Rebooting the U.S. Civilian Nuclear Power Program

First,
Some Nostalgia…


OMEGA RD.

LOS ALAMOS
HOEBUS 2-A


ABC LIQUORS
MEXICAN FOOD
15 MIN PARKING
ABC LIQUORS
BEER


BASKIN-ROBBINS
31
FLAVORS
ICE CREAM

Rebooting the U.S. Civilian Nuclear Power Program

Rebooting the U.S. Civilian Nuclear Power Program

The Necessary Investment in Ideas, People, and Tools

The 1950s

“Too cheap to meter…”

"It is not much to expect that our children will enjoy in their homes electrical energy too cheap to meter, will know of great periodic famines in the world only as matters of history, will travel effortlessly over the seas and under them and through the air, and will experience a life span far longer than ours. This is th forecast for an age of peace.”

Lewis Strauss, Chairman, AEC

The 1960s

- Oyster Creek – "turnkey contracts"
- General Electric vs. Westinghouse
- 48 plants ordered in 1966-67
- 200 plants operating, under construction, or on order by 1974

The 1970s

- OPEC oil embargo (crude oil > $40/bbl)
- Great concern about future energy sources
- Projections: 1,000 nuclear plants in U.S. by 2000
- Major investment in nuclear power

The Bottom Drops Out

- In 1979 Three Mile Island focused public concern on the safety of nuclear power plants
- Increasing regulatory challenges and delaying tactics brought licensing to a halt
- The Arab oil embargo and increased energy prices stimulated energy conservation.
- Utilities realized they had planned for too much capacity and began to cancel nuclear orders.
- All 103 plants operating today were ordered before 1975.

