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Risk Assessment and Expertise in Perception of Energy Sources

In the second half of the 1970s a general understanding seemed to emerge in America that nuclear power was an unsafe means of producing energy. After the 1970s no new nuclear power plants were ordered in the United States.[1] Despite the fact that more people were coming to understand that coal-fired power plants released toxic chemicals and potentially harmful quantities of carbon dioxide into the environment, support for nuclear power dwindled. Possibly the most basic method of assessing the dangers posed by a given technology looks at the expected value of negative side effects by taking into account only the likelihood of an event and its severity. According to this sort of analysis, nuclear power did not seem to pose an unacceptable amount of danger. Public opinion did not align with probabilistic risk assessment, however, indicating that something deeper was going on. Another method for understanding public acceptance of different types of risk looks at the nature of the negative impacts of each technology: who is affected, how much control they have over the risk and whether the consequences of the risk are observable.[2] This offered more leverage, but when applied to concern about climate change, it seem to leave something out.

There may, however, be other factors that explain the strong negative sentiment that some feel against nuclear power and the decades spent ignoring risks posed by conventional energy production. The goal of this paper is to examine the causes of nuclear fear and to examine the mechanisms that influence risk perception of other energy sources and of nuclear power in other times. In the United States, concern about nuclear power seems to be characterized by five elements, in addition to academic risk assessment. First, there are large *asymmetries of information* between technologists and the public. Coal-burning power plants have an easily understood heritage in the most primitive human energy sources. Nuclear energy, on the other hand, is deeply foreign to most people. Second, information asymmetries can be

[1] Department of Energy, Energy Information Agency. http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nuclearpower.html While there were plants approved through the end of the 1970s, most plans were cancelled. The last plant to come online was in approved in 1973 and began operation in 1996. Herbst, Alan M. and George W. Hopley. *Nuclear Energy Now.* (Hoboken, New Jersey: John Wiley & Sons, Inc., 2007) p. 36

[2] Slovic, Paul. "Perceptions of Risk" *Science.* Vol. 236, No. 4799 (April 17, 1987), pp 280-285 Slovic discusses many factors that affect popular perceptions of risk.

exacerbated by *the relationship between technologists and the public* and feelings of politicization. *Temporal trends* of technological perception define a third factor. In the United States, belief in science and technology seem to be cyclical. Literature on the rejection of nuclear energy in the late 1970s suggests a high level of societal distrust of science and technology in general, as compared to the decades before or after. An analysis of public trust in science in the 1990s and early 2000s, a period in which feelings about nuclear energy have softened somewhat also reflects more scientific optimism. Finally, the fourth factor is how the specific characteristics of a technology illicit *disgust or dread* in a way that makes the risk seem larger.[3] All these factors are relevant in determining how people respond to nuclear power in different times and places, and can be applied to another new major risk: catastrophic climate change.

In the sections that follow I will address how public risk perceptions of two sources of electricity, nuclear power, and coal, changed over three decades. I look at the second half of the 1970s, before the disaster at Three Mile Island, which shocked the world, and also at the current time period where levels of concern about nuclear and coal power seem to have traded places. As a side not I will also look at public attitudes towards nuclear power in France in the 1970s in an effort to demonstrate how nuclear power can be accepted without the fear of climate change.

<u>The First Era: Leading Up to TMI in 1979</u>

Nuclear Power in the late 1970s

Nuclear power is a source of electricity that is linked to real health and safety concerns. First created in the later half of the twentieth century, nuclear power underwent major scientific analysis to demonstrate safety. Unlike coal-burning power plants, nuclear power is based on advanced technology that is unfamiliar to the average citizen. For scientists nuclear power promised cleaner, cheaper energy than traditional fossil fuels. Painstaking analysis suggested the nuclear power was safe and so engineers moved forward with plant construction. Science focused on probabilistic risk assessment and event tree analysis, methods of assessment requiring intense technical training and detailed understanding of the most mundane details of power plant construction and use. The five factors laid out above, asymmetries of information; the public's

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[3] Stern, Jessica. "Dreaded Risks and the Control of Biological Weapons" *International Security*. Vol. 27, No. 3. (2002/3)

relationship with technologists/technocrats; temporal tends in support for science and technology; and perceptions of dread, are all important for understanding why the public reacted so strongly to nuclear power.

