"Acceptable Public Risk and Why"

by

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Presented at

American Nuclear Society

Fast Reactor Safety Meeting

Beverly Hills, California

April 4, 1974

To borrow a phrase of now Vice President Gerald R. Ford, acceptable public risk is whatever the public perceives it to be at the moment. Different people perceive risks in different ways. What is acceptable to one person is not acceptable to another. The examples are all too numerous -- smoking, florida-tion, flying, safety of nuclear reactors, skydiving, Nixon vs. McGovern, or simply Nixon as President of the United States. I add the last to clearly illustrate that the time at which the assessment is made is important. Public perception can be strongly influenced by information, be it fact, opinion, false statement, or dogma -- political or religious.

Some risks identified as public are assumed by most, but not all, without choice, some genetic diseases and "acts of God" for example. Others have been placed on society historically, through technological development. These risks in many cases also have been assumed for one reason, or another, without public choice. In some cases, the choice was made in the early stage of development when future risks were not well known. The development of the atuomobile arguably falls in that category. It surely does as presently perceived by at least a minority.

All people are to some degree risk averse. Life insurance is a manifestation of risk aversion. It is noteworthy that the cost of term life insurance is necessarily higher than the value of the policy weighted by the actuarial probabilities of life expectancy. Some risks associated particularly with technological developments do not manifest themselves until future generations. In other words, there can be an intergenerational transfer of risks relative to the benefits, and vice versa. Here, the risk-benefit tradeoff is perceived by some as an ethical, or moral issue that cannot be resolved except by public choice. Faustian bargains fall into this category.

Many public risks can be and many are assumed by choice -- often by government. The decision to accept a risk can be made by edict, fiat, democracy or personal choice for example. Some risks are generally perceived to be so minimal as they do not constitute matters of government. It is difficult, however, to think of a major technological development that did not or does not involve governmental decision making, in part, because government outlays account for most of the R&D expenditures in our country. Some technologies are so pervasive that decisions related to development of these and their attendant public risks should be made with public choice. The electric power industry is a good example here. Not only is the use of electricity pervasive, but its generation can also pollute the air and water -- both public goods.

In the United States it is a widely held view, and a tenet of our constitution, that the appropriate mechanism for public decision making is by representative government -- a democratic process. Governmental decisions often result in laws. These can increase or decrease public risk. One would not expect, nor does one find uniformity in public risks which are "acceptable" in the eyes of the law. It is legal to drive a car at 30 mph through a residential neighborhood or a crowded city street, however, it is illegal to drive at any speed past a school bus discharging children.

In his book, The Closing Circle, Barry Commoner rightly observes that the critical issues posed by advanced technology "are matters of morality, of social and political judgment." "In a democracy," he notes, "they belong not in the hands of 'experts,' but in the hands of the people and their elected representatives." Since the fundamental choices are value choices, a governmental response which effectively delegates the control of technological developments to a panel or group of technical or scientific experts is unacceptable. Because of this delegation of responsibility, a government decision to accept a risk does not imply that it is acceptable to the public. Furthermore, there is extensive literature analysing the effect of coalitions and government structure on decision making. In the best of all worlds representative government does not imply or reflect uniform representation.

Public participation in each phase or aspect of a federal effort to assess and control technologies is essential to the success of that effort. The greater the information and the more diverse the points of view to which government is exposed, the more accurate its appraisal and predictions are likely to be. Geesaman and Abrahamson have written in the Bulletin of the Atomic Scientists (Mar. 1973, p. 18):

> The wise use of technology, insofar as it is attainable in a democratic society, will better derive from decisions based on diverse pluralistic inputs and open adversarial confrontations, rather than on the unilateral assessments or judgments of monolithic institutions. In the social evaluation of technologies, pluralistic controversy complements rather than contradicts scientific objectivity.

One can in theory define a median level of acceptable public risk as the level of risk that 50 percent of a population finds acceptable. This however cannot serve as an operational definition and has no useful purpose where public risk decisions are made by representative government.

In conclusion, when in the course of development of a technology that is pervasive and has risks that are perceived by segments of society as unacceptable, and when you find yourself debating the question of an acceptable level of risk for this technology, the question should be resolved by public choice. In the United States the appropriate mechanism is through representative government. This should be an informed decision with the fullest public participation -- in other words, a decision reached following a national debate of the issue. In this debate different people will perceive the risks in different ways.

Plutonium vs. Botulism:
Choosing Energy R&D Priorities*

by

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June, 1974

Plutonium is aptly named, it means element of the Lord of Hell. It is the most toxic respiratory carcinogen known to man. Plutonium is the fuel of the liquid metal fast breeder reactor. In laboratory experiments with beagles, lung burdens on the order of 0.2 microcuries have produced lung cancers with almost certainty. This corresponds to about one microgram of LMFBR plutonium fuel. There are no experimental results at lower lung burdens in large animals.

Presently there is a petition before the EPA and AEC calling for a reduction by five orders of magnitude, of the existing radiation protection standards applicable to the internal exposure of man to insoluble alpha-emitting hot particles. This petition is based on a recent report by Dr. Arthur R. Tamplin and myself.

