Section 1: Introduction

***Disclaimer*: This draft report was prepared to help the Department of Energy determine the barriers related to the deployment of new nuclear power plants but does not necessarily represent the views or policy of the Department.**

Project Objectives for DOE's Office of Nuclear Energy, Science and Technology (NE)

- Build the business case for commercial deployment of new reactors by conducting an analysis of the financial and business hurdles that must be overcome to achieve the commercial operation of one or more new reactors by 2010, i.e., the completion of design, licensing and permitting, construction, and acceptance testing of a full-scale commercial unit.
- Building on the Near Term Deployment Roadmap (October 2001) issued by the Department of Energy's (DOE) Office of Nuclear Energy, Science and Technology (NE), understand the risk management perspectives of key private investors, lenders, and industry, i.e., carefully assess the business issues facing nuclear power generators, including developing a strong understanding of the economics underpinning the production of electric power from new reactors and assessing the risks inherent in such development.
  - What risk factors most strongly impede a positive private sector investment decision relative to building new nuclear power plants?
  - What is the relative importance of these risk factors to nuclear power's competitiveness?
- Evaluate market perspectives of the potential effectiveness of existing NE programs in addressing deployment risks.
  - What critical risk hurdles will remain after DOE actions based on current program authority (see NE budget on page *1-11*)?
- Understand under what conditions and financing structures new commercial reactors can be built and operated economically—and what private sector and DOE programs and financial mechanisms are critical to creating those conditions. Given the projected competitive position of new nuclear power plants…
  - What actions must the private sector take—alone or with the government—to help manage critical risks to the construction and commissioning of new commercial reactors?
  - What actions does DOE need to consider taking—alone or with the private sector—to help break down remaining critical barriers to new nuclear facility development?
  - What alternative federal financing mechanisms would be most effective in mitigating the key risk factors that impede private sector investment in new nuclear power plants—or other energy facilities?

The Business Case: Building on the Near Term Deployment Roadmap

Building on the Near Term Deployment Roadmap (NTDR)

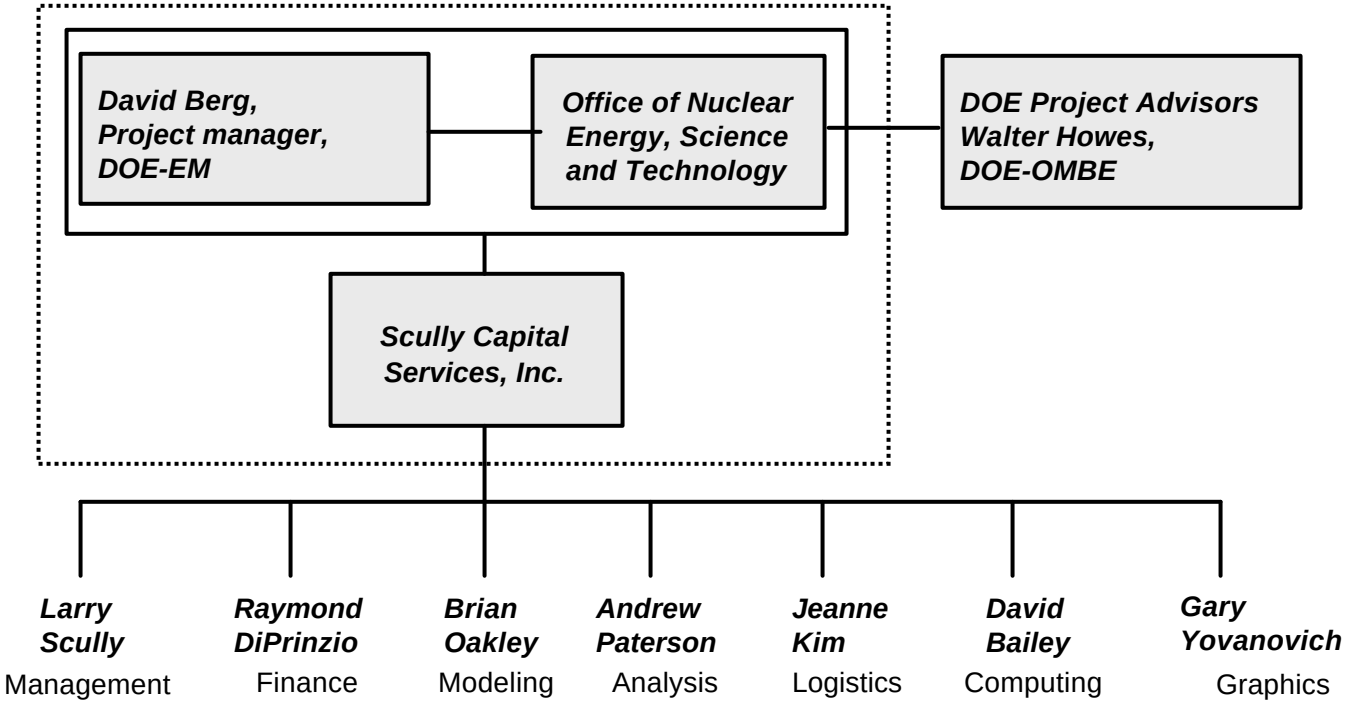
- NE has worked with the nuclear industry to establish the technical and regulatory foundation for new nuclear plants. NE's Near Term Deployment Group (NTDG) examined the prospects for new nuclear plants in the United States during this decade, identifying obstacles to deployment and actions for resolution. NE issued the NTDR in October 2001.
- Generic gaps identified by the NTDG:
  - Nuclear plant economic competitiveness, including capital cost issues
  - Business implications of the deregulated electricity marketplace
  - Efficient implementation of new regulatory structure (10CFR52)
    - Design certification (addressed in NTDR)
    - Early Site Permits (ESP)
    - Combined construction-operating license (COL)
  - Nuclear industry infrastructure
  - National Nuclear Energy Strategy and Policy
- Other significant issues identified:
  - Nuclear safety and plant security
  - Spent fuel management and disposal
  - Public acceptance of nuclear energy
  - Non-proliferation of nuclear material