Asymmetric information between scientists and the public made some people uncomfortable about moving forward with nuclear power. Many citizens viewed nuclear energy suspiciously because it was unfamiliar and unproven. Not only was nuclear energy itself new, the risk analysis itself was also based on new technology. The risks posed by nuclear power was so new, the probabilities in question were so low, and the disasters so terrible, that risk assessment could not be based on empirical observation of the past, but rather had to be based on complex mathematical and scientific calculations.[4] People could not give informed consent to production of nuclear power production because they could not understand the risks involved.

The debate over nuclear power was not limited to the domain of "fact" and "science." It hinged not only on the accuracy of the scientific analysis, but also on the public's trust in the credibility of the technologists. The semantic link that nuclear power shares to controversial military technologies made debate surrounding the use of the technology particularly susceptible linguistic capture. In her analysis of the fluid boundary between politics and science, Shelia Jasanoff suggests debates over language are characteristic when controversial natural science comes up against the policy world.[5] The direct association with the impact of an atomic bomb and the possibility of nuclear proliferation[6] were issues that weighed heavily on the mind even of those who thought that specific reactors could be safe if built to the correct standards and properly maintained. Proliferation meant that people who lived nowhere near a nuclear reactor had to account for personal safety in their individual risk appraisal of nuclear energy. Political and security concerns of this nature normally fall entirely outside of the normal technical risk assessment. The highly political issues that nuclear power brought to the surface were a main concern for nuclear opponents and made then question the scientists' inherent bias.

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[4] Slovic, Paul, Sarah Lictenstein and Baruch Fischoff. 'Images of Disaster: Perception and Acceptance of Risks from Nuclear Power." *Energy Risk Management* ed. G.T. Goodman and W.D. Rowe. (New York: Academic Press, 1979) p. 237 In his book, *Normal Accidents,* Charles Perrow discusses the great difficultly in accurately representing the risks associated with any complex system. Perrow, Charles. *Normal Accidents.* (Princeton, New Jersey: Princeton University Press 1999)

[5] Jasanoff, Sheila. 'Contested Boundaries in Policy-Relevant Science.' *Social Studies of Science* (SAGE, London) Vol. 17 (1987) p 197

[6] Holton, W. Conrad. 'Power Surge: Renewed Interest in Nuclear Energy' *Environmental Health Perspectives*, Vol. 113, No. 11. (Nov., 2005) pA745

Discrediting science and showing its inherent biases was one of the strongest tools of nuclear opponents. It was not their only technique, however. Beyond their distrust in secret safety evaluations, critics feared that the intense protection that reactors required from acts of terrorism might provide justification for impingement on normal civil liberties. The research that went into the design of the atomic bomb was highly secretive; what other measures could be justified in the name of national security? Some worried that the government would institute surveillance of anti-nuclear groups, and perhaps the general public.[7] Government denials of such possibilities could not be believed, and so the true probability of that sort of risk could not be openly assessed.

These societal fears were part of a general trend in the late 1970s of increased skepticism towards science and technology, especially regarding the balance of costs and benefits that it has imposed on day-to-day life.[8] Societal fears exacerbated the role that information asymmetries played in interpretation of the technical assessment of risk. The layman could not understand nuclear reactors. The data and analysis used in the calculation and understanding of risk had to be either accepted at face value, or rejected because it could not be independently verified. Nuclear energy had a huge disadvantage because both the science itself and the analysis of its safety were both so technical and difficult to understand. In this period of history, people's lives were not filled with technology that they could neither control nor understand. A deep skepticism of technology and unforeseen consequences that it might entail led people to be wary of the "paternalism of expertise." [9]

The unfamiliarity of nuclear power was also clear in the qualitative nature of the risk people perceived. Popular risk assessment of nuclear energy extended beyond the mere personal harm that might occur due to long-term exposure to radiation or the fallout of reactor malfunction. In the United States, these issues lent themselves to the exact sort of scientific analysis that anti-nuclear groups were less capable of questioning.[10] One study shows that people associated more personal psychological and physical risks with nuclear power than they did with

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[7] Bickerstaffe, Julia and David Pearce. 'Can There Be a Consensus on Nuclear Power?' *Social Studies of Science*, Vol. 10, No. 3. (Aug., 1980)

[8] Pion, Georgine M. and Mark W. Lipsey. 'Public Attitudes Toward Science and Technology: What have the Surveys Told Us?' *Public Opinion Quarterly*. Vol. 45: 303-316