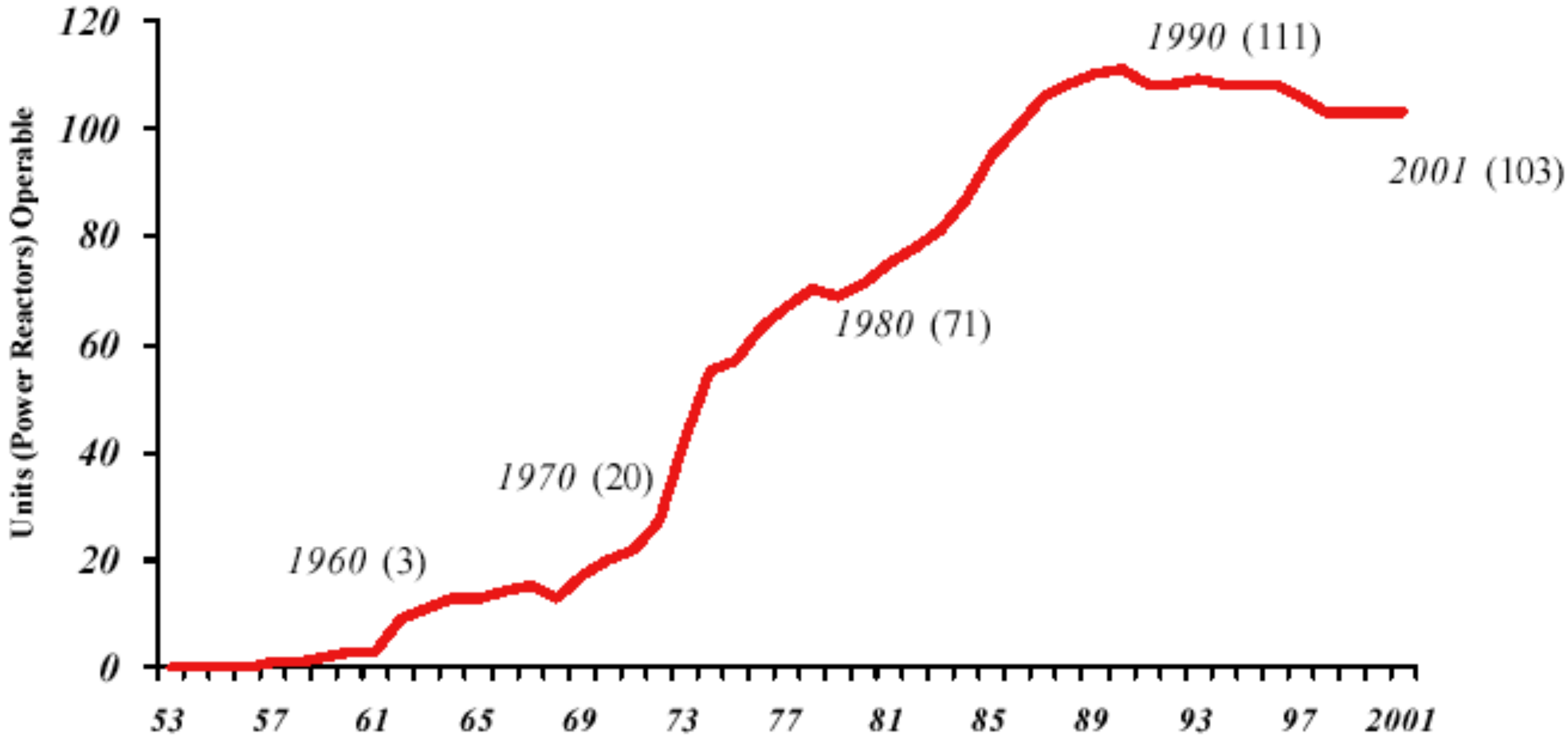
The 1980s

- High costs of nuclear plants protected by regulatory environment.
- Deregulation allowed for recovery of "stranded costs"
- Once capital costs were written down, nuclear plants could compete with fossil fuels on basis of operating costs

U.S. Nuclear Power Plants

103 Nuclear plants with operating licenses

Operable U.S. Nuclear Power Plants (Units) (1953-2001)

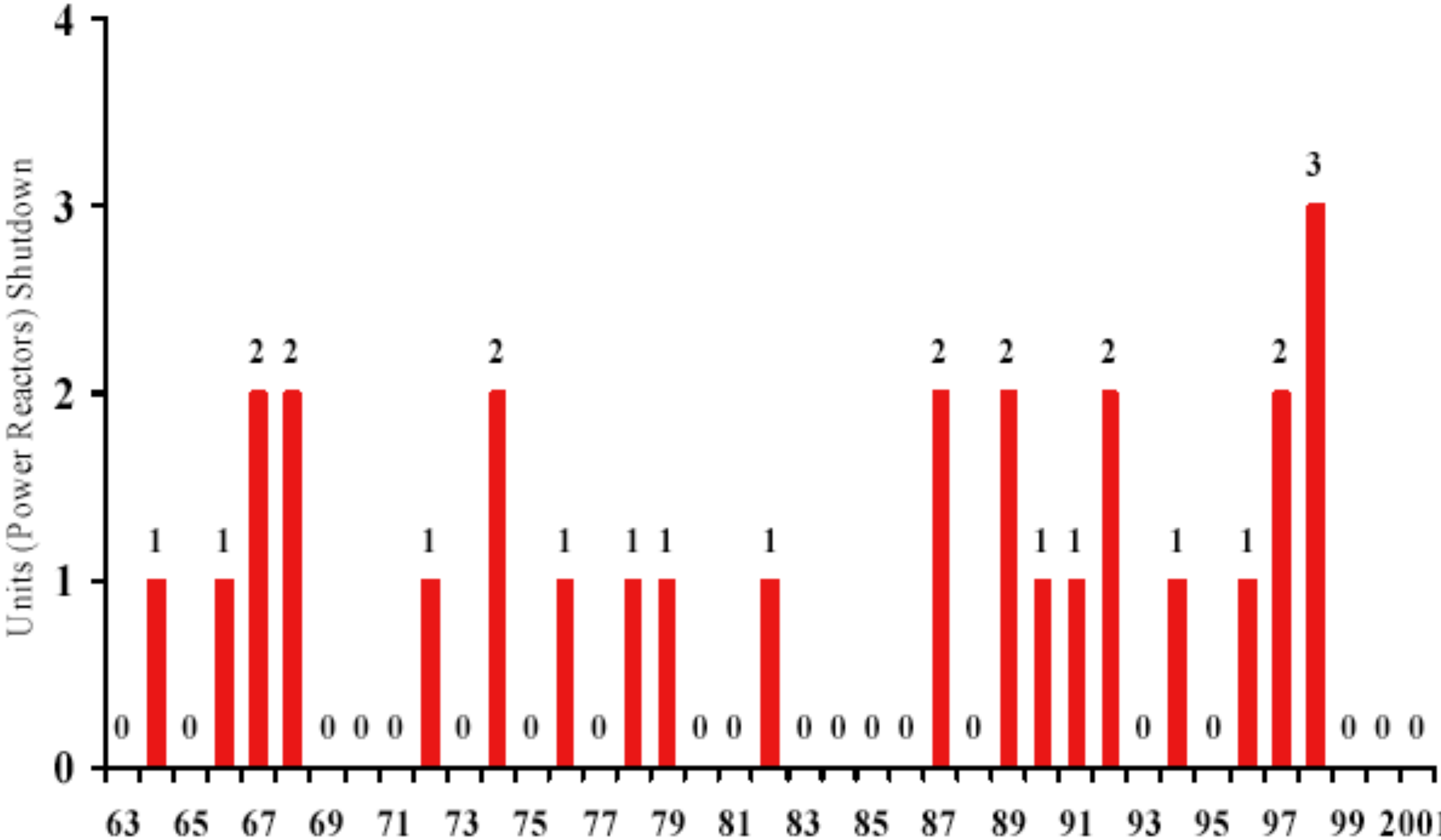


Total of units holding full-power licenses, or equivalent permission to operate, at the end of the year.

