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MASTER

Assistant Secretary for Nuclear Energy
Deputy Assistant Secretary for Nuclear
Reactor Programs
Office of Nuclear Power Systems

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AN ASSESSMENT OF THE NEED FOR AND FEASIBILITY OF
ESTABLISHING A NATIONAL REACTOR ENGINEERING SIMULATOR
FACILITY

Prepared By:
Office of Nuclear Power Systems

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AN ASSESSMENT OF THE NEED FOR AND FEASIBILITY OF
ESTABLISHING A NATIONAL REACTOR ENGINEERING SIMULATOR FACILITY

Summary

A study was conducted by the Department of Energy's Office of Nuclear Power Systems to determine the need for and feasibility of establishing a reactor engineering simulator facility at a National Laboratory. Input was obtained from a wide cross section of the Nation's nuclear industry, the Department's National Laboratories, the Nuclear Regulatory Commission (NRC), and the Advisory Committee on Reactor Safeguards in carrying out this study. Based on this input, the Department concludes that the proposed facility would not significantly contribute to the capability of the Nation's nuclear industry or the Department to foster research in generic design improvements and simplifications. Furthermore, the Department concludes that such a facility, although it is theoretically feasible, is not practical from an engineering viewpoint, and the significant national effort and expense, which would be required to develop, construct, and operate such a facility, is not justified.

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Larry E. Williams

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U.S. DEPARTMENT OF ENERGY
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I. Introduction

Section 5 of Public Law 96-567, the "Nuclear Safety Research, Development, and Demonstration Act of 1980," states that the Secretary of Energy "shall initiate a study of the need for and feasibility of establishing a reactor engineering simulator facility at a National Laboratory, for the primary purpose of fostering research in generic design improvements and simplifications through the simulation of the performance of various types of light water reactors under a wide variety of abnormal conditions and postulated accident conditions."

The Secretary was also instructed to consider relevant factors including, but not limited to:

1. The potential advantages that would accrue from the establishment of such a facility
2. The extent to which such a facility would further the generic safety research and development program established by this Act
3. The extent to which such a facility can be established by nongovernmental entities
4. The opportunities for cost sharing by nongovernmental entities in the construction and operation of such a facility
5. The importance of such a facility in emergencies to limit the extent of any future nuclear powerplant excursions
6. The potential for international cooperation in the establishment and operation of such a facility
7. The appropriate National Laboratory for siting such a facility

The Secretary was requested to submit, by January 1, 1982, to the Committee on Science and Technology of the House of Representatives and the Committee on Energy and Natural Resources of the Senate, a report characterizing the study and the resulting conclusions and recommendations.

The requested report is contained herein.

II. Background

During the course of the various congressional hearings, which preceded the passage of Public Law 96-567, several witnesses testified to the potential nuclear safety benefits that could arise from a National Reactor Engineering Simulator facility. In his testimony before the House Committee on Science and Technology on June 19, 1980, Dr. R. J. Budnitz of the Nuclear Regulatory Commission stated:

"Congress may want to consider inserting a provision which directs DOE to examine the necessity, feasibility, and effectiveness of a National Reactor Engineering Simulator facility. Such a facility could be an extension of an existing National Laboratory and be supported jointly by government and private industry. The facility might include computer capabilities for faster-than-real-time simulation of the performance of a spectrum of reactor designs. It would be available for use in emergencies, as well as for more routine uses, such as design evaluation and operator training."

The principal features of Dr. Budnitz' proposal were incorporated into Senate bill S.2884, which stated in Section 5(a):

"The Secretary shall initiate a study of the feasibility of creating a reactor engineering simulator facility at a national laboratory for the purpose of improving the simulation of the performance of various types of reactors under off-normal conditions and other associated activities."

This section of the proposed Senate bill was discussed by several witnesses in hearings that were held before the Senate Subcommittee on Energy Research and Development on July 22, 1980. Dr. Budnitz restated his support for this concept at these hearings, while several other witnesses presented concerns regarding potential uses for such a facility.

Mr. Robert Whitesel of the Electric Power Research Institute testified as to the relative benefits of such a facility as compared with existing simulators in training operators, stating:

"From an operator's point of view, the individual reactor powerplants are different. Thus, we believe that increased use of the existing simulators at utility and vendor sites will be more effective for training operators to respond to emergency situations."