[9] Bickerstaffe and Pearce, p. 323

[10] For discussion of how anti-nuclear movements were able to affect policy in different countries see Kitschelt, Herbert P. "Political Opportunity Structures and Political Protest: Anti-Nuclear Movements in Four Democracies." *British Journal of Political Science*. Vol. 16. No. 1 (Jan., 1986), pp 57-85

other methods of power production.[11] Debate over the safety of nuclear energy was expanded to encompass political factors that were considered irrelevant from a scientific perspective, including debates over nuclear weapons and civil liberties.[12] Nuclear power tapped into some of the deepest physical and psychological fears of the American public, spanning the distance from aversion to the mysterious physical ailments due to radiation all the way to the loss of the political freedoms that America was based on.

Conventional Energy in the late 1970s

Assessment of the risk associated with conventional energy originally focused on the effect of air pollution on human beings and our environment. Nineteenth century industrialization and the booming need for sources of energy had obvious environmental consequences whose impact on human health was readily observable. The risks of burning coal were observable in an immediate sense. This placed the technology in the uncontroversial region of risk analysis[13] where the appropriate use of regulation is generally agreed. The consequences of burning coal were uncontrollable; those people subjected to pollution could not easily accept them. Cases of uncontrollable risk present a clear path for regulation and over time standards for industrial coal burning have reduced the concentrations of toxic chemicals in the air. Most of the then-identified environmental externalities from energy production had been eliminated through regulation by midway through the twentieth century. The only environmental problem that remained unsolved was carbon dioxide emissions, which had no immediate health consequences, and whose long-term environmental impact was under debate. In other words, conventional methods of energy production appeared to have few risks and were technologically familiar to the public, and thus non-threatening.

By the early 1980s the general popular understanding of risks associated with coal and oil power was limited primarily to the environmental risks due to air pollution.[14] Environmental risks did not represent an immediate or irrevocable threat to human health and safety. The risks

[11] Thomas, Kerry; H. J. Dunster; C. Green. 'Comparative Risk Perceptions.' *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences,* Vol. 376, No. 1746. (Apr. 30, 1981) P. 44
[12] Falk, Jim. *Global Fission: The Battle Over Nuclear Power*. (Melbourne: Oxford University Press, 1982) Falk's largest concern about the impact of nuclear power is primarily the threat to democratic society. He seems to believe that governments *can* control nuclear power, but the sacrifices are not worth it.
[13] Slovic, (1987) and Morgan, M. Granger. 'Risk Analysis and Management' *Scientific American*. July 1993 pp. 24-30
[14] Thomas, Dunster and Green. p. 44.

associated with conventional energy production followed the model for well-understood low-dread hazards: people knew harm was possible, but the risks associated with conventional energy production were not the object of focus. Other well-understood, low-dread risks include bridges and home swimming pools. There may have been individuals who worked at or lived near power plants who worried about an explosion of the fossil fuels that were being converted into energy, but the general public did not see large personal risks in the continued use of this tried and true method of energy production. Concern about global warming had not yet made a significant impact on the public consciousness.[15]

In the late 1970s, however, there were some people who were already convinced of the latent risk of global warming. This hazard, which has come to be understood as probably the largest environmental problem facing us today, merits only one mention in the edited volume *Energy Risk Management*, published in 1979.[16] Somewhat ironically, it is used as an example of latent, unobservable risk. As the observable risks of burning coal for energy were eliminated the case for increased regulation of other, unobservable risk was weak. As late as 1986 only 39 percent of people surveyed had even heard of the greenhouse effect.[17] Carbon emissions fell into the realm of externalities that Morgan's risk space that combine being unobservable with uncontrollability. Like the case of hidden toxins with unknown consequences, carbon emissions were the exact sort of risk that lends support to the precautionary principle, as set forth by Nicholas A. Ashford and Claudia S. Miller. Global warming is a powerful example for those who suggest that there is a tendency for under regulation in the face of uncertainty and that early warnings are too often ignored.[18]

In addition, the taken-for-granted-ness of conventional power played a role how little attention was paid to the risks posed by conventional methods of energy production. People were in general familiar with the technology. Conventional energy production does not depend on greatly remote science. Production of energy by burning fossil fuels can be easily understood by most people who try to do so. It has its roots in primitive fires used for or heat and warmth. Even if the use of mechanical engines for the generation of electricity is not universally

