



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS  
WASHINGTON, D. C. 20555

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May 7, 1980

The Honorable Victor Gilinsky  
Commissioner  
U. S. Nuclear Regulatory Commission  
Washington, D. C. 20555

Dear Dr. Gilinsky:

This letter is in response to your letter of December 18, 1979, in which you raised several questions about the ACRS letter of December 11, 1979, concerning the pause in licensing.

1. In its letter of December 11, 1979 the Committee said:

"The ACRS believes that the risk to the public health and safety which is posed by the operating nuclear power plants is comparable to or probably smaller than the risk posed by other existing methods of generating the same quantity of electricity. The ACRS also believes that this risk is comparable to or less than that posed by many other technological activities of society."

You have asked to "know the Committee's technical basis for the risk comparison with other methods of electricity generation." The attachment to this letter, which was prepared by three ACRS Fellows, provides some details of the technical basis for this ACRS opinion. In brief, there have been a number of studies during the past several years in which the health effects of various methods of generating electricity have been assessed and compared. Such comparisons include quantitative evaluation of the occupational and public health impacts of each of the steps (e.g., mining, transportation, production) involved in the different methods of electricity generation, and evaluations of the different ways (e.g., respiratory illness, cancer, genetic consequences) in which each of these impacts manifests itself. However, all such studies are subject to large uncertainties due to their incomplete nature and to limitations on our knowledge of the health effects of various pollutants and the probabilities of serious accidents.

Air pollution due to combustion of fossil fuel represents a potentially very large health effect which includes many complex factors. Only a few epidemiological studies provide the basis for current risk estimates from such air pollution, and these studies are subject to controversy. However, it is clear that carcinogens, mutagens, and toxic substances of various kinds are emitted in large quantities from the combustion of coal, and the bulk of expert opinion is that a substantial, albeit uncertain, effect on health can result. The application of modern airborne pollutant controls would reduce this risk.

Essentially no risk estimates are available for large accidents from hydroelectric generation. However, knowledge of the failure rate for large dams, of the limitations of safety criteria used in dam design, and of the potentially very large number of fatalities which could result from the failure of various dams, indicates that the expected value, measured in terms of fatalities per MW-year, should not be insignificant. The generation of electricity from liquefied natural gas should fall in a category similar to that for hydroelectric generation.

Of course, the risks of major economic difficulties or even war which are associated with the use of oil are difficult to assess, just as are the risks of nuclear weapons proliferation from the use of LWRs. Also, the increase in atmospheric CO<sub>2</sub> concentration due to combustion of fossil fuels is unavoidable. Its effect upon the temperature of the earth, agreed to by nearly all experts, and the consequent effects are uncertain, but potentially catastrophic. Such risks were not explicitly factored into the available published risk comparisons or into the ACRS comment. The difficulty of including genetic effects or the potential for depriving society of access to the use of land and other resources further complicates such assessments.

Coal, oil, and nuclear plants all introduce risks from the acquisition of fuel, over and above occupational risks for which data exist. While estimates exist for the risk from the tailings of uranium milling operations, the ACRS is not aware of quantitative studies of chronic risks to the public health from the mining of coal, for example, from acid mine drainage. While considerable emphasis has been given to the need for careful, long-term disposal of high-level radioactive waste in the future, relatively little attention has been given to risks from the ongoing disposal of large quantities of solid wastes from coal-fired plants, and such risks have generally not been included in risk comparisons.

For plants to be constructed, nuclear and nonnuclear, a comprehensive comparison should allow for all contributions to risk, including those resulting from the acquisition of materials of construction, the fabrication of components, and the construction of the plant. Also, any risk comparison should allow uniformly for anticipated improvements in safety for each type of plant. However, the ACRS letter of December 11, 1979 referred to those LWRs whose construction is nearly complete; hence, a comparison of the risks from operation of such plants with the risks from operation of existing or newly completed coal, oil, or hydroelectric plants is probably relevant to your question.

In each study summarized by the ACRS Fellows, the risk to the public health and safety arising from the operation of nuclear power plants was assessed to be smaller than the risk posed by other existing (coal and oil) methods of generating the same quantity of electricity. Only if relatively pessimistic assumptions regarding nuclear safety are employed, is the risk of nuclear energy comparable.

