

penalty, environmental regulation and like issues derive from individuals' resistance to accepting information that threatens their cultural commitments. It follows that individuals are likely to resist factual information less if it can be presented in forms that affirm rather than denigrate their values.[75]

Professors Dan Kahan and Donald Braman have discussed the practical application of this "self-affirmation" strategy. They contend that affirming cultural identities renders individuals "more open"—both attitudinally and cognitively—"to reconsidering their beliefs on culturally contested issues."[76] Thus, policymakers seeking to overcome cultural biases on a particular issue should "design[] policies that are sufficiently rich in their social meanings to affirm the values of persons of diverse cultural worldviews simultaneously."[77]

Two examples of this approach are directly relevant here. The first relates to the development in the 1980s and 1990s of a tradable emissions permit scheme for sulfur dioxide and other air pollutants.[78] According to Kahan and Braman, policymakers achieved political consensus around this new regime by touting the permits as a market-based solution to air pollution, thereby (1) "vindicat[ing] individualists' belief that private orderings conduce to societal well-being"; (2) "affirm[ing]" hierarchists with "a policy that promised to empower . . . powerful commercial firms"; and (3) "recognizing" egalitarians' and solidarists' "view[s] of the dangers of unconstrained commerce and industry."[79] Overall, this approach made it easier for individualists and hierarchists to recognize the problem of air pollution, and for egalitarians and solidarists to recognize the inefficiencies of command-and-control regulation of pollution."[80]

The second relevant example concerns the nuclear power debate that is the subject of this Article. The same authors suggest, briefly, that their affirmation approach might work to convince the public to accept nuclear power as a solution to climate change:

> The self-affirmation effect suggests [that a proposal to renew investment in nuclear power as a way to reduce greenhouse gas emissions] might actually change minds, both about the dangers of global climate change and about the risks of nuclear energy. Individualists and hierarchists both support nuclear power, which is emblematic of the very cultural values that are threatened by society's recognition of the global warming threat. Shown a solution that affirms their identities, individualists and hierarchists . . . can be expected to display less resistance—not just politically, but cognitively—to the proposition that global warming is a problem after all. Likewise, when egalitarians and solidarists are exposed to the same

75. *Id.* at 168.
76. *Id.*
77. *Id.*
78. *Id.* at 169.
79. *Id.*
80. *Id.* at 169.

> information, they are likely to perceive nuclear power to be less dangerous: The affirmation of their identity associated with the recognition of the global warming threat lowers the cultural status cost of accepting information about nuclear safety that they have long resisted.[81]

According to this view, then, the self-affirmation effect offers an approach for policymakers who seek to shift public opinion about nuclear power. References in the below discussion to a "cultural cognition campaign" refer to a hypothetical realization of this approach.

II. RISK PERCEPTION AND THE NUCLEAR POWER DEBATE

Having outlined the two salient risk perception models, and each model's suggested tactics for shaping public perceptions, this Article next considers how we might expect these approaches to perform in practice. That is, in the context of a particular policy debate, would a public education strategy based on either the bounded rationality or cultural cognition model shift public opinion in the desired direction? And if so, is such a shift likely to lead to an objective improvement in public policy? Importantly, the latter two questions are distinct. As the following discussion of the nuclear power debate illustrates, an effective risk education campaign does not ensure equally effective public policy.

This Part introduces the debate: What are the risks of climate change and nuclear power? What would it mean for nuclear power to play a significant role in a climate change strategy? And what regulatory changes would be required to facilitate the necessary growth of the nuclear sector and to address any attendant risks?

Turning to the public opinion piece of this puzzle, this Part then hypothesizes a bounded rationality and a cultural cognition risk education strategy, each aimed at convincing people to support nuclear power as an approach to climate change, and asks (1) whether either strategy would be successful, and (2) if so, what that success would "look like" in practice. The results of this theoretical exercise are worrying, not just for nuclear enthusiasts, but for anyone who hopes to use insights from behavioral psychology to move public opinion in a useful direction.

A. *The Nuclear Power Example*

The increasing scientific certainty that global warming poses serious risks to present and future generations has revived interest in nuclear power as a "carbon-free" power source that could help satisfy the world's growing energy needs without contributing significantly to the greenhouse effect.[82] Even some environmentalists, formerly opposed to nuclear technology, have revised their

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81. *Id.*

82. *See supra* note 16 and accompanying text.

views, arguing that we should explore nuclear energy as a supplement to conservation and to renewable energy technologies like wind and solar power.[83] Other longtime opponents, incensed by this softening of position, remind the world in strident terms of the many unsolved problems nuclear power poses—notably its upfront costs, attendant safety and proliferation risks, and waste transport, storage, and disposal issues.[84]

Given the stridency of this debate, one important and largely unaddressed question is whether public opinion stands as an independent barrier to any climate change strategy based predominantly or even significantly on *safe* growth of the nuclear power sector. In other words, suppose policymakers uniformly believed that nuclear power posed lesser risks than climate change, and that we should shift a significant portion of U.S. energy production from traditional fuels to nuclear as part of our effort to reduce greenhouse gas emissions. Could the public be persuaded to support this approach? And of equal importance, what might be the consequences of an attempt to shift attitudes in this wholesale way?

This Article makes no effort to plumb the depths of current thinking on either climate change or nuclear power. It is sufficient for this discussion to make a few brief points: (1) the fact of human-induced climate change is increasingly certain, and current predictions suggest that the effects of the warming—though difficult to predict and almost impossible to monetize—will be massive and costly; (2) focusing strictly on greenhouse gas emissions, nuclear power is "cleaner" than traditional power sources, but converting much of the world's energy supply to nuclear is neither a complete solution to climate

83. *See, e.g.*, Felicity Barringer, *Old Foes Soften to New Reactors*, N.Y. TIMES, May 15, 2005, at A1 (citing articles and statements by Stewart Brand, founder of the Whole Earth Catalog; Fred Krupp, Executive Director of Environmental Defense; Jonathan Lash, President of the World Resources Institute; and James Gustave Speth, Dean of the Yale School of Forestry and Environmental Studies); James Lovelock, *Our Nuclear Lifeline: Go Nuclear? A Leading Environmentalist Says the Greens Are Plain Wrong to Oppose It*, READERS DIG., Mar. 2005, at 2; Patrick Moore, *Going Nuclear: A Green Makes the Case*, WASH. POST, Apr. 16, 2006, at B1; Peter N. Spotts, *Simpler—and Safer*, CHRISTIAN SCI. MONITOR, June 2, 2005, at 13 ("[F]aced with global warming, some groups, such as the Pew Center on Global Climate Change and Environmental Defense, appear willing to give nuclear energy a reluctant second look."); Amanda Griscom Little, *Green vs. Green: The Environmental Movement, Once Staunchly Antinuclear, Is Facing Resistance From Within*, WIRED, Feb. 2005, http://www.wired.com/wired/archive/13.02/nuclear.html?pg=5.

84. *See, e.g.*, CALDICOTT, *supra* note 18; Press Release, U.S. Public Interest Research Group, Nuclear Power Not Needed to Reduce Global Warming Emissions (May 25, 2005), *available at* http://www.commondreams.org/news2005/0525-03.htm ("Nuclear power is the most dangerous and expensive of all energy sources. . . . [N]one of the nuclear power industry's financial, security, safety, waste, or proliferation problems has been solved."); Greenpeace USA, Nuclear Power's Extreme Makeover, http://www.greenpeace.org/usa/campaigns/nuclear/nuclear-power-s-extreme-makeov (last visited Feb. 26, 2008); GREENPEACE USA, NUCLEAR ENERGY—NO SOLUTION TO CLIMATE CHANGE (2004), http://www.greenpeace.org/raw/content/usa/press-center/reports4/nuclear-energy-no-solution-to.pdf ("The nuclear industry's disingenuous claims to a role in alleviating climate change must be rejected for what they are: dangerous and self-serving fantasies which would create a serious legacy of deadly radioactive waste, increase the risks of catastrophic nuclear accidents and also vastly increase the threat of nuclear weapons proliferation.").

change nor a necessary piece of the solution; (3) to play a nonnegligible role in our climate change strategy, the nuclear power sector will have to grow drastically; (4) stimulating the required growth of the nuclear power sector will require regulatory action; and finally, (5) there are significant ancillary risks of that growth, and addressing those risks, too, will require substantial regulatory action.

1. Scientific Certainty About the Effects of Climate Change

Scientists have all but reached consensus about the seriousness of the risks of global climate change.[85] The most oft-discussed such risk is a rise in sea surface levels,[86] which will confront low-lying communities with a stark choice: either invest in elaborate levee systems or risk inundation. There are many other dangers, however, including increased storm intensity; increased rainfall (in some areas); pervasive drought (in others); more frequent wildfires; rapid loss of biodiversity, particularly in polar climes and in sensitive ecosystems like coral reefs; expanded seasons and ranges for some noxious species, including allergenic grasses and tropical disease agents; and even significant changes in ocean circulation and, as a result, coastal climates.[87] The costs to humans of these various changes in our natural environment are many and varied, ranging from minor weather changes to disruption of our food and water supplies, flooding and other natural disasters, and deadlier and more frequent epidemics.[88] Moreover, these effects will hit hardest in the poorest

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85. Elke U. Weber, *Experience-Based and Description-Based Perceptions of Long-Term Risk: Why Global Warming Does Not Scare Us (Yet)*, 77 CLIMATIC CHANGE 103 (2006); *see also* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 4, 5, 8 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf [hereinafter IPCC, PHYSICAL SCIENCE] ("Warming of the climate system is unequivocal."); NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE vi (2006), *available at* http://www.hm-treasury.gov.uk/media/3/2/Summary_of_Conclusions.pdf [hereinafter STERN REVIEW] ("The scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response.").