Admiral Eugene P. Wilkinson, President of the Institute of Nuclear Power Operations, provided additional perspective on the status and uses of simulators that were already available throughout the nuclear power industry, when he testified during these same hearings:

"The nuclear power industry has been using powerplant simulators as tools for training plant operators and staff personnel since the late 1960's...

"As the use has increased, so has related technology resulting in simulators that are very effective as training tools in simulating abnormal emergency and normal operating conditions. The typical simulator is capable of realistically simulating 200 to 300 malfunctions or casualties."

The final Senate version of this bill, which was reported out of Committee on September 15, 1980, reconfirmed the Committee's intent that a need and feasibility study be conducted on a National Reactor Engineering Simulator facility. However, this report made clear that two of the potentially objectionable uses for the facility, which were cited by Messrs. Whitesel and Wilkinson, were not to be considered for this facility, when it stated in Reference [1]:

"It is not intended that the simulator be used as a national training center for reactor operators, and it is not intended that the simulator supplant or duplicate the simulators owned by vendors and nuclear utilities."

The final version of Public Law 96-567, which was passed by Congress in December of 1980, reflected the principal thrust of Dr. Budnitz' original proposal for the National Reactor Engineering Simulator facility, as modified by the concerns that were expressed by the witnesses who testified on the need for, and potential uses of, such a facility.

Based on this background, the Department's interpretation of the intent of Congress in Public Law 96-567 in regard to the operational capabilities and potential uses of the National Reactor Engineering Simulator facility, is as follows:

1. The simulator should be capable of conducting rigorous engineering analysis of plant performance under normal plant operating conditions, as well as under a spectrum of abnormal and accident conditions, including those involving loss of initial core geometry
2. The simulator should be capable of real time or faster operation
3. The simulator should be capable of being used in conjunction with control room mockups representative of current or future designs
4. The simulator should be used in:
 - a. Identifying generic design improvements and simplifications
 - b. Developing means for limiting the extent of any future nuclear powerplant excursion that occurs during future emergencies

These capabilities and uses were the basis upon which the subject need and feasibility study was conducted.

III. Characterization of Study

1. Approach

The Department's approach in assessing the need for and feasibility of a National Reactor Engineering Simulator facility was to first discuss the concept of a National Reactor Engineering Simulator facility with a wide cross section of the nuclear industry and solicit their opinions on whether or not such a facility is needed or feasible. This step was considered to be crucial to the study because it is the Department's belief and its understanding of the intent of Congress that such a facility, in order to meet its objectives of fostering research in generic design improvements and simplifications and use during accidents, would have to be developed and used in close cooperation with the nuclear industry.

The second step taken in the study was to obtain input from those Department of Energy National Laboratories having expertise in light water reactor performance simulation, as well as from the Nuclear Regulatory Commission and from the Advisory Committee on Reactor Safeguards.

In the third step, the input obtained in steps 1 and 2 was evaluated by the Department. Consideration was given to the needs identified by the organizations contacted and to the role that a National Engineering Reactor Simulator facility could play in supporting the Department's generic safety research and development efforts to be carried out in response to Public Law 96-567. The conclusions and Department actions presented in Sections V and VI of this report were then formulated based on these evaluations.

2. Input Received

The study's interactions with nuclear community industrial organizations took place during the 3-month period between April and June 1981. Individual meetings were held with the following organizations:

Westinghouse Electric Corporation
Combustion Engineering, Incorporated
General Electric Corporation
Electric Power Research Institute
Nuclear Safety Analysis Center
Bechtel Power Systems

Sargent and Lundy
Middle South Utilities
Commonwealth Edison Company
Tennessee Valley Authority
Duke Power Company

Discussions were also held with Babcock and Wilcox and the Institute of Nuclear Power Operations.

The consensus of these organizations was that a National Reactor Engineering Simulator facility with the capabilities described above is not needed and, furthermore, is not cost beneficial. The major reasons given in support of this response were:

- a. Engineering simulator needs will be met by a combination of new training simulators, engineering simulators, and current calculational models that are already available, being built, or proposed by nuclear steam supply system vendors
- b. An engineering simulator that would accurately encompass severe accident conditions would require a long-range and difficult development program, with a low probability of ultimate success
- c. An engineering simulator that is plant specific with modules to mockup each plant would be very expensive

The reactor vendors within the group contacted emphasized that they have in-house calculational tools to analyze plant transient response and that they already use engineering simulators to optimize plant designs, control systems, and operations. One vendor group indicated that a national facility might negatively impact their potential market since they are prepared to meet any commercial request that they feel is likely to develop for an engineering simulator.