For example, one estimate [1] of the health effects of producing  $10^{10}$  kWh of electricity in 1975 gave the following results:

From Coal:	Estimated deaths	10-200
	Estimated disabilities	300-500
From Oil:	Estimated deaths	3-150
	Estimated disabilities	150-300
From Natural Gas:	Estimated deaths	0.06-0.3
	Estimated disabilities	4-27
From Nuclear:	Estimated deaths	1-3
	Estimated disabilities	8-30

The recent study by the Committee on Nuclear and Alternative Energy Systems of the National Academies of Science and Engineering considered the period 1985-2010 and arrived at similar conclusions.[2]

The ACRS has noted some of the constraints and shortcomings in such studies, such as the lack of actuarial data and the uncertainties in the epidemiological models employed. In all the studies reported, the estimated risk due to catastrophic nuclear accidents was based on WASH-1400 and is subject to large uncertainties. However, since the contribution of nuclear accidents to the estimated deaths and disabilities is extremely small, this contribution would have to be increased by a factor of about five hundred in order to make the total risk from nuclear comparable to that from coal. The next six to twelve reactors to be ready for operation are at sites which are neither the most remote nor the most densely populated. The ACRS expects the consequence calculations of WASH-1400 to be roughly applicable, although a conservative view might lead to use of an additional factor to allow for differences of opinion on the effectiveness of evacuation, the effects of low level radiation, etc. The conservative application of a factor of 20 to the probability of core melt and a factor of 5 to the consequences as estimated in WASH-1400 would still leave the health and safety effects of these LWRs smaller than or comparable to those estimated for oil or coal.

2. You have stated, "I would also like an explanation of the relevance to decisions on prospective operating licenses of the comparison with other technical activities." The ACRS believes that it is relevant to consider the risk from electricity generation in some broader societal context for a variety of reasons. All technological activities are not equally beneficial to society, nor do they pose equal risks. Nevertheless, an examination of comparative risks provides insight into the risk levels society has accepted, tolerated, or imposed; it also provides a partial insight into where the limited resources of society can be spent in a more nearly optimum fashion to reduce risk. Studies by Sinclair [3], Morlat [4], and Schwing [5], among others, provide some good examples of disparate societal expenditures to reduce risk.

If the risks from operating nuclear power plants to individuals or society were large compared to those posed by other ongoing technological activities of similar societal benefit, and if one had anticipated that the licensing pause would produce a significant reduction in this larger than "normal" risk, one might need some compelling motivation in order to grant additional operating licenses without a pause, even for interim operation at medium power levels for testing purposes. On the other hand, if society is routinely accepting, tolerating, or imposing risks from other ongoing activities which are much larger than those from light water reactors of current design, this fact should provide one significant input into the decision making involved in the pause.

The ACRS believes that society continues to accept large, acute and chronic risks from other technological activities; risks which are larger than those posed by LWRs. For example, dams which have been judged to be hazardous by the U.S. Army Corps of Engineers remain full of water and the operation of many dams has been tolerated, on at least an interim basis, even though the estimated likelihood of failure lay between 1 in 1000 and 1 in 100 per year. A similar situation exists for many thousand seismically substandard large buildings in Los Angeles and elsewhere. There are many other examples of substantial technological risks to be found throughout the United States, particularly from the storage and the disposal of hazardous chemicals.

In its letter of December 11, 1979, the Committee said:

"The ACRS has, in the past and again since the Three Mile Island accident, recommended that the NRC and the nuclear industry take major steps to improve the safety of nuclear power reactors. The ACRS believes that it is proper that nuclear power be safer than other comparable technologies. The Committee has sought this goal. It believes that the country wants a higher level of safety for nuclear reactors and is willing to pay for it. The ACRS also believes that the country wants a higher degree of assurance as to the level of safety which is being attained."

3. In its letter of December 11, 1979, the Committee said in part:

"While the ACRS believes that interim licensing of the next six to twelve nuclear power reactors for operation on the same basis as is now being accepted for currently operating reactors would not pose undue risk to the public health and safety, the ACRS favors the consideration of additional improvements in their safety on a case-by-case basis, as recommended by the President's Commission."

You have stated, "I would like to know what the Committee takes into account in defining 'undue risk.'"

The use of the term "without undue hazard" and "without undue risk" by the Atomic Energy Commission and the ACRS dates back more than two decades. The phrase, "without undue risk" was incorporated into Section 50.35(a) of 10 CFR 50, Code of Federal Regulations, more than fifteen years ago. The AEC Regulatory Staff provided a largely legalistic discussion of the meaning of "without undue risk" to the Atomic Safety and Licensing Hearing Boards for Malibu (Docket 50-214) and Fort St. Vrain (Docket 50-267) in 1966 and 1968, respectively.

