

2006

Uncertainty, climate change and nuclear power

David M. Hassenzahl

University of Nevada, Las Vegas, david.hassenzahl@unlv.edu

Follow this and additional works at: https://digitalscholarship.unlv.edu/sea_fac_articles

 Part of the [Climate Commons](#), [Environmental Policy Commons](#), [Oil, Gas, and Energy Commons](#), [Policy Design, Analysis, and Evaluation Commons](#), and the [Public Policy Commons](#)

Repository Citation

Hassenzahl, D. M. (2006). Uncertainty, climate change and nuclear power. *2006 IEEE International Symposium on Technology and Society* 1-3. Institute of Electrical and Electronics Engineers.
<http://dx.doi.org/10.1109/ISTAS.2006.4375885>

This Article is brought to you for free and open access by the School of Public Policy and Leadership at Digital Scholarship@UNLV. It has been accepted for inclusion in Public Policy and Leadership Faculty Publications by an authorized administrator of Digital Scholarship@UNLV. For more information, please contact digitalscholarship@unlv.edu.

Uncertainty, Climate Change and Nuclear Power

David M. Hassenzahl, Ph.D.
Department of Environmental Studies
University of Nevada, Las Vegas
Las Vegas NV 89154-4030
david.hassenzahl@unlv.edu

Abstract

Long time-horizon environmental risks with potential for global impacts have increased in visibility over the past several decades. Such issues as climate change, the nuclear fuel cycle, persistent synthetic chemicals, and stratospheric ozone depletion share some characteristics, including intergenerational impacts, strongly decoupled incidence of risks and benefits, substantial decision stakes and extreme uncertainty. What is not well understood are the similarities and differences among sources and implications of uncertainty among these global environmental threats, especially those associated with current and future human behavior. This describes the uncertainties associated with managing two global concerns: the nuclear (fission) fuel cycle and anthropogenic climate change. It finds that the two issues share some common uncertainties, some highly differentiated uncertainties and some interdependent uncertainty. It argues that these uncertainties preclude simple conclusions about the tradeoffs between risks from anthropogenic climate change and those from nuclear power. It concludes that a framework that treats uncertainty as an aspect of management, not as an analytical challenge, will both improve options for effective policy making and provide direction for useful (from a policy perspective) future research.

1. Introduction

This year we celebrate the remarkable advances in physics made by Albert Einstein¹. However, one point that arguably links Einstein more with classical physicists than with the physics he inspired is represented by his famous claim that “God does not play dice with the universe.” His contemporary and intellectual sparring partner Neils Bohr observed that it is not just the case that we cannot predict such things as the direction of a nuclear decay; rather, such things are irreducibly uncertain. They cannot be known.

Recently, Kennedy [2] presented an increasingly familiar argument: in making decisions about risks with

potential global-scale consequences, we should engage in risk-benefit tradeoff assessment at an appropriate scale. Kennedy took particular issue with social decisions about risks and benefits of nuclear power that do not address potential tradeoffs with the climate change potential of power from fossil fuels. However, recent research [3, 4, 5] suggests that uncertainty is likely to overwhelm meaningful differentiations based strictly on risks and benefits.

Further, both of these topics require informed actions at the individual, group, cultural and governmental levels and involve effects that span not only multiple generations, but possibly multiple civilizations. Consequently, relying on one peculiar deterministic tool—risk-risk tradeoff—is unlikely to result in a credible short-term solution. Further, making deterministic decisions in the face of extreme uncertainty could easily preclude future dominant options. This leads to the question: what if we treat uncertainty a central aspect of decisions, rather than as an analytical limitation?

Among Kennedy’s claims is that “when society makes a decision...it is usually based on a comparison of risks and benefits.” This claim is problematic—while considered by some to be a desirable decision rule, it is not clear that society does or can apply such a rule, whether formally or informally. Further, to the extent that Kennedy’s claim holds, it can only hold when we can reasonably predict optimum choices between various risks. This is not the case for nuclear power and climate change.

The extreme uncertainty associated with risks and benefits of nuclear power and global climate change preclude an optimizing calculation. Indeed, under certain assumptions about uncertainty, a risk-benefit tradeoff decision based on some set of calculated values would be less desirable than what we might expect from a random decision. This does not mean, however, that the historically *ad hoc* and disaggregated approach to nuclear energy and climate change policy should continue. In its place, an adaptive management approach that formally accounts for uncertainty will optimize the chances of not precluding the optimum decision. Such an approach seeks expected value decisions only when there is a high probability that they will occur, and otherwise a) avoids worst-case scenarios and b) maximizes alternatives.

