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# NEW ENERGY TECHNOLOGIES:

## *A POLICY FRAMEWORK FOR MICRO-NUCLEAR TECHNOLOGY*

## ON SOCIAL ACCEPTANCE OF NUCLEAR POWER

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PREPARED IN CONJUNCTION WITH AN ENERGY STUDY SPONSORED BY
THE CENTER FOR INTERNATIONAL POLITICAL ECONOMY
AND
THE JAMES A. BAKER III INSTITUTE FOR PUBLIC POLICY
RICE UNIVERSITY – AUGUST 2001

## Introduction

Social acceptance is essential for any activity that affects large sectors of a nation. In the case of nuclear power such acceptance has been withheld in many democratic countries to such an extent that the role of nuclear power in the international energy economy has been significantly restricted. Explanations offered for this range from fear of things nuclear through judgments about the nuclear power technologies themselves. Understanding the bases the social treatment of nuclear power is important in enabling nuclear power to provide the energy and environmental benefits that it can potentially bestow. In this paper I examine some of the more influential arguments on this matter and offer some conclusions. Hopefully the evidence presented here will be helpful to others in considering the future of nuclear power.

The two explanations of the degree of acceptance accorded nuclear power examined here are trust-based and technology-based. The essence of the **trust-based** treatment is that when non-experts examine a controversial technology they are not actually trying to form an independent opinion concerning how well the technology will likely perform, but rather are trying to decide which group of people to trust concerning how it should be managed. The **technology-based** explanation is that people wish to decide for themselves whether a technology is acceptable, based upon understanding the available evidence regarding the technology. In this paper I argue that the former explanation is likely to be close to the truth than the latter. Whether this is correct is important, as the answer ultimately accepted will play a major role in guiding future efforts to gain social acceptance for nuclear power.

The technology-based argument is widely held among technologists, and has been the guiding principle for many efforts to gain public acceptance for nuclear power. In this paper I question the proposition that social acceptance of nuclear power can be gained through creation of demonstrably safer technologies. I suggest, rather, while safer technologies are to be desired for their own sakes and can result in good performance results, that the degree of social acceptance accorded a politically charged technology such as nuclear power is more likely to be governed by factors external to its public safety performance (providing that that performance is good enough) of which public trust of the organizations and individuals using the technology is most important.

Research to test what is true concerning such matters is needed as part of the overall program for nuclear power advancement. A purpose of this paper is to advocate performance of this research, and to contribute to the agenda for it. The scope of the following discussion is restricted to the United States; for other countries other treatments may apply.

## The Triad

Ultimately the argument of this paper is that a triad of factors governs whether nuclear power will be accepted socially; the technology itself (which must permit acceptable results to be achieved), the organizations using the technology (which must be sufficiently competent to achieve acceptable results) and the degree of trust gained by those involved in using the technology (which depends upon the collective integrity, competence and track record of operations).

## The Trust-Based Path to Social Acceptance, or "Don't Bother Me"

The trust-based argument is that most individuals attempt to understand at a fundamental level only the small set of topics that are very important to them. For other topics (which includes nuclear power for most people) acceptance demands that it be viewed as being both especially beneficial and managed adequately by a trustworthy party. Over much of the past three decades nuclear power has failed on both counts with most people; thus, it is not surprising that its acceptance level is low.

The electricity provided by nuclear power is not highly valued by affluent societies (until it is unavailable), and until the 1990s the operational record of the nuclear power plants did not keep them sufficiently out of the news that they could be viewed as being matters of unconcern. The fact that the western version of nuclear power has not harmed a member of the public is viewed as being nice, but unimpressive. Society has also demanded that the nuclear power technologies not be a source of worry. Thus, if the trust-based argument is correct then the development of safer technologies is unlikely to change social acceptance matters much. Rather, social

acceptance will depend much more on the individuals and cultures of the organizations using the technologies.

The Technology-Based Path to Social Acceptance

The technology-based argument concerning social acceptance posits that acceptance of nuclear power can be obtained through a combination of the creation of much safer nuclear power plants and a program of public education to permit the man in the street (perhaps assisted by experts) to understand the nuances of nuclear public risks and the merits of improved technologies. If these merits can be demonstrated in physical tests, so much the better, but it is argued that this is not essential for social success. This argument especially advances the case for low power capacity reactors (sometimes termed "passively safe") where the fission product decay heat is more easily removed from the core than with higher power reactors. The corollary to technological advancement as a path to social acceptance is that through education the ignorant can be made to accept nuclear power. In effect the nuclear advocates are saying, “If you knew what I know, you would believe what I believe.”

