2. PLAN IMPLEMENTATION

INTRODUCTION

Implementation of this Plan will involve U.S. national laboratories, universities, utilities, industry, and also international participants. Shrinking resources for nuclear R&D at both DOE and EPRI has forced both organizations to consider means of coordinating their research to get more done with less. Because government and industry R&D priorities may differ, this Plan strongly advocates seeking alignment in the selection and prioritization of specific R&D options, wherever possible. Therefore, it is important to define the optimum relationship of government and private industry to best meet the nation's energy needs in the most cost-effective manner. This chapter describes the roles and responsibilities for DOE and EPRI, the criteria for selecting and prioritizing R&D activities, and desirable mechanisms for coordinating R&D between the two organizations.

This Joint Strategic Plan defines nuclear energy research and development (R&D), prioritized from a combined government and industry perspective, and in the context of national needs to maintain a viable and long-term nuclear energy option. Although the current focus is on the next five to ten years, this plan will be maintained as a living document that will serve as the primary strategic planning document for joint nuclear energy R&D planning into the future between DOE, representing the overall national interest, and EPRI, representing the nation's nuclear utilities.

RELATIONSHIP OF THIS PLAN TO PCAST ENERGY STUDY

The November 5, 1997, report of the Energy Research and Development Panel of the President's Committee of Advisors on Science and Technology (PCAST) made two key recommendations related to nuclear fission energy R&D:

"Operating Reactors: Extending the operation of nuclear plants will make it easier to meet GHG emission goals. The Panel recommends that DOE work with its laboratories and the utility industry to develop a program to address the problems that may prevent continued operation of current plants. We recommend such a program be funded at $10M per year, to be matched by industry"

"Nuclear Energy Research Initiative: DOE should establish a new program—the Nuclear Energy Research Initiative—funded initially at $50 million per year and increasing by FY2002 to $100 million per year (as-spent dollars), which would competitively select among proposals by researchers from universities, national laboratories, and industry to address key issues affecting the future of fission energy, including: proliferation-resistant reactors or fuel cycles; new reactor designs with higher efficiency, lower-cost, and improved safety to compete in the global market; lower-output reactors for use in settings where large reactors are not attractive; and new techniques for on-site and surface storage and for permanent disposal of nuclear waste. This approach is in contrast to the traditional style of directed research of the DOE Nuclear Energy Program (in which the program office defines the topics, milestones, and scope) and follows instead a model along the lines of the Environmental Management Science Program (EMSP)."

The R&D included in this Joint Strategic Plan is directed to the specific technology program needs that follow from a goal-based review of national requirements, principally those goals related to ensuring the cost-effective operation and life cycle management of currently operating nuclear plants. In general, this R&D is market-driven and focused on near-term and medium-term technology requirements. Thus, this Strategic Plan fully encompasses and addresses the first recommendation of PCAST for current plants.

In addition, this Strategic Plan relates in part to the second recommendation to establish a Nuclear Energy Research Initiative (NERI). It is possible that some requirements identified in this plan might be the basis for a future proposal under NERI, and that R&D conducted under NERI could form the basis for new R&D projects identified in future revisions to this plan.

Both this Joint R&D Strategic Plan and the NERI approach offer the advantages of making the R&D selection and prioritization process more open and independent, responsive to PCAST and Congress.

ROLES AND RESPONSIBILITIES

Coordination Needs and Benefits

Energy industry leaders, and in particular, electric utility industry leaders, have many shared interests with the national policy makers with planning or budgetary responsibility for energy R&D. Both generally support preserving the strategic and economic advantages of a mix of energy supply options competing on an even playing field in a free market. Both are acutely aware of the need for reducing the cost and increasing the market value of R&D. Both are challenged by the taxpayers and ratepayers of the nation to ensure that energy will always be delivered safely, reliably and at low cost to all energy consumers, using fuels, supply technologies and transport methods that sustain our natural resources and environmental quality. Both are vitally interested in leveraging the strengths of our U.S. energy technology and economic vitality to compete in world energy markets – exploiting technology leadership, where we still enjoy it, to improve balance of trade and expand high-tech domestic job opportunities. These shared interests and objectives should encourage joint planning, prioritizing, and resource leveraging (where appropriate) of R&D as it is being aggressively transitioned to the private sector for commercialization.