In commenting on the usefulness of an engineering simulator to evaluate proposed design changes to a plant, the utility organizations emphasized that once a plant is on-line there is limited interest in modifying the plant design unless significant safety or availability problems arise. Thus, the cost of developing a detailed simulation capability for use in design modifications would be difficult to justify from an economic standpoint. The emphasized utility position was that the development and implementation of a sound operator training program utilizing existing and planned training simulators was of much higher priority for new expenditures than was the development of a National Reactor Engineering Simulator facility.

Although these organizations did not generally support a Department of Energy-funded National Reactor Engineering Simulator facility, they did feel that their own activities to develop and apply simulators could benefit from a Department-sponsored technology development effort to improve the computer models and data used in performance prediction and analysis. Such activities, which currently constitute a significant portion of the Nuclear Regulatory Commission-sponsored research and development effort, were recommended for consideration as part of the Department's overall Light Water Reactor Safety Research and Development effort.

The study's interactions with the Nuclear Regulatory Commission staff took place in a meeting held in May 1981. The Nuclear Regulatory Commission's representatives indicated that although Dr. Budnitz of the Nuclear Regulatory Commission had originally suggested in his testimony that consideration of a National Reactor Engineering Simulator be included in the Act, the NRC is now considering supporting the development of an "engineering analyzer" for incorporation into existing simulators as opposed to a national simulator facility for use within the Nuclear Regulatory Commission for exploratory studies of small break accidents and plant transients. These representatives did not identify a regulatory-related need for a National Reactor Engineering Simulator facility of the type being considered in this study. Instead, they stated that

what the NRC was developing (and what they encouraged Department of Energy efforts in support of) were improved engineering models and codes to use in better understanding potential accident sequences.

In July 1981, the Department provided to NRC, for review and comment, drafts of this report. The NRC comments, Reference [2], are presented below.

"We agree that a National Reactor Engineering Simulation Facility should not be built. Differences in the design and layout of plant systems, control regimes, and control room arrangement even among plants incorporating reactors from the same vendor would cause any one simulator arrangement to be atypical of most other plants. Use of such a simulator for training or for diagnosis of specific accidents in a given plant could result in misinformed judgments in handling certain transients and accidents. Even if the exact system arrangement could be simulated, in order to use such a facility for help during emergencies, the current, up-to-date conditions of the plant would have to be known. More specifically, the actual condition of the core would be needed (loading, burnout, etc.), as would the flows and thermal conditions within both the primary and the secondary systems, the actual line-up of all valves, conditions of all trips and control settings, stored ECC fluid (inventory, temperatures, boron content, etc.), and numerous other initial and boundary conditions.

"There is a related effort which we believe would contribute significantly to our ability to understand and provide guidance for accident handling. This would be the development of a plant analyzer that would be used to study generic transients and accidents. We have initiated a feasibility study to see if a combination of specialized modified software with a type of computer which incorporates parallel processing can be used to provide an accurate representation of transients and accidents in faster than real time. It could also be used to study system interactions including the safety implications of control interactions. Heretofore most complex reactor situations involving two-phase (liquid/ vapor) flow have required many hours of computer time for each accident.

"Should this investigation prove the concept to be feasible then the understanding derived from analyses on such a unit could be incorporated into existing simulators to allow more realistic thermal-hydraulic feedback to take the place of the present preprogrammed "canned" reactions. Since these existing simulators already incorporate a modelling of the specific plant involved, including the balance of plant and auxiliary systems, these units will then be more realistic for training and will also become useful for accident analysis and control studies. We are aware that EPRI and BMFT in West Germany are also interested in such a project.

"We invite DOE to be the catalyst in bringing together all interested parties to become actively involved in the development of the hardware and to work with us in a coordinated program to develop software appropriate for NRC use and for industry use."

A copy of the draft response was also provided to ACRS for its review and comment. In addition, meetings were held between the Department, NRC, and ACRS on September 9 and 10 to discuss the subjects further. The ACRS response, Reference [3], is presented below.

