
March 1999

NUCLEAR REGULATION

Strategy Needed to Regulate Safety Using Information on Risk



**Resources, Community, and
Economic Development Division**

B-281928

March 19, 1999

The Honorable Joseph R. Biden, Jr.
United States SenateThe Honorable Joseph I. Lieberman
United States Senate

In the United States today, 103 operating nuclear power plants supply electricity to about 65 million households, meeting about 20 percent of the nation's needs. Now, the entire electric utility industry is faced with an unprecedented development: the economic restructuring of the nation's electric power system, from a regulated industry to one driven by competition. The economics of plant operations will play a critical role as the nation moves to electricity deregulation and nuclear utilities compete for the first time with other forms of electricity generation.

To maintain safety in this changing environment, the Nuclear Regulatory Commission (NRC) has been moving from its traditional regulatory approach, which was largely developed without the benefit of quantitative estimates of risk, to an approach—termed risk-informed regulation—that considers relative risk in conjunction with engineering analyses and operating experience to ensure that plants operate safely. NRC believes that a risk-informed approach would reduce unnecessary regulatory burden on utilities and their costs, without reducing safety. In some cases, NRC believes such an approach could improve safety. NRC differentiates between “risk-informed” and “risk-based” regulation, noting that the latter approach relies solely on the numerical results of risk assessments.¹

You asked us to examine various issues related to the safe operation of commercial nuclear power plants. As agreed with your offices, this report addresses (1) some of the challenges that NRC and the nuclear power industry could experience in a competitive environment, (2) issues that NRC needs to resolve to implement a risk-informed regulatory approach, and (3) the status of NRC's efforts to apply a risk-informed regulatory

¹Risk assessments systematically examine complex technical systems to identify and measure the public health, environmental, and economic risks of nuclear plants. They attempt to quantify the probabilities and consequences of an accident's occurrence. By their nature, risk assessments are statements of uncertainty that identify and assign probabilities to events that rarely occur.

approach to two of its oversight programs—plant safety assessments and enforcement.²

Results in Brief

The Congress and the public need confidence in NRC's ability to ensure that the nuclear industry performs to the highest safety standards.³ As the electric utility industry is restructured, operating and maintenance costs will affect the competitiveness of nuclear power plants. Competition challenges NRC to ensure that safety is not compromised by utilities' cost-cutting measures and that the decisions utilities make in response to economic considerations are not detrimental to public health and safety.

NRC has not developed a comprehensive strategy that could move its regulation of the safety of nuclear plants from its traditional approach to an approach that considers risk information. In addition, NRC has not resolved certain basic issues. First, some utilities do not have current and accurate design information for their nuclear power plants, which is needed for a risk-informed approach. Second, neither NRC nor the nuclear utility industry has standards that define the quality or adequacy of the risk assessments that utilities use to identify and measure risks to public health and the environment. Furthermore, NRC has not determined the willingness of utilities to adopt a risk-informed approach. According to NRC staff, they are aware of these and other issues and have undertaken activities to resolve them.

In January 1999, NRC released for comment a proposed risk-informed process to assess the overall safety of nuclear power plants. This process would establish industrywide and plant-specific safety thresholds and indicators to help NRC assess plant safety. NRC expects to phase in the new process over the next 2 years and evaluate it by June 2001, at which time NRC plans to propose any adjustments or modifications needed. In addition, NRC has been examining its enforcement program to make it consistent with, among other things, the proposed process for assessing plant safety. The nuclear industry and public interest groups have criticized the enforcement program as subjective. In the spring of 1999,

²On Feb. 4, 1999, we testified on some of these issues before the Committee on Clean Air, Wetlands, Private Property, and Nuclear Safety, Senate Committee on Environment and Public Works (see Nuclear Regulatory Commission: Strategy Needed to Develop a Risk-Informed Safety Approach (GAO/T-RCED-99-71)).

³Nuclear Regulation: Preventing Problem Plants Requires More Effective NRC Action (GAO/RCED-97-145, May 30, 1997), Nuclear Regulatory Commission: Preventing Problem Plants Requires More Effective Action by NRC (GAO/T-RCED-98-252, July 30, 1998), and Performance and Accountability Series: Major Management Challenges and Program Risks: Nuclear Regulatory Commission (GAO/OCG/99-19, Jan. 1999).

NRC staff expect to provide the Commission with recommendations for revising the enforcement program.

Background

NRC is responsible for ensuring that the nation's 103 operating commercial nuclear power plants pose no undue risk to public health and safety. According to one study, as many as 26 of the nation's nuclear sites are vulnerable to shutdown because production costs are higher than the projected market prices of electricity.⁴ The analysis also estimates that 39 plants whose operating licenses are scheduled to expire by 2020 will seek to extend their licenses.

Since the early 1980s, NRC has been increasing the use of risk information in the regulatory process. For example, in 1986, the agency issued safety goals that, according to NRC staff, supported the use of risk analyses in making regulatory decisions. In August 1995, NRC issued a policy statement advocating certain changes in the development and implementation of its regulations through a risk-informed approach. Under such an approach, NRC and the utilities would give more emphasis to those structures, systems, and components deemed more safety significant. The following example illustrates the difference between NRC's traditional approach and a risk-informed approach: One nuclear utility identified about 635 valves and 33 pumps that must be operated, maintained, tested, and replaced at one plant, according to NRC's traditional regulations. However, about 515 valves and 12 pumps present a low safety risk while 120 valves, 21 pumps, and 25 components present a high safety risk. Under a risk-informed approach, NRC has approved the utility's concentrating on the elements presenting a high safety risk while continuing to comply with NRC's traditional regulations for the remaining elements but at less frequent intervals.

Early in calendar year 1998, the Nuclear Energy Institute (NEI) contracted with the Center for Strategic and International Studies to examine NRC's regulatory processes.⁵ NRC, the Union of Concerned Scientists, and others are members of the steering committee for the study. The Center's review focuses on answering three questions: What is NRC's safety expectation? Are NRC's rules and regulations properly focused on safety? Are NRC's

⁴World Energy Service: U.S. Outlook, Standard and Poor's (Apr. 1998).

