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COMPARATIVE ANALYSIS OF
LMFBR LICENSING IN THE
UNITED STATES AND
OTHER COUNTRIES -
NOTABLY FRANCE

Executive Summary

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EXECUTIVE SUMMARY

Introduction

This report is concerned with the United States system of nuclear safety regulation, and especially with the licensing of future Liquid Metal-cooled Fast Breeder Reactor (LMFBR) projects. During the past decade dissatisfaction with this system has grown steadily among many sectors of the nuclear power industry, and also among those opposed to further use of nuclear power. With Light Water Reactor (LWR) projects it has a record of delivering licensing decisions in an inconsistent, protracted and tentative manner. For such projects this has often meant costly design changes, construction delays and interruptions and large cost overruns.

This situation has caused concern for the future licensing of United States LMFBR projects which - compared to LWR's - have the additional licensing liabilities of being less well understood in terms of their physical phenomena (but not necessarily less safe), and of being highly controversial politically.

Organization of the Work

In the work of this project the safety-related design aspects and licensing experiences of LMFBR projects in other democratic countries have been studied and contrasted to those in the United States in order to understand the importance of different approaches to safety, and also to understand better the system of the United States. The regulatory systems and LMFBR programs of France and the United States are contrasted in detail, and that of West Germany is also studied. The programs of Japan and the United Kingdom receive considerably less attention, and that of the Soviet Union is ignored.

Socioeconomic Systems and Patterns of Nuclear Power Development

The western European democratic countries typically have patterns of greater governmental involvement in economic management than the United States, of major state ownership of the electric power sector, and of centralized governmental administration and economic planning. These features apply strongly to France and the United Kingdom and less so to West Germany. The United States uses an unplanned free-market economy, a regulated free-market electrical sector, and largely private ownership of that sector.

All of the countries mentioned previously have developed large integrated nuclear power industries based on thermal neutron reactors, and featuring LMFBR development programs. Among them only the United States has abundant indigenous uranium and only it has had a near-shutdown of its major LMFBR project - the Clinch River Breeder Reactor (CRBR) - during recent years.

France

Currently both the French LWR and LMFBR programs are the most vigorous of their kind in the world. By contrast, those of the United States and West Germany have encountered serious obstacles during the past decade. The differences between these two classes of experience are due primarily to the differences in political, economic and nuclear safety regulatory systems in these countries.

In France, reflecting the high degree of governmental centralization and control of economic activities, the electric power sector and reactor development efforts are both run as national enterprises. The determination of the need for specific projects, for specific technologies and the safety standards to govern them are made by the national govern-

ment as aspects of national socioeconomic policy. The safety regulation of nuclear projects - whether LWR or LMFBR - is carried out in the climate of fulfilling national economic goals subject to public safety and environmental protection constraints. Such activities are carried out away from public view (e.g. the names of the regulatory personnel and the safety analysis documents are treated as restricted information), and the individual citizen is able to participate in the process only as a witness in preliminary legislative-style land-use hearings. A member of the public opposed to the national nuclear policy, a specific project, or a technical aspect of a project may advance his opinion only via the route of trying to change the policies of the national government by which he is affected. In this system nuclear safety regulation decisions are made as a collaborative effort involving agencies of the national government, the national electric utility company, and major project equipment vendors. This has been the system used in both LWR and LMFBR project regulation. The nature of the system is reflected in LMFBR safety requirements which are formulated in a systematic self-consistent fashion.

The French LMFBR program is carried out collectively by the national government and its agencies, the national utility company and the government-directed equipment vendors. The major recent LMFBR efforts are the Phenix (operational) and Super-Phenix (in construction) projects. In comparing the safety-related aspects of the two projects an increase over time in shutdown system and core-monitoring redundancy, in decay heat removal capability, and in hypothetical core disruptive accident (HCDA) capabilities is evident.

French requirements for LMFBR safety are typically determined early in the life of a project, and held fixed throughout its life unless

strong evidence of need for a change becomes apparent. Their requirements are typically less extreme in terms of quantitative design limits than in other countries, but very demanding in terms of system reliability and redundancy. With both LWR's and LMFBR's, the speed with which French nuclear projects have been licensed and constructed has - in recent years - been the world's greatest.

The French government, elected in 1981, has recently announced intentions to decentralize the system of government, to reexamine the justification for the national nuclear power program and to increase public participation in nuclear project regulation. Consequently, the observations made here could become invalid in the near future.