Source: EIA

NEI

U.S. Nuclear Power Plant Shutdowns



"Shutdown" = removed permanently from service

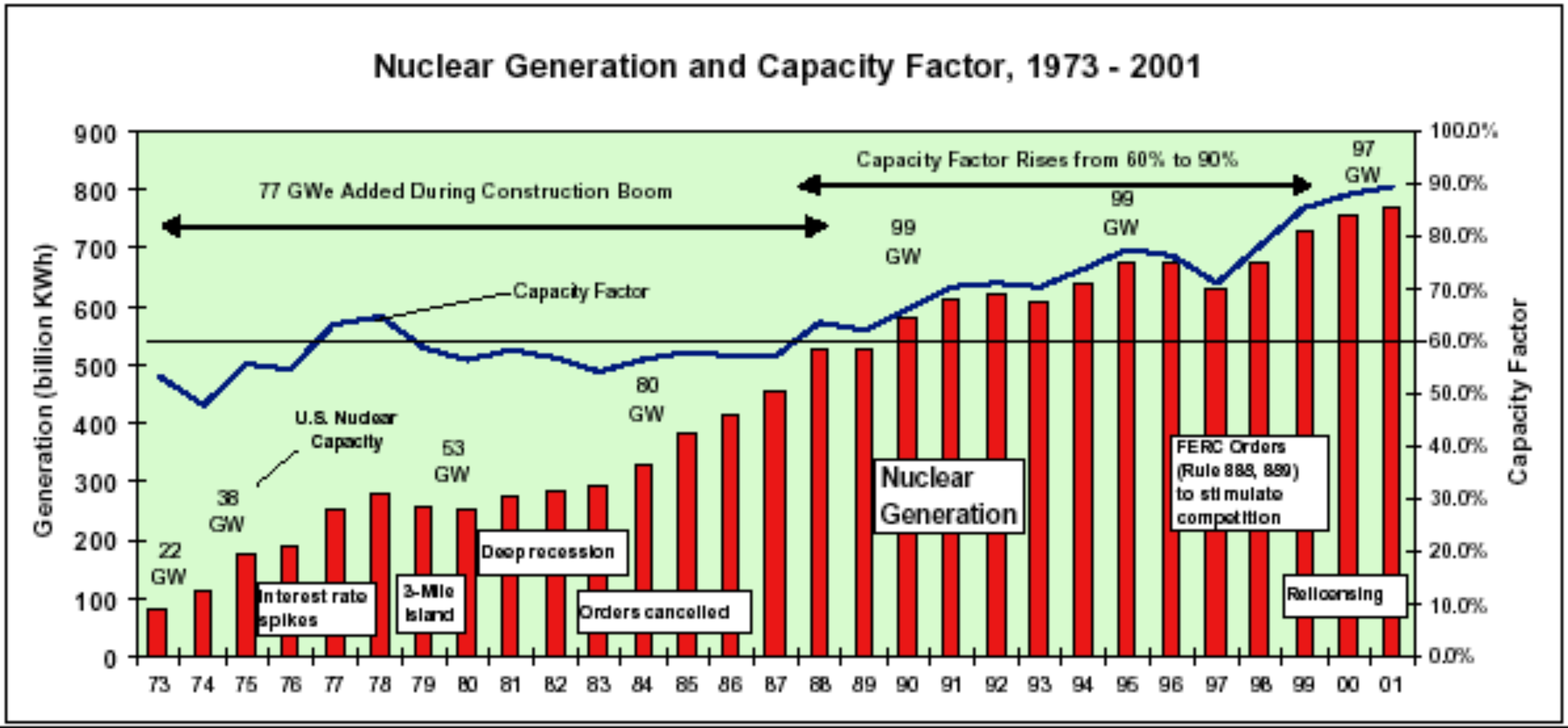
Source: EIA

The 1990s

- Recovery of stranded costs
- Improvement in capacity factors (60% to 90%)
- Consolidation of nuclear plant operators
- By 1999, nuclear plant operating costs had dropped below those of coal-fired plants (2 cents per kwh)