During the years since the Three Mile Island (TMI) accident in 1979 much effort has gone into developing new nuclear technologies that, it is hoped, would overcome this reaction. The fact that new technological concepts and public education efforts so far have had little effect in changing nuclear averse attitudes has not yet led to more creative and effective responses or even to re-examination of the conventional wisdom.

The technology-based argument appears to be accepted widely among the nuclear technological community, but so far it has not resulted in success. Evidence against its validity is that development during the 1980s of passively safe reactor concepts has not engendered their construction or even a popular demand for it. Further, no example exists where social acceptance of a technology has been gained in this fashion. It is unfortunate that the lack of success to-date has not led to re-examination of the validity of the technology-based argument, but within the nuclear community there appears to be little interest in questioning this argument. Rather, a

feature of nuclear gatherings is the repetition of a body of conventional wisdom to explain (or at least bemoan) this nuclear power aversion of most Americans.

The evidence needed to sort out the competing arguments does not (and may never) exist. However, an important task of nuclear power advancement is to find and follow the truth in these (and possibly other) arguments. Notably, such work has not yet been included in the reactor innovation research agenda. Rather, we have more often had individual designers proposing their own answers to these questions and the responding to them with new reactor concepts, thus far without social success.

## History

Since its inception nuclear power has gone through three eras of social acceptance in the United States. The three eras of interest are the following:

1. Early Optimism: the Eisenhower and Kennedy years before 1968 and the Vietnam War.
2. Doubt, Criticism and Pessimism: The Vietnam War and its Aftermath.
3. Let the Good Times Roll: The Economic Expansion Following the Early 1990s.

The social experience of nuclear power during these three eras reflected different economic and social conditions. Also, the performance of the organizations using the nuclear power technologies changed during these three eras, and these changes may explain some of the differing social treatments of nuclear power; however, the nuclear power hardware did not change—and thus, cannot be cited as a fundamental factor in the degree of social acceptance of the technology. In the case of nuclear power over the span of ten years following 1968 it went from being strongly favored to being widely disliked (or at least viewed warily). It appears that this occurred because the needs of society changed, and with it so did attitudes toward nuclear power.

Early Optimism: the Eisenhower and Kennedy years before 1968 and the Vietnam War

Until the days of the Vietnam War (mid 1960s) nuclear power was generally viewed as a prestigious and highly favored technology within American society. Schemes for nuclear powered airplanes and rockets were supported generously; every serious university wanted its own research reactor. For electric utility companies to be non-nuclear was to be backward.

During this time the orders for most of the currently operating nuclear power plants were placed or planned. In retrospect the uncritical approval given the technology undermined the ability of the nuclear enterprise to respond effectively to criticism when the climate of opinion subsequently turned.

Doubt, Criticism and Pessimism: The Vietnam War and its Aftermath

The years of the Vietnam War and its aftermath (late 1960s to early 1990s) were a time of economic stagnation and uncertainty, and of persistent internal conflict regarding the proper directions and policies for the United States. Inevitably nuclear power was caught in these conflicts, and because it had been an important symbol of the validity of the values of the previous era it was attacked vigorously, especially in the technological and business arenas.

Fear of nuclear accidents, wastes and weapons have been cited as major factors supporting such anti-nuclear attitudes, even prior to the accidents at TMI and Chernobyl. Underlying these concerns has been the fear of nuclear power linked to its creation as an outgrowth of the WW-II nuclear weapons program. When the United States held nuclear weapon hegemony, nuclear weapons were not viewed within American society as the threat that they have become; but today they are in the hands of many parties and the number is growing. Nuclear weapons are now scary, and nuclear power is unavoidably linked to them.

The technological method of attack upon nuclear power was to publicize the weaknesses of the nuclear power technologies and to criticize the nuclear establishment for having failed to recognize and correct them. The principal criticisms concerned the safety of reactors, focusing

more upon the problem (as with the TMI accident) of removing heat from irradiated reactor fuel due to fission product decays than upon uncontrolled fission power increases.