By insoluble alpha-emitting hot particles we mean aerosols of alpha-emitting nuclides which are insoluble in lung tissue.

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*/ Based on a presentation made before the American Physical Society in Washington, D. C., April 22-25, 1974.

PuO_2, the chemical form of LMFBR fuel, is capable of being formed into aerosols by fire or explosion and therefore fits into this category. In our report, Tamplin and I argue that the presently available biological evidence suggests that the risk of lung cancer per hot particle retained in the deep respiratory tissue is on the order of one in 2000.

There is a window in the aerosol activity and size that defines hot particles. The lower size limit is set by the radiation dose to the surrounding tissue, the upper limit is the maximum aerosol size that once inhaled is deposited in the pulmonary region of the lung. For aerosols composed of LMFBR fuel, the window would correspond to 0.07 to 100 picocuries or particle diameters between about 0.6 and 5 microns. While there is a paucity of data on particle size distributions, existing measurements suggest a significant fracti of routine and accidental LMFBR fuel releases to the atmosphere may lie within this window. Believing we are correct, hot particle lung burdens 3 orders of magnitude less than the 0.2 microcurie beagle dog lung burden would carry a substantial cancer risk. Suffice it to say that lung burdens on the order of 1 microgram of plutonium LMFBR fuel are known to cause cancer and a substantial cancer risk may still exist at burdens 3 orders of magnitude lower.

Now, a nominal size (1000-Mw) LMFBR will contain between 2 and 4 metric tons of plutonium. Annually, approximately one-half this amount, one-to-two tons, will be removed for reprocessing and will be circulated through the fuel cycle. The AEC has proposed that between 1987 and 2020 we build some 1100 of reactors twice this size. Over the lifetimes of these plants we are talking about a cumulative flow of some 100 million kilograms of plutonium through the nuclear fuel cycle. This is the plutonium economy in all its glory. This flow would correspond to about 10^{17} cancer doses of one microgram each or about 10^{20} cancer doses if the risk estimate by Tamplin and me is appropriate. For reference purposes the AEC estimates that of the plutonium activity released routinely, one can expect about one part in 250,000 to be deposited in the deep respiratory tissue of someone's lung. This gives you a fair idea of the containment required both at the reactor and in the fuel cycle.

Given the toxicity of this fuel, do we want to make it the backbone of our electrical energy economy around the turn of the century and beyond? Do we as a first priority want to establish a plutonium economy? To answer this question, I would like to draw an analogy with the aid of a little poetic license.

The year is 1984 and General Lethal, the Director of the Fort Dietrich Biological Warfare Laboratory in Maryland has an audience with Mr. John Hammerhill, recently appointed Director of the Federal Energy Agency. The purpose of the meeting is to brief Hammerhill on the new and revolutionary energy source that is expected to become the backbone of the nation's electrical energy economy shortly after the turn of the century.

The General opens the conversation by saying, Mr. Hammerhill, as you probably know, our laboratory has been a principal supplier of bacteriological warfare agents in this country and abroad. This work was largely an outgrowth of an extensive program that we initiated during the Viet-Nam war. This was the hush-hush work that caused such a flap back in 1977 when Jack Anderson released it to the public. By way of background, you recall that shortly thereafter the Congress passed the Bacteriological Energy Act which gave the Bacteriological Energy Commission (BEC) the responsibility of developing the peaceful uses of bacteriological warfare agents.

In the course of our work almost a decade ago, we discovered that when you confine two to four tons of botulin toxin in a small volume, a few cubic meters, it gives off an immense quantity of heat. Several biological warfare agents do the same, however, botulin toxin appears to be the most efficient heat source.[1]

For the seven years our laboratory, under the direction of the BEC, has undertaken the necessary research and development to make use of this heat to generate electricity. We have discovered that by blanketing the botulin core with clostridium botulinum in sewage sludge, we can breed more botulin toxin than we burn, hence the name "botulin breeder." We will be able to provide an inexhaustable supply of botulin toxin, and therefore, electrical energy. If for no other reason, we should develop the botulin breeder because it provides the most efficient means of utilizing sewage sludge. This is one of several significant spinoffs from this technology, but let's not get sidetracked by discussing that here.

For the past five years, the botulin breeder has been the priority civilian energy R&D effort in the BEC, and the nation for that matter.

1/ The lethal dose of botulin toxin has been reported as about 10^{-10} g/kg body weight or 6×10^{-3} ug for a 60 kg man. [Metzger, H. Peter, The Atomic Establishment, Simon and Schuster, New York (1972), Ref. no. 225, p. 287.] This would be comparable to the hot particle cancer risk proposed by Tamplin and me.

Following the endorsement of a demonstration plant by the Joint Committee on Botulin Energy (JCBE), in his June 4, 1981 Message on Energy to the Congress of the United States, the President presented a program which included "... A commitment to complete the successful demonstration of the botulin breeder by 1990." He further stated that "... Our best hope today for meeting the Nation's growing demand for economical clean energy lies with the botulin breeder. Because of its highly efficient use of botulin toxin, the breeder reactor could extend the life of our fuel supply from decades to centuries, with far less impact on the environment than the power plants which are operating today."

