AUDIENCES, RATIONALES AND QUANTITATIVE MEASURES FOR DEMONSTRATIONS OF NUCLEAR SAFETY AND LICENSING BY TESTS

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Nuclear power is one of several potential prime movers under consideration for central station production of electricity. As with any technology, the extent of its utilization depends on a complex set of interactions determined by its particular physical embodiments and the structure and temper of the society in which its use is considered. This paper focuses on the situation in the United States; its conclusions cannot easily be extrapolated to other nations. The interplay of indigenous resource base, political structure, and history is complex and must be analyzed case-by-case.

I believe that the development of nuclear power plants with the ability to survive a definitive worst-case, "absolute," test is a minimum requirement if nuclear power is to play a significant role in the future.* The test protocols are somewhat dependent upon plant design, but include, at a minimum, simultaneous loss of coolant, control rod withdrawal, and the presence of a malicious operator. The test requirements are not determined by cost-benefit analysis nor by the imposition of mandated safety goals. They are substantially more stringent than would be required to meet even the most conservative commercial standards. Nonetheless, imposition of an absolute test is essential if the social and political prerequisites for the utilization of nuclear power are to be put in place. There are, of course, many other essential conditions, low cost being prime among them.

The *de facto* imposition of an absolute test requirement would have several notable beneficial side effects: It would, for example, change the role of the NRC to one that has far greater public acceptance and it would lead to "market force" standardization with attendant commercial ramifications.

The argument is based on the following assertions:

A) <u>There is no nuclear imperative.</u>

The U.S. has enough fossil fuel to take us through 2030 with ease. Coal supplies are sufficient to last far longer than that. Improved designs of fossil plants will allow substantial mitigation of acid rain and related artifacts without major cost penalty. The U.S. will not respond to global CO_2 considerations because exogenous sources such as China will dominate the global balance. This argument does not deny that nuclear power, properly deployed, is the least environmentally damaging of all near term prime movers. It is simply recognition of the fact that we do not "need" nuclear power for commercial or national security purposes.

B) <u>There is no nuclear dynamic.</u>

The fossil infrastructure will grow stronger with use. Vendors will develop a range of competitive coal burning plants (primarily based on integrated gasification) and manufacturing

* The future as defined here extends through approximately 2030. This is long enough for technologies now in the earliest conceptual phase to have substantial and unpredictable effect. Consider, for example, the potential impact of large-scale solar generation of hydrogen by bioengineered organisms.

and support facilities will be put in place. The network of natural gas pipelines will be substantially expanded. During this period, the nuclear infrastructure will continue to atrophy. It will grow increasingly difficult for nuclear power to achieve market penetration.

C) Nuclear power will not be used unless it is "substantially better" as viewed by the utilities.

Capacity addition of any sort will be difficult. Fossil systems have difficulties of their own but there is no gainsaying that the legal and political barriers are highest for nuclear systems. Utilities, therefore, have little incentive to favor nuclear systems and will consider them only if they have substantial advantages with respect to alternatives. The criteria for comparisons include both cost and financial risk. Nuclear power must first show substantial advantages when conventional cost elements are considered: capital, fuel, O&M, decommissioning, all under the assumption of normal industrial availability. Risk is reflected in the potential for substantial-to-total loss of availability due to features inherent to nuclear systems:

Mechanical Causes – Unrepairable Components;

Regulatory Causes – Unacceptable Backfit Requirements;

Legislative-Juridical Causes – Public Input Reflected Through Legislation.

The possibility of substantial loss of availability (due to regulation) or total loss of investment is higher for nuclear plants than for conventional fossil systems. It is here that socio-political considerations have the greatest impact. The risk premium is hard to quantify, but it is clear that it increases the cost advantages needed for a new technology to gain market share at the expense of established technologies.

D) Vendors must provide nuclear power systems that convincingly meet cost and risk requirements if nuclear power is to be used.

Because of the increased burden-of-proof that nuclear systems must meet, the claims for low cost and risk must be particularly robust. Operating principles must be simple and easily explained, cost projections must be based on demonstrated industrial capacities. These claims will be most convincing if they are made by a vendor that has assumed the normal commercial risks.

E) If a convincing demonstration that nuclear systems are "substantially better" is not made, nuclear power will play a minor, and decreasing, role in the U.S. energy supply picture.

F) Because the test will have three audiences and must satisfy all three, the only convincing demonstration is the full-scale, worst-case test of a commercial plant.

The audiences are utilities, the NRC, and the "public." The utilities' technical requirements will be easiest to satisfy. The provision of an operational vendor-supplied commercial product would demonstrate availability and offer a firm basis for costing. The utilities would be expected to be satisfied with normal commercial risk if the NRC and public were satisfied by the absolute test and thus removed as major players. The utilities presumably would also need to have demonstrated that the replacement of major components could be carried out at acceptable levels of time and effort. The NRC and the public set a much higher standard. The test(s) must demonstrate that there is no impact on the public at the plant boundary in a combination of events which includes total loss of coolant, breach of the primary system, failure of the control system, and the presence of a malicious operator. "No impact" could be defined, for example, by application of the EPA's Protective Action Guidelines. The plant would, of course, also have to meet the mandated 10 CFR requirements. If this condition cannot be met, then the NRC has a mandated role, and siting issues will remain irresolvable. The resulting uncertainty would be a highly significant barrier to utility acceptance.

G) These requirements are incompatible with Defense-in-Depth at the level of safety required for nuclear systems.

The complexity of existing plants makes them expensive to build, hard to understand, difficult to operate, and is reflected in the extraordinarily complex and inefficient licensing and regulatory process. With time, the plants get even more complex (because of regulatory pressures) and harder to maintain. The potential for human error is large, possibly dominant. This reliance on human vigilance almost ensures that high visibility accidents will occur in any large population of reactors. The absolute test condition cannot be met by systems which rely on Defense-in-Depth, because it is effectively impossible to test every possible configuration for every possible failure.

H) The imposition of true worst-case testing has important implications for the role of the NRC.

If plants survive a true worst-case test, there would be no need for detailed regulatory oversight nor justification for rule changes in plants identical to the tested plant. The role of the NRC would change to that of inspectors at the vendor's facility, ensuring that the plants were being manufactured to original specifications. The NRC would become a very strong presence at the vendor and very much less apparent to the utilities. The NRC would evolve to a FAA-like organization.

I) License-By-Test would produce *de facto* standardization.

If plants could be licensed only on the basis of full-scale tests of a commercial model, then potential vendors would undergo the cost of presenting a new model only if they were sure that the new model offered substantial advantages, or fit a new marketing niche. The situation would be quite similar to that of the aircraft industry, where there are a few dominant designs, capable of evolving with technology and need. This is a market-based rather than a regulatory-based approach to standardization.