86. Indeed, some sea level rise has already been observed. IPCC, PHYSICAL SCIENCE, *supra* note 85, at 5, 7. Interestingly, this sea surface rise results not just from an increase in ocean volume as polar icecaps melt, but also from a decrease in the density of ocean water as average water temperatures rise. NASA Jet Propulsion Laboratory, What's up with Sea Level (June 2006), http://sealevel.jpl.nasa.gov/newsroom/features/200606-1.html ("'Global sea level can rise for one of two reasons,' says JPL oceanographer Dr. Josh Willis. 'One is when water gets hotter, it expands. The other is when water is added to the ocean, which changes its mass. That happens, for example, when glaciers melt.'").

87. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 15–18 (2007), *available at* http://www.ipcc-wg2.org/ (follow "Summary for Policymakers" hyperlink) [hereinafter IPCC, IMPACTS]; *see also* Institute for Energy & Environmental Research, *supra* note 17, at 12–36.

88. *See generally* IPCC, IMPACTS, *supra* note 90 at 10–12; Institute for Energy & Environmental Research, *supra* note 17, at 12–36; STERN REVIEW, *supra* note 85, at vi (summarizing likely effects on the human environment).

countries, posing "a grave threat to the developing world and a major obstacle to continued poverty reduction."[89]

Predicting which effects will happen where, and when, has proven virtually impossible, but the best minds in the business have concluded that warming is all but certain to impose enormous worldwide costs unless we take drastic action to reduce global greenhouse gas emissions.[90] For example, a recent UK economist's report concludes that "if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP" and up to "20% . . . or more . . . each year, now and forever."[91] The same author estimates that the annual costs of stabilizing greenhouse gas concentrations at a safe level would be "significant but manageable"—on the order of 1% of GDP by 2050.[92] These dollar figures need not be strictly accurate for one to conclude that society should carefully evaluate the cost effectiveness and feasibility of all serious suggestions for mitigating greenhouse gas emissions.

2. *Nuclear Power as Part of the Solution*

One widely touted such suggestion is to increase reliance on nuclear power. With respect to greenhouse gas emissions, nuclear power is cleaner than traditional fuel sources and competitive with renewable technologies.[93] Moreover, nuclear power is cleaner even on a cradle-to-grave accounting that takes full account of the greenhouse gases emitted in mining, processing, transporting, storing, and disposing of radioactive fuels.[94] Thus, shifting some percentage of U.S. energy production from traditional fuels to nuclear power would provide climate change benefits.[95]

It would not be feasible, however, to convert 100% of the U.S. power sector to nuclear energy. Among other things, nuclear power is generally used to meet baseload demand, meaning that additional (carbon-emitting) "peaker"

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89. NICHOLAS STERN, THE ECONOMICS OF CLIMATE CHANGE: EXECUTIVE SUMMARY vii (2006), *available at* http://www.hm-treasury.gov.uk/media/4/3/Executive_Summary.pdf [hereinafter STERN REVIEW EXECUTIVE SUMMARY]; *see also* IPCC, IMPACTS, *supra* note 87, at 12.

90. STERN REVIEW EXECUTIVE SUMMARY, *supra* note 89, at ix.

91. STERN REVIEW, *supra* note 85, at vi.

92. STERN REVIEW EXECUTIVE SUMMARY, *supra* note 89, at xii.

93. *See* Institute for Energy & Environmental Research, *supra* note 17.

94. *Id.*

95. This claim is, of course, tempered by the fact that existing atmospheric greenhouse gas concentrations may make some warming inevitable, Press Release, Nat'l Sci. Found., Climate Change Inevitable in 21st Century (Mar. 17, 2005), *available at* http://www.nsf.gov/news/news_summ.jsp?cntn_id=103108, and by other countries' growing contribution to the problem, *see IAE: Build more nuclear power plants*, *supra* note 16 ("Within two years, [China will] produce more greenhouse gases from human sources than the United States."). This Article focuses on the United States' nuclear industry, however, in part because a worldwide shift to nuclear power is unlikely without significant U.S. involvement. *See* MASSACHUSETTS INSTITUTE OF TECHNOLOGY, THE FUTURE OF NUCLEAR POWER: AN INTERDISCIPLINARY MIT STUDY 3 (2003), *available at* http://web.mit.edu/nuclearpower/pdf/nuclearpower-full.pdf.

facilities are necessary.[96] Moreover, even if complete conversion were possible, the United States would still contribute significantly to global greenhouse gas emissions. As noted above, mining, processing, transporting, storing, and disposing of radioactive fuels produce significant quantities of greenhouse gases.[97] Further, other sectors of the U.S. economy are significant sources. The transportation sector, for example, currently accounts for about one-third of U.S. energy-related carbon dioxide emissions.[98]

An equally important and related point is that wholesale conversion to nuclear power is not necessary to global greenhouse gas mitigation efforts. Other approaches that could, in some combination, produce the necessary emissions reductions include: reduced vehicle use; more efficient appliances, buildings, and vehicles (for example hybrids and fuel cell vehicles); greater use of wind and other renewable energy sources; better agricultural practices; use of "clean coal" technologies; and further development and implementation of carbon capture and storage technologies.[99] Comparing the costs, benefits, and feasibility of nuclear power and these various other greenhouse gas reduction alternatives is well beyond the scope of this Article; the important point for this discussion is that the "nuclear option" is neither a complete solution to climate change nor a necessary part of the country's efforts to reduce greenhouse gas emissions. Accordingly, society must make a measured decision whether significant investment in the sector is both practicable and worthwhile.

3. *Scale of the Necessary Investment in Nuclear Power*

One variable relevant to this choice, often overlooked in popular debates, is the scale of the investment in nuclear energy that would be necessary to make a dent in greenhouse gas emissions. It turns out, pivotally, that nuclear

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96. Energy Information Agency, Nuclear Power and the Environment, http://www.eia.doe.gov/cneaf/nuclear/page/nuclearenvissues.html (last visited Feb 27, 2008).

97. *See supra* note 17 and accompanying text.

98. ENERGY INFORMATION ADMINISTRATION, REP. NO. DOE/EIA-0573(2005/es), EMISSIONS OF GREENHOUSE GASES IN THE UNITED STATES 2005: EXECUTIVE SUMMARY 4 (Feb 2007), *available at* http://www.eia.doe.gov/oiaf/1605/ggrpt/summary/pdf/0573(2005)es.pdf; *see also* U.S. EPA, REP. NO. 430-R-06-002002, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2004 at ES-13 (April 2006), *available at* http://www.epa.gov/climatechange/emissions/downloads06/06_Complete_Report.pdf.

99. Stephen Pacala & Robert Socolow, *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, 305 SCIENCE 968, 969–70 (2004) (describing fifteen so-called "wedges," or potential carbon reduction approaches, any seven of which would be sufficient to stabilize carbon *emissions* at their current levels for the next fifty years, thereby keeping open the possibility that we could, eventually, develop the additional technologies necessary to reduce emissions still further and stabilize atmospheric carbon *concentrations*); *see also* Roger A. Pielke, Jr., *What Just Ain't So: It Is All Too Easy To Underestimate The Challenges Posed By Climate Change*, 443 NATURE 753, 753 (2006) (reviewing WILLIAM SWEET, KICKING THE CARBON HABIT: GLOBAL WARMING AND THE CASE FOR RENEWABLE AND NUCLEAR ENERGY (2006), and noting that "Pacala and Socolow recognize that what they have proposed is only a start. . . [. E]ven after the successful implementation of seven of their wedges by 2054, 'fossil fuel emissions must decline'. . . by about an additional two-thirds over the subsequent 50 years.").

power cannot significantly reduce the risk of climate change unless we commit to a *vast* global investment in the technology.[100]

To estimate the scale of the necessary investment over the next half-century, one must first answer several preliminary questions. For example, how is per capita power demand likely to grow in developed, developing, and least-developed countries? How is each country's population likely to grow during the same period? And what are the mid-century alternatives to nuclear power likely to be? In 2050 will we still rely on coal, oil, and natural gas to supply power needs that are not met by nuclear, or will other affordable alternatives exist?[101]

A 2003 interdisciplinary Massachusetts Institute of Technology study, *The Future of Nuclear Power* ("MIT Study" or "Study"), makes a credible effort to address these questions.[102] As a baseline, the authors use 2002 figures for global electricity consumption, observing that in that year, nuclear power accounted for 20% of U.S. electricity use and 17% of global use.[103] The Study then models mid-century electricity demand, using U.S. and UN predictions of annual population growth and annual per capita growth in electricity demand.[104] The resulting estimates of mid-century electricity use are staggering, ranging up to a figure 180% higher than 2000 levels.[105] Moreover, the Study's predictions for 2050 levels are relatively conservative, falling

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100. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 25. ("From a public policy perspective, the scenarios that merit analysis are either a large-scale deployment or a phase-out of nuclear power over the next half-century."); *accord* Arjun Makhijani, *Atomic Myths, Radioactive Realities: Why Nuclear Power Is a Poor Way to Meet Energy Needs*, 24 J. LAND RESOURCES & ENVTL. L. 61, 66 (2004) ("If the world continues to use oil for transportation . . . [thousands] of nuclear power plants will have to be built in the next four decades to mitigate carbon dioxide emissions."); MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 28 ("[T]he nuclear power option makes sense only if possible deployment is quite large, since no small deployment can make a significant contribution to dealing with the greenhouse gas problem. . . . Indeed it is misleading to focus on small increases in nuclear capacity justified by significant CO_2 reduction.").