Like all energy systems, the botulin breeder has environmental risks associated with it. In the case of the botulin breeder, these are minor in nature. We have resolved most of them and we have a research program that will solve the remainder. First, in the process of producing heat, the toxin is destroyed and a spectrum of toxic waste products are produced. It is necessary to separate the waste products from the botulin fuel. We propose to remove from each breeder annually roughly one-half or about one to two tons of botulin toxin together with half the toxic wastes. These are sent first to a pharmaceutical company, for reprocessing. The botulin toxin recovered from this operation is then shipped to a second pharmaceutical facility for fuel fabrication and then back to one of the numerous botulin breeders to be used again as fuel.

Some of the waste products removed at the reprocessing plant, for example, staphylococcus enterotoxin and tetnus toxin, we refer to as high level waste. We propose to store these in mausolea for several decades until we develop a satisfactory perpetual storage concept. The volumes of these toxins are small. In fact, on a per capita basis the annual production of these toxic materials would be no more than the size of an aspirin. We foresee no waste disposal problems that cannot be resolved through reasonable advances in engineering technology. The intermediate waste, the streptococci, staphylococci and salmonella typhosa will be disposed of in appropriate commercial land burial sites. The low level materials, the syphylis spirochete, gonococci and cold viruses we will release routinely. The doses to the public from these releases will be only a small fraction of that which they normally receive from natural sexual activities, and therefore these releases pose no threat to the public.

One minor difficulty somewhat unique to botulin breeders is the explosive potential of these devices. We believe these accidents to be exceedingly low probability events. For one thing, we have a negative caloric feedback which inhibits the growth rate as the temperature increases above the normal value. Furthermore, because of the anaerobic nature of clostridium organisms, we have incorporated two emergency oxygen systems which will scram the reaction before any transient activity builds up to an explosive level. Finally, there are multiple containment barriers which we believe to be adequate to contain the toxin following any hypothetical ferminator disruptive accident (HFDA) with failure to scram. We have been studying the explosive potential of these botulin breeders for the past twenty years, and while considerable work needs to be done to confirm their explosive potential, through the use of very conservative assumptions in our computer codes we believe we have determined an upper limit on the mechanical energy release for any credible accident scenario. For credible accidents the energy release is below that of the design basis accident. One can of course arbitrarily postulate fermenting growth rates that will lead to explosions exceeding the containment capability. Granted there is no way to demonstrate scientifically that these events could not occur, however, we believe accidents scenarios leading to these high ramp rates are exceedingly low probability events, if they could occur at all. We just don't see a credible mechanism leading to these events. At any rate, with the completion of a Fast Flux Fermentory Facility (4F) and the Clinch River botulin breeder (the demonstration plant) we will demonstrate the safety and reliability of these systems.

One final problem arises because botulin breeders are a potential hazard to the public in that they create the means, in theory at least, of a new form of anti-social behavior. The concern here is that small quantities of toxin on the order of a few kilograms, can be fashioned into highly dangerous bacteriological weapons. I think I can dispel any fears you might have in this regard if you will permit me to read a short passage from the Draft Environmental Impact Statement on the Botulin Breeder recently prepared by the BEC.

> "The expected growth of commercial botulin power in the United States, including the botulin breeders with its large quantities of botulin toxin, indicates the need for continuous upgrading and strengthening of the governments safeguards program. The currently defined program objectives and elements are believed to provide the broad scope and flexibility necessary for timely development, placement and enforcement of such modified or new safeguards requirements as may be found necessary. The program elements themselves are not fixed, but may be strengthened or expanded as the result of continuing in-house review. Similarly, while the safeguards program in its present implementation provides a strong base, it must be viewed as an evolving program. Additional investigations, analyses, social studies and hardware developments are anticipated."

This Environmental Impact Statement was recently prepared under court order by the BEC. The report envisions that a commercial botulin breeder program would be available to utilities by 1997, with the possibility of as many as 400 breeders in operation by the year 2010. The BEC's director of botulin research and development recen told a press conference that the BEC had examined a number of energy technology alternatives, but none was identified which could adequately substitute for the botulin breeder in expanding the nation's energy resource base during the next 30 to 40 years. The BEC projects that an additional four to five billion dollars will be spent in botulin breeder research and development between 1985 and 2020.

In considering environmental effects the impact statement concluded that a fully developed botulin breeder industry is expected to be able to meet environmental quality and safety standards and, therefore, not have a significant adverse environmental impact.

The report further concluded that toxin releases from the botulin breeder would cause from near zero to less than 1/1000 potential health effects for each 1000 Mwe year of electric power generated by the botulin fuel cycle. As I noted earlier this is considerably less than those caused by normal sexual activities.

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There can be little doubt that the public and governmental decision makers would be very skeptical of such an Orwellian strategy for meeting our electrical energy needs. Certainly one would hope that this nation would thoroughly pursue all alternative approaches for electrical energy before opting for the botulin breeder. However, an examination of our present strategy demonstrates that we are actively pursuing today a botulin-like breeder reactor as our priority research and development program in the energy field. And we are doing this at the expense of promising and far more acceptable alternate energy sources.