¹ This paragraph draws heavily on [1]

2. Uncertainty: Similarities, Differences, Overlap

Nuclear power and anthropogenic climate change are among the most intractable of public decision arenas. Both are “transcientific” in the sense envisioned by Weinberg [6], where questions can be asked of science but not answered by science. We cannot directly test, nor even come close to testing the hypotheses we’re most interested in. For example, to test the hypothesis that a 1% annual increase in global CO₂ will increase global temperatures by 1 C over a 50 year period would require running one set of earths at fixed CO₂ and another set at a 1% annual increase. Similarly, questions about the frequency of future radiation releases along the nuclear fuel cycle, and about the potency of low doses of that radiation, cannot be directly assessed.

Nuclear power and anthropogenic climate change have some similar sources of uncertainty, some common sources of uncertainty, some different sources of uncertainty, and some imbalanced sources of uncertainty. In both cases, decisions will be made long before the outcomes will be known with any degree of certainty, expected incidence of impacts increases with time, multiple and interacting disciplines contribute knowledge, and decision stakes are extremely high. Both require long-term energy use and price forecasting.

However, while both will have global impacts, the individual negative impacts of nuclear power will be more local than those of climate change. Also, while both areas require interdisciplinary inputs, both have evolved distinct practices of analysis and communication. Perhaps more important, the trans-generational incidence of costs and benefits is inverted: costs of climate change abatement will be immediate with benefits accruing to future generations. In contrast, the benefits of nuclear power are immediate, while potential costs are spread among current and future generations. The following section expands on each of these similarities and differences.

As noted above, the nature of these two areas precludes direct examination. One consequence of this is the need for contributions from diverse disciplines, with different and sometimes conflicting analytical norms. It is clear from cases of high uncertainty but more localized context, disciplinary conflict can create or highlight uncertainty. For example when the Congress reauthorized the Clean Air Act, epidemiologists and toxicologists suggested very different conclusions about the potency of various particles [7]. Similarly, as the California Department of Health Services developed rules for exposure to electromagnetic fields (EMF’s) from high voltage power lines, historically vitriolic disputes among epidemiologists, toxicologists and physicists undermined efforts to generate useful and credible information [8].

Many decision rules—especially the types of decision rules that we are comfortable with—treat uncertainty as a component of analysis. In this context, uncertainty is usually seen as a shortcoming or limitation of analysis. Often, decisions appear to assume that a) uncertainty will

get smaller as we develop more information and b) that we should expect the tightened uncertainty bars to converge on some central point in the uncertainty range. Alternatively, some upper or lower values is selected as a sort of “hedge” against uncertainty [9, 10]. Indeed, this is another form of behavioral uncertainty: we don’t understand well how decision makers, nor even experts, interpret uncertainty.

Thinking of uncertainty, especially the extreme and long-term uncertainty associated with climate change and nuclear power, as part of the management process, may lead to more salutary decisions. Where uncertainty as a limitation leads to deterministic decisions, uncertainty as a decision component leads to adaptive management. Rather than seeking to minimize, adjust for or avoid uncertainty, we can make decisions that allow flexibility in the face of new information.

In the case of nuclear waste disposal, the US is currently committed to making a decision based on deterministic technical modeling over a time frame (one million years) over which uncertainty in the technical models is utterly obscured by uncertainty about human conditions. Analyses that attach some minimal flexibility to our current and future states of knowledge suggest considerably different dominant solutions than those we are currently pursuing[11]. We should expect similar results to follow application of adaptive management methods to other highly uncertain risks.

Clearly, disciplinary conflict has long been documented in both the nuclear power and anthropogenic climate change debates. However, the academic and policy community have pay insufficient attention to remedies for this sort of conflict. This failure has allowed conflicts of varying degrees of credibility to fester—for example, there is reasonable debate about the chronic impacts of small doses of ionizing radiation, while there may be unreasonable debate about the expected failure rate of containers destined for Yucca Mountain. Treating expert conflict as a type of uncertainty, and developing communicative tools for managing this uncertainty, is a critical step.

Another uncertainty that the two issues have in common is that impacts will be incident on far future generations. In traditional risk-benefit analysis, with discounting over multiple generations, effects beyond 50 or so years—and certainly by 100 years—will have negligible value in current dollars. The ethics of discounting over such time periods has been the subject of extensive debate [12]. Less well explored, however, is our ability to predict the nature of human behavior and interactions in 200 years, much less the 10,000 or 1,000,000 years we associate with the nuclear waste debate.