The business-related method of attack was to utilize the NRC's licensing processes as a tool to impose additional expense upon new nuclear power plant projects. The principal line of attack was to raise in the public hearing process many technological objections to licenses for the new plants. Reflecting the unsettled nature of society and widely felt ambivalence toward nuclear power, the NRC utilized very low standards in deciding which technological objections to consider. Consequently, the licensing process became flooded with them, with resulting project delays, costs and uncertainties. Ultimately about half of the nuclear power units initially ordered (about 250) were cancelled before completion of construction. Today about 100 units operate, providing roughly 20% of the nation's electricity.

How did the nuclear power social acceptance environment change to make the United States inhospitable to nuclear power, and why have efforts to reverse the change been so ineffective? My view is that the stresses of the Vietnam War created a strong need to criticize the establishment. The close identification of nuclear power with the agenda of the establishment (and its image of near perfection) made it an easy target for attack. These conditions, coupled with existence of a set of poorly publicized potential perils tied to nuclear power provided the fuel for transforming a formerly uncritically approved technology into one that is mostly distrusted and feared.

As is noted above factors cited most often as justifying these fears include reactor safety worries (mostly concerned with core cooling, but also with uncontrolled reactivity - i.e., fission rates - increases), high-level waste disposal and nuclear weapons proliferation. These factors all existed during the time when public opinion was favorable to nuclear power, but they did not then engender a reaction against the technology. Why? In part they were either little recognized or viewed as being manageable, while faith in the value of nuclear power reinforced a sense of national superiority and competence. Later when it became desirable to many people to criticize nuclear power, these weaknesses were available as rationalizations for a critical position.

Polling data for the United States (see Fig. 1) have shown that most people do not hold strong positions concerning nuclear power, indicating that it is relatively unimportant to them. Using essentially the same questionnaire, Bisconti Research, Inc. has tracked public opinion in this area for the Nuclear Energy Institute for over 12 years. The results have been fairly constant with approximate values for the sizes of the opinion groups indicated in Fig. 1 as follows: strongly opposed: 10%, somewhat opposed: 23% (opposed total = 33%), somewhat favorable: 41%, strongly favorable: 26% (favorable total = 67%). Thus, the fraction for use of nuclear power has typically been about half of those polled, but with its size being sensitive to events such as the accidents at TMI and Chernobyl, and to concerns about global warming and regional electricity reliability. Small minorities hold strong positions for and against the technology. Those against it have been able to utilize the decentralized structure of the United States political system (particularly the safety regulatory system, which is not accountable for the economic implications of its decisions and processes) to make it effectively impossible to build new nuclear power plants, and to make it needlessly expensive to operate the existing ones. In this situation the majority has remained disinclined to become involved in changing matters even when it is their money being spent needlessly by the inefficiencies imposed by the opponents of nuclear power. This description has been applicable to nuclear power in the United States over the past 30 years. It can be explained by the great majority attaching no special benefit to nuclear power and the opposed minority as being greatly frightened by it.

Let the Good Times Roll: The Economic Expansion Following the Early 1990s.

Since the early 1990s a period of sustained economic expansion has boosted national confidence and optimism. The result has been to diminish, to an extent, concerns about various perceived threats, including those of nuclear power. This situation has been bolstered by steady improvements in the operational record of the nuclear power plants (e.g., typical unit capacity factors have increased by about 20%) - substantially a result of the efforts of the Institute for Nuclear Power Operations (INPO)- established following the TMI accident, and of the possibility of direct market competition among electric generating units.

In more recent years the operation record of the nuclear power plants has become very good, with a low frequency of events that could cause public alarm. The result has been a diminution of both interest in and frequency of nuclear power-related stories in the news media. The consequence has been that the social climate concerning nuclear power has changed to the point that political pressure has been used by the nuclear power plant owners to cause the NRC to relax its detailed intrusion into how the plants are operated. This situation reflects growing social acceptance of nuclear power as more ordinary citizens have concluded that nuclear power is not enough of a problem they need to worry about it.