⁵NEI includes members from all utilities licensed to operate commercial nuclear plants in the United States, as well as nuclear plant designers, major architectural/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry. NEI establishes unified policy for the nuclear industry on such matters as generic operational and technical issues.

processes focused on safety? According to the Director of NRC’s Office of Nuclear Regulatory Research, the steering committee for the study discussed whether the Center would define “an acceptable level of safety.” Recognizing that providing such a definition is a difficult and challenging task that NRC and others have attempted over the years, the study’s steering committee believed that the Center should focus instead on how safe NRC expects commercial nuclear power plants to be and how consistently NRC applies that expectation to the plants. The Center expects to issue its report in April 1999.

Competition Presents a Challenge for NRC

Commercial nuclear power plants will continue to generate electricity for some time in the future. NRC issues a plant operating license for 40 years. After 20 years, a utility can apply to extend the license for an additional 20 years.⁶ Table 1 shows the time frames during which the existing plant licenses could expire.

Table 1: License Expiration Dates for the Existing Generation of Nuclear Power Plants

Period	Number of licenses that could expire	Number of licenses remaining
2005-2010	8	96
2011-2015	35	61
2016-2020	15	46
2021-2025	26	20
2026 and beyond	20	0
Total	104^a	

^aIncludes Browns Ferry Unit 1. Although this plant has not operated since 1985, the owner (Tennessee Valley Authority) has not announced plans to permanently shut down and decommission the plant.

Source: United States Nuclear Regulatory Commission Information Digest, NUREG-1350, Vol. 10 (1998).

The Energy Policy Act of 1992 has resulted in the restructuring of the nation’s electric power industry and the emergence of competition in the business of electricity generation. As the electric utility industry is restructured, operating and maintenance costs will affect the competitiveness of nuclear power plants. Competition challenges NRC to ensure that utilities do not compromise safety through cost-cutting measures. As of February 1999, 18 states had implemented plans to

⁶On Apr. 8, 1998, Baltimore Gas and Electric applied to NRC for license extensions for its two Calvert Cliffs plants, and on July 7, 1998, Duke Power applied for extensions for its three Oconee plants. Southern Nuclear expects to apply for an extension for its Hatch plant in 1999.

restructure the electric utility industry by enacting legislation or adopting final orders. In the 13 states that have enacted legislation, utilities operate 34 nuclear power plants that produce between 20 percent and 59 percent of the states' electricity. In the 5 states that have adopted final orders without enacting legislation, utilities operate 17 nuclear plants that supply between 15 percent and 74 percent of the states' electricity.⁷

Competition will pose difficult issues for some nuclear utilities, and efforts to achieve economies of scale will spur the growth of nuclear operating companies as a means of minimizing overhead and maximizing institutional experience. Other cost reduction efforts being pursued by the industry include mergers, acquisitions, the use of contract operators, and spin-offs of generating assets. For example, Alabama Power Company and Georgia Power formed a subsidiary—Southern Nuclear Operating Company—to operate six plants for the utilities. In addition, in July 1998, AmerGen Energy Company, a joint venture formed in 1997 by PECO Energy Company and British Energy, announced plans to purchase Three Mile Island 1 from GPU Nuclear Corporation. Furthermore, Duke Power bought Pan Energy (a gas company) as a means of diversifying its operations. Given the added economic pressures competition is likely to bring, NRC will need to continue to be vigilant to ensure that the decisions utilities make primarily in response to economic pressures are not detrimental to public health and safety.

NRC, NEI, and many utility executives believe that the key for nuclear plants to compete is efficient plant operations. To achieve such efficiency, NRC and NEI believe that fewer and fewer companies will operate more and more of the existing nuclear plants. Consolidation will allow companies to achieve economies of scale in, for example, their refueling and engineering staffs. Some experts believe that in the future only 5 to 10 companies will operate all nuclear power plants to ensure cost efficiency and survive in a competitive environment.

⁷The status of the states' electric utility deregulation activity was derived from *Status of Electric Industry Restructuring by State*, published by the Energy Information Administration. The percentage of electricity generated by nuclear power plants was derived from *Electric Power Monthly* (Jan. 1999), published by the Energy Information Administration. The data shown are as of Oct. 1998.

NRC Has Not Resolved Many Issues Needed to Implement a Risk-Informed Regulatory Approach

NRC staff estimate that it could take 4 to 8 years to implement a risk-informed regulatory approach and are working to resolve many issues to ensure that the new approach does not endanger public health and safety. Although NRC has issued guidance for utilities to use risk assessments to meet regulatory requirements for specific activities and has undertaken many activities to implement a risk-informed approach, more is needed to

- ensure that utilities have current and accurate documentation on the design of each plant and its structures, systems, and components and safety analysis reports that reflect changes to the design and other analyses conducted after NRC issued the plant's operating license;
- ensure that utilities make changes to their plants on the basis of complete and accurate design and safety analysis information;
- determine whether and what aspects of NRC's regulations should be changed;
- develop standards on the scope and detail of the risk assessments needed for utilities to determine that changes to their plants' design will not negatively affect safety; and
- determine the willingness of utilities to adopt a risk-informed approach.

Inaccurate and Unreliable Design and Safety Analysis Information Can Impede NRC's Efforts to Consider Risk Information

Whether NRC uses a traditional or a risk-informed regulatory approach, it must have current and accurate documentation to oversee nuclear plants. These documents include the (1) design of the plant and of the structures, systems, and components within it and (2) safety analysis reports that reflect changes to the design and other analyses conducted (including those related to the process that allows utilities to change their plants without obtaining NRC's approval) since NRC issued the operating license. To effectively implement a risk-informed approach, NRC must have confidence that each plant's design reflects current safety requirements and that accurate baseline information exists for each plant. Without such information, neither NRC nor the utility can determine the safety consequences of making changes to the plant.