There is a general consensus that much energy R&D, particularly short-term R&D, should be an industry responsibility, and that some energy R&D, particularly basic and/or high-risk research, should be a government responsibility. What is not well understood and determined is how to manage and fund the vast range of R&D activities that lie between basic research and short-term R&D. As a basic principle, government and industry R&D efforts should be coordinated to avoid duplication and excessive costs and delays in bringing R&D results to commercialization. A synergistic public/private partnership can dramatically improve the cost-benefit ratio of energy R&D.

The objectives and functions of DOE and EPRI are quite similar. Both organizations strive for high performance standards, value the important contribution of nuclear energy to society, and

share an interest in the efficient execution of nuclear energy R&D. Both organizations also plan R&D, obtain funding for that R&D, select contractors, and manage those contractors to complete assigned tasks on schedule and within budget. In addition, both are responsible for publishing R&D results and encouraging the application of those results to the benefit of their respective funding sources, i.e., the U.S. taxpayers who fund DOE's R&D and the U.S. utilities and their customers who fund EPRI.

The scope and funding levels for DOE's nuclear energy R&D are set by the Administration and Congress in the annual budget appropriations process. DOE contracts with universities, national laboratories, and private companies to carry out this R&D under federal contracting and procurement laws. EPRI is a nonprofit (501.C.3) institution that obtains funding from domestic and international electric utility companies and others with membership rights. It manages a collaborative R&D program in all areas of energy generation, transmission, and end-use, as well as in related science and technology areas that are of interest to the energy enterprise. EPRI also contracts under its competitive selection rules with universities, national laboratories, and private sector companies; the majority of project work is performed by the latter.

As the resources of the two organizations have shrunk, guidance from R&D sponsors (i.e., Congress, utilities) has been for DOE to focus on long-term research, and for EPRI to focus more on short-term research. The percentage of DOE-sponsored R&D intended to be in used in the market place within five years is small; the corresponding percentage of EPRI-sponsored R&D in this same category is expected to be large, roughly 60 to 80 percent of the total.

This strong bias of R&D strategies toward these time frames is difficult and unnatural for independent R&D organizations. Experience has shown that most long-term research that is completed and "put on the shelf" never gets to the marketplace. In DOE's case, this could mean losing contact with consumers and moving away from market relevance if at least some of its R&D efforts are not steered toward commercialization. EPRI faces the risk of not having the "seed money" needed at the front end of the R&D pipeline to support a largely near-term R&D portfolio. To keep their programs truly viable, DOE and EPRI must coordinate their efforts by managing this transition between long-term and short-term R&D to deliver the greatest possible value.

Working with EPRI under this strategic plan will provide DOE with a single, direct interface with utilities for all nuclear energy R&D, to obtain market input and provide pilot application of DOE-developed technologies. EPRI will fill DOE's need to show value to its long-term research efforts through the product development phase and enable private sector commercialization, while DOE will fill EPRI's need for basic, long-range research to support its more applications-oriented, near- and mid-term R&D. DOE also will act as a catalyst for industry to develop needed technologies that have economic value and are beneficial to the Nation, but are considered high-risk for sole industry investment.

Priorities and Responsibilities

Under this Plan, R&D priorities should reflect (1) major national criteria such as economic strength, energy security, environmental quality, and science and technology leadership and

(2) major industrial and consumer requirements such as safety, reliability, economic competitiveness, stable fuel supply, and efficient regulation. These R&D priorities should be set in a collaborative process where industry and government work together to define needs and priorities and allocate R&D funding in accord with the following responsibilities. In this context, short-term refers to 0 to 5 years, mid-term refers to 5 to 20 years, and long-term represents 20 to 50 years.

Sole industry responsibility: Short-term, low-risk development to the point of commercial readiness, or R&D needed by industry that does not include a compelling public or national interest involved.

Sole government responsibility: R&D requirements where there is a vital national interest involved, but no direct commercial interest or benefit to industry. Examples include nonproliferation technologies and very long-term or basic research with no clear horizon for commercial application, such as nuclear fusion.