Central Issues for the Industry Analysis

- Examine the latest trends in nuclear capacity and generation compare with those of other fuel sources.
  - How does nuclear power's capacity factor compare?
  - What is the outlook for relicensing?
  - What is the competitive position of nuclear v. gas?
- Document how nuclear power's market share varies across the U.S. power regions.
- Discuss the status of transmission capacity constraints.
  - How do constraints impinge on new baseload plants?
- Describe the latest trends in nuclear fuel.
- Put dimensions on the financial health of U.S. nuclear owner / operators, and discuss industry consolidation.
- Outline the state of nuclear supply (reactor types, vendors, E&C firms) in the United States and globally.
- Discuss the status of the nuclear workforce and the state of university training.
  - Is the workforce adequate for new plant orders?
- Summarize the status of certain high-profile government actions which directly impact the industry.
  - Yucca Mountain repository for spent fuel
  - NRC regulatory processes (COL, ITAAC)
- Describe how regulatory shifts and prospects for emissions trading affect the outlook for nuclear power.

Integrated Project Team

- To facilitate consideration of the complex issues involved in the project and ensure contractor access to important data from NE, as well as to provide streamlined project processes, an integrated project team (IPT) was instituted.
- The IPT members included the contractor, the DOE project manager, the Office of Management, Budget and Evaluation, and key NE staff. Senior NE management participated in project meetings and decision-making.
- NE membership on the IPT included individuals from the Office of Industrial Analysis and the Office of Technology and International Cooperation.
- The IPT met weekly, and consultations outside the meetings were on an "as needed" basis. In this fashion, assumptions were vetted on a real-time basis and the combined knowledge of the members of the team could be brought to bear rapidly.



Project Scope / Approach and Timeline

- The project consisted of six tasks, as shown graphically on page *1-7*, that were performed over a ten-week period starting in late March 2002.
- **Task 1:** The first task included the establishment of project processes and confirmation of the project objectives. During this period, the IPT was established, the central questions to be addressed were identified, and the outputs to be produced were defined.
- **Task 2:** The next task involved data gathering about and analysis of relevant segments of the private sector, including equipment manufacturers, engineering and construction firms (E&C), and the parts of the financial community that are involved in making equity investments, providing debt capital, and insuring companies in the nuclear power generation and sales business. The Near Term Deployment Roadmap and markets for electricity in the United States were reviewed. Non-NE members of the IPT also learned about the NE program and its objectives. Industry associations, sources of private-sector financial information, trade groups, and non-governmental organizations were pulsed.
  - Deliverable A: Documentation of industry and financial data and trends relevant to the deployment of advanced nuclear technology, as reflected in DOE, industry, financial, and other sources.
- **Task 3:** The third task involved extensive outreach to key non-DOE players to develop a clear understanding of current perspectives toward the risks that pertain to nuclear energy projects involving Generation III reactors.