In 1973, in connection with the publication of WASH-1270, "Anticipated Transients Without Scram for Water-Cooled Power Reactors," the Regulatory Staff proposed as a safety goal that the chance of a serious accident with consequences in excess of 10 CFR 100 be no greater than one in a million per reactor year for a large population of reactors. This philosophy was incorporated in part into the Standard Review Plan and was stated to the Congress by L. Manning Muntzing, the then Director of Regulation, without adverse comment by the Atomic Energy Commission itself.

As you know, during hearings of the Joint Congressional Committee on Atomic Energy on March 2, 1976 you stated that there had never been an explicit quantitative safety standard set by the Congress, by the AEC, or by the NRC, and that you thought there was a need for such a standard. The ACRS was asked by the Joint Committee on Atomic Energy to comment on this statement. The ACRS response of April 12, 1976 stated in part:

"The ACRS believes it will be difficult to establish such safety standards and that it will be impossible to apply them without considerable reliance on engineering and scientific judgment. The ACRS has endorsed the development of a simple probabilistic risk standard as a reasonable starting point with full recognition that there are various degrees of seriousness in postulated accidents and that, for the long term, a relation between acceptable probability and consequence may be needed. Also, there

does not currently exist a well-defined means for factoring uncertainties pertaining to the estimation of low probability events into decisions using a quantitative probabilistic safety standard.

"The ACRS believes that, for reactors to be constructed in the next several years a probability of less than one in a million per reactor year for an accident having serious consequences to the public health and safety is suitable as an interim objective."

The minutes of the April 1976 ACRS meeting show that the Committee agreed that a "serious" accident would be one having consequences equivalent to that of a fatal crash of a loaded commercial aircraft. It is noted that the Congress did not react unfavorably to the ACRS interim objective.

In its letter of December 11, 1979, the ACRS used the term "undue risk" in connection with the possible interim licensing of the next six to twelve nuclear power reactors. The ACRS does not yet have the benefit of systematic evaluations of the reliability of systems important to safety for each reactor in question, i.e., evaluations which the ACRS has recommended in the past and which the NRC is initiating now. Nevertheless, the Committee believes it unlikely that even those persons living closest to any of the reactors under consideration would be subject to a risk greater than  $10^{-5}$  per year of early death from exposure to a large quantity of radioactive material following a serious accident, if those reactors meet the current post-TMI requirements. The Committee would expect this risk to be still lower from interim operation at limited power as recommended for consideration in its letter of December 11, 1979.

The ACRS anticipates that similar probabilities are applicable for the chance of a sizable population group receiving a large collective dose due to a major release of radioactive material.

While the ACRS has favored and continues to recommend that measures, as practical, be taken to mitigate potentially serious accidents, the ACRS believes that society has not in the past prohibited activities which pose the potential for low probability-high consequence events and that society is not and should not be so risk averse to such events that it incurs substantially greater risks or loses major benefits as a result.

In its letter of May 16, 1979 to Chairman Hendrie, the ACRS recommended that the Nuclear Regulatory Commission develop quantitative safety criteria for nuclear reactors. In its letter of February 14, 1980 to Chairman Ahearne on siting, the ACRS recommended that the NRC develop

an overall safety policy. The Committee continues to believe that the definition of "no undue risk" represents a major policy decision which the Nuclear Regulatory Commissioners should take and present to the Congress and the nation to approve or disapprove.

4. You concluded your letter of December 18, 1979, as follows:

"I must add that in reflecting on your advice on what does and does not 'pose undue risk' I am reminded of a meeting we had with the Committee soon after the Three Mile Island accident on whether or not to suspend operations at the plants with B&W reactors. No member of the Committee thought it necessary or desirable to suspend operation at these plants. The NRC staff later decided that a more conservative approach was required and recommended that the plants be shut down for necessary modifications. This difference in outlook is evident again today."

