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NUCLEAR POWER IN ITALY

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As is known to most of this audience in November of 1987 a referendum determined a rejection of nuclear power in Italy. The referendum may be taken into consideration here as a large scale experiment which offers points of interest to this conference and problems to be aware of, in approaching a severe confrontation with the public.

To give a synopsis of the Italian perspective I will examine: first the public acceptance in the situation before Chernobyl, then the most disturbing and sensitive factors of Chernobyl's consequences; how the opposition to nuclear energy worked with the support of most media and the strong pressures of an anti-nuclear political party, the syllogism of the opponents and the arguments used, the causes of major weakness of the defenders and how a new perception of nuclear risk was generated in the public.

I will come to the topic of utility acceptance by mentioning that ENEL, as the National Utility, in its role is bound to a policy of compliance with Government decisions. It is oriented today to performance of feasibility studies and development of requirements for the next generation of reactors in order to maintain an updated proposal for a future recovery of the nuclear option.

I will then try to identify in general terms the factors determining the future acceptance of nuclear power. They will be determined in the interdisciplinary area of politics, media and public interactions with the utilities the uses of the technology are forced to follow, by political constraints, two main directives: working only in new projects to achieve, if possible, new safety goals.

Before the Chernobyl accident, the public did not believe that catastrophic nuclear power events were really possible. The worst expected situation was something similar to that of TMI: a precautionary evacuation from a limited area around the plant, with the possibility to recover use of the affected territory after a short time (a few weeks), without substantial economic losses, without loss of life, or at worst limited to a few individuals. Even this was expected only under circumstances which seemed very unlikely to occur.

Nuclear power was generally accepted, though there was an initial opposition from local residents who asked for financial compensation for economic losses or contributions to solve territorial or town planning problems, which were identified initially or claimed to be correlated to the construction of the plant.

To solve this problem, the Government obtained the approval of a specific law which allowed the National Utility ENEL to compensate the local administrations for financial losses: the financial resources were used to solve town planning problems, employ resident workers and build houses for temporary workers. The local residents always had a positive experience near an operating plant. An example of this is given by the fact that the Caorso and Trino residents offered to host a second nuclear power plant in the same two sites.

During the Chernobyl accident the most disturbing factors were:

- The unexpected consequences (mainly the long term evacuation, the definitive loss of territory and, in addition to near term losses of human life, the unknown worldwide consequences for future generations).

- The long distance propagation of consequences. This fact helped the opponents of nuclear energy to create the impression that a common risk was originated from a common technology and that we were close to approaching the "planetary catastrophe" (cf. Umberto Eco) described by many science fiction writers.

To help convince the most absent-minded, a direct involvement was created by restrictions on trade and consumption of food and by the fear of genetic effects generated by "microdoses," as it has been stated by "famous experts" never heard before.

The excessive activity of the press and TV networks, promoting debates among all kinds of experts with contradictory conclusions, convinced the public they were being served by an unreliable information system, so they tended to lean toward the worst, conservative assumptions.

After Chernobyl, a new perception of risk was then generated, rejecting the low probability concept mentioned by some scientists, coming to the conclusion that, although high risks of low probability are acceptable if consequences have predictable boundaries, the consequences of severe accidents from a nuclear power plant are not acceptable, at any low probability or cost, being perceived as a catastrophe with unknown limits, extending into the future with genetic effects, and implying definitive impossibility to live in one's own territory.

To this new perception of risk we have to add the damage generated by the public distrust of institutions and the present nuclear technology in general which was mainly built up by the anti-nuclear party. This party was supported by a predominant part of the media (five out of seven networks siding against nuclear power, one mildly neutral, one absent from debates).

It is interesting for our purposes to synthesize the syllogism used by the opponents to nuclear energy whose premise was that Chernobyl is representative of the present nuclear plant technology, and whose conclusion was that the use of nuclear energy today has to be rejected, the consequences being unacceptable.