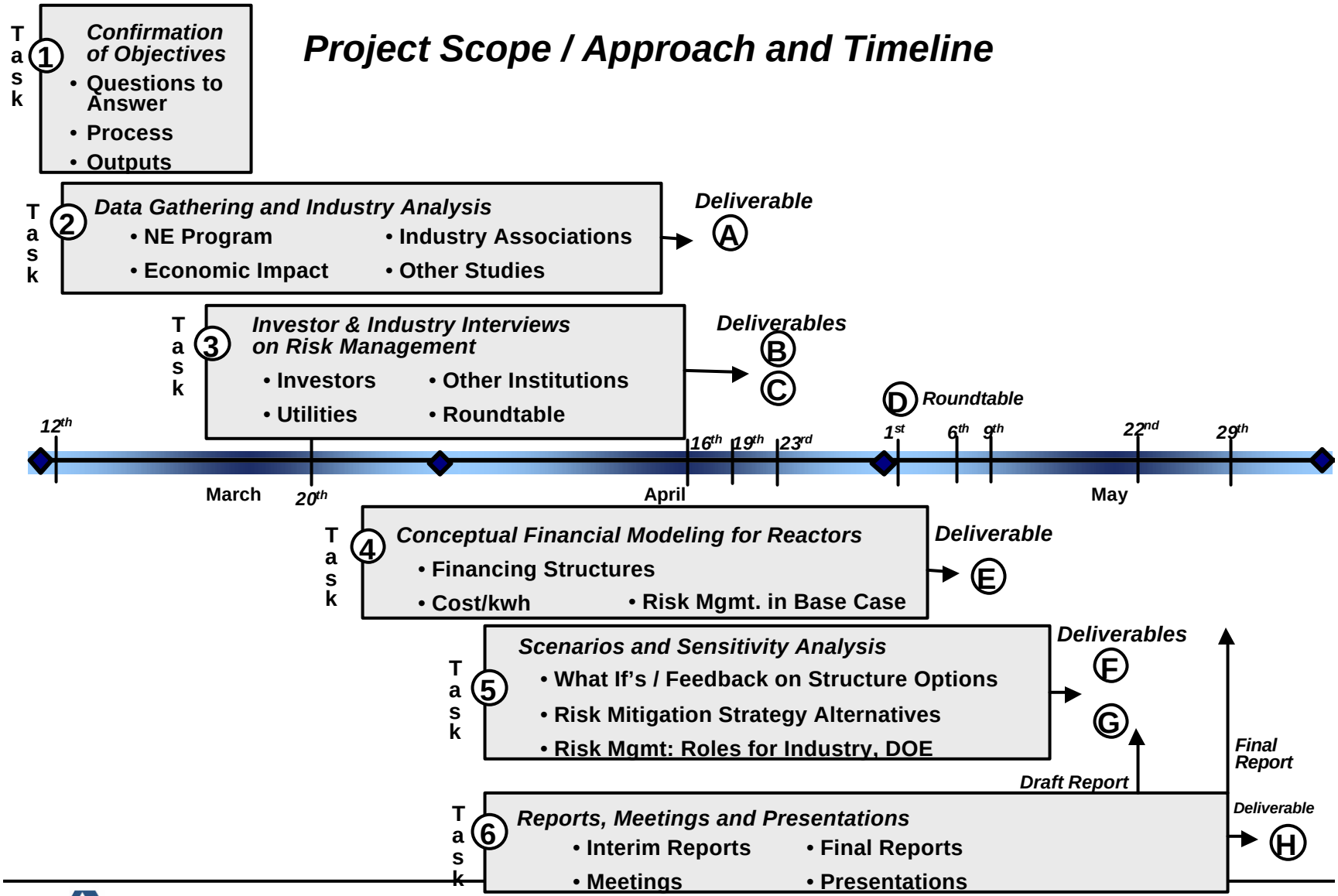
A risk framework was developed based on the analysis of data gathered in Task 2. More than 25 interviews were conducted with leading senior executives who work for manufacturers of nuclear power equipment; consulting and engineering firms; power generators; electricity distribution companies; financial companies that are involved in financing, lending to, and insuring companies in the nuclear power generation and sales business; and non-governmental organizations interested in nuclear power. More than 20 of these individuals then participated in one of two roundtable discussions of the highlights of the interviews, along with NE and NRC. A key to the product: A deepened understanding of the financing risks and hurdles that impede development of new nuclear plants.