101. This question is important because without some estimate of the mid-century level of greenhouse gas emissions in the *absence* of a significant nuclear industry, one cannot predict either (1) the level of emissions reductions necessary to abate global warming, or (2) the extent to which a given investment in nuclear power would produce such reductions.

102. For skeptics, it is worth noting here that the MIT study cautiously supports expansion of the nuclear sector. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 1.

103. *Id.*

104. *Id.* app. A at 109–15. The authors subdivided developing countries into three categories: more advanced (projected to achieve a benchmark electricity demand of 4000 kWh per person per year by 2050); less advanced (projected to reach "acceptable" levels of energy demand in the range of 1500–4000 kWh per person per year by 2050); and least advanced (unlikely to reach even 1000 kWh per person per year by 2050).

105. *Id.* at 115. This increase represents an annual growth rate of 2.1%. By comparison, global population is only projected to grow by about 50% in the same fifty year period. *Id.* at 115 tbl.A-2.1e. As may be obvious, growth in energy demand is projected to outstrip population growth principally because developing countries' energy demand is likely to increase rapidly as their citizens' standards of living improve.

between the U.S. Energy Information Agency's "low growth" and "business as usual" scenarios, and well below its "high growth" figures.[106]

Next, the MIT authors consider various possible growth scenarios for the nuclear power sector, from growth at a rate just sufficient to maintain nuclear power at its current share of world electricity capacity (17%), to growth sufficient to reach a market share of 25% by 2050.[107] These scenarios are not predictions; rather, they estimate the extent of deployment required for nuclear power to maintain its current market share—a baseline that the authors use to represent the minimum industry growth necessary for nuclear to play a significant role in greenhouse gas reduction efforts.[108]

These calculations lead the authors to a mid-century estimate for the nuclear industry of 1000 to 1500 gigawatts electric capacity ("GWe").[109] Several things about this range are immediately noteworthy. First, it reflects an increase of between 170% and 300% above current global nuclear capacity.[110] Second, reaching the high end of the range would require construction of more than *1100 new, large*[111] *nuclear facilities* somewhere in the world by 2050—almost twenty-five per year, or about one every two weeks.[112] Of these, the MIT authors speculate that nearly a third would be in the United States, for an average construction rate of seven to ten large facilities per year.[113] By comparison, in the heyday of nuclear power, "*worldwide* construction" of light

106. *Id.* at 110. The Energy Information Administration's scenarios end in 2020, but the curve on which the MIT Study's maximum 2050 estimate is based falls between the EIA's "reference" and "low growth" scenarios in the years 2000–2020. *See id.* at 110 fig.A-2.2. Not surprisingly, much of the predicted expansion in electricity demand is expected to occur in the developing world. *Id.* at 20.

107. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 25. The authors do not actually expect the nuclear power sector to follow any of these growth scenarios; they merely analyze the scenarios to determine what changes would facilitate the necessary sector growth. That is, they *assume* a worldwide decision to keep nuclear power at or above its current share of global power production, and analyze what political and technological changes would be necessary to make that happen.

108. One can, of course, quibble about the MIT Study's definition of "significant," but with energy demand growing at the rates predicted by the EIA and others, *see supra* note 106 and accompanying text, it seems reasonable to assert that if nuclear power is to have *any* real role to play in a climate change strategy, it must at least maintain its current market share of just under 20%.

109. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 25 tbl.3.1.

110. *Id.* at 3; *see also* INTERNATIONAL ATOMIC ENERGY AGENCY, NUCLEAR TECHNOLOGY REVIEW—UPDATE 2005 at 1 (2005), *available at* http://www.iaea.org/About/Policy/GC/GC49/Documents/gc49inf-3.pdf.

111. Large nuclear plants have a capacity of about 1 GWe. If countries chose instead to build smaller facilities, the rate of construction would have to be correspondingly higher.

112. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 25–28. Current capacity is equivalent to 366 1 GWe plants. Achieving a global capacity of 1500 GWe would therefore require construction of at least 1134 new large (1 GWe) facilities. This is an underestimate, however, because some existing plants will undoubtedly need to be replaced by mid-century.

113. *Id.* at 26 tbl.3.2. This is the rate required to build the 300 1000 MWe plants hypothesized in Table 3.2 over the course of forty years. Given that no plants are currently under construction in the United States, and many existing plants are reaching the end of their lifecycles, however, building rates toward the end of this half-century period would probably have to be considerably *higher* than ten large plants per year.

water reactors "totaled about 400 plants over 25 years, for an average of 16 plants completed per year."[114]

The MIT study is not the only one to conclude that we must build thousands of new nuclear plants in the next decades if we hope to make nuclear power a real part of our climate change solution. The president of the Institute for Energy and Environmental Research, for example, estimates that to achieve a significant reduction in mid-century carbon dioxide emissions, we would have to increase global nuclear capacity to about 2,000 GWe over the next four decades, which in turn would necessitate a plant construction rate of about fifty per year or one per week.[115] And an important recent *Science* article on climate change, which identifies policy alternatives to stabilize greenhouse gas emissions by mid-century, indicates that even if nuclear power is just one of seven strategies on which we place equal reliance, we must increase capacity by about 700 GWe by 2050 (or almost twenty new large plants each year).[116]

Finally, to drive home the point that only a truly massive investment in nuclear power will permit the industry to play a nonnegligible role in mitigating greenhouse gas emissions, it is worth emphasizing that the hypothetical deployments discussed above would fall far short of solving the climate problem. Indeed, constructing the new plants that would be necessary to reach the low end of the MIT Study's hypothetical range would avoid only about a quarter of the anticipated *growth* in anthropogenic carbon emissions between 2000 and 2050.[117]

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114. *Id.* at 49 (emphasis added).

115.

> If the world continues to use oil for transportation . . . a very large number of nuclear power plants [would] have to be built in the next four decades to mitigate carbon dioxide emissions. . . . In order to make a significant dent in CO_2 emissions, at least one-third, and perhaps one-half or more of the global growth in electricity demand must be supplied by nuclear power. In any scenario involving two percent or greater global electricity growth, the use of nuclear power will mean the construction of thousands of nuclear power plants in the next four decades. Consider for instance, an electricity growth rate of two percent, which is far less than that occurring in China and India, but more or less typical of recent U.S. trends. To make a substantial contribution to reducing greenhouse gas emissions, we might hypothesize that (i) all present day nuclear power plants will be replaced by new ones, (ii) half the electricity growth will be provided by nuclear power, and (iii) half of the world's coal-fired plants will be replaced by nuclear power plants. This would mean that about *two thousand large (1,000 megawatts each) nuclear power plants* would have to be built over the next four decades. That is a rate of about one per week.

Makhijani, *supra* note 100, at 66 (emphasis added).

116. Pacala & Socolow, *supra* note 99, at 970 tbl.1. As noted above, these authors identify policies that could stabilize *emissions* by 2050. These policies fall far short of what would be required to stabilize atmospheric *concentrations* of greenhouse gases, as will eventually be necessary to avert climate change. *See* Pielke, *supra* note 99, at 753.

117. To make this calculation, the MIT authors assume that "[d]espite the efforts to promote renewable energy options, . . . a large fraction of the incremental and replacement investments in electric generating capacity needed to balance supply and demand over the next 50 years will, in the absence of a nuclear generation option, rely on fossil-fuels." MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 37. For purposes of this discussion, the important implication of this passage is that for the

4. *Economic Incentives to Boost the Nuclear Sector*

What would it take, then, to stimulate growth of the U.S. nuclear sector at a rate far higher than that in the heyday of the industry? At the very least, regulators would have to address the dismal economics of nuclear power.