Coupled to this improved view of nuclear power has been growing concern about the environmental effects of the non-nuclear energy technologies - especially those using coal. Areas of particular concern are global warming and regional air pollution, both of which are avoided by using nuclear power. Conceivably these factors will lead people to revalue nuclear power. Should the majority to come to view nuclear power as having important (newly recognized?) benefits its degree of social acceptance could increase markedly, perhaps to the point that new nuclear power plant orders would be placed. Whether and how this will occur remains unclear.

**Safety Regulation**

The unstable decision-making climate created for nuclear power plants by the NRC has been the most important deterrent to the use of nuclear power in the United States. Until recently the behavior and policies of the NRC were cumbersome and unpredictable, as were the consequent costs to the nuclear power plant licensees. Nuclear safety regulation is inherently political, as it involves expressing the social will concerning acceptable performance outcomes of a politically charged technology. In the early days of nuclear power, when public approval was high, safety regulation was viewed as a technical problem best left to (trusted) technicians, who were getting satisfactory results.

When the tide of opinion turned against nuclear power it also became critical of regulation. As a result, the regulatory process became highly politicized as reflected in frequent criticism of the Nuclear Regulatory Commission (NRC) by Congressional committees, by use of public hearings

(required for issuance of an NRC license) as forums for surrogate debate of the effective national energy policy, and for the environmental review process being used for examination of the effective adequacy of regional energy supply policies.

In this process the NRC has been subject to criticism - usually via the Congress - for either performing poorly or for permitting poor performance from its licensees. Thus, when the NRC became criticized (for whatever reasons) they typically have become tougher on their licensees. The result has been that in order to deflect criticism from itself the NRC operated in a fashion effectively punitive to the plants that it regulated, and more importantly in a highly unpredictable one. This unpredictability was reflected in high uncertainty in the ultimate (delay-related) cost of a nuclear power plant, thereby discouraging them from being undertaken.

Social acceptance is essential for efficient and effective regulation of nuclear power, as efficient regulation requires the ability of the regulator to exercise judgment and discretion in its decision-making, reflecting subtleties of the issues being addressed. In a situation where such discretion is not allowed by society, as was typical until quite recently, the result is imposition of rigid criteria and processes upon licensees. The result has been waste of economic resources and achievement of needlessly low levels of safety.

During the past decade two important improvements have occurred in the NRC's approach to its work. The most important is a shift to risk-informed regulation, which has been proceeding incrementally, with each step supported by the results of preceding regulatory experiments. The essence of risk-informed regulation is utilization of a systematic analysis of the contributions of all nuclear power plant elements to overall public risks. Doing this permits much better identification of the important targets for risk reductions, than under the unsystematic deterministic treatment of nuclear safety that the risk-informed treatment is gradually moving to replace.

The second change is to the culture of the agency via a shock delivered in 1998 when the Congress threatened to halve its budget. This threat was made at the behest of the nuclear utilities, which argued that the agency was behaving in such a wasteful and unpredictable fashion

that both safety and economic plant performance were endangered. The effect of the shock has been to cause the agency to perform in a more efficient and intellectually disciplined fashion in doing its work - to the ultimate improvement of the performance of both the agency and the nuclear power plants that it regulates.

Neither of these changes would have been possible in the absence of growing public acceptance of nuclear power that has occurred during the past decade. These are examples of a positive feedback dynamic where improved nuclear power plant performance generates improved social acceptance, which in turn improves the regulatory environment within which the plants function, which then improves plant performance further.

**Nuclear Power Plant Siting**

Difficulty in siting nuclear power plants has surely not been reduced by social resistance to use of nuclear power. However, it may be a mistake to interpret resistance to new plant siting as a primary consequence of the social rejection of nuclear power. It may be more correct to view the reluctance of individuals living near a proposed nuclear power plant site as reflecting the more general "not in my backyard" (nimby) rejection of proposals for new large infrastructure facilities. Nuclear power plants are only some of the more visible facilities to have had siting difficulties during recent decades.

Other facilities that have also encountered resistance include airports and their expansion, utility transmission facilities, dams, highways, refineries and even universities (e.g., each of the two most important Japanese airports has only a single runway). This is an international phenomenon that typically involves the refusal to accept an external cost by individuals who judge that they are likely to receive insufficient benefits from the new facility to justify their cooperation in developing it. Rather than treating such resistance concerning nuclear power plants as an anti-nuclear phenomenon it may be more useful to view it as a market failure where those proposing a new facility have refused to make sufficiently attractive offers to those whose cooperation is needed.