- Deliverable B: Documentation of the views of important nuclear industry executives, the investment community, the lending community, electricity utility executives, developer / operators, regulators, and nuclear industry observers to identify the relevant risk factors associated with new nuclear power projects and to understand private sector perspectives about the management of these risks and about current conditions in the electricity marketplace.
- Deliverable C: Identification of (a) the most critical barriers that hinder the nuclear development and (b) the most critical areas for DOE partnering with industry.
- Deliverable D: Two one-day workshops for DOE senior management with selected investor and industry participants who were part of the interview process.

Project Scope / Approach and Timeline

- **Task 4:** A conceptual financial model was developed of the base case for a new nuclear power plant that shows the internal rate of return achieved at current prices for electricity given a particular capital structure. The model is built around a financial snapshot of a nuclear power project and was utilized during the project to calculate the financial impacts of both changes in the base case and the application by either the private sector or public sector of risk mitigation techniques.
  - Deliverable E: A base-case financial model that (a) illuminates how DOE and industry work together to manage the risks associated with construction of a nuclear power plant and (b) can be used in Task 5.0 to perform analyses of alternative financing structures to estimate the impact of various risk mitigation and financing strategies on project economics. Analyses using the model should identify critical market sensitivities and DOE's current ability to positively impact these sensitivities.
- **Task 5:** Several scenarios and sensitivity analyses were performed using the financial model to examine the impact on financial outcomes of changes in the base case and to project the impact on financial outcomes of a variety of potential risk mitigation methods that the private sector and government might use. Page *1-10* illustrates that, under certain conditions, nuclear plants may be built and commissioned.
  - Deliverable F: Results of scenario-based analyses testing alternative roles / risk mitigation strategies that DOE can consider using to provide support to the development and construction of new nuclear plants. The varying effectiveness of these potential roles and strategies should be evaluated, as should the level of risk that DOE may be assuming as it potentially utilizes these alternative financing and programmatic strategies.
  - Deliverable G: A framework, described in writing and illustrated in graphic form, for risk mitigation strategies that arrays the critical risks of new nuclear-based power facilities against current and potential DOE roles and risk mitigation strategies, and that assesses the potential usefulness of these roles and risk mitigation strategies in stimulating economic power production using new nuclear technology.
- **Task 6:** Outputs include the final report and presentations about the methodology, findings, and conclusions from the study to NE, senior management of DOE, and others.
  - Deliverable H: Final report and PowerPoint presentation to DOE of project progress, results, and conclusions.

Project Scope / Approach and Timeline



Near Term Deployment Roadmap (NTDR) Generic Gaps: Linked to Industry Analysis and the Risk Framework

- The Near Term Deployment Roadmap (NTDR) identified generic gaps that affect the prospects for new nuclear units. Some of these gaps are critical, or controlling, factors in new plant decisions. The industry analysis in this report addresses key elements of these gaps.
- In addition, the industry analysis provides basic data for the development of a risk-based framework for the business case and an assessment of the key risks related to early orders of nuclear units.

Generic Gaps in NTDR	NTDR Gaps Addressed in Section 2 (Industry Analysis)	NTDR Gaps Addressed in Section 3 (Risk Framework)
1. Nuclear plant economic competitiveness - Capital costs of reactor designs, and performance specifications	• Current construction of plants • Operating record of utilities • Financial health of utilities, vendors, and engineering firms • Fuel supply markets, prices	• Technology / design risks • Construction risks • Operating risks • Fuel price, supply risks
2. Business implications of the deregulated electricity marketplace	• Electricity rates and dispatch • Regional status of deregulation • Regional generation supply • Transmission capacity, investment	➢ *FERC Orders + State legislation* • Transmission availability risks • Electricity demand risks • Market dispatch risks
3. Efficient implementation of new regulatory structure (10CFR52)	• Early Site Permits filed by utilities	➢ *NRC Implementation of COL, ITAAC*** • Regulatory risks (NRC) • Commissioning risk
4. Nuclear industry infrastructure	• Experience, vitality, and practices of engineering firms and suppliers • University programs, graduates	• Construction, vendor supply risks
5. National Nuclear Energy Strategy	• Public concerns, demand for energy security, reliability, curbs on pollution • Emissions advantages of nuclear	➢ *National Energy Policy* ➢ *Energy legislation* ➢ *DOE programs (Nuclear Power 2010)*
	➢ *Denotes government action*	***Rated as a "show-stopper" issue*