The first commercial nuclear power plant opened its doors in Shippingport, Pennsylvania, in 1957. In the next four decades, just over 100 reactors came online at sixty-five sites in thirty-one states. Since 1978, however, no new plants have been ordered and more than 100 reactor contracts have been canceled.[118] No units are currently under construction, though there are twenty-two submitted applications with the Nuclear Regulatory Commission (NRC) for licenses to build and operate thirty-three new reactors.[119] Given regulatory constraints, a potentially rate-limiting supply chain for reactor parts, and the need to train new nuclear operators, though, industry analysts predict that some new reactors will not be completed until 2020.[120] Even if these new reactors eventually come online, the industry will have seen zero growth for decades.[121] The same is true in many other countries—a $4 billion nuclear plant now facing costly construction setbacks in Finland, for example, is the first plant to be built in Europe in fifteen years.[122]

Writers on all sides of the nuclear debate agree that the principal reason for the industry's present state is the high cost of nuclear power.[123] While operating plants are generally competitive with coal- and natural gas-fired power plants, construction costs for new plants are prohibitively high.[124] Indeed, assuming moderate gas prices, the levelized cost of electricity from a *new* nuclear plant is about 60% higher than from a new coal or gas plant.[125] Although a national tax on carbon emissions would even this playing field somewhat, the tax would have to be near the upper end of the literature range

foreseeable future, it is appropriate to use fossil-fuel emission rates as a conservative baseline in calculating how additional nuclear capacity would affect greenhouse gas emissions. Painting an overly rosy picture of mid-century energy production (e.g., assuming that by 2050, 50% of U.S. electricity will be supplied by wind and solar power) would understate the necessary level of investment in nuclear.

118. Mark Holt, *Nuclear Energy Policy* 1 (Cong. Research Serv., CRS Report for Congress Order Code IB88090, Oct. 26, 2004), *available at* http://www.iags.org/CRS_IB88090.pdf.

119. Nuclear Regulatory Commission, Expected New Nuclear Power Plant Applications: Updated April 28, 2008, http://www.nrc.gov/reactors/new-licensing/new-licensing-files/expected-new-rx-applications.pdf.

120. Matthew L. Wald, *Plan to Build Reactors Is Running Into Hurdles*, N.Y. TIMES, Dec. 5, 2007, at C1.

121. The last U.S. reactor to come online (the Tennessee Valley Authority's Watts Bar reactor in Tennessee) was ordered in 1970 and licensed in 1996.

122. David Gauthier-Villars, *Trials of Nuclear Rebuilding*, WALL ST. J., Mar. 7, 2007, at A6.

123. *See, e.g.*, MARTIN CASTELLANO ET AL., UNIVERSITY OF CHICAGO, THE ECONOMIC FUTURE OF NUCLEAR POWER, at xi (2004); Holt, *supra* note 118, at 2; MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at ix; NATURAL RESOURCES DEFENSE COUNCIL, POSITION PAPER: COMMERCIAL NUCLEAR POWER 5–6 (2005), *available at* http://www.nrdc.org/nuclear/power/power.pdf.

124. *See, e.g.*, Holt, *supra* note 118, at 2; NATURAL RESOURCES DEFENSE COUNCIL, *supra* note 123, at 6.

125. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 42 tbl.5.1.

($100–200 per ton of carbon) before nuclear becomes fully cost competitive.[126] To "make early nuclear plants more competitive," therefore, researchers at the University of Chicago suggest such federal policies as "loan guarantees, accelerated depreciation, investment tax credits, and production tax credits."[127]

The Energy Policy Act of 2005[128] made some of these changes. For example, it created a $125 million per year per gigawatt tax credit for up to six gigawatts of new nuclear capacity (about six large plants) for up to eight years of operation—in other words, up to six plants could receive up to $1 billion each in production tax credits.[129] The Act also extended the Price-Anderson Act's liability indemnification provisions (and pool of funds) for another twenty years, to 2025.[130] In addition, it addressed the historic problem of regulatory delays, authorizing the Department of Energy to reimburse utilities for up to $500 million in costs related to NRC delays. Finally, the Act established a federal loan guarantee program, backing up to 80% of construction costs, to improve the odds of repayment for lenders, who have historically charged higher interest rates for nuclear plant construction loans.[131]

These and other recent changes (including higher natural gas prices), have contributed to some utilities' growing interest in building new nuclear plants.[132] As yet, however, no utilities have dedicated resources to nuclear power development at the level that would be necessary to build seven to ten new plants *per year* for the next four decades. If those numbers even approximate our goal, the billions of dollars of economic incentives provided in the Energy Policy Act fall far short of what would ultimately be necessary.

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126. *Id.* at 42.

127. *See, e.g.*, MARSHALL GOLDBERG, FEDERAL ENERGY SUBSIDIES: NOT ALL TECHNOLOGIES ARE CREATED EQUAL 3 (2000), *available at* http://www.crest.org/repp_pubs/pdf/subsidies.pdf ("From 1943 to 1999, cumulative federal government subsidies to [nuclear, wind, photovoltaic, and solar thermal electricity generating technologies] . . . totaled almost $151 billion (in 1999 dollars)," of which the "nuclear industry received $145.4 billion, or over 96 percent."); Holt, *supra* note 118, at 13, 18, 21 tbl.3 (indicating that in 2007, Congress appropriated almost $800 million to the Department of Energy for civilian nuclear power research and development, and another half a billion dollars for civilian nuclear waste disposal). Note further that these figures do not include the vast sums in indirect subsidies from nuclear research and development activities undertaken in connection with national defense.

128. Pub. L. No. 109-58, 119 Stat. 594 (Aug. 8, 2005).

129. *See* Notice 2006-40, 2006-18 I.R.B. 855 (Internal Revenue Service, implementing the credit).

130. 42 U.S.C. § 2210 (2006).

131. Holt, *supra* note 118, at 5.

132. *Id.*; *see also* NUCLEAR ENERGY INSTITUTE, U.S. NEEDS NEW NUCLEAR PLANTS TO MEET ENERGY DEMAND, MAINTAIN SUPPLY DIVERSITY (2007), *available at* http://www.nei.org/filefolder/U_S__Needs_New_Nuclear_Plants_to_Meet_Energy_Demand_Maintain_Supply_Diversity_1007.pdf; David A. Repka & Kathryn M. Sutton, *The Revival of Nuclear Power Plant Licensing*, 19 NAT. RESOURCES & ENV'T 39 (2005); Nuclear Energy Institute, New Nuclear Plants, http://www.nei.org/keyissues/newnuclearplants (last visited Mar. 3, 2008).

5. *Risks and Possible Regulatory Reforms*

Growing the nuclear sector at the MIT Study's hypothetical rate would pose significant risks. The Study authors discuss these risks in three categories: safety, proliferation, and waste.

a. *Reactor Safety*

The Three Mile Island accident in Pennsylvania and the Chernobyl disaster in the former Soviet Union highlight one of the most salient nuclear power risks—the chance of leakage from or meltdown of a reactor. Investing heavily in the nuclear sector would also raise other safety concerns, though, including the increased likelihood of either a natural disaster (for example an earthquake or flood) or a terrorist attack at a nuclear plant. Moreover, other than meltdown, none of these concerns is confined to energy-producing reactors; they extend to the various components of the nuclear fuel cycle, including fuel fabrication facilities, waste handling, storage, and disposal facilities, and, if a closed fuel cycle is used, fuel reprocessing facilities.[133]

The important risk factors, then, are (1) the likelihoods of these various disasters, and (2) their projected costs, not just in people injured or killed, but in disruption of power supplies, destruction of capital assets, and—of particular relevance to this Article about public risk perception—erosion of "public confidence in nuclear generation."[134]

Unfortunately, yet predictably, the likelihood of a nuclear disaster increases with significant expansion of the nuclear sector. Experts who have evaluated the disaster issue with probabilistic risk assessment conclude that, assuming current technology, the "best estimate of core damage frequency [is] about 1 in 10,000 reactor-years."[135] For the current U.S. fleet of about 100 reactors, this works out to a rate of about one accident per century. But a three-fold increase in nuclear capacity—what the MIT Study dubs a "global growth scenario"—would yield an expected core accident rate of four by 2055.[136] Harvard professor of earth and planetary sciences Daniel Schrag agrees with this dire prediction: "Think about a world with 10,000 nuclear reactors. . . . We have only a few hundred today. What is the probability of a big accident? It's going to happen."[137]

That likelihood only increases when one accounts for the possibility of a terrorist attack. In the United States, all licensed commercial plants are required to have a series of physical barriers and a trained security force.[138] But the Energy Policy Act of 2005 essentially admitted the inadequacy of existing

133. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 47–51.
134. *Id.* at 48.
135. *Id.*; *see also* Holt, *supra* note 118, at 13.
136. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 48.
137. Jonathan Shaw, *Fueling Our Future*, HARV. MAG., May-June 2006, at 39, 41.
138. Holt, *supra* note 118, at 15.

security procedures, requiring the NRC (1) to revise its "design basis threat" (the most severe threat for which plants must be prepared) based on estimates of terrorist threats (including suicide attacks) and the possibility of several coordinated attacks; (2) to conduct security exercises at nuclear facilities every few years; and (3) to fingerprint all nuclear facility workers.[139]