West Germany

In West Germany the only major LMFBR project in progress has, until now, been subject to continually-escalating safety requirements mainly concerning events external to the containment building. These requirements have resulted in the need for extensive redesign, in project delays, and in greatly increased costs. The experience of West German LWR projects has been similar. West German containment building design requirements are recognized as the most stringent in the world, and they have evolved to this position during the past decade when most West German nuclear projects have been in the planning and construction phases. In that country, as in the United States, an effective moratorium on new nuclear projects has prevailed since 1974 because of a common combination of adverse economic, political and regulatory factors.

In the Federal Republic of West Germany, nuclear safety regulation is performed by the government of the state in which the project is located. This is done with heavy reliance upon external expert consulting organizations, and subject to standards and oversight from the federal

government (and its consultants). The electric economy is more closely coordinated and owned to a greater degree by governmental units than in the United States, but less so than in France. Thus, nuclear safety regulation occurs in a climate where the economic justification for the project has been established as a matter of state policy, and the safety criteria to be applied as a matter of national policy. However, the involvement of the regulatory agencies in a project occurs only after a proposed design and license application are presented to them. Thus, the West German system is much less collaborative than that used in France. The West German system also is focussed much more upon purely technical questions, and is much less guided by a literature of laws, regulations, court decisions, and regulatory guidance documents than that of the United States. Consequently, it is less formal and legalistic than the United States system.

Public participation in safety regulation may occur via testimony in legislative-style public land-use hearings concerning the project site, by voting in occasional referenda on the fates of selected projects and via litigation concerning the legality or correctness of the procedures under which a project has been licensed. As in France, the main avenue for influencing the future of a particular project is through political action directed toward the state or national policy under which the project is going forward. Thus, the major way in which political opposition to nuclear power has become evident in nuclear safety regulation has been through the influence of such opposition in determining the governmental policies concerning the need for new projects and the appropriate nuclear safety standards. Unlike the case in the United States, the West German nuclear industry has not complained strongly about licensing process delays

in nuclear regulation. Rather, the complaints have focussed upon the severity of the design standards imposed upon them, and of the hardships imposed upon projects in progress as standards have been made more stringent.

West German LMFBR design features a degree of safety system redundancy and reliability similar to that seen in France, and use of considerably more stringent design limits and conservative modeling assumptions (e.g. concerning the kinetic energy release to the containment atmosphere during a hypothetical core-disruptive accident - HCDA).

The United States

In the United States political system, explicit economic planning is not used, and the justification for each nuclear project must be made in the licensing process on an ad hoc basis - although use of regional power pool expansion plans is sometimes made for that purpose. Planning in the electric power sector is done only on a voluntary basis for each utility via membership in regional power pools.

Similarly, the nuclear power industry, while established with early federal governmental assistance, consists largely of a collection of private organizations, each of which pursues its interests independently. Governmental programs of nuclear technology development are implemented largely by contracting individual projects to governmental laboratories, private organizations, and universities, subject to central program direction by governmental agencies. The major current fission reactor technology development program in the United States is that of the LMFBR, most of which is directed (at least indirectly) toward furthering the CRBR project.

The United States experience in LWR licensing is typically that of a group of independent parties - having disparate interests - being engaged

in an adversarial interaction, with each trying to negotiate a commonly acceptable set of safety licensing requirements for the project in a way which maximizes its individual goals. The important actors are the utility and its consultants and suppliers, the Nuclear Regulatory Commission (NRC), other uncoordinated federal, state and local governmental agencies, public intervenors, and the federal courts. The interests of these parties may range from desire to complete the project as rapidly and cheaply as possible, to implacable opposition to completion of the project under any circumstances. The NRC is responsible for regulating the project in order to 'provide adequate protection for public health and safety' - as the Atomic Energy Act puts it - and protection for the environment. The agency implicitly has a duty to try to manage the licensing process so that each of the participants feels fairly treated. Not surprisingly, this is often impossible to accomplish.

The licensing process is carried out without explicit guidance from the political system concerning either the economic justification for a project or what constitutes an adequate level of safety. Much of the difficulty of United States nuclear safety licensing arises from the need to resolve both classes of what are essentially political issues for each project licensed. Further, the 'arms-length' nature of the relationships between the various parties results in their interactions being very formal and governed by a large literature of law, agency regulation and precedent. This tends to make licensing proceedings often acrimonious, protracted and painstaking.