"We agree that a National Reactor Engineering Simulator facility, as described by DOE, is not needed. However, we do believe that a cohesive national light water reactor system simulation program should be undertaken. A principal goal should be the development of computational ability to study a wide range of transients and accident sequences, including the effects of human intervention and design variants. The increased knowledge of system and plant behavior which would be gained by such a program should result in improved safety through modifications both in design and improved operator training."

Recommendations from six National Laboratories* were received over a 6 month period. The consensus of the laboratories was that a large simulator facility was not needed, although two laboratories favored a large systems simulation capability. The concerns expressed over a large facility were similar to those expressed by the private industry respondents. Some of the laboratories questioned the need for a large simulator facility that would take the form of

*Idaho National Engineering Laboratory, Oak Ridge National Laboratory, Sandia National Laboratory, Pacific Northwest Laboratory, Argonne National Laboratory, Brookhaven National Laboratory.

an elaborate control room mockup and also questioned the technical feasibility and need for incorporating existing codes and models into a real-time predictive tool.

IV. Analysis

The Department's analysis of each of the factors identified by Congress for consideration are as follows:

- a. "The potential advantages that would accrue from the establishment of such a facility."--No advantages were identified. Engineering simulator needs will be met by a combination of new training simulators, engineering simulators, and current calculational models that are already available, being built, or proposed by nuclear steam supply system vendors.
- b. "The extent to which such a facility would further the generic safety research and development program established by this Act."--The facility, per se, will not further the Department's generic safety research and development program. The intent of providing such a facility can best be achieved by conducting research and development efforts to improve simulation and develop reactor/plant performance prediction tools for use in existing facilities of the commercial nuclear industry and National Laboratories. It is the Department's belief that such a facility would unnecessarily divert financial and personnel resources that could better be applied to other much higher priority activities and would be a detriment to the required development efforts of this program.
- c. "The extent to which such a facility can be established by nongovernmental entities."--Nongovernmental entities could theoretically establish such a facility. However, as discussed in a and b above, the Department does not see a need for such a facility. The Institute of Nuclear Power Operations, which would have been a logical nongovernmental candidate for such an activity, concluded that such a facility should not be established.
- d. "The opportunities for cost sharing by nongovernmental entities in the construction and operation of such a facility."--Cost sharing by nongovernmental entities is only feasible where a clear incentive can be identified. Lacking such incentives, no such opportunities have been identified.
- e. "The importance of such a facility in emergencies to limit the extent of any future nuclear powerplant excursions."--No potential beneficial use of this facility during emergencies was identified. In fact, we conclude that because the facility could not correctly simulate the real time condition of a nuclear plant in trouble, such a facility, if used during an emergency, could be detrimental by providing unconfirmed, potentially confusing input to the plant operators.
- f. "The potential for international cooperation in the establishment and operation of such a facility."--The potential for international cooperation was not explored since a domestic need for the facility was not identified.
- g. "The appropriate National Laboratory for siting such a facility."--The appropriateness of sites for the subject facility was not explored pending identification of a need for the facility.

V. Conclusions

Based on a careful evaluation of merits of developing a National Reactor Engineering Facility and after considering the views of the nuclear industry, the Department's National Laboratories, and the Nuclear Regulatory Commission, the Department reached the following primary conclusions:

1. A National Reactor Engineering Simulator facility is not needed by the Nation's nuclear industry or by the Department of Energy in order to foster generic design improvements and simplifications for light water reactors or for use during accidents. Furthermore, although such a facility is theoretically feasible, the benefits that would accrue from the facility do not justify the significant national effort and expense that would be required to develop, construct, and operate it. The establishment of the facility would only detract from the broad based efforts underway to improve nuclear safety.
2. Further efforts to develop and improve simulation techniques would have potential generic safety benefits. These efforts would place principal emphasis on development of models and acquisition of plant data to improve system transient codes. The goal of these efforts would be to extend

present capabilities towards more complete system modeling, consideration of severe accidents, and real-time computation. In developing the priorities of its safety R&D program and interacting with other involved entities, the Department will give considerable emphasis to R&D to improve simulation and reactor plant performance prediction tools.

VI. References

1. Senate Report No. 96-941, page 7, dated September 15, 1980.
2. Letter, Robert B. Minogue (NRC) to Jerry D. Griffith (DOE), dated September 11, 1981.
3. Letter, J. Carson Mark (Chairman, ACRS) to Jerry D. Griffith (DOE), dated September 16, 1981.

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