With respect to the costs of an accident, the news is more mixed. On the one hand, the U.S. nuclear industry's single true accident—Three Mile Island—caused no deaths or injuries to workers or neighboring citizens,[140] and a health study of more than 30,000 people who lived within five miles of the reactor at the time of the accident found no statistically significant increase in cancer rates (through 1998).[141] The Chernobyl accident was far more serious, killing more than thirty people within hours or days, necessitating the immediate evacuation of 116,000 people and the subsequent evacuation of an additional 230,000, and releasing "massive amounts of radioactivity into the environment."[142] Even in Chernobyl, though, the most recent United Nations health figures are more (albeit not wholly) positive:

> [T]he total number of people that could have died or could die in the future due to Chernobyl originated exposure over the lifetime of emergency workers and residents of most contaminated areas is estimated to be around 4,000. This total includes some 50 emergency workers who died of acute radiation syndrome (ARS) in 1986 and other causes in later years; 9 children who died of thyroid cancer; and an estimated 3,940 people that could die from cancer contracted as a result of radiation exposure. The latter number accounts for the 200,000 emergency and recovery operation workers from 1986–1987, 116,000 evacuees, and 270,000 residents of most contaminated areas.[143]

These are not insignificant numbers, but they are hardly shocking, particularly when compared to other relevant risks. Coal mining accidents, for example, kill seventeen miners *per day* in China[144] and almost fifty per year in the United States.[145]

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139. *Id.*

140. U.S. Nuclear Regulatory Commission, Fact Sheet on the Three Mile Island Accident (Feb 29, 2007), http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html; *see also* CHERNOBYL FORUM, CHERNOBYL'S LEGACY: HEALTH, ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS 3 (2005), *available at* http://un.by/pdf/HighlightsRecommendations+Figs-rev-acc.pdf.

141. Holt, *supra* note 118, at 7 (citing Evelyn O. Talbott et al., *Long Term Follow-Up of the Residents of the Three Mile Island Accident Area: 1979–1998*, 111 ENVTL. HEALTH PERSP. 341 (2003)). The authors of the study noted, though, that some health effects "[could] not be definitively excluded." *Id.*

142. U.S. Nuclear Regulatory Commission, Fact Sheet on the Accident at the Chernobyl Nuclear Power Plant (December 2000), http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fschernobyl.html.

143. CHERNOBYL FORUM, *supra* note 140, at 5.

144. *China Sets Coal Mine Accident Reduction Goal*, PEOPLE'S DAILY ONLINE (ENGLISH), Mar. 1, 2007, http://english.people.com.cn/200703/01/eng20070301_353481.html.

145. U.S. Dep't of Labor, Injury Trends in Mining, http://www.msha.gov/MSHAINFO/FactSheets/MSHAFCT2.HTM (last visited March 3, 2008).

Both regulators and the public naturally fear that the next nuclear accident will be more serious, release more radiation, and cause more immediate and long-term deaths. Even an accident that exacts a low public health toll imposes significant other costs. Plant loss imposes billions of dollars in upfront costs and could restrict local electrical generating capacity.[146] And perhaps more significantly, for this Article's purpose at least, a serious, widely reported accident—or even a near miss—could well derail efforts to revitalize the nuclear industry as a partial solution to climate change. As Professor Schrag puts it, "[T]he impact of Chernobyl is not measured in terms of deaths. . . . The world got scared of nuclear power."[147]

b. Proliferation

A related risk of growing the nuclear sector is the possibility that technology proliferation could lead to weapons proliferation, either because weapons-usable material is "diverted" by a subnational terrorist group, or because a nation that does not currently have nuclear weapons chooses to misuse its fuel cycle and research facilities—and its knowledgeable nuclear engineers—to produce them.[148] To date, "[s]pent fuel discharged from power reactors worldwide contains well over 1000 tonnes [(2.24 million pounds)] of plutonium. . . . With modest nuclear infrastructure, any nation could . . . [separate the plutonium with high purity] . . . at the scale needed to acquire material for several weapons."[149] Reprocessing facilities in Europe, Russia, and Japan have already accumulated about 200 tonnes (448,000 pounds) of separated plutonium—enough to build 25,000 weapons.[150]

The risks associated with this accumulation of radioactive materials are manifest—and they grow rapidly under the various plausible scenarios for mid-century nuclear plant deployment. For example, by 2050 the "developing world might plausibly account for about a third of deployed nuclear power" and "dramatic growth of nuclear power in the sub-continent could be a pathway for nuclear arsenal expansion in India and Pakistan."[151]

c. Waste

In addition to ensuring facilities' operational safety and limiting the threat of nuclear weapons proliferation, the nuclear industry must also safely dispose of the massive quantities of radioactive waste produced by existing and new facilities. To understand the Herculean nature of this task, one must first have a sense of the scope of the waste issue. According to the Department of Energy's

146. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 48.
147. Shaw, *supra* note 137, at 41.
148. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 65.
149. *Id.* at 66.
150. *Id.*
151. *Id.*

(DOE) Office of Civilian Radioactive Waste Management, as of 2005, the United States had accumulated about 53,440 tonnes (120 million pounds) of spent fuel from nuclear reactors.[152] Under current regulations, the proposed Yucca Mountain underground storage facility in Nevada could someday contain all of this waste. The Yucca Mountain facility would not come close, however, to solving the waste disposal problem for the MIT Study's proposed new plants.

> A worldwide deployment of one thousand [large reactors]...with today's fuel management characteristics would generate roughly three times as much spent fuel annually as does today's nuclear power plant fleet. If this fuel was disposed of directly, new repository storage capacity equal to the currently planned capacity of the Yucca Mountain facility would have be to created somewhere in the world roughly every three or four years. For the United States, a three-fold increase in nuclear generating capacity would create a requirement for a Yucca Mountain equivalent of storage capacity roughly every 12 years.[153]

For nuclear power simply to maintain its current share of the electricity sector over the next half-century, then, the world would have to build between eleven and fifteen new (and operational) "Yucca Mountains," and the United States would have to build about four. One need only review Yucca Mountain's pathetic history to recognize the near impossibility of this task:

1978: DOE began studying Yucca Mountain, in Nevada, to determine its suitability as the "nation's first long-term geologic repository for [the] spent nuclear fuel and high-level radioactive waste... [c]urrently stored at 126 sites around the nation."[154]

1982: Congress first directed the federal government to take responsibility for permanently disposing of the nuclear waste.[155]

1984: DOE formally identified Yucca Mountain as a potential site for a permanent geologic repository.[156]

1987: To cut down on costs and regulatory delays, Congress focused DOE's attentions exclusively on Yucca Mountain.[157]

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152. Dep't of Energy, Office of Civilian Radioactive Waste Management, How Much Nuclear Waste Is in the United States?, http://www.ocrwm.doe.gov/ym_repository/about_project/waste_explained/howmuch.shtml (last visited Mar. 24, 2008).

153. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 61.

154. Dep't of Energy, Office of Civilian Radioactive Waste Management, Yucca Mountain Repository, http://www.ocrwm.doe.gov/ym_repository/index.shtml (last visited Mar. 24, 2008).

155. Nuclear Waste Policy Act, Pub. L. No. 97-425, 96 Stat. 2201 (1982) (codified as amended at 42 U.S.C. §§ 10101–10270 (2006)).

156. Nuclear Energy Inst., Inc. v. EPA, 373 F.3d 1251, 1259 (D.C. Cir. 2004).

157. *Id.* at 1260.

2001–2002: EPA, NRC, and DOE issued health and safety standards, licensing standards, and site-suitability criteria, respectively, to govern the Yucca Mountain facility. The State of Nevada and various other groups filed suit challenging both the rules and the underlying decision to focus all federal waste disposal efforts on the Yucca Mountain site.[158]

2004: The D.C. Circuit struck down aspects of the EPA and NRC rules, holding that the agencies had no scientific basis for their use of a 10,000-year limit on radiation releases from the repository.[159] The agencies went back to the drawing board.

2005: DOE disclosed emails from geologists that made clear that some Yucca Mountain safety documents had been falsified.[160] Senator Harry Reid (D-NV) stated, "It should be obvious to everyone now that Yucca Mountain isn't going anywhere. It is abundantly clear that there is no such thing as sound science at Yucca Mountain."[161]

2006: Secretary of Energy Samuel Bodman told members of the House Appropriations Committee that construction of the Yucca Mountain repository probably would not begin until at least 2011.[162] DOE's "Best-Achievable Repository Construction Schedule" indicated that the repository could not possibly begin receiving wastes for disposal until March 31, 2017.[163]

2008: Senator James Inhofe (R-OK) introduced a bill that would establish a phased licensing regime, under which the Yucca repository would be used as a waste *storage and monitoring* (rather than disposal) facility for the next several centuries before finally being sealed.[164]

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158. *Id.* at 1260–61.

159. Specifically, the court held that the agencies had no reason to select 10,000 years rather than a longer limit that would correspond more closely to the million-year "time scale of the long-term stability of the fundamental geologic regime . . . at Yucca Mountain." *Id.* at 1267, 1315.