For more than 10 years, NRC has questioned whether utilities have accurate, available, and current information on the design of their plants. Inspections of 26 plants completed early in fiscal year 1999 confirmed that (1) some utilities had not maintained accurate design documentation; (2) with some exceptions, NRC had assurance that safety systems would perform as intended at all times; and (3) NRC needed to clarify what constitutes design information. NRC staff expect to recommend an

approach to the Commission in June 1999 to clarify design information and seek approval to obtain public comments on the recommended approach. NRC staff could not estimate when the agency would complete this effort but said that the agency would oversee design information issues using such tools as safety system engineering inspections.

In addition, in 1993, NRC found that Northeast Nuclear Energy Company for many years had taken actions at its Millstone Unit 1 plant that were not allowed under its updated safety analysis report. Since that time, NRC has not had confidence that some utilities update their safety analysis reports as required following analyses and changes that modify the existing descriptions or create new descriptions of facilities or their operating limits. Failure to update the reports results in poor documentation of the plants' safety bases. As a result of the lessons learned from Millstone and other initiatives, NRC determined that additional guidance is needed to ensure that utilities update their safety analysis reports to reflect changes to the design of their plants, as well as the results of analyses performed since NRC issued the plants' operating licenses. On June 30, 1998, the Commission directed the staff to work with NEI to finalize the industry's guidelines on updating safety analysis reports, which NRC could then endorse in a regulatory guide. NRC expects to endorse the guidelines by the end of September 1999.

Furthermore, for more than 30 years, NRC's regulations have provided a set of criteria that utilities must use to determine whether they may change their facilities (as described in their safety analysis reports) or procedures or conduct tests and experiments without NRC's prior approval. The finding in 1993 that Millstone Unit 1 had taken actions that were not allowed by its updated safety analysis report led NRC to question this regulatory framework. As a result, NRC staff initiated a review to identify the short- and long-term actions needed to improve the change process. For example, in October 1998, NRC published a proposed regulation on plant changes in the *Federal Register* for comment; the comment period ended on December 21, 1998. NRC requested comments on criteria for identifying changes that require an amendment to a plant's license and on a range of options, several of which would allow utilities to make changes without NRC's prior approval, despite a potential increase in the probability or consequences of an accident. NRC expects to issue a final rule in June 1999. In addition, in December 1998, NRC staff provided their views to the Commission on changing the scope of the regulation to consider risk information. NRC's memorandum that tracks the various tasks related to a risk-informed approach did not show when NRC would resolve this issue.

According to NRC staff, they will develop a plan to implement the Commission's decision after it is received.

Making Its Regulations Risk Informed Will Be a Challenge to NRC and the Industry

Until recently, NRC did not consider whether and to what extent it should revise its regulations pertaining to commercial nuclear plants to make them risk informed. Revising the regulations will be a formidable task because, according to NRC staff, the regulations are inconsistent and a risk-informed approach would focus on the safety significance of structures, systems, or components, regardless of where they are located in a plant.

NRC staff and NEI officials agree that the most critical issues in revising the regulations will be to define their scope (that is, whether the regulations will consider risk, as well as the meaning of such concepts as "important to safety" and "risk significant") and to integrate the traditional and risk-informed approaches into a cohesive regulatory context. After defining the scope of the regulations, NRC can determine how to regulate within the revised context. In October 1998, NEI proposed a phased approach to revise the regulations. Under this proposal, by the end of 1999, NRC would define "important to safety" and "risk significant." By the end of 2000, NRC would use the definitions in proposed rulemakings for such regulations as those on the definition of design information and the environmental qualification of electrical equipment. By the end of 2003, NEI proposes that NRC address other regulatory issues, such as the change process, the content of technical specifications, and license amendments. After 2003, NEI proposes that NRC address other regulations on a case-by-case basis.

NRC staff agreed that the agency must take a phased approach when revising its regulations. The Director, Office of Nuclear Regulatory Research, said that if NRC attempted to revise all provisions of the regulations simultaneously, it might accomplish very little. The Director said that NRC needs to address one issue at a time while concurrently working on longer-term actions. He cautioned, however, that once NRC starts, it should commit itself to completing the process. In January 1999, NRC staff presented their proposal to the Commissioners. At that meeting, the Chairman suggested a more aggressive approach that would entail a risk-informed approach for all relevant regulations across the board. NRC's memorandum tracking the various tasks involved in implementing a risk-informed approach did not show when the agency would resolve this issue.

Variation in the Quality of Utilities' Risk Assessments Raises Questions About the Feasibility of Implementing a Risk-Informed Approach

NRC and the industry view risk assessments as one of the main tools for identifying and focusing on those structures, systems, or components of nuclear plant operations having the greatest risk. Yet neither NRC nor the industry has a standard that defines the quality, scope, or adequacy of risk assessments. NRC staff are working with the American Society of Mechanical Engineers to develop such a standard.

However, this issue is far from being resolved. The Society is developing the standard for risk assessments in two phases. The first phase would address assessments of the probability of accidents initiated by a certain set of events internal to the plant; the second phase would address accidents initiated by events external to the plant, such as earthquakes, or occurring while the plant is shut down. NRC staff estimate that the agency would have a final standard for the first phase by June 2000 but could not estimate when the second phase would be complete. To ensure consistency with other initiatives, in December 1998, NRC staff sought direction from the Commission on the quality of risk assessments needed to implement a risk-informed approach. In the meantime, the lack of a standard could affect NRC's efforts to implement a risk-informed regulatory approach. According to NRC staff, they recognize that limitations exist with risk assessment technology and are working, and will continue to work, to enhance the technology.

In addition, in the past, operational data needed to enhance the quality of risk assessments were not available for some critical structures, systems, or components. Utilities had to extrapolate the information from like systems in other industrial applications. Today, the reliability and availability of data for performing risk assessments are enhanced in many areas by almost 40 years of operational experience. Much of this information is disseminated to other utilities, partly because, in a regulated environment, the utilities do not compete with one another for market share.