[15] Pion and Lipsey
[16] Thedéen, Torbjörn, 'The Problem of Quantification' *Energy Risk Management* ed. G.T. Goodman and W.D. Rowe. (New York: Academic Press, 1979) p. 179
[17] Nisbet, Matthew C. and Theresa Myers. 'The Polls – Trends: Twenty Years of Opinion About Global Warming.' *Public Opinion Quarterly*. Vol. 71, No. 3, Fall 2007. p. 445
[18] Ashford, Nicholas A. and Claudia S. Miller. 'Low-Level Chemical Exposures: a Challenge for Science and Policy.' *Environmental Science and Technology*. Vol. 32, Issue 21, pp 508A-509A

knowledge, the technology of conventional energy production was not to be feared. It was a risk that could be understood and brought the benefits of industry and the comforts of modern amenities. Social backlash against science, distrust of technology and psychological dread played no role in public understanding of coal.

French nuclear power in the late 1970s

The American response to nuclear power was no the only possible response. Public concerns about the amount of risk involved in nuclear power production seems to have been comparatively small in the French story. There was never the public outcry against nuclear power that is so strongly associated with nuclear power in the United States.[19] The same factors, which made nuclear power untenable in the United States, kept the public from becoming overly concerned about nuclear power. First, the asymmetries of information which were so strong in the United States were also present in France, perhaps even to a higher degree. But, the second factor, the strained relationship between the public and the technologists was not present in France. Technology was more openly political and accepted as such. Without a serious attempt on the part of scientists to be seen as neutral, there was no need for the public to call them on their biases in the way that occurred in the United States. Avenues for public access to nuclear decision-making and implementation were severely limited, thus anti-nuclear activists had little room to grow and people did not have access to information which might make them upset. An opposition of the scale that characterized American anti-nuclear protests never materialized. The third factor, which made nuclear power unpopular in the United States, a sense of trust in technology as a threat, was also not present. The idea of technology as a force for public betterment has a strong place in French culture. The forth factor, where nuclear technologies are particularly dreaded and the avenues for access were both taken care of by a strictly top-down nuclear power program in France.

There was some concern on the part of the French people about the construction of nuclear reactors in their villages and towns, but it focused much less on the physical risk than did American concerns. Instead they wanted reactors to bring jobs and money to depressed areas

[19] Falk

and to fit with their aesthetic ideals.[20] The French people seem to have had more trust in the expertise of the scientists. The sort of skepticism, which had become pandemic in American anti-nuclear movements, never materialized in France. The largest debates about the construction and operation of nuclear power plants came from arguments between Commissariat à l'Energie Atomique and Electricité de France, arguing about what sort of reactors should be constructed, and from the Unions, who periodically raised issues about plutonium production.[21]

The French people seem to have embraced technology more fully than Americans except for during a short period time after the Second World War. The idea that a country could be governed people with technical expertise is far from the American model. The French were able to see technical experts as individuals who would engineer society to be a better place.[22] In contrast to the American model, they railed against "technocrats" who claimed to be a-political, instead preferring the honesty of "technologists" who openly admitted that technical choices were political choices, driven not by some scientific ideal but by social objectives.[23]

Dread of radiation seems not to have concerned the French people to the same degree as it did Americans. Even plant workers treated the risks of nuclear power production very cavalierly. Safety guidelines seem to have been followed only when convenient. At Marcoule, researchers "treated radioactivity with distain."[24] While they treated it more respectfully in later years, stories of radioactive hijinks were looked upon with nostalgia. While today France has a reputation for advocating caution in the face of new technology, the precautionary principle was certainly not in action in the French nuclear program.

1970s Technological Caution

The story of energy production in the late 1970s shows that there was no coherent stance on the use of the precautionary principle or the need for proof before consequences in the assessment of risk from various methods of energy production. The precautionary principle was applied to the technologically foreign, but possibly innovative, science of nuclear energy. On the other hand, there was a relative lack of analysis of the risks associated with conventional energy

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[20] Hecht, pp 201-240 Hecht describes the different concerns that the residents of Touraine, where the CEA's Marcoule reactor was built, and Gard, the site of EDFs Chinon reactor. Each town had very different expectations and concerns.
[21] Hecht, p 197
[22] Hecht, p 23
[23] Hecht, p 38, p 65
[24] Hecht, p 178

production, reflecting the requirement of proof of harm before action would be taken for regulating the familiar technology. One can even go further and suggest that the public was systematically looking for harm caused by nuclear power, but was uninterested in investigating the suspected risks of conventional methods of energy production. The precautionary principle was applied to the new risk, but not to the old. Instead, scientists, and those who distrusted science, politically influenced reactions to technology.