Through the actions of the opponents, who proceeded in various phases to create distrust of official experts and institutions, consulting all manner of unofficial "experts" to bring about debates destroying public trust in scientists, this rough syllogism was successful in the face of the scientists' inability to talk to the general public, and the poor support of the media.

Although defenders of the nuclear option were not only scientists, there was not an organized pro-nuclear party. Scientists did participate as volunteers in debates, which were mostly chaired by opponents. It is useful to identify four weak points:

(1) Scientists are mostly unable to talk to the general public. Although they do not like to admit it, this requires specific training and expertise.

(2) Scientists lose in debates against even mediocre opinion makers. In a debate, a scientist's function should be to explain, not to engage in the actual debate. Scientists are used to expressing complex truths, not trying to alter emotional opinions; opinion makers do not have these constraints.

(3) A scientist's language is inadequate for debate. Terms such as probability, passive, and inherent are not understood in their exact meanings. These words are borrowed by politicians and misused.

(4) Technical arguments are unproductive, including those of the "skeptical elite." People ask for simple answers to specific issues like severe accident consequence protection, dose effects, waste management. They are not interested or cannot follow arguments such as severe accident scenarios, steam explosions, hydrogen detonation, DCH and related design provisions. They only realize that there is a debate, and they support the contender they trust more.

Coming to the utility acceptance I have to mention that ENEL is the unique national public utility and as such must reflect the Government decisions. It always had a positive attitude toward the use of nuclear energy, understanding its strategic role, although it was forced to proceed in this direction very slowly. (ENEL took 10 years to construct Caorso, whereas, before the nationalization and formation of ENEL, the private utilities SENN, EDISON, and SIMEA took only four to five years to construct the first three nuclear power plants.)

After Chernobyl, ENEL at first opposed the Government decision to halt construction on Trino-2 and Alto Lazio, defending the nuclear option and the massive resources invested in the construction of these plants. (Trino-2 was the first of three plants projected to be built to a standardized design of the pre-Chernobyl National Energy Plan.) ENEL conformed later to the Government decision to stop construction and also agreed to shut down Trino-1 and Caorso.

ENEL maintains a small staff (about thirty people) to follow the development of design criteria for future applications. ENEL participates as a utility in the development of EPRI requirements; supports the adoption of internationally acceptable safety principles; accepts the use of severe accidents as a design basis, provided they will be defined within a minimal cut-off frequency (probability of occurrence of, say, 10^{-6} or 10^{-7} or so); and gives priority to the requirements leading to the avoidance of an early (i.e., planned) evacuation, which is a determining factor in the local acceptance question. The simplification is welcomed as a way to reduce operator errors, cost, and construction time.

The factors determining acceptable nuclear power technology in the future may be identified and represented by an intersection of decision areas concerning politics, the public, the media, and technology. Separate initiatives in each field would be unproductive; the necessary synergism is likely to appear as soon as combined corrective actions are taken in:

- Politics – increasing sensitivity to strategic aspects of the use of nuclear technology (economic pressure, public consent, new majority).

- Public arena – renewed trust in the institutions (receiving assurance), awareness of the necessity of nuclear power (economic cognizance from media), more sophistication, improved control of politics, (new generations, legal reforms).

- Media – more correct, impartial, independent information. Present difficulties include current procedures too slow in correcting false news, non-experts may be incorrect and factious (I realize independence is perhaps utopian).

- Technology – substantial new achievements in safety (no offsite consequences should arise after a severe accident), develop an attitude of communication.

Two main directives are given by the Government to the operators of the "Nuclear presidio" today:

- The residual resources that can be allocated to nuclear research are justified only if most effort is devoted to new design developments (effect of the syllogism – Chernobyl equals state of the art) in the expectation of substantial improvements in safety.

- The expected safety goal will be achieved if the assurance can be given that a long term evacuation (and loss of territory) from a plant site will not be necessary in all accident conditions.