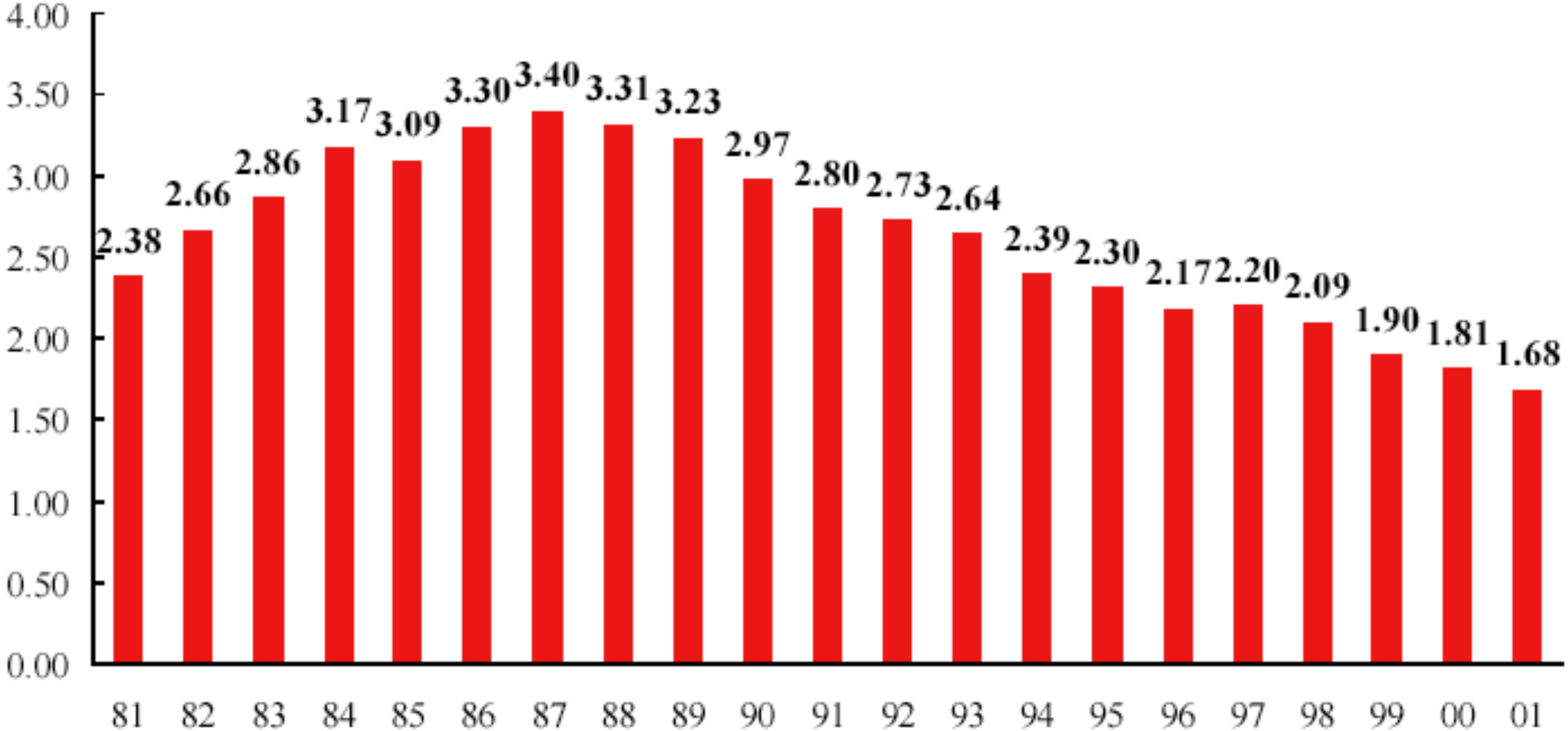
U.S. Nuclear Power Generated, Capacity Factor Improved, 1973 – 2001

- Nuclear power produced in 2001: 768 billion KWh (up from less than 100 billion KWh in 1973, driven by the addition of 77 GWe of capacity between 1973 and 1987). U.S. nuclear plants operate as baseload units.
- Commercial orders were cancelled in the early 1980s, in part due to high interest rates, the TMI accident, and recession. Some units were finished in the mid-1980s, but no net capacity was added after 1989.
- U.S. fleet-wide capacity factor. Rose from 60% in 1987 to over 90% in 2001 due to advances in management systems and practices and much shorter fuel outages. Upratings could add another 7 GWe before 2010.
- Because the U.S. nuclear fleet is now approaching a real capacity-factor ceiling, future increases in KWh generated will be limited unless new reactors are built.