However, under the approaching deregulated environment, nuclear utilities will compete for market share—with each other as well as with other generators of electric power. As a result, the utilities may no longer want to share proprietary operational data previously available to upgrade the quality of risk assessments. NRC has already acted as a clearinghouse to disseminate the results of examinations undertaken at its direction to determine each plant's vulnerabilities to severe accidents. For example, in December 1997, NRC reported on improvements made to individual plants as a result of the utilities' examinations, the collective results of the

examinations, plant-specific design and operational features, the modeling assumptions that significantly affected estimates of how frequently the reactor core is damaged and how well the plant contains radiation, and the strengths and weaknesses of the models and methods used by the utilities to perform the examinations. However, NRC does not plan to collect and disseminate this information on a regular basis.

A Risk-Informed Approach May Not Be Advantageous for All Nuclear Utilities

In December 1998, NRC staff recommended that implementation with revised risk-informed regulations be voluntary, noting that it would be very difficult to show that requiring compliance would increase public health and safety as required by the backfit rule. The staff also noted that requiring compliance could create the impression that current plants were less safe. The staff's recommendation did not indicate the number of utilities that would be interested in a risk-informed approach. In commenting on a draft of this report, NRC said that the number of utilities likely to operate under risk-informed regulations would depend on economic judgments the utilities would make once the Commission clarifies the details of a risk-informed regime. In January 1999, the Commissioners expressed concern about a voluntary approach, believing that it would create two classes of plants operating under two different sets of regulations. Nevertheless, in commenting on a draft of this report, NRC said that compliance would be voluntary.

Our discussions with officials from 10 utilities that operate 16 nuclear plants and NRC documents showed that utilities may be reluctant to shift to a risk-informed regulatory approach for various reasons. First, the number of years remaining on a plant's operating license is likely to influence the utility's views. NRC acknowledged that if a plant's license is due to expire in 10 years or less, then the utility may not have anything to gain by changing from the traditional approach. Second, considering the investment that will be needed to develop risk-informed procedures and operations and to identify safety-significant structures, systems, or components, utilities may question whether a switch will be worth the reduction in regulatory burden and cost savings that may result. Third, design differences and age disparities among plants make it difficult for NRC and the industry to determine how, or to what extent, a standardized risk-informed approach can be implemented across the industry. Although utilities built one of two types of plants—boiling water or pressurized water reactors—each has design and operational differences. Thus, each plant is unique, and a risk-informed approach would require plant-specific tailoring.

**Utilities Acknowledge That
Uncertainties Exist**

Utility officials with whom we spoke confirmed the issues discussed above and revealed the range of views held by them. The official of a small, single-unit utility said that because a limited number of years remained on the plant's license, the utility would not be able to realize many benefits from a risk-informed approach. An official from another utility told us that the company has been focusing its attention on replacing steam generators and did not know if it could find the resources needed to comply with a risk-informed approach. Another official said that the utility has a risk assessment that works for that plant but is less detailed and costly than risk assessments prepared by some utilities for newer, larger plants. Several officials said that their utilities were planning to use risk assessments more in the future than in the past and that any changes to the plants or operating procedures would have to demonstrate benefits through a cost/benefit analysis.

Another official said that the utility wants to move cautiously in applying risk assessments at its plants because it does not want to undo some other aspects of their operations that could affect safety. Several officials noted that they are monitoring the actions that NRC eventually takes concerning a graded quality assurance pilot project implemented at the South Texas nuclear power plant. According to staff, NRC approved the pilot project, but the utility has not realized the expected benefits because of constraints imposed by other regulations. NRC staff said that they will address the constraints if the agency takes a risk-informed approach to its regulations. Other utility officials said they have a "living" risk assessment that is updated frequently. They said that their utilities have used the assessment to support applications for license amendments and to determine the impact of NRC's inspection findings on the plants.

**NRC Does Not Have a
Strategy to Implement a
Risk-Informed Approach**

Since the early 1980s, NRC has been increasing the use of risk information in its regulatory process. NRC staff estimate that it will be at least 4 to 8 years before the agency implements a risk-informed approach. However, NRC has not developed a strategy that includes objectives, time lines, and performance measures for such an approach. Rather, NRC has developed an implementation plan, in conjunction with its policy statement on considering risk, that is a catalog of about 150 separate tasks and milestones for their completion. It has also developed guidance for some activities, such as pilot projects in the four areas where the industry wanted to test the application of a risk-informed approach. Furthermore, in August 1998, the Executive Director for Operations identified high-priority areas—including risk-informed regulation, inspection,

enforcement, and organizational structure—and provided short- and long-term actions and milestones to address each of the areas. NRC has revised the schedules for completing some of the identified actions several times since August 1998.

Given the complexity and interdependence of NRC's requirements as reflected in regulations, plant designs, safety documents, and the results of ongoing activities, it is critical that NRC clearly articulate how the various initiatives will help achieve the goals set out in its 1995 policy statement supporting risk-informed regulation. Although NRC's implementation plan sets out tasks and expected completion dates, it is not a strategy with goals and objectives. Specifically, it does not

- ensure that short-term efforts are building toward NRC's longer-term goals or link the various ongoing initiatives;
- help the agency identify the staffing levels, training, skills, and technology needed—or the timing of those activities—to implement a risk-informed approach;
- provide a link between the day-to-day activities of program managers and staff and the objectives set out in the policy statement; and
- address the manner in which NRC would establish baseline information about the plants to assess the impact on safety of a risk-informed approach. Establishing such a baseline may be particularly important because NRC, NEI, and the Union of Concerned Scientists do not believe that the agency can demonstrate the industrywide impact of implementing such an approach. Therefore, if NRC subsequently determines that it wants or needs to demonstrate the impact of a risk-informed approach on safety, the agency will have to do so on a plant-by-plant basis.