NUCLEAR POWER PUBLIC AND UTILITY ACCEPTANCE ISSUES IN SOME OTHER COUNTRIES

DISCUSSION

The majority of the discussion of this session covered issues similar to those of the previous sessions, such as the advantages of large versus small reactors and of passive versus active safety features. In cases where the comments were made by one of the international panelists with specific reference to the situation in his country, the speaker is identified here. A synopsis of the similarities and differences of the views from participants from various countries, as presented in the four panelists' papers and ensuing discussion is presented in the Rapporteur's summary, following Session Six.

In response to an assertion that probabilistic risk assessments (PRAs) quantify the core damage frequency at values which are roughly equal for reactors using purely passive safety systems and proposed ABWR and APWR concepts using active or semi-passive safety systems, one participant warned against dismissing too lightly the smaller, passively safe reactor. He reasoned that if there is a core-damaging accident in a 1200MWe reactor, the entire power-producing capacity is lost, whereas the loss of one of a pair of 600MWe reactors means that the plant can still produce 600MWe (assuming that society permits the remaining reactor to continue to operate). He also cited advantages in terms of power planning and construction as additional reasons to explore the option of smaller nuclear power plants.

Mr. Rim countered this viewpoint, saying that this approach will lead to additional siting problems as the industry attempts to use a growing number of plants to attain the same generating capacity. He explained that Korea currently has three sites with nine plants in operation and four or five more committed. Those sites may accommodate about twenty plants in all, but the current Korean plan is to build fifty more reactors during the next thirty years. To do so they must find new sites. This will almost certainly lead to problems in a country as densely populated as Korea. He also listed cost as a reason to avoid moving to smaller reactors, citing the economy of scale of a larger plant as being a considerable economic advantage for large plants. Not having to address the full range of socio-political licensing problems that have plagued the American nuclear power industry, Korean companies can complete a plant, large or small, in four to five years. Thus the Korean industry would not gain greatly from the decreased construction time of smaller plants.

One of the American participants agreed with this position, saying that he sees the construction and operating costs of a very large number of small plants as being much higher than with fewer, larger plants. The question arose concerning whether a small reactor could be built on a much smaller site than a large one; the response was that the size of the site would be virtually unchanged, as the size of the reactor and turbine are relatively small, and that the majority of the land is taken up by warehouses and maintenance and waste management facilities.

Although it did not come out in the discussion explicitly, it should be noted that the most probable layout for smaller, passively safe reactors would be a number of reactors clustered on one site, sharing support facilities. This eliminates the argument that smaller reactors would mean the need for additional sites. It might also be pointed out that, as current reactors reach the end of their design lives, reactors of the next generation could very easily be built on the same or adjacent sites, thus taking advantage of existing facilities, greatly easing the task of monitoring the decommissioned reactor, and eliminating the need to search for additional sites and draft new emergency plans.

Coincident with the discussion of the issues of small versus large reactors was discussion of the advantages of passive and active safety features. It was noted that, while passive safety has a most positive influence on public perception, from a technical viewpoint we must look carefully to see if it is possible to construct a truly passively safe reactor. It was stated that the greatest advantages of introducing passive safety features may be to increase diversity and decrease the frequency of common mode failures.

The addition of many more passive safety features is aimed at reducing the probability of core damage and of offsite exposure. But, it was asked, if some extremely unlikely event were to occur causing a severe accident, could we be sure of having small consequences? The response was that one thing that emerged from the discussion and studies which have been done in the passively-oriented LWR program, is the result that much more substantial use of passive safety features could bring about significant reduction in the expected risk. The assertion was made that this promising technological avenue need not be pursued in a pure way, that a marriage between the use of active and passive components in a creative fashion could produce a good result.

One aspect of safety features that was cited by this participant is the factor of uncertainty. He stated that the question of which approach to take (active or passive) becomes hard to resolve, because through use of redundancy with active features, one can drive the expected frequency of accident to a very low value, provided one is careful not to become susceptible to common mode failures and human errors. He went on to say that an additional factor which favors the use of passive safety features is that the uncertainty associated with such features is also generally lower than with active features.