160. Holt, *supra* note 118, at 19.

161. Statement of Senator Harry Reid Before the Subcommittee on the Federal Workforce and Agency Organization of the United States House of Representatives Committee on Government Reform, "Yucca Mountain Project: Have Federal Employees Falsified Documents?" (Apr. 5, 2005), http://democrats.senate.gov/newsroom/record.cfm?id=236002&; *see also Yucca Mountain Project: Have Federal Employees Falsified Documents?: Hearing Before the Subcomm. on the Federal Workforce and Agency Organization of the H. Comm. on Government Reform*, 109th Cong. (Apr. 5, 2005) (Ser. No. 109-60).

162. *See* Institute for Energy & Environmental Research note 17, at 15.

163. Dep't of Energy, Office of Civilian Radioactive Waste Management, Yucca Mountain Repository: About the Project, http://www.ocrwm.doe.gov/ym_repository/about_project/index.shtml (last visited Feb. 28, 2008).

164. Nuclear Waste Policy Amendments Act of 2008, S. 2551, 110th Cong. (2008).

In sum, the federal government has had its eyes on Yucca Mountain for more than a quarter century, yet it does not plan to break ground until 2011, waste disposal will not begin until 2017 at the earliest, and even that delayed timeline remains open to debate and modification. The implications are clear. As of 2017, the Yucca project will have been in the works for forty years. Assuming consecutive implementation of each of the MIT Study's four hypothetical repositories, following a site selection, licensing, litigation, construction, and testing schedule like that of Yucca Mountain, we could expect the fourth to open its doors well after the middle of the *twenty-second* century.

d. Regulatory Reforms to Address These Risks

Given the serious safety, proliferation, and waste problems associated with deployment of new nuclear plants, it should be clear that *safe* reinvigoration of the nuclear sector requires regulatory action—and, in turn, the political will to push the necessary reforms through the relevant legislatures and agencies. This Article does not attempt to list, let alone discuss, all of the reforms that experts have proposed. A brief summary of a few waste management–related suggestions suffices to make the point on which this discussion turns—if we hope to make nuclear power a safe and significant part of our climate change strategy, we must significantly amend the regulatory landscape.

The MIT Study identifies the management and disposal of high-level radioactive waste as "one of the primary obstacles to the development of the nuclear power industry around the world."[165] The Study urges several specific regulatory changes, including (1) "replacing the current ad hoc approach to spent fuel storage with an explicit strategy to store spent fuel for a period of several decades, prior to reprocessing [or] geologic disposal"; (2) building "centralized facilities for storing spent fuel for several decades," both in the United States and internationally; (3) broadening U.S. waste-related research and development efforts to encompass approaches other than permanent geologic disposal; (4) organizationally separating the research and development program from waste management operations "to resist pressures to narrow the scope of the R&D program"; (5) upping the current per-kilowatt-hour fee charged to plant operators for waste management, both to improve the financial position of the federal waste program and to increase utilities' incentives to develop waste minimization strategies; and (6) "actively pursu[ing] closer international coordination of standards and regulations for waste transportation, storage and disposal."[166] These and other potential changes in the current regulatory regime would, in turn, pressure relevant agencies to make additional

165. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 86.
166. *Id.* at 85–87.

changes, notably including updating the accounting methods and assumptions they use to estimate the adequacy of waste-related funding.[167]

Each of these suggestions for regulatory reform may seem achievable on its face. But after close to thirty years of legal wrangling, we are still several years shy of *breaking ground* at Yucca Mountain. Imagine the political and legal battles that would likely ensue if, for example, the government announced plans to build centralized facilities equipped to store high-level waste for several decades, as the MIT Study recommends. Clearly, "support for keeping the nuclear power option open... depend[s] on convincing the public and their elected representatives that large-scale deployment can overcome" the technology's economic, safety, proliferation, and waste problems.[168]

B. We Can't Get There from Here

Are policymakers likely to be successful in making the case for a vast expansion of nuclear power? Due to the tiered structure of the nuclear power risk, the answer is probably either "no" or "only partially," and, interestingly, there are reasons why we might prefer "no."

1. Simple Failure

The first possible outcome of any effort to "sell" nuclear power to a skeptical public is outright failure.

Entrenched fears could prove resistant to even the most carefully designed education efforts. Due to the heuristics and biases discussed above, people tend to fear nuclear power more than climate change. As Gregory N. Mandel has observed, nuclear power's attributes "read like a laundry list of aggravating traits concerning risk. Th[is] technolog[y's] risks commonly are perceived to be: dread, uncontrollable, potentially catastrophic, fatal, inequitably distributed, place future generations at risk, involuntary, not observable, unknown, new, irreversible, human created, complex, and unfamiliar."[169] In short, nuclear power occupies an "extreme position[] in psychometric factor space[]."[170] The

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167. *See, e.g.*, Michael A. Mullett, *Financing for Eternity the Storage of Spent Nuclear Fuel: A Crisis of Law and Policy Precipitated by Electric Deregulation Will Face New President*, 18 PACE ENVTL. L. REV. 383, 455–56 (2001) ("[E]lectric industry restructuring may be expected to precipitate a crisis for current law and policy, the resolution of which will require significant changes in the structure and financing of the Nuclear Waste Fund.").

168. MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *supra* note 95, at 28.

169. Gregory N. Mandel, *Technology Wars: The Failure of Democratic Discourse*, 11 MICH. TELECOMM. TECH. L. REV. 117, 161 n.152 (2005).

170. Paul Slovic, *Perception of Risk*, *in* THE PERCEPTION OF RISK, *supra* note 3, at 220, 229; *see also* Wouter Poortinga, Nick Pidgeon, & Irene Lorenzoni, *Public Perceptions of Nuclear Power, Climate Change and Energy Options in Britain: Summary Findings of Survey Conducted During October and November 2005*, at 7 (School of Environmental Sciences, University of East Anglia, Understanding Risk Working Paper 06-02, 2006), *available at* http://tyndall.webapp1.uea.ac.uk/publications/energy_futures_full_report.pdf ("The general stigma, which we know is invariably attached

risks of climate change, on the other hand, are less well known and less "available" to the imagination. Historically at least, people have shown little understanding of climate-related dangers, and even less willingness to take on significant costs to avoid them.[171]

U.S. antiproliferation rhetoric only reinforces this dichotomy. Political discussion of the risk that Iran and North Korea could use nuclear power facilities for bomb development[172] heightens public fear of nuclear power. To make matters worse, experts suggest that at the scale of nuclear deployment envisioned in the MIT Study, another big nuclear accident is all but certain—and such an accident is all but certain to erase any gains in public acceptance.[173]

Thus, a large scale effort to convince the public to endorse nuclear power (whether based on the bounded rationality model or on cultural cognition) might prove a colossal waste of money. A series of memorable Katrina-like events could, of course, increase public concern about climate issues, and correspondingly increase acceptance of alternatives (possibly including nuclear power). Absent such a catastrophe, however, an education campaign may do little to reshape attitudes.[174]

2. *Partial Success*

Utter failure of a pro-nuclear campaign may be preferable to the other likely outcome of such a campaign: partial success that leaves us at a regulatory dead end, with a booming nuclear industry but without the political will to push through comprehensive safety, proliferation, and waste regulations.

We could arrive at this perhaps incongruous final position in one of two ways, each of which turns on the division of the nuclear risk into preliminary, or first-tier, risks (those associated with reactor safety) and collateral, or

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to nuclear power, remains. Many respondents think that it creates dangerous waste (84% agree or strongly agree) and is a hazard to human health (70%).").

171. Nancy Stauffer, *Climate Change Poorly Understood, Not a High Priority, Shows MIT Public Survey*, ESD REPORTS (Engineering Systems Division, Massachusetts Institute of Technology, Cambridge, Mass.), Summer 2005, http://esd.mit.edu/esd_reports/summer2005/climate_change.html; *see also* Jon Palfreman, *A Tale of Two Fears: Exploring Media Depictions of Nuclear Power and Global Warming*, 23 REV. POL'Y RES. 23, 24 (2006) (detailing the results of focus groups on nuclear power and climate change and asking, "What accounts for such widely differing public attitudes?").

172. *E.g.*, Howard LaFranchi, *Iran's Pursuit of Nuclear Power Raises Alarms*, CHRISTIAN SCI. MONITOR, Feb. 27 2007, at 1.

173. *See supra* notes 137 & 147 and accompanying text.