In effect, United States licensing experience has produced a set of de facto definitions of adequate criteria for formulation of safety requirements and for economic justification for nuclear projects; however, they

always remain fundamentally ambiguous and subject to revision in each licensing proceeding. Consequently the basis for production of speedy consistent definitive licensing decisions does not exist. As a result, licensing of LWR's in the United States has often been characterized by delays, requirements of costly design changes, inconsistency and very cautious treatments of uncertainty in the understanding of physical phenomena. In that the resulting nuclear projects are very costly, the process is frustrating to proponents of nuclear power; as it does not provide a means of definitively stopping nuclear projects it is equally frustrating to the opponents of nuclear power.

These problems have been exacerbated until recently by an organizational structure in the NRC which provided for fragmented policy formulation and management direction, with the result that the NRC staff was required to deal with this difficult licensing climate without the internal support and discipline provided by a strong management structure. Following the Three Mile Island accident-related investigations of the performance of the NRC, the organizational structure has been revised to provide better management direction. However, it is too early to know how effective this change is.

In LMFBR licensing the United States experience does not permit definitive general observations to be made. The only LMFBR's to go through the complete licensing process, FERMI-1 and SEFOR, did so more than fifteen years ago. Both the regulatory climate and LMFBR technology have changed so much since then that there effectively exist no data concerning modern LMFBR licensing. During the 1970's the Fast Flux Test Facility (FFTF) was designed and built. However, as a government-owned research reactor it was not legally required to go

through the complete NRC licensing process. Its design was subjected to only the NRC safety and environmental reviews, but the project avoided the public-hearing and post-licensing-appeal procedures which contribute a large part of the acrimony and delay of current LWR licensing. Particularly considering the current sensitivity of the national LMFBR program as a political issue, and the opportunities which these latter phases of the licensing process present for use of the process as a forum for political combat over these issues, it appears inevitable that the licensing of future LMFBR's through the complete process will be very contentious, protracted and expensive - if not fatal - for the project.

The United States approach to LMFBR safety is best illustrated by the designs of the FFTF and CRBR projects. In examining safety-related aspects of both projects' designs, it is seen that the requirements for FFTF are more self-consistent (i. e. the level of concern for various hazards appears to be roughly uniform) than those for CRBR, and approximately similar to those of its near-contemporary, Phenix. The technical areas examined are reactivity control systems, core monitoring systems, routine and emergency core-cooling systems and systems for HCDA mitigation. In comparing the CRBR design to that of its near-contemporary Super Phenix, use of more relaxed requirements for redundancy in core-monitoring and core-cooling capability is evident as is a more severe design standard for HCDA mitigation systems. In that sense the CRBR safety design is less consistent than those of the other projects examined. This is not surprising, in view of the fact that CRBR licensing activities were stopped, by Presidential order in 1977, and remain incomplete. Since then the world's other LMFBR projects have moved forward and reflect both the additional experience gained and changes in regulatory perspectives.

However, the condition of the CRBR design also reflects the nature of United States safety regulation in which a systematic approach to assurance of safety is much less evident than in other countries. Rather, in the United States, safety regulation tends more to be initially reactive to the design proposed by a license applicant, with various aspects of the design being considered separately, in parallel with others. In this fashion the final safety standards are more the result of a set of simultaneous independent safety reviews of various aspects of the project design than the products of a coordinated global strategy. The former type of system is inherently more prone to providing inconsistent design requirements than is the latter. With the resumption of CRBR licensing the parallel march of these safety reviews will continue, and will likely result in increased safety requirements in many areas.

A further issue in LMFBR licensing in the United States is the relatively less-understood nature of important safety-related physical phenomena (e. g. sodium void propagation) in comparison to LWR's. Relative to the other regulatory systems discussed here, that of the United States is very intolerant of ignorance concerning the behavior of physical systems, and tends to treat such uncertain knowledge very conservatively. This implies that a substantial portion of future LMFBR licensing would be taken up with evolution of the safety standards appropriate for the project. The consequences of such an evolution would likely be design changes and expenses in addition to those alluded to previously.