Joint government/industry responsibility: Requirements for near- to mid-term R&D that support common interests, but represent high economic risk to the industry for sole industry funding.

This last category contains the largest and most strategically vital segment of R&D; because of these dual responsibilities, it is the one that requires the greatest planning effort for success. For this category, DOE would be almost exclusively responsible for the exploratory and feasibility phases of technology development. After these phases, industry involvement would progressively increase into prototype demonstration through first demonstration in a plant. The commercialization phase would be the industry's sole responsibility.

Relationship to Nuclear Research Performed by the Nuclear Regulatory Commission

NRC's role (specifically, the role of the NRC's Office of Nuclear Regulatory Research) is very different from the roles of DOE and industry. Most importantly, NRC does not develop new technology to address issues at nuclear power plants. In fact, much of NRC's research program is focused on conducting confirmatory testing and analysis on technologies used by commercial nuclear power plants. NRC's role is to assure that it can provide the regulatory offices within NRC, and the public at-large, with <u>independent</u> assurance that the technologies developed by DOE and/or industry for use in nuclear power plants are safe. NRC must also conduct confirmatory research as part of its responsibility to develop regulations for use of new technology in nuclear power plants.

There are many instances in which DOE and/or industry conducts research, for which there is no corresponding research activity at NRC; e.g., developing new technologies for nuclear plants which do not require regulatory approval. Sometimes NRC conducts research in an area for which no corresponding research activity exists at DOE or in industry. An example is research on a regulatory issue for which industry believes no safety concern exists, but for which NRC has an obligation to confirm that issue does not present a significant risk to the public. Finally, there are instances where, of necessity, DOE, industry, and NRC all need to conduct research because it is within their respective missions, or legal responsibilities, to obtain answers to a technical issue. In

such cases, NRC is obligated to arrive at its safety conclusions independently. That does not mean that NRC cannot share the cost of an expensive test program or data collection effort with DOE, industry, or both, to help answer a technical issue, as long as the cooperation is restricted to the scientific, data collection phase of the research. When a research effort reaches a point where data have been collected and interpretation of that data is ready to start with regard to what that data show about adequacy of safety or the potential need for additional regulation, NRC must do its work independently.

Regarding the proposed R&D activities in this Strategic Plan, there are instances in which NRC already has ongoing programs, or might have R&D programs in the future. NRC's programs will always be focused on providing the technical basis for regulatory decisions, in contrast to the focus of DOE's and industry's programs, which is on development of new technology, methods, and equipment that could be used to achieve the Goals of this Plan. In the area of license renewal, DOE's role is in support of the utilities as applicants to NRC, much as was DOE's role during the ALWR program as a supporter of reactor designers applying for design approval and design certification.

DOE, industry, and NRC closely coordinate their planning to assure that the respective programs are complementary and cost-effective. Both DOE and industry have Memoranda of Understanding (MOU) with NRC governing cooperation and avoidance of duplication. In an increasingly significant number of cases, research is jointly funded to conserve taxpayer or ratepayer funds.

PROJECT SELECTION, PRIORITIZATION, AND COORDINATION

Selection and Prioritization

The R&D areas for this Plan were identified based on information received by both DOE and EPRI from utilities, utility organizations, national laboratories, NRC, and other stakeholders over the past several years. Initial prioritization of work identified in Chapters 3 through 5 and detailed in Volume III has been done by DOE and EPRI staff. The highest priority tasks have been organized along project lines; more in-depth details of these projects are included in Volume II. It should be noted that the priorities of projects are recommendations at this stage, and are subject to review and approval by DOE and industry, taking into consideration what research is being supported by the Nuclear Regulatory Commission. Selected activities will be closely coordinated within both DOE and EPRI, as well as with utilities, universities and national laboratories. Both organizations are committed to ensuring the relevance and technical excellence of their nuclear energy research and development efforts. However, funding priorities are different for the two organizations, and funding decisions will be made by both organizations based on their respective roles described above.