## Recent Conditions

A history of trouble-free nuclear power plant operation is necessary but not sufficient for social support of the nuclear power enterprise. Support for other hazardous technologies (e.g., commercial air travel, high rise elevators, steam power) has the common feature that each is viewed as being very beneficial, and has been operated with an acceptably low frequency of alarming events. This implies that future social support of nuclear power may have to wait until society accords it a similar sense of benefit, and with the frequency of alarming incidents being kept low. Conceivably this condition could arise should nuclear power become seen as a remedy for global warming, or for avoiding other fossil fuel environmental effects, such as air pollution and resource extraction. Whether nuclear power will also be valued for producing hydrogen or for desalination of water is questionable, as these products are currently inexpensive and are also available from other energy technologies including the renewables.

To a large extent whether such a valuation occurs is independent of the nuclear power technology itself, but does depend upon how the nuclear power plants are operated (i.e., staying off of the television news and out of the newspapers). Notably it does not depend upon factors often cited within the nuclear community as being important in the development of new nuclear power technologies—such as passive safety, low electricity costs and demonstrations (via tests) of high safety.

Since the TMI accident many efforts in nuclear power innovation have been focused upon preventing accidental core damage. Core damage is always intolerable; today core damage has been made very unlikely and such events are now rare. Thus, making core damage still less likely by improving the nuclear power technologies further is not likely to change appreciably the frequency of such events experienced by the public.

However, conceivably doing a better job of preventing accident initiating events and subsequent bad publicity may be more important for gaining greater social acceptance. An article of faith in nuclear power innovation has been that development of safer (and maybe cheaper) nuclear power plants will lead to increased social acceptance, and with it smoother regulation and siting. The

argument is that a combination of integral test demonstrations and endorsements by experts of the merits of an improved technology is both necessary and sufficient to win future acceptance (notably, the design of a broadly convincing test remains an unsolved problem - the technologically successful loss of cooling tests of the AVR gas-cooled pebble bed reactor at the West German national laboratory at Julich were largely ineffective in changing social attitudes about that reactor specifically or nuclear power generally).

This view has come to be widely held among nuclear technologists, despite the fact that no evidence exists for its validity (notably, no other hazardous technology has come to be accepted via this route). However, this argument is plausible to many technologists in the sense that such proofs would be sufficient to themselves; thus, it is argued they will be sufficient for others as well. Perhaps this is an example of the technologists being too easily swayed by the logic of their own arguments, leading them to forego the search for a broader set of hypotheses to consider in formulating their technology development strategies. If so, the success of the next generation of nuclear power plant technology may find no greater social acceptance than has the past one.

Rather, it is plausible that significant improvements in the nuclear power technology will also require a period of use before such improvements can become sufficiently recognized that they will change social attitudes. Tests of early prototypes by themselves may be insufficient as change agents. This will be especially the case if the primary obstacle to social acceptance is mistrust of the nuclear organizations rather than disapproval of the nuclear hardware. In that case safety demonstration tests are likely to change nothing.

Concerning nuclear weapons proliferation resistance and reduced nuclear waste production, even though the goals of better performance are often proclaimed as being important much less has been done in technological innovation to achieve improvements in these areas. However, increased nuclear weapons proliferation, or the use of nuclear weapons in the future could have a serious adverse affect upon the acceptance of nuclear power, as could the continued absence of a "solution" to the problem of nuclear waste disposal. Importantly such a solution may simply consist of the establishment of a trustworthy long-term action plan to dispose of the wastes. It may not require operation of a permanent repository, as is often assumed.

## Social Acceptance as an Element of Nuclear Power Advancement

A useful test of the validity of the technology-based argument would be to apply it in areas where the nuclear technologists are laymen (e.g., genetic engineering safety). As a test of the validity of the proposition that intellectual arguments can lead to social acceptance of a feared technology, it might be instructive to learn what would be required in terms of demonstration tests and expert endorsements in order for the nuclear experts to decide to accept a controversial procedure or technology in a different field.