A comprehensive strategy could also enhance NRC's efforts to comply with the Government Performance and Results Act of 1993. The Results Act requires federal agencies to develop goals, objectives, strategies, and performance measures in the form of a 5-year strategic plan, an annual performance plan, and, beginning in fiscal year 2000, an annual program performance report assessing the agency's success in achieving the goals set out in the prior year's performance plan. The annual performance plan would give NRC the opportunity to clearly specify the actions it will take to achieve its risk-informed strategy and the resources, training, and other skills needed to do so. The annual assessment report would give the Congress and the public an opportunity to determine the extent to which NRC has achieved its goals.

In a December 1998 memorandum, NRC staff said that once the Commission provides direction on whether and how to apply a risk-informed approach to the regulations and guidance on the quality of risk assessments, they would develop a plan to implement the direction provided. The staff did not estimate how long it would take to complete the plan.

The Status of NRC's Assessment and Enforcement Processes: Many Unresolved Issues Remain

The nuclear industry and public interest groups have criticized NRC's plant assessment and enforcement processes, saying that they lack objectivity, consistency, and predictability. As part of its risk-informed initiatives, in January 1999, NRC proposed a new process to assess overall plant safety using industrywide and plant-specific safety thresholds and performance indicators. NRC is also reviewing its enforcement process to ensure consistency with the direction recommended by the staff for the assessment process and other programs.

NRC Is Trying to Make Its Plant Assessment Process More Objective and Transparent

In 1997 and 1998, we noted that NRC's process to focus attention on plants with declining safety performance needed substantial revisions to achieve its purpose as an early warning tool and that NRC did not consistently apply the process across the industry.⁸ We also noted that this inconsistency has been attributed, in part, to a lack of specific criteria, the subjective nature of the process, and the confusion of some NRC managers about their role in the process. NRC acknowledged that it should do a better job of identifying plants deserving increased regulatory attention and said that it was developing a new process that would be predictable, nonredundant, efficient, and risk informed.

In January 1999, NRC proposed a new safety assessment process that includes seven "cornerstones."⁹ For each cornerstone, NRC will identify the desired result, important attributes that contribute to achieving the desired result, areas to be measured, and various options for measuring the identified areas. Three issues cut across the seven cornerstones: human performance, safety consciousness in the work environment, and problem identification and resolution. As proposed, NRC's plant assessment process would use performance indicators; inspection results; utilities' self-assessments; and clearly defined, objective thresholds for making

⁸Nuclear Regulation: Preventing Problem Plants Requires More Effective NRC Action (GAO/RCED-97-145, May 30, 1997) and Nuclear Regulatory Commission: Preventing Problem Plants Requires More Effective Action by NRC (GAO/T-RCED-98-252, July 30, 1998).

⁹The seven cornerstones are initiating events; mitigation systems; barrier integrity; emergency preparedness; and public, occupational, and physical protection.

decisions. The process is anchored in a number of principles, including the beliefs that (1) a certain level of safety performance could warrant decreased NRC oversight, (2) performance thresholds should be set high enough to permit NRC to arrest declining performance, (3) NRC must assess both performance indicators and inspection findings, and (4) NRC will establish a minimum level of inspections for all plants (regardless of performance). Although some performance indicators would apply to the industry as a whole, others would be plant specific and would depend, in part, on the results of utilities' risk assessments. However, as stated earlier, the quality of risk assessments vary considerably among utilities.

NRC expects to use a phased approach to implement the revised plant assessment process. Under this approach, it plans to begin pilot testing the use of risk-informed performance indicators at 13 plants in June 1999, fully implement the process by January 2000, and complete an evaluation and propose any adjustments or modifications needed by June 2001. Between January 1999 and January 2001, NRC expects to work with the industry and other stakeholders to develop a comprehensive set of performance indicators to more directly assess plants' performance relative to the cornerstones. When it is impractical or impossible to develop performance indicators, NRC plans to use its inspections and utilities' self-assessments to reach a conclusion about plants' performance. NRC's proposed process illustrates an effort by the current Chairman and other Commissioners to improve NRC's ability to help ensure the safe operation of the nation's nuclear plants, as well as address the industry's concerns about excessive regulation. By ensuring consistent implementation of the process ultimately established, the Commissioners would further demonstrate their commitment to this process.

NRC's Enforcement Process Remains in a State of Flux

NRC has revised its enforcement policy more than 30 times since implementing it in 1980. These revisions reflect changing requirements, regulatory policy, and enforcement philosophy. Although NRC has attempted to make the policy more equitable, the industry has had long-standing problems with it. Specifically, NEI believes that the policy is not safety related, timely, or objective. Among the more contentious issues are NRC's practice of aggregating lesser violations for enforcement purposes and NRC inspectors' use of the term "regulatory significance."

To facilitate a discussion of the enforcement program, including these two contentious issues, NRC asked NEI and the Union of Concerned Scientists to review 56 enforcement actions that it had taken during fiscal year 1998.

For example, NEI reviewed the enforcement actions on the basis of specific criteria, such as whether the violation that resulted in an enforcement action could cause an off-site release of radiation, on-site or off-site exposures to radiation, or damage to the reactor core. Overall, the Union of Concerned Scientists concluded that NRC's enforcement actions were neither consistent nor repeatable and that the enforcement actions did not always reflect the severity of the offenses. According to NRC staff, they met with various stakeholders in December 1998 and February 1999 to discuss issues related to the enforcement program.

NRC inspectors' use of the term "regulatory significance" is an issue, according to NEI and the Union of Concerned Scientists, because inspectors use the term when they cannot define the safety significance of a violation. Then, when a violation to which the term has been applied results in a financial penalty, the utility does not understand the reason for the financial penalty and cannot explain to the public whether the violation presented a safety concern.

NEI has proposed a revised enforcement process. NRC is reviewing this proposal, as well as other changes to the enforcement process, to ensure consistency with the draft plant safety assessment process and other changes being proposed as NRC moves to risk-informed regulation. NRC staff expect to provide recommendations to the Commission in March 1999 on the use of the term "regulatory significance" and in May 1999 on the consideration of risk in the enforcement process.