The approval process on the EPRI side will include review and concurrence by the Nuclear Power Council, representing all the nuclear utility members of EPRI. This utility review and concurrence will ensure market relevance of all proposed projects and assist in adjustment of priorities to obtain the greatest value from the proposed R&D. Even though the Nuclear Power Council has

asked EPRI to focus its R&D more toward short-term products, this group of utility executives is the best executive-level industry group available to advise on long-term nuclear R&D. This Council has engaged in strategic planning and gap analysis of R&D plans and well understands which long-term efforts are most likely to preserve and advance nuclear technology in the right directions and produce the best value to the Nation. Hence, on an annual basis, EPRI will facilitate a comprehensive utility review of the projects proposed under this joint R&D plan, as well as recently completed work under this plan, to ensure proper selection, adequate oversight, proper prioritization, and adequate progress against R&D performance measures.

DOE will use an Advisory Committee on Nuclear Energy Research and apply independent peer reviews to ensure the R&D selected is consistent with national policy objectives and the technical work performed is high quality, makes the best use of the funds provided, and is carried out by the most qualified performers.

The R&D selected for funding by DOE must have generic applicability to the industry, must represent high economic risk to the industry for sole industry investment, and must have the potential for high payoff in national energy security goals in the mid- to long term. Ultimately, the prioritization and selection will be based on answers to the following questions:

- Does the activity help maintain or increase the operating lives of existing plants?
- Does it reduce regulatory or economic uncertainty?
- Is it applicable to multiple plants?
- Is it mid- to long-term R&D of high economic risk to the industry?
- When is it needed and what is the likelihood of success?
- Can DOE, including national laboratories, provide unique, value-added contributions to execute the activity?
- What is the cost to DOE?

The funding for different projects will generally involve participants other than DOE and EPRI. Not all activities will be funded by both EPRI and DOE. In general, the DOE will use standard government procurement practices for all directed, competitively bid work scopes. For activities that are jointly funded, a cooperative agreement between EPRI and DOE will be established. Specific technical projects will be awarded on a competitive basis, unless there is some unique capability that requires the work to be performed at specific locations or by a specific organization.

Mechanisms for Coordinating Research

EPRI and DOE have jointly established a Sustainable Electricity Partnership (SEP), chartered by Secretary O'Leary and EPRI President Balzhiser in 1994, to increase their coordination and joint sponsorship of energy R&D. The key elements of this initiative are an annual coordinating

conference and a new set of standardized, high-level financial agreements (a model cooperative agreement and a model participation agreement) that allow EPRI and DOE to jointly fund work or transfer funds from one organization to the other to help fund the work of the other organization. These agreements come under government rules for cooperative agreements with nonprofit organizations, not under standard government contract rules. This gives both organizations greater flexibility to cost-share work for mutual benefit. The standardized SEP model agreements have been pre-approved by all DOE regional offices, so specific work done under them can be expedited. Examples of energy R&D between DOE and EPRI that have been managed under cooperative agreements include the Advanced Light Water Reactor (ALWR) First-of-a-Kind Engineering Program and the Advanced Battery Consortium for electric cars.

Another mechanism proven to work well for DOE and EPRI (e.g., under the SEP) is to agree on a baseline, comprehensive R&D program that includes all the work needed by both organizations, with sufficient coordination to ensure no overlap or gaps and the proper prioritization and sequencing of all the projects. Under this Plan, inputs will be solicited from NRC, industry, and interested international participants. The recommendations of advisory groups to both organizations will also help in the research selection process. After this is done, projects can be either cost-shared or funded separately by either DOE or EPRI. This Plan supports both approaches, i.e. it can lead to either co-funded activities or separate, but coordinated activities. The process for project coordinations, selections, annual reviews, revised directions, and funding sources identification is shown diagrammatically in Figure 2-1.