If our nuclear experts are like myself they will find that they are not interested in developing independent opinions about the safety of the technology in question (and, thus, not really interested in the evidence provided by demonstrations and endorsements). Rather, they may want a basis for believing that the technology is not a problem requiring their attention. This is usually achieved via a combination of trouble free experience, a belief that the technology is beneficial and trust in those using the technology, not via demonstrations and reassurances from experts. If this argument is correct it amounts to a validation of the trust-based argument. In this interpretation the process of examining arguments concerning the merits of a particular technology may be interpreted as a search for whom to trust in using it rather than an investigation of the pertinent technical information.

## Areas of Neglected Nuclear Power Plant Performance Improvement in Recent Reactor Innovation Efforts

Areas of potentially important improved nuclear power plant performance that have typically been assigned low priority with nuclear power plant innovation efforts include avoiding adverse publicity and improving the ease of trouble-free operations.

Keeping a Low Profile

Notably, a factor identified as being important for gaining social support, achieving a low frequency of alarming events, has largely been either ignored or not treated seriously in the formulation of new nuclear technological directions. New technologies (under the passive safety banner) have tried hard to decrease the frequencies of core damaging events in new concepts, but not those of initiating events, occupational accidents and economic failures that could cause bad publicity as well as economic losses.

Improving Operability

The need for trouble-free nuclear power plant operations has become widely recognized, but has not yet been translated into a requirement for technological innovation. Rather improved operational performance has come to be viewed as a problem for the team operating the reactor, and as one largely not susceptible to better hardware and support systems (including models for improved operational performance). In terms of developing better nuclear power technologies this view of priorities and possibilities may be the most hazardous to the overall enterprise. Increased operational availability has been stated as an important future nuclear power plant performance goal but it has never been treated as being important, that is to say made a dependent variable to be optimized in the design of a single new nuclear power plant or concept.

**Summary**

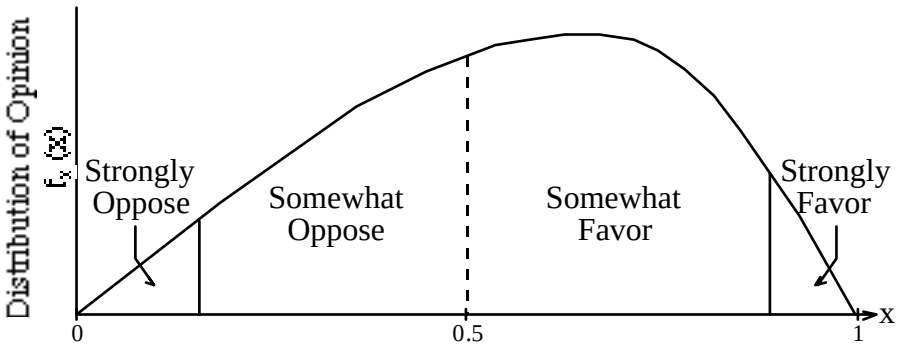
How should future nuclear power plant technology innovation be undertaken? Improvements in economic and safety performance are important and should be pursued. Concerning social acceptance this paper suggests a set of alternative hypotheses (the trust-based and technology-based arguments) for consideration in formulating the strategy for nuclear power technology advancement. It would be wise to test them in order to establish an objective basis of facts as a foundation for strategy formulation. Then, the strategy to be followed should be formulated so that new technologies will have improved performance in the areas where society will actually reward them, rather than only in areas where persons close to the technology think that they should be rewarded. It would be wise to incorporate a process of social testing and of modifying

technology development efforts to be in harmony with social attitudes as an integral part of the overall effort to develop new nuclear power technologies. Doing this would be an original departure from past practice and would likely lead to greater future successes.

If public acceptance of nuclear power depends upon earning the trust of society, improved technologies may play an important long-term role in achieving trouble-free, economical nuclear power operations, but in the short term the policies and practices of the organizations using the technologies are likely to be much more important in affecting the degree of acceptance that is gained.

## Figure 1.

Population distribution of opinion concerning the acceptability of nuclear power.




x = approval rating for nuclear power (x > 0.5 indicates approval, x = 1 indicates total approval, x = 0 indicates total disapproval, x = 0.5 indicates indifference)

f = distribution function of nuclear power approval rating within population

Function Shape Depends Upon

- Sense That Nuclear Power is Beneficial
- Recent Nuclear Power Operational Track Record