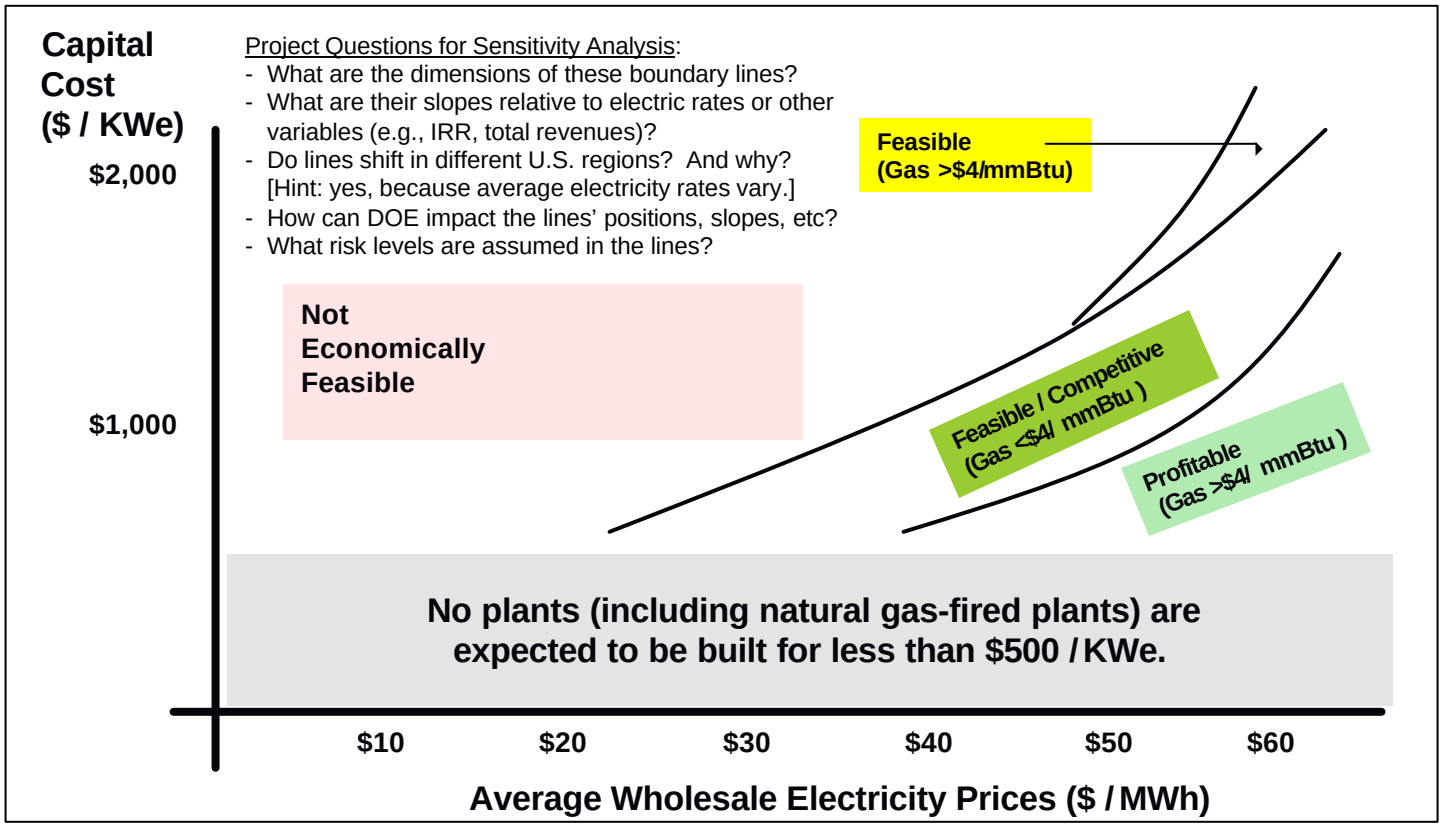
NTDR Significant Issues: Linked to Industry Analysis and Risk Framework

- In addition to generic gaps, the NTDR also identified other significant issues that affect the prospects for new nuclear units. The industry analysis in Section 2 and Appendix A of this report addresses key elements of these issues.
- Government actions, such as Price-Anderson Act reauthorization or government domestic security programs, are vital to resolving specific critical risks. With nuclear power, particularly for new units, collaboration between the government and industry, for instance on safety engineering and plant security measures, is more critical than ever in resolving key risks.
- As discussed in Section 3, financings for early orders of new plants most likely will not occur without resolution of the key risks by the combined efforts of government and the private sector.
- The industry analysis also draws out key issues and ranges of variables that are highlighted in the financial model developed for this study, which is outlined in Section 4 and Appendix B, and the sensitivity analysis of internal rate of return and electricity price to key factors, as laid out in Section 5.