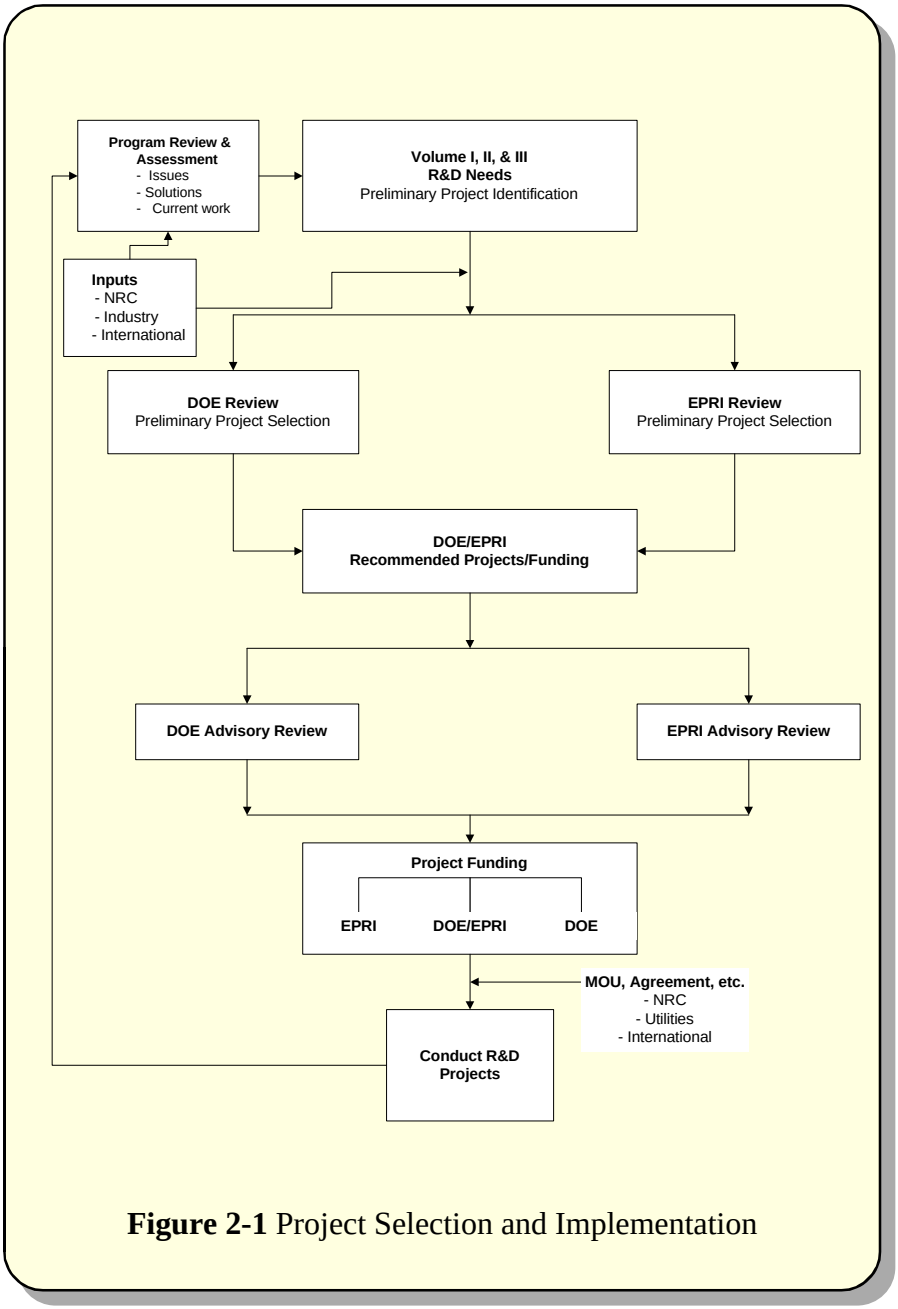

Figure 2-1 Project Selection and Implementation

The use of cooperative agreements between DOE and EPRI, in combination with DOE's and EPRI's own contracting rules and vehicles for the contractors selected for the work, should be sufficient to

cover all situations envisioned under this joint R&D plan. A separate Memorandum of Understanding (MOU) between DOE and EPRI covering nuclear energy R&D may prove desirable in the long run to help expedite cooperative agreements and contracts and facilitate achievement of R&D objectives. A recent MOU between EPRI and NRC Research for cooperative or cost-shared research could serve as a model if an MOU is deemed appropriate for DOE. The EPRI-NRC MOU is a high-level agreement under which specific R&D project agreements fall. It specifies that overall coordination, integration, prioritization, and management of cooperative R&D be done under a management board consisting of representatives from both organizations. The management of each R&D project is subject to a Steering Committee comprised of all the funders of that research. It provides guidelines related to funding, publishing results, adding or deleting tasks, project reviews, handling of proprietary data, patents, etc. If modeled by DOE, this MOU also would be a useful vehicle for three-way cooperation between NRC, DOE, and industry.