Average U.S. Nuclear Industry Production Costs (O&M + Fuel) (1981-2001)

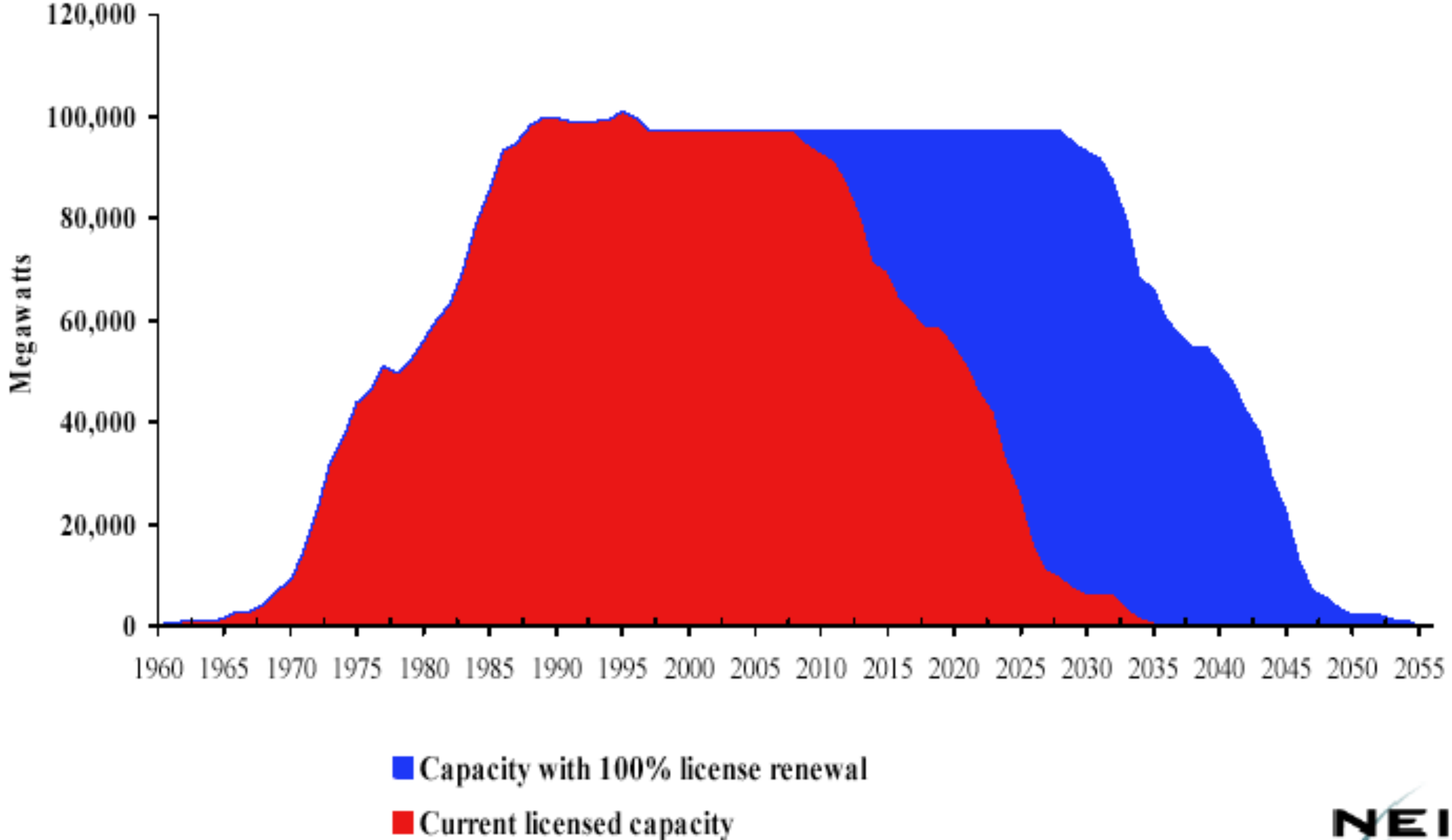
(in cents per kilowatt-hour: 2001 dollars)



Source: NEI: Compiled from FERC data and EUCG industry reports

NEI

U.S. Nuclear Generating Capacity With and Without License Renewal



NEI

Tomorrow

So the debate about whether nuclear plants can compete with goal and gas plants is over. The answer is clearly yes.

But simply being competitive today will not meet our needs for tomorrow. To meet that demand, new plants must be built.

Three signposts to the future…

- National Energy Policy
- Department of Energy Mission Statement
- Nuclear Energy Research Advisory Committee

National Energy Policy

"The fundamental imbalance between supply and demand defines our national energy crisis.

We are concerned about not only an increased dependence on foreign oil but on an increasingly narrow range of energy options.

For example, today about 90% of all new plants under construction will be fueled by natural gas. While gas has many advantages, an over reliance on any one fuel source leaves consumers vulnerable to price spikes and supply distribution.

The National Energy Policy seeks to lessen the impact on Americans of energy price volatility and supply uncertainty."