This last point was countered by one participant who asserted that there is in fact greater uncertainty with passive systems insofar as one has more control over active systems. He added that most active designs on the board and nearing completion from a design standpoint have done much to increase both diversity and redundancy to a greater degree than in the currently operating plants. He contrasted this trend with that of recent passive designs, which rely heavily on one type of safety system (e.g., a robust fuel element).

Both Dr. Santarossa and Mr. Schaefer alluded to the fact that a potential design goal might be that a plant should be required not to have an accident that would require evacuation. They explained that this may be a realistic requirement for public acceptance in their countries and does not necessarily reflect expectations for designs in progress.

This discussion led a former Commissioner of the NRC present at the Conference to describe the origin of current United States emergency planning and evacuation requirements. These came out of the Three Mile Island (TMI) accident. The NRC attempted to correct for the low level of advance emergency planning that existed at that time. This attempt was intended to cause the utility, in conjunction with the local community, to develop emergency plans. These were not called evacuation plans. The focus was on what to do in case of an emergency and how to characterize it. It was based on the assumption that the most likely result would be an accident with no release of radiation. The most likely best action to take, were there radiation release, would be to stay inside shelters until the resulting radioactive plume had passed. Evacuation, however, became the lightning rod of the issue, and it is there that most of the heated discussion has been focused ever since.

It was asked of Mr. Schaefer if he meant that he would want the reactor to be designed to give very high confidence that one need not do any emergency planning around the site. His response: "How strictly can we limit the consequences of an accident? Of course, we can not do that in an absolute manner. We need some cutoff criterion to define accidents which we do not consider. This is necessary because we can always construct some catastrophe, such as a meteor hitting a reactor, which does not limit the consequences in the fashion of the most plausible accident. But look at the actual situation. We have a core damage frequency of 10^{-4} or 10^{-5}

per reactor year, and recent NRC risk studies show that consequences of these core damage accidents can be tremendous. For each core damage accident, there is a rather high probability that the consequences will not be kept within low bounds.

"The conditional probability of large consequences, given a core damage accident, should be decreased by much greater use of mitigative features in comparison with current reactors. This is necessary because the overall probability of large consequences is a product of the core damage probability and the conditional probability for large consequences given core damage. There should be an allowed upper limit of 10^{-7} per reactor year or less on the occurrence of large catastrophic consequences. Then one should ask the question of whether emergency planning is required. If we can achieve an efficient mitigation of core damage accident by a factor of 10 to 100 in probability, it can be argued that there is no reason for emergency planning. However, even if such an effort were successful, I do not know if politicians would accept that idea. At least there would be a scientific basis for it."

One participant of the nuclear power industry asserted that such risk values are not believable, that one can invent accident scenarios, including external events, that drive the core damage probability back into the neighborhood of 10^{-4}. He added that the issue goes beyond what can be described by numbers and PRAs, that there are fundamental socio-political factors at play here that allow countries such as Korea and France to continue to build new reactors, while others such as Italy and the U.S. are stymied.

To the suggestion that what is needed for a nuclear power revival is the education of the public, one participant stated that the important social factor is not one of ignorance. Rather, some of the industry's strongest critics are very knowledgeable about nuclear power technology and radiation. He said the fundamental concern of these people is the inability, or perceived inability, to limit the consequences of an accident within acceptable bounds, due to the uncertainties involved. He went on to say that we find some of the most sophisticated people, with regard to risk, responding the same way in the face of uncertainty as does the public: those in the insurance industry. For example, in this country it is almost impossible to get insurance for liability claims for pollution associated with hazardous waste facilities. That is because no insurance company wants to enter into a situation where they may be subject to risks that can not be bounded confidently. The public is responding much the same way.