Conclusions

Effective regulation, whether traditional or risk informed, needs to be anchored in information that adequately describes the design and safety parameters of a plant, changes to the plant's design and operations that affect safety, and assessments that define the structures, systems, or components that are safety significant. Yet NRC does not have assurance that this information is available and accurate. Although the Nuclear Energy Institute, speaking for the industry, has embraced the risk-informed approach as a solution to overregulation by NRC, some utilities do not see the benefits of a risk-informed approach because they consider it too costly or inappropriate for the size and age of their plants. Since NRC has stated that compliance will be voluntary, the agency will be regulating under two different systems—a situation that will compound challenges in an already complex regulatory environment.

In addition, NRC has no comprehensive strategy to guide the process of moving to a risk-informed regulatory approach. A strategy would provide NRC and the industry with a framework for implementing a risk-informed approach. This framework would identify the interrelationships of the various components, establish time lines, and define goals and performance measures. Such a strategy would identify the costs and benefits of a risk-informed approach, indicate which utilities would be regulated in a risk-informed environment, and provide information on the cost and approach for NRC's future regulation. The strategy could also provide a mechanism to foster continued information sharing so that the quality of risk assessments and NRC's risk-informed initiative would not suffer in a competitive environment.

NRC's new approach to assessing nuclear plant safety performance should provide valuable lessons and insights as NRC changes more of its processes and regulations to consider risk information. But whatever processes NRC ultimately adopts must be consistent, visible, and clear. The need for clarity in NRC's processes may be even more important today than it has been in the past. In a competitive environment, utilities will not always be able to pass the costs of regulatory compliance on to consumers. Yet because of concerns about the risks of catastrophic accidents, the public will continue to pressure NRC and the industry to explain their actions. A clearly defined strategy would help both NRC and the utilities address the public's concerns.

Recommendation

To help ensure the safe operation of plants and the continued protection of public health and safety in a competitive environment, we recommend that the Commissioners of NRC direct the staff to develop a comprehensive strategy that includes but is not limited to objectives, goals, activities, and time frames for the transition to risk-informed regulation; specifies how the Commission expects to define the scope and implementation of risk-informed regulation; and identifies the manner in which it expects to continue the free exchange of operational information necessary to improve the quality and reliability of risk assessments.

Agency Comments and Our Evaluation

We provided a copy of a draft of this report to the Nuclear Regulatory Commission for its review and comment. Although the Nuclear Regulatory Commission did not comment on our recommendation, the agency stated that its strategic plan and 1995 policy statement specify its goals and objectives to implement a risk-informed approach and that its efforts are

supported by the planning, budgeting, and performance management process. The Nuclear Regulatory Commission also noted that it has issued regulatory guidance documents to implement the strategic plan, policy statement, and 1986 safety goals. The Nuclear Regulatory Commission said that it actively supports the development of risk assessment standards and will continue to develop methods and tools to improve the assessments. In addition, the Nuclear Regulatory Commission said that we did not sufficiently recognize its many ongoing risk-informed initiatives and progress. We did not change the report to recognize the agency's concerns because we believe that we provided sufficient information on the status of its and/or the nuclear industry's activities for each of the initiatives that we discussed.

The Nuclear Regulatory Commission also commented that the report raises issues that it, the nuclear industry, and other stakeholders are addressing. We acknowledge that the agency has identified and is working to resolve the issues addressed in the report, as well as many other initiatives. However, given the complexity and interdependence of its efforts, we continue to believe that the Nuclear Regulatory Commission needs a comprehensive strategy that includes clearly defined goals and objectives; clear links between and among its various initiatives; identified staffing levels, training, skills, and technology needs; and a link between the day-to-day activities of program managers and staff. Without such information, the Nuclear Regulatory Commission does not have a mechanism to ensure that its short-term efforts are building toward its longer-term goals and to help staff understand when and if activities will affect them. In addition, such a strategy would flow from—and not duplicate—its strategic planning efforts and planning, budgeting, and performance management process to help ensure that the agency is moving in the right direction.

The Nuclear Regulatory Commission provided several clarifying comments that we have incorporated, where appropriate. The agency's letter and our response to its specific comments are provided in appendix I.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 14 days after the date of this letter. At that time, we will send copies to the Honorable Shirley Ann Jackson, Chairman, Nuclear Regulatory Commission; the Honorable Greta Joy Dicus, the Honorable Nils J. Diaz, the Honorable

Edward McGaffigan, Jr., and the Honorable Jeffrey S. Merrifield, Commissioners, Nuclear Regulatory Commission; and the Honorable Jacob Lew, Director, Office of Management and Budget. We will make copies available to other interested parties on request.

We conducted our work from May 1998 through February 1999 in accordance with generally accepted government auditing standards. Appendix II provides details on our scope and methodology.

If you or your staff have any questions about this report, please call me on (202) 512-3841. Other major contributors to this report are listed in appendix III.

A handwritten signature in black ink, appearing to read "Victor S. Rezendes". The signature is fluid and cursive, with the first name "Victor" being the most prominent.