174. Indeed, early results of an effort to use the affirmation effect in this way have been disappointing. *See* Poortinga et al., *supra* note 170, at 1–2 ("A recent reanalysis of data linking the issues of climate change and radioactive waste from a national comparative survey and focus groups . . . shows that people do interpret nuclear energy in a different way when it is positioned alongside climate change. In effect, people in the focus groups became more ambivalent and less antagonistic about nuclear power as an energy source. *Despite this, few of our participants actively and wholeheartedly supported climate change mitigation through new nuclear build as an acceptable policy position.*" (emphasis added)).

second-tier, risks (those associated with mining, transport, processing, storage, and disposal of radioactive materials). Second-tier risks might elicit more fear, and thus more public opposition, than first-tier risks, either because these collateral risks trigger more, or more significant, perceptual biases (more dread, less well understood, etc.[175]) or because the collateral risks are politically "hotter" and more culturally divisive.[176]

For example, consider basic reactor safety (first-tier), on the one hand, and waste risks (second-tier), on the other. We are used to seeing reactors on our city skylines; they have good safety records, at least in recent years; their technology is reasonably well understood and familiar; and 103 existing facilities spread around the nation already supply close to 20% of our power. In contrast, waste handling facilities present new and less well understood risks; they use unfamiliar technologies; and the waste goes in tanks, pools, or underground, where we cannot see it and reassure ourselves of its continued containment. The theory therefore suggests that people may prove more fearful of waste-related issues than of reactors themselves.[177]

John Weingart offers a stark account of the depth of public fear of radioactive waste sites. Director of New Jersey's Low-Level Radioactive Waste Disposal Facility Siting Board in the 1990's, Weingart tried to find a New Jersey community willing to host a radioactive waste facility for *low-level* waste (that is, lightly contaminated waste from medical facilities and other sources, which is typically far less dangerous than that from nuclear power operations[178]). At first, Weingart was optimistic about his chances of success. But when it came time to accept such a facility in their "backyards," people simply could not let go of their fears.

> At the Siting Board's open houses, people would invent scenarios and then dare Board members and staff to say they were impossible. A person would ask, "What would happen if a plane crashed into a concrete bunker filled with radioactive waste and exploded?" We would explain that while the plane and its contents might explode, nothing in the disposal facility could. And they would say, "But what if explosives had mistakenly been disposed of, and the monitoring devices at the facility had malfunctioned so they weren't noticed?" We would head down the road of saying that this was an extremely unlikely set of events. And they would say, "Well, it could happen, couldn't it?[179]

175. *See supra* Part II.B.1–.2.

176. *See supra* Part II.B.2.–.3. Poortinga et al.'s results tend to support this dichotomy, albeit weakly: in a comprehensive empirical survey of British public opinion on future energy options for the United Kingdom, they found that 84 percent of respondents feared nuclear power's waste products, while only 70 percent feared the technology itself. Poortinga et al., *supra* note 170, at 7.

177. *See supra* notes 44–48 and accompanying text.

178. *See* U.S. Nuclear Regulatory Commission, Low-Level Waste, http://www.nrc.gov/waste/low-level-waste.html (last visited Feb 26, 2008).

179. JOHN WEINGART, WASTE IS A TERRIBLE THING TO MIND: RISK, RADIATION, AND DISTRUST OF GOVERNMENT 362 (2001).

It is at least possible, then, that the public will feel a little better about new reactors than about the new waste storage, processing, and disposal facilities that those reactors necessitate. As a result, a majority could learn to accept reactor construction but continue to fight necessary collateral actions like siting, construction, and operation of waste storage and disposal facilities. Our present situation affords an example of the public's ability to hold such seemingly incongruous beliefs. We now *have* an operating (if somewhat stagnant) nuclear industry that supplies close to 20% of our power, yet we have fought tooth and nail, thus far successfully, against development of a permanent radioactive waste disposal facility. There are very real problems with the Yucca Mountain site, but nothing about that battle suggests that a more geologically appropriate site choice would have ensured a less contentious licensing process.

The current situation in France provides further evidence that people can hold tight to seemingly incompatible views about nuclear power and its collateral risks. There, nuclear energy makes up more than 75% of the electric power sector, and the public largely supports the industry.[180] When it came time to develop a waste facility, however, people balked. There were widespread demonstrations and even riots. And the problem has yet to be solved.[181]

The second, even more intractable impact of the tiered structure of the nuclear power risk is only relevant under the cultural cognition model. As noted above,[182] cultural cognition theorists suggest that it may be possible to overcome public opposition to a particular policy choice by structuring policy proposals to affirm multiple groups' worldviews simultaneously. According to this idea, policymakers could potentially make headway in the nuclear debate by expressly pushing nuclear power as part of the country's response to climate change. By affirming individualists' and hierarchists' positive views of nuclear power, this approach could reduce such individuals' "political[]" and "cognitive[] . . . resistance . . . to the proposition that global warming is a problem after all."[183] At the same time, "when egalitarians and solidarists are

180. One possible explanation for this support is that the French are somewhat more hierarchical than Americans, and hence more willing to believe assurances from their leaders that nuclear power is safe. Jon Palfreman, *Why the French Like Nuclear Energy*, FRONTLINE, July 13 2006, http://www.pbs.org/wgbh/pages/frontline/shows/reaction/readings/french.html ("[S]cientists and engineers have a much higher status in France than in America. Many high ranking civil servants and government officials trained as scientists and engineers (rather than lawyers, as in the United States), and, unlike in the U.S. . . . these technocrats form a special elite.").

181. *Id.* ("Things were going very well until the late 80s when another nuclear issue surfaced that threatened to derail their very successful program: nuclear waste. . . . The same rural regions that had actively lobbied to become nuclear power plant sites were openly hostile to the idea of being selected as France's nuclear waste dump. . . . There were riots.").

182. *See supra* note 27 and accompanying text.

183. Kahan & Braman, *Cultural Cognition*, *supra* note 14, at 169.

exposed to the same information, they are likely to perceive nuclear power to be less dangerous."[184]

The fly in the ointment is that the resulting coalition is likely to support one thing and one thing only: market-based incentives for more nuclear power development. Individualists and hierarchists are unlikely to support the necessary top-down regulatory controls for the second-tier risks of the uranium fuel cycle. Why would they? The impetus for their support of the sector is their positive views of nuclear power; nothing about the affirmation effect seems likely to increase their *concern* about nuclear power's side effects. Moreover individualists and hierarchists are predisposed to favor market-based solutions to social problems, making them that much less likely to recognize a need for command-and-control waste- or proliferation-related reforms. Thus, while it may be possible to build a coalition to support industry-stimulating government programs, that coalition is all but doomed to be unstable when confronted with nuclear power's collateral risks.

In conclusion, then, both the bounded rationality and cultural cognition models suggest that a public education campaign about the "nuclear option" could overcome opposition to nuclear sector growth, but could well fail to build adequate support for second-tier command-and-control regimes. For all the reasons discussed above (risks related to reactor safety, nuclear weapons proliferation and radioactive materials), significant sector growth is only safe if there is parallel regulatory progress on all levels. Thus, depending on the relative sizes of the climate change and nuclear power risks, idiosyncratic public support for the nuclear sector could actually prove *harmful*, leaving us worse off than under the status quo.

IV. LESSONS FROM THE NUCLEAR POWER DEBATE

The debate about the role of nuclear power in our climate change strategy is concededly unique, pitting risks about which the public has sticky attitudes against risks that are diffuse, scientifically complex, and virtually impossible to quantify with any certainty. Nevertheless, the conclusions of Part III have broad application both within and outside the risk context.

First, as Sunstein and others have noted, some risks are "hot."[185] Risks may be hot (1) because people have strong affective responses to them, solidified by recent newspaper accounts, and made partisan by effects like group polarization and normative bias; or instead (2) because the risks trigger cultural or political biases. Regardless of the root cause, however, perceptions about hot risks will prove resilient to most and perhaps all efforts to shift public opinion. In particular, it may not be possible to shift opinions about a hot risk (nuclear) by making dire predictions about a "cooler" one (climate change). This is not a surprising observation, but it is worth noting, if only to temper the

184. *Id.* at 170.

185. Sunstein, *Misfearing*, *supra* note 6, at 1115.

enthusiasm of those who blithely assume that the choice to reinvigorate the nuclear industry in response to climate change is one that regulators can make without considering public opinion.

The more interesting lesson from the nuclear power debate concerns the structure of risks. Many risks involve tradeoffs—as Sunstein puts it, "There are risks on all sides of social situations."[186] Addressing the most obvious "first" risk, then, will almost always create, expose, or augment some related or derivative risk. When the underlying risk layers are of the same nature as the first, there is reason to hope that both expert and lay risk assessors will reach some reasonable middle ground, recognizing and accepting the need to balance regulatory responses to achieve a sensible overall policy. Thus, for example, when air bags turned out to *cause* some deaths in car accidents, regulators were quick to realize that some people (infants in car seats and small children) should be discouraged from sitting in a seat "protected" by an air bag.[187] For these people, the derivative risks of the first order regulatory change (requiring airbags) proved greater than the hazard that regulation sought to correct. But because the first- and second-tier problems were similar in kind—injuries and deaths in car accidents—there was little disagreement about the proper solution: scale back the notion that *all* passengers should be protected by airbags. Instead, passengers of the right size and weight should be protected *by* airbags, while others should be protected *from* air bags.[188]

In contrast, when the first and second risk layers differ in kind (differently certain, differently controllable, differently catastrophic, triggering different normative biases, and even receiving different news coverage) there is every reason to be concerned that first-tier action will lead directly to a peculiar form of regulatory dead end—in mathematical terms, a local minimum. As discussed above, for instance, action to stimulate the nuclear industry could well lead to development of second-tier risks that trigger different public reactions. In turn, these second-tier risks could prove more intractable than the initial regulatory dilemma, leaving us frozen in a regulatory position that few would have chosen at the outset.