One critic of the industry suggested that perhaps the best approach to limiting or bounding an accident would be to employ consequence analysis rather than probability analysis. This suggestion arose from the fact that there is a finite amount of radioactivity in the core. He presented the example of permanent land contamination, which is dominated by releases of radioactive cesium: the land area that can be contaminated by an accident involving a 1000MWe reactor at equilibrium is limited to 200 square miles for an individual radiation exposure dose of 10 rem over thirty years. Similarly, a 100MWe reactor is limited to 20 square miles with a 50% release of the cesium activity from the core. A CANDU type reactor, where the radioactivity is continuously removed from the core and taken away from the site is even less threatening. He concluded that the acceptance criterion of a maximum dose of 10 rem in thirty years may be reduced in the future to a maximum dose of 1 rem. The best option is still to have a small reactor, such as a 100MWe reactor, for which it is almost impossible to have an accident event resulting in any early fatalities.

Returning to the disparity in various countries' abilities to further their nuclear power programs, it was suggested that the impasse among countries such as the U.S. and Italy is driven by the absence of an imperative to use nuclear power, that to the present this has been a no-cost decision. This situation could be changing in the near future; in the U.S. there is the saturation of excess electricity capacity, in Italy, the (at least short term) imminence of $40 per barrel imported oil, and in Korea, an electrical demand growth rate of 14% annually, which is a doubling every five years. It was noted, that, in a situation where the decision-making is one-sided, and where the performance standard demanded is close to perfection, it is very hard to obtain solutions.

One participant pointed out that public acceptance is not itself a safety goal, and the two should not be confused. The scientists must first be convinced of the reality of expected safety and then should use professional opinion makers to get the point across. This is because scientists are not generally able to make themselves well understood by the public. In this manner, he concluded, the technologists can gain the trust of each other and the public.

The point was expressed that many of the problems in the nuclear power industry in the U.S. today are infrastructure related, not technical, and that such managerial problems would be seriously compounded by the existence of a large population of small reactors. Three pieces of the management problem were identified as: (1) construction management, where in the United States there have been several economic disasters characterized by very long construction schedules and resulting high costs; (2) operations management, where some utilities have been compelled to shut down their entire reactor fleet due to identified managerial problems; and (3) the maintenance problem associated with a large number of reactors.

A final note in the discussion was that of the irony in the situation between Italy and France. We see the Italians insisting on developing a very safe reactor and raising concerns about territory loss due to potential radioactive contamination, and not building new plants until these issues are resolved. Meanwhile, France continues to build new large plants with seeming disregard for these issues. The irony lies in that Italy imports much of its electricity from France, with this electricity generated by plants which are upwind from Italy.

KEYNOTE ADDRESS

FACTORS AFFECTING THE NEXT GENERATION OF NUCLEAR POWER

Forrest J. Remick

Commissioner, U.S. Nuclear Regulatory Commission

INTRODUCTION

DINNER ADDRESS

The Conference dinner was addressed by Dr. Forrest J. Remick, Commissioner in the U.S. Nuclear Regulatory Commission. Prior to becoming a Commissioner Dr. Remick has served as a long-term member of the NRC's Advisory Committee on Reactor Safeguards, and had been a Professor of Nuclear Engineering at the Pennsylvania State University. His address was particularly important for the Conference as a reflection of the thinking within the NRC concerning advanced nuclear power technology. In the view of many observers the NRC is likely the single most important institution affecting whether nuclear power will have an important future role in the United States.

The portion of his address which generated greatest subsequent discussion in the Conference was the statement that the NRC is not required to continually increase safety standards as technological capabilities improve. Rather, his position is that, having defined an acceptable level of safety, the obligations of the NRC are to ensure that it is satisfied and to provide incentives for, but not requirements, for plant license holders to reach still higher safety levels. Several Conference participants later argued that the NRC should demand the best feasible performance from new plants. This approach would be consistent with the NRC's treatment of low level radioactive exposures, where under the "As Low As Reasonably Achievable (ALARA) principle" such exposures are required to be kept small when available technologies permit, even though averted health risks may be small.