3. Predicting Human Behavior

Predictions made in the 1970’s about “by the end of the century” energy predictions probably tell us more about the 1970’s than they do about today [13]. However, we are still operating within the same cultural milieu as we were

then—with some of the same energy analysts or their students still at work. This should give us pause as we think about our predictions for energy demand in, say, 2050. Hubris would have us believe that we have learned from past mistakes and now can predict well [14]. Humility, however, should lead us to expect that our estimates will be wrong, even if this does not give us a sense of how they will be wrong nor how wrong they will be. Our response should be to think about energy futures in flexible terms that will preclude large mistakes and maximize better choices.

Current studies in human behavior suggest how uncertain we are even about decision making and preferences of ourselves and our contemporaries. Gilbert [15] observes that we chronically overestimate how bad potential negative scenarios will be, and how good positive scenarios will be. Traditional deterministic assumptions of economists do not appear to hold for individuals under a wide range of conditions. Economists continue to believe that this represents an analytical shortcoming, while post-modernists find the fault in economic assumptions.

Uncertainty about human behavior goes well beyond the individual. Asimov [16] once envisioned psychohistory—wherein Harry Seldon used computers and data to predict human society into a distant future. It is now clear that sociological prediction is closer to Bohr's world than it is to Einstein's: we cannot reasonably predict individuals in 2007, society in 2050, civilization in 2200.

Our best approach for making effective decisions—assuming that it matters to us that far future generations have a strong set of options—is to leave open the best choices not just for a future society like ours but for future civilizations unlike ours. Risk – benefit tradeoffs may not be part of the traditions in that future, even if we design for them now. Adaptive management, broadly conceived, will almost certainly lead to more robust choices on not just nuclear power and climate change but emerging diseases, water resources planning, and other highly important, highly uncertain issues.

4. Acknowledgements

The author thanks Rob Goble for extensive comments and the National Science Foundation Human and Social Dimensions directorate for support.

5. References

- [1] Peat, F. David (2006). *From Certainty to Uncertainty: The Story of Science and Ideas in the Twentieth Century*. Joseph Henry Press, NY NY.
- [2] Kennedy, D. (2005). "Editorial: Risks and risks." *Science* 309: 2137.
- [3] Hassenzahl, D. M. (2006). "Implications of Excessive Precision for Risk Comparisons: Lessons from the Past Four Decades." *Risk Analysis* 26(1): 265 – 276
- [4] Hassenzahl, D. M. (2005). "The effect of uncertainty on 'risk rationalizing' decisions." *Journal of Risk Research* 8(2), 119 – 138.
- [5] Heinzerling, L. (2002) Five-Hundred Life-Saving Interventions and Their Misuse in the Debate over Regulatory Reform. *Risk: Health, Safety and Environment* 13(1/2): 151-175.
- [6] Weinberg, A. (1972). "Science and Trans-Science." *Minerva*, **10**, 209-221
- [7] Ross, H. (2000). *The Search for an Intelligible Principle: Setting Air Quality Standards Under the Clean Air Act. Resources for the Future* Washington DC.
- [8] Hassenzahl, D. M., Kammen, D. M., Goble, R. L., Hattis, D. B. (1998). "Can risk assessments conclude that there is no risk?" Paper and presentation for the *Society for Risk Analysis* Annual Meeting (6-9 December, 1998, Phoenix, Arizona).
- [9] Hammitt, J. (1990) *Probability is all we have*. New York, Garland Publishing.
- [10] Finkel, A. M. (1989) Is Risk Assessment really too conservative? revising the revisionists. *Columbia Journal of Environmental Law* 14: 427-467.
- [11] Keeney, Ralph A. and von Winterfeldt, Detlof (1994). "Managing nuclear waste from power plants." *Risk Analysis* 14(1) 107 – 130.
- [12] Dasgupta, P. and Maler, K-G. (1994). *Poverty, Institutions, and the Environmental-Resource Base*. World Bank environment paper no. 9. Washington, DC: The World Bank.
- [13] Nordhaus, W. D. (1994). Expert opinion on Climate Change. *American Scientist* 82: 45 – 51.
- [14] Perrow, Charles (1999). *Normal Accidents: Living with High-Risk Technologies*. Princeton University Press, Princeton NJ.
- [15] Gilbert, Daniel (2006). *Stumbling on Happiness*. Knopf, NY NY.
- [16] Asimov, Isaac (1951). *Foundation*. Gnome Press