National Energy Policy (cont)

1. Our energy challenges begins with our expanding economy, growing population, and rising standard of living that will require new energy supplies.
2. The second challenge is to repair and expand our energy infrastructure, our outdated network of generating plants, transmission lines, pipelines, and refineries.
3. Increasing energy supplies while protecting the environment is the third challenge. Estimate that from 1,300 to 1,900 new plants will be needed over next two decades."

Department of Energy Mission

"The overarching DOE mission is national security. Quite obviously the defense side of DOE fits well within that mission. But so should our other programs. It is time to understand that DOE's energy and science programs should be judged by whether they advance this nation's energy–and hence national–security."

Secretary Spencer Abraham

DOE Priorities

- Ensuring out energy security by strengthening our ability to identify and protect the critical infrastructure that supports the production and delivery of energy in America.
- Implement the President's National Energy Plan, by focusing on programs that help America increase its supply of energy by increased domestic production, that revolutionize how we approach conservation and energy efficiency, and that help us identify a wider array energy options.
- Directing our R&D budgets at ideas and innovations that are relatively immature in their development and ensuring the greater application of mature technologies.

PCAST Energy R&D Panel (1997)

"Fission's future expandability is in doubt in the United States and many other regions of the world because of concerns about high costs, reactor-accident risks, radioactive-waste management, and potential links to the spread of nuclear weapons. We believe that the potential benefits of an expanded contribution from fission in helping address the carbon dioxide challenge warrant the modest research initiative proposed here (NERI and NEPO), in order to find out whether and how improved technology could alleviate the concerns that cloud this energy option's future.

To write off fission now as some have suggested, instead of trying to fix it where it is impaired, would be imprudent in energy terms and would risk losing much U.S. influence over the safety and proliferation resistance of nuclear energy in other countries. Fission belongs in the R&D portfolio."

PCAST Recommendations on Nuclear Energy R&D

- A major extramural research program (investigator-initiated, peer reviewed, long range) (Nuclear Energy Research Initiative - NERI)
- A major research program aimed at extending the life of operating plants (Nuclear Energy Plant Optimization - NEPO)
- A high level advisory body to DOE (Nuclear Energy Research Advisory Committee - NERAC)

NERAC

Nuclear Energy Research Advisory Committee

"To provide expert, independent advice on long-range plans, priorities, and strategies in nuclear energy research to the U.S. Department of Energy"

NUCLEAR ENERGY RESEARCH ADVISORY COMMITTEE

Overview

The Nuclear Energy Research Advisory Committee (NERAC) was established on October 1, 1998, to provide independent advice to the Department of Energy (DOE) and Office of Nuclear Energy, Science and Technology (NE) on complex science and technical issues that arise in the planning, managing, and implementation of DOE's nuclear energy program. NERAC will periodically review the elements of the NE program and based on these reviews provide advice and recommendations on long-range plans, priorities, and strategies to effectively address the scientific and engineering aspects of the research and development efforts. In addition, the committee will provide advice on national policy and scientific aspects on nuclear energy research issues as requested by the Secretary of Energy or the Director, NE. The committee includes representatives from universities, industry, and national laboratories. Particular attention was paid to obtaining a diverse membership with a balance of disciplines, interests, experiences, points of view, and geography. NERAC operates in accordance with the Federal Advisory Committee Act (FACA)(Public Law 92-463), 92nd Congress, H.R. 4383' October 6, 1972) and all applicable FACA Amendments, Federal Regulations and Executive Orders.

TOP

NERAC Membership

- John Ahearne, Duke
- Tom Cochran, NRDC
- Allen Croft, Oak Ridge NL
- Marvin Fertel, Nuclear Energy Institute
- Beverly Hartline, LANL
- Bill Kastenberg, UC-Berkeley
- Dale Klein, U Texas - Austin
- Bob Long, Nuclear Stewardship
- Warren Miller, Jr., LANL
- Richard Reba, U. Chicago
- Lynn Rempke, INEEL
- Paul Robinson, Sandia NL
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- Allen Session, Queens College
- Daniel Sullivan, NIH
- Bruce Tarter, LLNL
- John Taylor, EPRI
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NERAC Subcommittees

- Long Range Planning (Ahearne)
- Nuclear Science and Technology Infrastructure (D. Klein)
- Operating Nuclear Power Plant R&D (Taylor)
- Isotope Research and Production (Reba)
- Proliferation Resistant Nuclear Technologies (Taylor)
- Transmutation of Radioactive Waste (Richter)
- Blue Ribbon Committee on Nuclear Engineering (Corradini)
- Nuclear Space Propulsion (A. Klein)
- Nuclear Impact on Air Quality (Ahearne)

The Near Term Challenges to Civliian Nuclear Power

Nuclear Power, circa 2003

The current performance of U.S. nuclear plants is excellent! Capacity factors are above 90%, safety has been superb, and nuclear generated electricity costs are now less than coal.