The risks associated with Nuclear energy were new and frightening so policy makers, and society as a whole decided to abide by the precautionary principle for the new technology. Environmental challenges associated with traditional power plants could be managed by keeping the toxic chemicals from leaving smokestacks and the general risk of power-plant disaster was so remote and uninteresting that the public chose to ignore it. Until a convincing argument for switching from one technology to another was made the public wanted to stay with the familiar. Risk appraisal was biased towards the familiar and regulations of the conventional power industry did not take into account the most significant possible consequence: global climate change. A coherent application of the precautionary principle would require detailed analysis of an extremely large number of highly specific risks associated with conventional power as well. In the face of global warming, it is not clear that coal could pass that test. Reflecting in 1989 on what appeared to a failed nuclear power industry, Joseph G. Morone and Edward J. Woodhouse talk about how society's investment in conventional methods of electricity production and the scale and lag-time of reactor construction contributed to a generalized inertia.[25] It is no surprise that vested interests in other means of energy production and the slow development of nuclear technology contributed to lower levels of support.

The Second Era: Global Climate Fear

Conventional Energy Today

Societal appraisal of the risks associated with energy from coal and oil has become much more focused in the past three and a half decades. Science has slowly reached a consensus that

[25] Morone, Joseph G. and Edward J. Woodhouse. *The Demise of Nuclear Energy* (New Haven: Yale University Press, 1989) p. 125

global warming will have serious consequences if it is not curtailed.[26] Polls show that awareness of the greenhouse effect has risen from 39 percent in 1986 to 91 percent by the spring of 2006.[27] It is now understood that the risks associated with global warming are not only severe, but also certain to occur if practices do not change. Global warming poses a risk that cannot be immediately observed; invisible carbon dioxide causes incremental change in the temperature of the planet. Global warming is also uncontrollable on an individual level. This places it on similar footing with nuclear power. The risks of conventional energy production are no longer the only concerns about environmentalism and general air-quality, which that many people were able to ignore in previous years. The consequences of global warming are personal and universal. The externalities have the potential to be a public ill on a global scale and no one is certain what they might be.

Asymmetries of information have also become a greater issue in the analysis of the costs and benefits of conventional methods of generating power. This is being reflected in the societal assessment of the reality of climate change. Among those who accepted its existence, there has been disagreement about whether human activity is its cause, and if it can be slowed down or prevented by curtailing these behaviors. Polls show that even as awareness of the greenhouse effect became almost universal, belief in the significance of global warming or climate change was by no means unanimous.[28]

Like the political scientific conflicts of the late 1970s, fights over climate change hinge on assessment of the skill and integrity of the scientists and their own personal biases. Debates over the proper regulation of conventional energy production and carbon dioxide emissions took on the deconstructive nature that Jasanoff suggests is present in all science policy. Even the inconsistency in the language, 'climate change' versus 'global warming,' reflects the fights for power that go on under the guise of scientific debate. While many people were involved in the public debate, few were actually able to make meaningful contributions. This is in some part due to the fact of global warming is essentially a scientific issue requiring expert opinion to reach any decision about the risks it poses. The public cannot offer much of their own interpretation because they lack the tools to make an independent appraisal. The tendency is therefore to

[26] United Nations Intergovernmental Panel on Climate Change. G8 Summit Statement on Climate Change, May 2007. http://www.pik-potsdam.de/news-1/joint-science-academies2019-statement. Also 2008 UN Climate Change Conference in December 2008, Poznań, Poland.
[27] Nisbet and Myers, p. 446
[28] Nisbet and Myers, p. 454

assess the technologists themselves, rather than the content of the statements. This task is complicated by the scientific community's belief in its own neutrality.