Other Significant Issues Cited	NTDR Gaps Addressed in Section 2 (Industry Analysis)	NTDR Gaps Addressed in Section 3 (Risk Framework)
Nuclear safety and plant security - Safety of reactor designs	• Operating record of utilities	• Accident risks ➢ Price-Anderson Act reauthorization** ➢ *NRC security rules + Utility measures* ➢ *Defense programs*
Spent fuel management and disposal	• Yucca Mountain construction and approval; transport planning	• Disposal risks, including transport ➢ *Yucca Mountain authorization***
Public acceptance of nuclear energy	• Safety and operating record of nuclear plants (e.g., downtime)	• Development / siting risks
Non-proliferation of nuclear material	➢ *Tracking of nuclear material (NNSA)*	• Accident risks (e.g., terrorist actions) ➢ *Government security programs*
	➢ Denotes government action	***Rated as a "showstopper" issue*

Overview of New Nuclear Plant Economic Feasibility

Analysis of the business case for nuclear power does not yield a simple "yes or no" answer. Rather, nuclear power makes sense under certain conditions and financing assumptions, some related to the cost of alternative fuels, such as natural gas. The conceptual graphic below illustrates how investment in new power generation capacity is dependent on changing values in a number of factors which combine to determine the relative competitive position of new versus existing capacity and one fuel source versus another.



NE Budget 2001 – 2003: Shift Toward Deployment

NE's proposed technology budget includes significant additional funding for the "2010 Deployment Initiative" (source: NE). The additional funds for this initiative will be focused on reducing some of the most important areas of risk to prospective new nuclear power plant projects (e.g., expedited site permitting, waste disposal). With this initiative, DOE will address areas of "show-stopper" risk that otherwise are likely to limit the prospect that any new plants will be built by 2010.

		Actual	Proposed	% Total	2001 - '03
Funding Category	**FY2001**	**FY2002**	**FY2003**	**FY2003**	**Change**
University Reactor Fuel Assistance	$12.0	$17.5	$17.5	7.0%	$5.5
R&D					
Nuclear Energy Plant Optimization	$4.8	$6.5	$0.0	0.0%	-$4.8
Nuclear Energy Research Initiative	$33.9	$32.0	$25.0	10.0%	-$8.9
NE Technology (2010 Initiative)	$7.5	$12.0	$46.5	18.6%	$39.0
Advanced Nuclear Medicine	$2.5	$2.5	$0.0	0.0%	-$2.5
Total R&D	**$48.7**	**$53.0**	**$71.5**	**28.5%**	**$22.8**
Infrastructure					
Fast Flux Test Facility	$38.4	$36.4	$36.1	14.4%	-$2.3
Radiological Facility Management	$88.3	$86.7	$83.0	33.1%	-$5.3
Total Infrastructure	**$126.7**	**$123.1**	**$119.1**	**47.5%**	**-$7.6**
Spent Fuel Pyro & Transmutation	$68.7	$76.4	$18.2	7.3%	-$50.5
Program Direction	$23.8	$23.8	$24.3	9.7%	$0.5
Total NE Funding ($ millions)	**$279.9**	**$293.8**	**$250.6**	**100.0%**	**-$29.3**
Total Without Transmutation	$211.2	$217.4	$232.4		$21.2

Japan, France Lead Global R&D Expenditures for Nuclear Fission

- Worldwide, nuclear fission R&D has declined since the early 1980s from its $5 billion-per-year peak to about $3 billion a year, almost all of it in OECD countries.
- Japan has taken over the lead in funding for nuclear power-related research with large recent increases; French R&D support has been stable at $500 million per year since 1985.
- Since 1985, Japan has funded and managed 60% of global R&D on the next generation of nuclear reactors. Japanese companies recently built two GE ABWR reactors and have executed orders for 10 new reactors by 2010. These companies are pioneering modular construction techniques, an important step in accelerating new plant construction and reducing cost.
- NE indicates that the United States still leads in some key areas of R&D, but the discrepancy in funding levels jeopardizes this lead, despite potentially positive impacts from the 2010 initiative.