Regulatory System Modifications

The overall regulatory system: Because of the high level of dissatisfaction which has arisen concerning the current United States nuclear safety regulatory system during the past decade, many proposals

have been offered in the Congress and elsewhere for modifications of this system. These proposals are surveyed in the report. Most address modifications of the licensing process (e. g. use of 'one-stop' licensing), but not restructuring of the responsibilities in the overall regulatory system for addressing the political issues which are currently imbedded in the licensing process. Because of this omission the potential value of most of the proposed regulatory modifications is limited. In examining the regulatory systems of France and the United Kingdom it is seen, with each, that the major source of the success which they each enjoy is a political system which removes political issues from the licensing procedures for individual nuclear projects. In doing this these issues are resolved in the formulation of national socioeconomic policy, which then provides guidance to regulatory decision-making.

Among the modification proposals surveyed in this work, a notable exception to the pattern of proposing changes only with the licensing process is the proposed (but not implemented) Nuclear Siting and Licensing Act of 1978. It suggests several initiatives which are endorsed in this work.

The major requirements of any successful future modifications to the nuclear safety regulatory system are the following:

- The transfer to other political institutions of responsibility for addressing the class of social issues the resolution of which currently cripples the licensing process.
- The limitation of opportunities for reversal of licensing decisions which are taken by the regulatory authorities.

If both sets of regulatory system modification goals are reached, the resulting licensing system can be expected to be much more consistent,

speedy and definitive in its decision-making: in short, stable. In general such modifications would require passage of new legislation.

Possible avenues for achieving these goals are divided into modifications of the regulatory system and modifications of the licensing process. The necessary changes in the overall regulatory system to achieve stability involve depoliticization of the licensing process in a way which preserves the opportunities for the political interest groups concerned with nuclear power and with individual projects to pursue their various goals. The suggested changes are the following:

- Formulation - in a definitive and permanent fashion - of a comprehensive nuclear safety goal which, if used in regulatory decision-making, would not be permitted as a basis for a challenge to the decisions reached.
- Transfer to other political institutions of the responsibility for determining the need-for-power (i. e. the economic justification) and environmental protection requirements for a proposed nuclear facility.

Actions are currently being taken - upon Congressional direction - by the NRC to implement the former recommendation. The major fears concerning this effort are that the safety goal resulting from it will either not be endorsed explicitly by the Congress (which would greatly diminish its value), or that it will be formulated incompletely. A complete safety goal necessarily is a vector quantity, which includes such factors as economic costs and many types of risk. It can be stated in both probabilistic and deterministic terms and is inescapably supported in some areas by highly uncertain physical data. The danger in defining a safety goal is that the short-term political attractions of an overly-simple

formulation will cause these complexities to be ignored, with the resulting statement of the goal being too limited to be of broad long-term value in decision-making.

A proposal encompassing the latter set of modifications was initially presented in the Department of Energy proposals for licensing reform legislation in 1978. If the need-for-power and environmental protection issues are to be removed from the licensing process they must be resolved elsewhere. It is suggested that these responsibilities be transferred to the state in which the project would be sited (or alternatively to a newly-created regional authority), since this is the political unit in which the great majority of the risks and benefits from the project would be received. The questions of whether such risks and benefits are acceptable - on balance - are resolved most appropriately in the United States political system by the people most affected by them, which is the justification for the particular form of this proposal.

A complementary set of recommendations - concerning the licensing process - which would reinforce the previous suggestions is the following:

- Permitting challenges to be brought against generic safety criteria when they are formulated, and prohibiting such challenges in the licensing of individual projects.
- Permitting challenges to the technical basis of specific licensing decisions to be pursued only within the NRC, but continuing to permit challenges to the procedural correctness of licensing decisions to be pursued within both the NRC and federal courts.
- Changing to a legislative-type format for licensing hearings, in which public intervenors would be permitted to give testimony,

but not to pursue the type of active participation in the licensing process which is currently permitted.

These changes would permit objections to regulatory criteria and specific projects to be heard in the licensing process, but would permit rendering of licensing decisions more quickly and definitively than is possible currently.

Licensing of future LMFBR's: It appears doubtful that complete LMFBR licensing is possible under the current system, both because of the experimental nature of such projects and because of their politically controversial status. Their prospects for successful licensing would be much greater if either their unusual character were used to justify special treatment or if the licensing system were modified according to the previous suggestions. If such modifications were not made, the regulatory treatment (as an alternative to complete NRC licensing) which would provide the greatest probability of successful completion of the project would be to continue to treat such projects as national enterprises subject only to NRC safety and environmental reviews as in the case of FFTF. This would be appropriate since such projects in the foreseeable future will be far from having commercial status, which is what the current licensing process is best structured to consider. Implementation of either of these suggestions would require passage of new legislation.