There is a cultural aspect to this phenomenon as well. As noted in the nuclear context, the self-affirmation effect suggests that a regulatory regime designed to provide "something for everyone" can garner support from a surprising coalition of people. Again, however, there is a problem. The coalition that learned to support the first-tier regulation could well prove unstable in the face of the second-tier risks. In this case, the proximate cause of the change in majority view would not be a change in the nature of the risk (differently dread) but a change in the form of the available policy approaches

186. SUNSTEIN, LAWS OF FEAR, *supra* note 7, at 4.

187. *See, e.g.*, Federal Motor Vehicle Safety Standards; Occupant Crash Protection, 65 Fed. Reg. 30,680, 30,681–82 (May 12, 2000) (to be codified at 49 C.F.R. pts. 552, 571, 585, 595) (describing behavioral and technological changes that have reduced air bag fatalities).

188. *Id.*

(command-and-control regulation, say, rather than market incentives). Regardless of the mechanism, though, the end result is the same. Regulators who design a first-tier regulatory regime to attract the support of a diverse majority of voters could find themselves confronting equally or more hazardous second-tier risks without the benefit of that public support.

Path dependence of this kind is ubiquitous. In 1966, for example, Alfred E. Kahn suggested the following hypothetical. Suppose, in 1880, "some being from outer space" had proposed a new "means of transportation that could... permit you to travel about, alone or in small groups, at 60 to 80 miles an hour" at a price of 40,000 lives per year.[189] In Kahn's view, we would have found this proposal profoundly unappealing.[190] Yet we "reached the same result gradually, unwittingly."[191] Each car purchase made the next one cheaper, easier, more appealing, and eventually more necessary, as people relied on the ubiquity of cars in making decisions about where to work and to live. At few points along this trajectory did we look back to ask whether society, as a whole, was moving in a useful direction.

Kahn does not discuss this problem in terms of risk perception, but it can be recast in that light. The first-tier risks of the automobile were relatively certain and controllable—not particularly dread, raising few cultural red flags. Each individual could choose whether to drive a car, few people recognized the pollution costs,[192] and accidents were fewer and less catastrophic. In short, there were few fear-triggers, so people could support development of the industry. With each generation of the automobile age, however, the risks shifted subtly, until now we find ourselves confronted by automobiles that exact enormous public health tolls and, worse, exacerbate oil dependence, local and regional pollution, and atmospheric carbon loading.

These second-tier automobile risks are different in kind, both from the first-tier risks and from each other. We may not fear cars' immediate public health hazards as much as they warrant, but we do fear them. We call to mind injured friends and relatives and see news reports of multi-car pileups, and our resulting fear leads us to support some level of costly regulation to address these risks (traffic signals, speed limits, side impact bars, seat belts). As a society, we are somewhat more agnostic about local and regional air pollution, which has less obviously catastrophic effects—we fear it enough to support better catalytic converters, but not enough to support regulations that would reduce miles traveled (carpooling requirements, walking streets and intercept parking, dollars to public transportation rather than road construction). And we

189. Alfred E. Kahn, *The Tyranny of Small Decisions: Market Failures, Imperfections, and the Limits of Economics*, 19 KYKLOS: INT'L REV. SOC. SCI. 29–30 (1966).

190. *Id.* at 30.

191. *Id.*

192. Indeed, cars *solved* the local pollution problem of horse manure on city streets. Stephen J. Dubner & Steven D. Levitt, *Freakonomics: Dog-Waste Management*, N.Y. TIMES, Oct. 2, 2005, § 6 at 32.

are so complacent about the risks of climate change that we ask, in all seriousness, whether carbon dioxide from cars and other sources should be considered an air pollutant.[193] Overall, then, society's differing attitudes toward the different layers of automobile risks have produced a largely incoherent regulatory regime that does next to nothing to protect us from some of the most significant automobile hazards.

The automobile example hinges on the triggering of different perceptual biases at different steps along the regulatory chain, but examples of the related problem of coalition instability abound as well. For instance, different cultural attitudes toward drug use (widely derogated) and urban blight (of greater concern to egalitarians and solidarists than to others) have left us with a national drug policy that cracks down on users and dealers without addressing any of the social ills created by a policy of imprisonment.[194] Very similar dynamics led to the deinstitutionalization of many mentally and physically handicapped individuals, and the subsequent failure to construct the residential group homes that were supposed to replace large institutions.[195] Analogously, the coalitions that champion state abortion restrictions sometimes break down when they are asked to support second-tier reforms like improved counseling for pregnant women, streamlined adoption procedures, and social and economic support networks for single mothers.[196] And similar coalition instability helps to explain why political parties that must pander to multiple interest groups to win elections subsequently have difficulty governing.[197]

In short, multilayered regulatory dilemmas are common, and local "regulatory minima"—undesirable policy dead ends from which policymakers

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193. Massachusetts v. EPA, 127 S. Ct. 1438 (2007).

194. *See* Erik Luna, *Drug Exceptionalism*, 47 VILLANOVA L. REV. 753, 796 (2002) ("[T]he brunt of [drug-war] violence is shouldered by those who are least able to bear the costs: poor, largely urban and minority communities. . . . With the flight of human and financial capital away from urban blight, these communities are left totally devastated by the drug war.").

195. Kevin J. Zanner, *Dispersion Requirements for the Siting of Group Homes: Reconciling New York's Padavan Law with the Fair Housing Amendments Act of 1988*, 44 BUFFALO L. REV. 249, 249 (1996) (noting that "[m]unicipalities and siting agencies have struggled to integrate these individuals into residential communities, often encountering the familiar cry of 'not in my backyard'").

196. *See, e.g.*, Nadine Strossen, *Women's Rights under Siege*, 73 N.D. L. REV. 207, 228 (1997) ("[T]he 'Contract with the American Family,' and many members of Congress who support[ed] it, [sought to deny] low-income women . . . any funding for abortions, even if their pregnancies resulted from rape or incest. . . . Ironically, though, under the welfare 'reform' proposals supported by some of the very same organizations and individuals, many poor women are denied any funding for the babies to whom they give birth."). *But see* Kahan & Braman, *Cultural Cognition*, *supra* note 14 at 168 (suggesting that in France, the affirmation effect resulted in the success of some first- *and second*-tier efforts to address unwanted pregnancies).

197. *See, e.g.*, Ryan Sager, *Purple Mountains: Could the interior West—long seen as an archetypal red region—be turning blue? The fate of the Republican Party may hinge on the answer*, ATLANTIC MONTHLY, July-August 2006, at 37, *available at* http://www.theatlantic.com/doc/200607/purple-west ("[A]s the South has become central to Republican Party strategy, its particular flavor of social conservatism, moral certitude, and activist government has infused the national party's character. This is slowly alienating the other major bloc in the Republican coalition: small-government conservatives, especially those who value individual liberty most highly.").

cannot emerge because the political dynamics changed unexpectedly between the first and second tiers of the regulatory effort—are ubiquitous. The problem has particular import in the risk context, though, because risk perception theorists are actively trying to use behavioral psychology insights to sway public opinion. In this context, it is especially important to consider the consequences of any such education strategy. Failure to do so could produce an entrenched and irrational regulatory policy that addresses first-tier risks but leaves us threatened by equally or more serious second-tier risks that defy regulatory solution.

CONCLUSION

Public risk perceptions could play an important role in the eventual resolution of the debate about whether to build hundreds or thousands of new nuclear power plants in response to climate change. The public's antipathy for all things nuclear could defeat any effort either (1) to persuade former opponents to support growth of the nuclear sector, or (2) to build a coalition of odd bedfellows willing—each for their own reasons, and some reluctantly—to agree to that growth. Alternatively, such an effort could have mixed results, increasing public support for a first round of market-based regulatory changes to facilitate sector growth (for example, tax credits and liability guarantees), but failing to shift opinion about the command-and-control regulations necessary to address second-tier risks, including those associated with radioactive waste transport, processing, and storage. The latter scenario would deposit us at the closed end of a regulatory blind alley, unable to revoke new power plant licenses, but also unable satisfactorily to address their collateral safety and public health risks.

This last unexpected and unfortunate outcome results from a little-discussed attribute of the regulatory process: regulating risk is a tiered exercise. Often, an unintended consequence of the first set of regulatory changes is the exposure or augmentation of *new* risks that require their own round of regulatory solution. The likelihood that policymakers will be successful in addressing each of these new risks hinges, in part, on public support for a regulatory solution. And such public support depends on the nature of the risk (is it particularly dread?) and on the nature of the required solution (appropriate for a market-based approach or better suited to command-and-control regulation?).

This wedding cake or onion peel view of risk and regulation has important implications for those who would use behavioral psychology insights to shift public opinion about existing risks. In brief, watch what you wish for. That such an approach could fail altogether turns out to be the good news. Far worse is partial success, which can build support for first-tier regulatory reforms that expose or augment equally or more serious second-tier risks less amenable to regulatory solutions.