This suggests another mechanism for cooperation between DOE and EPRI that should be considered to extend the partnership principles above into the NERI process, as it gets underway in 1999. Although NERI will encourage independent proposals for medium and long-term nuclear energy R&D without strict management oversight of R&D directions, the value of market-based input and advice along the way cannot be discounted. The greater likelihood of eventual application of that new technology suggests great value added in involving EPRI and/or utilities in a review mode. Certain NERI project areas that would require major utility input and feedback during the research phase could be managed directly by EPRI under the SEP Cooperative Agreement process.

All of these mechanisms involve direct utility participation in the actions and decisions by EPRI, since the nuclear utilities oversee EPRI's work and have a vital interest in the success of all joint efforts with DOE.

Finally, all research projects must be coordinated with NRC at the planning and selection stage. For many proposed R&D projects described in this document, there is no corresponding NRC research; however, independent evaluations, confirmatory research, or testing may be required prior to in-plant demonstration of DOE and industry developed technologies. And, as discussed under Roles and Responsibilities, NRC may also fund joint research or use data collected from DOE and EPRI research for their regulatory function. DOE and NRC must closely coordinate their planning to ensure that the two government programs are complementary, not duplicative. DOE, EPRI, and industry will coordinate their efforts under this Strategic Plan with NRC's actions to minimize duplication of effort and maximize R&D output in a cost-effective manner.

Performance Measures

Tasks will be selected based on the criteria outlined above. The planning of each selected project will require the establishment of specific, quantifiable (where appropriate) performance measures/milestones before the work begins so that the success of the project can be measured and tracked.

Overall Funding Requirements

Commercial nuclear energy R&D has been a very small percentage of DOE's overall energy R&D budget in recent history, and has been on a steady decline since 1992. It dropped from $125 million in 1992 to $38 million in fiscal year 1997 and was eliminated entirely in fiscal year 1998. At $38 million in fiscal years 1996 and 1997, this level of R&D investment represented less than two percent of DOE's energy R&D spending, and less than a quarter of one percent of the total DOE budget. EPRI's total annual spending on nuclear energy R&D has ranged between $70 million and $115 million over the past decade, reaching a peak of $115 million in 1995 (the year of highest utility spending on the ALWR Program), and declining to about $90 million in 1997/1998. On average, roughly 25 percent of EPRI's utility-controlled budget (which has been essentially market-driven in recent years) has gone to nuclear energy R&D; however, overall utility investment in all energy R&D, including nuclear, has gone down more than 20 percent in the past three years. This is primarily due to the pressures of deregulation and increasing retail competition. Further decreases are anticipated.

PCAST recommended that DOE work with its laboratories and the utility industry to develop a program to address the problems that may prevent continued operation of current plants. The recommended funding level of this program is $10 million per year, to be matched by industry. The total DOE funding levels recommended by PCAST for fission energy (including NERI and university programs) are initially at $66 million in 1999 and increase to $119 million in 2003.

Each project identified in Volumes II and III includes an estimated funding requirement. It should be noted that, although identification and description of the critical R&D needs is fairly complete in this Plan, the projects included in Volumes II and III are expected to evolve during implementation. The degree of definition for each project included in Volumes II and III varies in accordance with the current state of development for the proposed technology. For example, tasks such as direct measurement of reactor vessel embrittlement are focused on investigating the technical feasibility of a proposed solution, whereas tasks such as application of ASIC technology are focused on demonstrating an existing technology for nuclear power plant applications. Obviously, in cases where the feasibility is demonstrated, technology development could proceed until it actually can be used, and the associated funding requirements would increase. On the other hand, in cases where more than one potential solution is being investigated, only the most promising solutions would proceed through the phases of prototype demonstration and commercialization. It should be further noted that the duration of project completion provided in the project descriptions is only for the work identified and does not represent the time period required to make a particular technology available for deployment.

Schedule

The planning of each selected project will require the establishment of a schedule before the work begins so that the progress of the project can be measured and assessed.