The ACRS wishes to make several observations in regard to this comment:

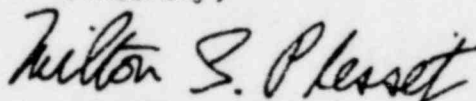
- o It is to be expected that separate groups or individuals forming independent judgments on matters of safety will differ.
- o During the last fifteen years, the ACRS has frequently been more conservative than the Regulatory Staff and the Commissioners themselves. This was true in 1965-66 when the ACRS recommended major improvements in pressure vessels, ECCS and primary system integrity. It was the case when in 1966 and the thirteen succeeding years the ACRS recommended the development and implementation of measures to mitigate core melt accidents. It was the case when in the late 60's and 70's the ACRS recommended improvements in design and increased preparedness measures beyond the low population zone for highly populated sites accepted for reactor construction. It was the case on Three Mile Island, Unit 2 with regard to instrumentation to follow the course of accidents. And it has been the case for the last few years in the Committee's efforts to put life into the program for research to improve reactor safety.
- o No member of the ACRS had a technical basis for recommending shutdown of the B&W reactors based on the information available to the ACRS during its meeting in April 1979. During the days following the April ACRS meeting, the NRC Staff decided it was sufficiently concerned about the probability of a transient leading to a stuck open relief valve in B&W reactors that it would recommend reactor shutdown and a few specific modifications. The ACRS was not asked a second time and in view of further developments has not provided any opinion on the need for these specific actions on the time scale utilized. However, the Committee believes that there exists a large body of ACRS recommendations to which the NRC Staff and the Commission have responded far more slowly than the Committee believes was prudent.

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The ACRS, therefore, does not agree with your conclusion, if you are suggesting that the NRC Staff or the Commission has generally adopted a more conservative position than the Committee.

Additional comments by Members H. W. Lewis and P. G. Shewmon are presented below.

Sincerely,



Milton S. Plesset  
Chairman

Additional Comments by Members H. W. Lewis and P. G. Shewmon

The Committee has gone on record here with an estimate of  $10^{-5}$  as an upper limit to the risk per year of early death for those living closest to a reactor. This number is based on no study of which we are aware, and we are dismayed that the Committee should invent an important number after the Commission has expended so much time, effort, and money to have this risk calculated as well as one could (Reactor Safety Study, WASH-1400). These calculations, such as they are, yield numbers two to three orders of magnitude smaller as best estimates of this risk.

After the above comments were written, the Committee also adopted the section assessing the risk from the next six to twelve reactors, and repeated the previous performance by inventing factors of twenty and five for accident probability and consequences, respectively. These are called conservatisms, but are, in fact, multiplicative factors with no solid basis. I believe that a Committee of the minence and stature of this one has the responsibility to use in its reports only numbers which have an agreed scientific base, or at least, where this is lacking, to justify the estimate. Had these factors been chosen in the other direction, a righteous uproar would have ensued. I believe that if the Committee is going to adopt a position revising the WASH-1400 risk upward, it should do so as a result of a deliberate review of the current position. The only such review so far (The Risk Assessment Review Group) specifically eschews such a revision.

In addition, the Committee was asked to provide the "technical basis for the risk comparison with other methods of electricity generation." To be responsive to such a request, the comparison must be made even-handedly, and it is wrong to penalize or exalt any method. It is not proper to arbitrarily penalize nuclear power just because some calculations make it appear so much safer that one is embarrassed. Yet in the case in the previous note the Committee has chosen not only to assess the nuclear risk to a person living



right next to a reactor (while not doing the same for alternate methods), but has then on top of that, multiplied the nuclear risk by a factor of one hundred to one thousand. In this case the factor is "only" one hundred, but it is just as arbitrary, and does not lend itself to an objective answer to the question to which this letter was supposed to be responsive.

Attachment:

"A Survey of Risks of Alternative Fuel Cycles," by ACRS Fellows,  
J. M. Griesmeyer, D. H. Johnson, W. E. Kastenberg, April 28, 1980.

REFERENCES:

1. L. D. Hamilton and A. S. Manne, "Health and Economic Costs of Alternative Energy Sources," IAEA Bulletin, 20, pp 44-57, August 1978.
2. National Research Council, "Energy in Transition 1985-2010," Final Report of the Committee on Nuclear and Alternate Energy Systems, 1979.
3. C. Sinclair, P. Marstrand, P. Newick, "Innovation and Human Risk: The Evaluation of Human Life and Safety in Relation to Technical Change (Centre for the Study of Industrial Innovation, London, 1972).
4. G. Morlat, "Un modele pour certaines decisions medicales," Cahiers du Seminaire d'Econometrie, Centre Nationale de la Recherche Scientifique, Paris, 1970.
5. R. C. Schwing, "Technological Forecasting and Social Change," 13-333 (1979).