The analysis of conventional energy requires as much technical expertise as the analysis of nuclear power did in the late 1970s. There is no reason for the average person to think that familiar methods of power production are suddenly going to cause huge negative consequences for the world. While there has been some debate over whether scientists have reached a consensus about whether global warming is really happening[29] and how acute its consequences will be, the public has not sounded opposition against technical models of climate change in the way that they did against probabilistic risk assessment. This indicates a greater willingness to accept the scientific claims of integrity and political neutrality.

Investigation of general attitudes in 2006 show that 91 percent of American believe that science and technology are making their lives "healthier, easier, and more comfortable."[30] This suggests that the conditions for public assessment of scientific knowledge are qualitatively different from the late 1970s, when belief that science and technology caused improvement in quality of life had fallen to the low 70s, from 83 percent in the late 1950s.[31] Debates over the effects of specific technologies now take place in a much friendlier environment for scientific risk assessment. This faith keeps the debate between different scientific interpretations, rather than shifting it outside of the realm of science, as was that case for highly technical issues in eras of increased skepticism towards science.

The production of energy by conventional methods has entered the public consciousness as something that posses currently unobservable and probably involuntary risks, pushing them closer to those associated with nuclear power plant failure. Indeed, climate change is beginning to take on the characteristics of a dreaded risk. These risks from carbon emissions are also different from the clear environmental and health consequences of other air pollutants. They are invisible and delayed and thus call for scientific evaluation, introducing the need for experts. The assessment of scientific knowledge, which had not previously been acutely relevant to the conventional power industry, became an important factor that could be used by different groups to gain power over the political process. Public opinion about the reality of global warming and

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[29] Nisbet and Myers, p. 450
[30] Science and Technology Indicators Ch7, p. 23
[31] Pion and Lipsey, p. 304

about the degree of scientific consensus has fluctuated accordingly.[32] Levels of doubt out of proportion with those expressed by scientific experts are a reflection of the power dynamics of leaders fighting over expert analysis. Even so, the impact of carbon emissions on climate is the pivot point for analysis of the role of conventional energy production in the future, as the MIT study *The Future of Coal* demonstrates.[33]

Nuclear Power Today

The technical facts of nuclear energy are essentially the same as they were by the end of the 1970s, as few new plants have been built, but the way in which the technology's risk is perceived appears to have changed with years of experience.[34] Time has show that our safety structures prevent nearly all incidents from becoming disasters. Public support has shifted back in favor of science and technology's influence on out day-to-day lives.[35] Renewed trust in science moves the front line of debate back towards the world of science and technical risk assessment away from discussion of the scientists' credibility. Time has shown that the likelihood of major accident at a nuclear reactor is low, and the regulations put into place have effectively kept most people safe. The only major nuclear accident in the public consciousness, the 1986 Chernobyl disaster, while horrific, has in some ways demonstrated that nuclear power generation is only a problem when it is systematically mismanaged. Well-run plants go to extraordinary efforts to keep their workers and public safe. The four decades of industrial nuclear power generation provides us with a track record that can be used for better calculation of the rates of irregular incidences at well-run reactors.

Another factor is that the impact of any asymmetric information between the scientists and the policy makers plays out in a less adversarial way in 2007 than in was in the late 1970s. Questions of the whether nuclear energy is safe and appropriate no longer take place in the context of increasing dissatisfaction with the impact of science on people's lives. Non-scientists may be as disadvantaged in their understanding today as they were in the 1980s, but they are more willing to engage in scientific discussion to the best of the ability and to trust scientific data.

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[32] Nisbet and Myers, p. 460
[33] MIT. *The Future of Coal: Options for a Carbon Constrained World.*
[34] MIT, *Future of Nuclear Power.*
[35] Science and Technology Indicators p 23

Today, the idea that a technocratic society where we rely on experts for the materials of our day-to-day life is much more of a reality than it was in the 1970s. Whether it was right to fear the "paternalism of expertise" or not, the issue has become irrelevant. Most people now require cell phones and computers, that they can neither understand nor control, just to meet their normal obligations. These technologies, and their ubiquity in our personal lives might provide fertile ground for opponents of technology, but these opponents are largely out numbered. In general, our sensitivity to the asymmetries of information associated with technology may be lower because we are faced with it every day. We live in the technocratic society that some people feared might occur, but we do not find it a terrible place.