BUT, no nuclear plants have been ordered in the U.S. for 25 years, due to the capital intensive nature of plants, the long-term commitment required for construction, the financial risks, and most recently, the deregulation of the electricity marketplace.

Key Criteria for Success

- Nuclear plant "time to market" is a key factor affecting economic competitiveness in the deregulated marketplace. Long lead times prior to construction and long construction periods reduce economic competitiveness and increase project risks.
- Resolution of licensing issues before project commitment is essential to ensuring acceptably short lead-times.

Economic Criteria (continued)

- Project "overnight" capital cost must be contained at about $1,500 per KWe, with $1,200/KWe or less to secure broad market acceptance. Large nuclear plants will require total investments as high as $2 B.
- Nuclear plant generating costs (fuel and O&M expenses) should be held to 1 cents/kWhr.
- Nuclear plant lifetime capacity factors should be sustained at 85% or higher.

Economic Criteria (continued)

- In general, locations where market prices can be forecasted to remain above 4 cents/kWhr for at least the first 10 operating years would be preferable.
- Deregulation of the energy markets do not eliminate the prospects for capital-intensive base load generation options such as nuclear and coal-fired plants.

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.**

Business Case for New Nuclear Power Plants

Bringing Public and Private Resources Together for Nuclear Energy

Mitigating Critical Risks on Early Orders for New Reactors

Briefing for NERAC
October 1, 2002

SCULLY CAPITAL

Nuclear Energy

Market Context for Nuclear Power

- Nuclear power provides about 20% of the nation's electricity and adds diversity to the mix of fuels used to generate electricity. Stable allies provide most U.S. supplies of uranium fuel; supplies and prices are steady.
- Nuclear power has reached >90% capacity factor, demonstrating high reliability. Only with new plants can nuclear power maintain a 20% market share.
- Coal provides >50% of U.S. electricity supply, but environmental constraints and cost issues jeopardize construction of new coal plants.
- Market share for gas is rising rapidly, but many new gas plants provide intermediate, rather than baseload, electricity supplies.
- Renewable-based electricity: Additions in renewables and biomass will barely offset the decline in hydropower projected by EIA through 2020.
- Nuclear power, which emits neither carbon nor other important regulated environmental pollutants (e.g., SOx, NOx, mercury), can play a critical role in meeting carbon-reduction goals, if unique regulatory processes that affect new plant decisions can be surmounted.
- Why worry? NERC projects that electricity supply margins may disappear in about five years (~2006).

Primary Findings and Conclusions

- **Outlook for nuclear power has improved since 1990** due to several market and industry developments, particularly:
  - A sharp rise in fleet capacity factor (65% in 1990; nearly 90% in 2000), plus
  - Lower marginal cost of power produced relative to competing sources.
  - Lower interest rates.
  - Good safety record and improved public sentiment in several regions.
- **New nuclear plants can be competitive** (@ "Nth" plant costs = ~$1100 / KWe).
- **Three unresolved key barriers could prevent new U.S. orders:**
  - Spent fuel disposal, including transportation.
  - Reauthorization of accident indemnification.
  - Clear, finite NRC licensing processes, particularly for commissioning.
- **Early-plant capital costs appear to be too high**, especially with gas <$3:
  - Capital costs (financing included) could be >$1600 / KWe for first plants, declining to ~$1200 / KWe for 4th/5th plants.
  - Therefore, orders of first plants could require government assistance.
  - Such assistance should more precisely address risks than cost-shared grants or contracts and should reduce potential costs to government.