Victor S. Rezendes
Director, Energy, Resources,
and Science Issues

Contents

Letter	1	
Appendix I Comments From the Nuclear Regulatory Commission	22	
Appendix II Objectives, Scope, and Methodology	26	
Appendix III Major Contributors to the Report	28	
Table	Table 1: License Expiration Dates for the Existing Generation of Nuclear Power Plants	4

Abbreviations

GAO	General Accounting Office
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission

Comments From the Nuclear Regulatory Commission



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 5, 1999

Ms. Gary Jones
Associate Director, Energy,
Resources, and Science Issues
United States General Accounting Office
Washington, D.C. 20548

Dear Ms. Jones:

On February 19, 1999, Nuclear Regulatory Commission (NRC) staff members met with GAO representatives to discuss a draft version of your report to Senators Lieberman and Biden on NRC risk-informed regulatory activities. Subsequently, I received your letter of February 24, 1999, formally soliciting our comment on a revised draft. We appreciate the opportunity to comment on the revised draft report and are pleased that some of the feedback we provided your staff in the February 19, 1999, meeting has been reflected in the revised draft. However, in addition to the enclosed comments, we believe it is still necessary to reinforce some of the points made by the staff in the February 19, 1999, meeting and to provide a clear statement of our positions. This letter summarizes those positions, and we would request that a copy of this letter be included with the final GAO report. Specifically, we believe it is important to note the following:

- The NRC Strategic Plan, with our 1995 Probabilistic Risk Assessment (PRA) Policy Statement, articulates the NRC goal of making our regulatory processes more risk-informed. This plan and policy statement commit the agency to focus our resources and those of our regulated industries on the most important safety issues, using risk insights, as appropriate.
- Consistent with the requirements of the Government Performance and Results Act, the Commission has implemented a Planning, Budgeting and Performance Management (PBPM) process, which is a direct outgrowth of our Strategic Assessment and Rebaselining, carried out in 1995. Key components of PBPM are an agency strategic plan and performance plan that specify agency goals and objectives. A strategy in these existing plans is to increase the use of risk-informed approaches to eliminate unnecessary or duplicative regulatory requirements. The PBPM process recognizes that our planning is not static. Using the PBPM process, with support from an independent consulting firm, the Commission is updating its Strategic Plan to reflect the latest direction for implementing risk-informed regulation. The revised Strategic Plan and the policy direction resulting from the Commission decisions on issues currently being considered form the foundation for building more specific implementation plans.
- NRC has made considerable progress towards making regulatory processes more risk-informed. Building on a history of using risk information in regulatory decisionmaking that dates from the 1970s, we have begun the systematic modification of our processes, and institutionalization of the changes. In 1998, we issued a series of regulatory guidance documents describing how traditional engineering and PRA information should

**Appendix I
Comments From the Nuclear Regulatory
Commission**

2

be used in the process for changing the operating licenses for power reactors. These documents provide a practical approach for implementing the Strategic Plan and PRA Policy Statement goals, as well as our 1986 Safety Goal Policy Statement. Using this guidance, a number of reactor licensees already have proposed, and the NRC has approved, changes to their operating licenses to better focus their resources on safety.

- In our next steps, we have begun to change our reactor oversight process (including inspection, enforcement, and assessment activities), and will soon begin work to make our basic reactor regulations more risk-informed. We expect in the near future to have a framework for making our nuclear materials licensing and regulatory processes, and our research program, more risk-informed. We also expect to revisit some of our basic policy documents, including the Safety Goal Policy Statement, to provide up-to-date and consistent descriptions of our risk-informed goals and policies. Detailed plans are being developed for some of these expected activities, building on the basic framework and Commission decisions on policy issues.
- We continue to improve the technical validity of PRA methods while expanding their use. To wit, we are actively supporting the development of PRA standards by organizations such as the American Society of Mechanical Engineers, and we are working with the reactor industry in their PRA "certification" efforts. We also are continuing to develop and demonstrate improved PRA methods and tools, focusing on key areas such as human reliability analysis, the risks of accidents initiated by fires, and the assessment of operational events in licensed reactors.

These represent only a snapshot of many ongoing risk-informed initiatives at the NRC. I strongly believe that your report did not sufficiently recognize these and other important efforts, our progress to date, our efforts to ensure that utility documents reflect current designs, or our plans to make the NRC regulatory programs more risk-informed. The NRC safety standard remains adequate protection with cost-beneficial safety enhancements. Absent such acknowledgment, I believe that the report merely raises issues that we, the nuclear industry, and other stakeholders already are addressing. This could impede further progress. I am sure that is not your intent.

If you have any questions or comments, please contact me.

Sincerely,



Shirley Ann Jackson

Enclosure:
Comments on Draft GAO Report

**Appendix I
Comments From the Nuclear Regulatory
Commission**

Comments on Draft GAO Report

Now on p. 1.

1) On Page 1 of the report, in the second sentence of the second paragraph, the NRC position would be more accurately represented by adding the following to the end of the sentence:

“... [without reducing safety] and, in some cases, improving safety.”

Now on p. 2.
See comment 1.

2) On Page 3, the third sentence in the first full paragraph does not appear to differentiate between “risk-informed” and “risk-based”; a distinction that was recognized earlier in the report (see the first full sentence on Page 2). Consider the following replacement sentence:

“First, while all utilities have sufficiently current and accurate information to support a risk-informed approach, few, if any, utilities have sufficiently complete and precise design information to support a risk-based approach.”

Now on p. 10.

3) On Page 14, suggest the following revision, beginning with the sentence that continues from the previous page:

“... [difficult to show that requiring compliance would increase public health and safety], as would be required by the Commission’s backfit rule. Furthermore, according to the staff, requiring compliance could create the impression that current plants were less safe. The staff’s recommendation did not indicate the number of utilities that would be interested in such an approach. That number would depend on economic judgments made once the details of the risk-informed regime were clarified. In January 1999, the Commissioners expressed concern about a voluntary approach, believing that it would create two classes of plants operating under two different sets of regulations. Since that time, based on communications with the Chairman and Commissioners, the NRC has clarified to GAO that a voluntary approach will be used.” (additions underlined)

Now on p. 15.
See comment 2.

4) On Page 21, with regards the first two sentences of the Conclusions, the NRC is strongly of the view that current regulations in the areas of design information, changes in hardware and operations, and safety assessments, such as 10 CFR 50.59, 10 CFR 50.71, and 10 CFR 50 Appendix B, have been and remain effective in providing reasonable assurance of adequate protection to the health and safety of the public, as required by the Atomic Energy Act (Section 182a).

GAO's Comments

The following are GAO's comments on NRC's letter dated March 5, 1999.