The debates over knowledge are placed in a different framework by decreased sensitivity to the possible negative impact of high technology on our lives. Trust in science allows experts to have greater impact in framing the policies that are put forth. Now that debates over nuclear power do not ultimately come down to philosophical ideas about the role of science in society, it is much easier for technical experts to present their findings on physical risk and have them heard. Nevertheless analysis of the future of our energy industry leads to the conclusion that public debate is a permanent part of energy policy making. Some suggest that nuclear energy will only emerge as a primary method of energy production in our adversarial policy making environment if the apparent risks of global warming become more severe or if the United States seeks independence from the global oil market.[36]

The risks of nuclear energy continue to occupy the unobservable and uncontrollable category of Morgans's 'Risk Space.'[37] As such, decisions about regulation are likely to be the subject of controversy because we cannot agree on a solution. These risks are easily targeted as needing more regulation because it is difficult, if not impossible to restrict their effects to only those who knowingly consent to them, but how to regulate is unclear. The same can be said of the environmental costs of conventional energy production, but the slow nature of climate change does not engender the same reaction as the fallout from a nuclear power plant disaster. The risks associated with the technology of nuclear energy production itself have not been tested

[36] For example. Smil, Vaclav. *Energy at the Crossroads.* (Cambridge, Massachusetts: MIT Press, 2003) P. 316
[37] Morgan, p. 30

to some people's satisfaction. Discussion of risks now includes the technical debate about a new generation of reactors that have high-tech safety mechanisms.[38]

Other risks, like the possibility of nuclear proliferation and the disposal of nuclear waste are outside of the technical analysis of the safety of nuclear reactors. These objections may be seen as some of the most salient to nuclear power production.[39] However, in the face of a possible crisis caused by conventional energy, whose probability only seems to be growing, the risk-benefit trade off may tip in nuclear power's favor. It is interesting to note that, in the United States, the use of nuclear power as a major way to produce carbon-free energy had yet to penetrate the public consciousness as late as 2003.[40] When this becomes more clear, the dreadedness of nuclear power may seem less terrifying by comparison.

Conclusions For Today

It remains to be decided what options for energy production are the best or ultimately the safest. However, we now have the benefit of hindsight about the conclusions drawn in the late 1970s. It is clear that neither the precautionary principle, nor proof before action were chosen as the guiding model for assessing the risk of various means of producing energy. The reason that caution was advocated in one situation while the other was ignored was not based on the scientific data at hand. Nuclear energy was judged too risky because of the on the emotional response of the public to fears about technology's impact on modern life. Whether in any given situation the public has the correct understanding of the risks different technologies pose is not the issue though.

The real issue is understanding the systematic bias in our assessment of risk and determining whether that bias is justified, or not. The differences in treatment of these two methods of energy production show a tendency to shy away from the unknown, even when the details of familiar technologies have not been fully evaluated. The context in which knowledge is evaluated in scientific debate will affect the final conclusion. The debates over the risks of nuclear power and conventional power production now take place in an environment that is much more open to science and to the opinion of scientists. This allows the risks of global warming to be generally recognized, despite its foundation in invisible scientific theory. The

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[38] Holton, p. A747
[39] MIT. *The Future of Nuclear Power: An Interdisciplinary MIT Study*. 2003 pp. 10-12
[40] MIT, p.6

greater acceptance of science also allows assessment of nuclear power to focus on the safety of the technology itself and reasonable assessment of the problem of waste disposal, rather than an argument about its impact on human liberty.

Nuclear energy continues to engender a more visceral reaction to the dangers it poses because it is seen as an alternative, something that we have to actively choose to embrace, while conventional methods of energy production are by default allowed to function. This is based in the default assumption that what we see every day is safe. It may lead the public to have higher expectations for risk minimalization in new technologies than they do for familiar technologies. This sort of contradiction is captured in the more people fear planes than do automobiles, yet a person is more likely to die in the car on the way to the airport than in a plane crash. There may be no answer to the problem that the public does not assess risk according to mere probability and degree of harm.

Those who believe in science should not be too quick to view a return to scientific assessment and a belief in the general neutrality of science as a positive development. Rather it reflects a change in the power dynamics between science and more traditional political concerns. Scientific decisions still have political consequences. There are fundamental values that cannot all be served by any on choice. The use of scientific expertise and the encouragement of a climate where science is considered unbiased is only one of many methods that can be used for acquiring influence or achieving a particular end. The ability of science to make asymmetries of information more accessible and thus restrict the number of players who participate in a decision making process is particularly interesting.