1. We have not included NRC's suggested language in the report. NRC says that all utilities have sufficiently current and accurate information to support a risk-informed, but not a risk-based, approach. Yet NRC found as late as several months ago that some utilities did not have complete and accurate design information. Until NRC resolves this issue, we do not believe that a foundation exists upon which to move forward with a risk-informed approach.
2. We did not state that regulations do not provide reasonable assurance of adequate protection to the health and safety of the public. Our conclusion is based on the fact that NRC has not resolved many fundamental issues needed to implement a risk-informed approach. Therefore, we have not changed our report.

Objectives, Scope, and Methodology

Senators Joseph R. Biden, Jr., and Joseph I. Lieberman asked us to examine various issues related to the safe operation of commercial nuclear power plants. On the basis of discussions with their offices, we agreed to answer the following questions: What challenges will the Nuclear Regulatory Commission (NRC) and the nuclear industry experience in a competitive environment? What issues does NRC need to resolve to move forward with risk-informed regulation? What is the status of NRC's efforts to apply a risk-informed regulatory approach to two of its oversight programs—plant safety assessments and enforcement?

We reviewed prior General Accounting Office reports; relevant sections of the Atomic Energy Act of 1954, as amended; and NRC regulations, staff requirement memorandums, and various analyses provided by the Executive Director for Operations or other offices for the Commission's consideration. We also reviewed NRC's responses to questions resulting from the July 1998 hearing before the Subcommittee on Clean Air, Wetlands, Private Property, and Nuclear Safety, Senate Committee on Environment and Public Works.

To determine the pressures that the nuclear industry will experience in a competitive environment, we reviewed Standard and Poor's World Energy Service: U.S. Outlook (Apr. 1998) and the Nuclear Energy Institute's (NEI) Nuclear Energy: 2000 and Beyond—A Strategic Document for Nuclear Energy in the 21st Century (May 1998). We also examined NRC's Office of Inspector General's June 1998 report on the results of the safety culture and climate survey conducted in the fall of 1997. In addition, we obtained the Energy Information Administration's Status of Electric Industry Restructuring by State and Electric Power Monthly (Jan. 1999). We also met with officials from Energy Resources International, Inc., and reviewed an October 1998 report, Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity, to obtain views on the future of nuclear power.

To determine the issues that NRC needs to resolve to move forward with a risk-informed approach, we reviewed comments that NRC received on its May 1997 proposed regulatory guidance on the process that allows utilities to change their plants without NRC's prior approval and on its October 1998 proposed regulations for implementing the change process. We also reviewed various analyses prepared by NEI, including guidelines for the conduct of safety evaluations required by the change process. We contacted 10 utilities that operate 16 nuclear plants to obtain their views on a risk-informed regulatory approach. We selected the utilities on the

basis of information provided by NRC on the quality of their risk assessments, as well as discussions with NRC staff. We attended meetings held by the Advisory Committee on Reactor Safeguards on risk assessment and the change process, a public workshop held by NRC on its risk-informed regulation (July 22, 1998), and meetings held by the Commission in July 1998 and November 1998 with various stakeholders, including NEI, the Union of Concerned Scientists, the World Association of Nuclear Operators, and utility officials. We also attended the January 1999 briefing by NRC staff to the Commissioners on their proposed approach to making the regulations that apply to nuclear power plants risk informed. We met with staff responsible for NRC's initiatives related to design information, safety analysis reports, the change process, and risk-informed regulation, as well as with knowledgeable representatives of NEI, the Union of Concerned Scientists, and Public Citizen's Critical Mass Energy Project.

To determine the status of NRC's efforts to make its plant safety assessments and enforcement programs risk informed, we attended a public workshop held by NRC on its proposed process (from Sept. 28, 1998, through Oct. 1, 1998) and meetings held by the Commission in July 1998 and November 1998 with various stakeholders, including NEI, the Union of Concerned Scientists, the Institute for Nuclear Power, and utility officials. In addition, we reviewed NRC's January 1999 proposed plant safety assessment process, as well as an Assessment of the NRC Enforcement Program (NUREG-1525, Apr. 1995), the NRC Enforcement Policy Review: July 1995 - July 1997 (NUREG-1622, Apr. 1998), and the General Statement of Policy and Procedures for NRC Enforcement Actions (NUREG-1600, Rev. 1, May 1998). We also reviewed NEI's proposal related to a risk-informed, performance-based assessment, inspection, and enforcement process. We met with staff responsible for NRC's initiatives related to plant safety assessments and enforcement, as well as with knowledgeable representatives of NEI, the Union of Concerned Scientists, and Public Citizen's Critical Mass Energy Project.

Major Contributors to the Report

Resources,
Community, and
Economic
Development Division
Washington, D.C.

Vondalee Hunt
Gary Jones
Mary Ann Kruslicky
Michael Rahl

Ordering Information

The first copy of each GAO report and testimony is free. Additional copies are \$2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Superintendent of Documents, when necessary. VISA and MasterCard credit cards are accepted, also. Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

Orders by mail:

U.S. General Accounting Office
P.O. Box 37050
Washington, DC 20013

or visit:

Room 1100
700 4th St. NW (corner of 4th and G Sts. NW)
U.S. General Accounting Office
Washington, DC

Orders may also be placed by calling (202) 512-6000 or by using fax number (202) 512-6061, or TDD (202) 512-2537.

Each day, GAO issues a list of newly available reports and testimony. To receive facsimile copies of the daily list or any list from the past 30 days, please call (202) 512-6000 using a touchtone phone. A recorded menu will provide information on how to obtain these lists.

For information on how to access GAO reports on the INTERNET, send an e-mail message with "info" in the body to:

info@www.gao.gov

or visit GAO's World Wide Web Home Page at:

<http://www.gao.gov>

**United States
General Accounting Office
Washington, D.C. 20548-0001**

**Bulk Rate
Postage & Fees Paid
GAO
Permit No. G100**

**Official Business
Penalty for Private Use \$300**

Address Correction Requested