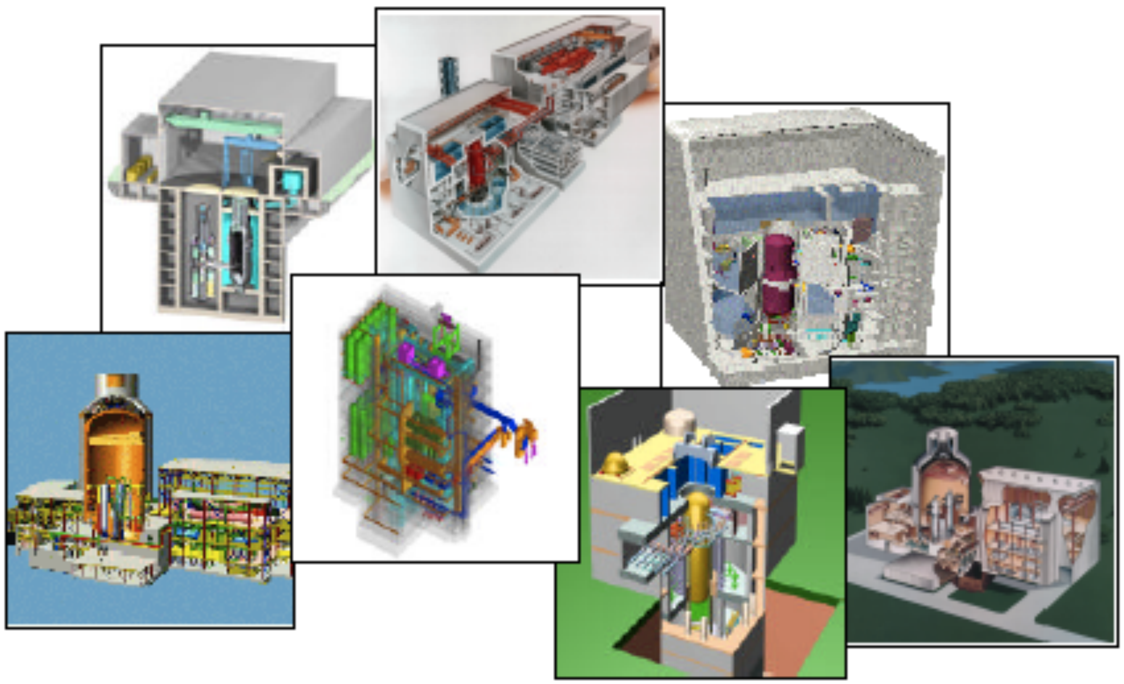
Primary Findings and Conclusions (continued)

- **New nuclear power plants by 2010?:** Plants financed solely by the private sector face serious obstacles, including foremost:
  - Three key barriers, termed by some industry executives "show-stopper" risks; these risks may limit a go-forward investment decision, and
  - Current electricity market conditions and industry forecasts—particularly adequate supply and moderate prices, and the difficulty of projecting demand and price to 2010.
  - Long lead time, high capital costs of nuclear plants cause earnings dilution.
- **Plus, high capital costs** jeopardize market competitiveness of electricity generated in the first new plants:
  - The first several new nuclear plants may deliver economic returns that are below generating companies' cost of capital (10% – 12%, after-tax).
- **Conclusion of the analysis: Once the first several plants have been built and operated, nuclear power *can be competitive* in electricity marketplace.**
- Concentrate effort on first units in regions most supportive of nuclear power.

Primary Findings and Conclusions *(continued)*

- **Government is making progress on the three key barriers:**
  - Waste disposal: Congress voted to proceed toward opening Yucca Mountain.
  - Accident indemnification: The Administration is working with Congress on re-authorization of the Price-Anderson Act to cover new plants.
  - Commissioning: NRC has not yet completed defining approval processes for new plants (e.g., ITAAC). The processes are not yet certain and finite.
- **Industry and the financial community are capable of addressing—to varying degrees—most new plant development business risks.**
- **Without government participation, some risks and costs of new nuclear plants may remain at unmanageable levels, particularly:**
  - Regulatory risk not due to contractor fault that leads to delays during plant construction and commissioning.
  - First-of-a-kind engineering (FOAKE) costs for first new plants.
  - High capital costs for the first few nuclear plants, plus potential construction cost overruns for early plants using new designs.
  - Forecasting electricity demand and price levels for 2010 and beyond.
  - Transmission availability and congestion, which vary widely by region.

Near Term Candidates



Can We Build New U.S. Reactors By 2010? *Yes!*

Can Be Deployed by 2010
- ABWR (General Electric)

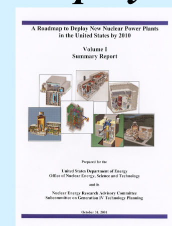
Probably Can Be Deployed by 2010
- AP600 (Westinghouse)
- AP1000 (Westinghouse)
- PBMR (Exelon)

Possibly Can Be Deployed by 2010
- SWR-1000 (Framatone)
- ESBWR (General Electric)
- GT-MHR (General Atomics)

Cannot Be Deployed by 2010
- IRIS (Westinghouse)

2010

Conclusions of the Expert Study: *A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010*



Summary of Recommendations to DOE

- **Address the three key barriers:**
  - Building on DOE project results, complete the licensing and construction phase for Yucca Mountain.
  - Complete work with the Congress to re-authorize Price-Anderson Act.
  - Complete development of certain, finite commissioning process for new plants. (Assist first plants during completion, testing of COL, ITAAC procedures).
- **Evaluate authority, financing mechanisms, and funding sources for a federal energy credit program** that uses a financial risk-based approach.
  - Sharply focus risk-based framework to better target assistance, mechanisms.
  - Use business case financial model to optimize structure of DOE acquisition strategy. *Negotiate* assistance on first plants with industry, investors.
  - **Consider energy credit program that is applicable across all energy sectors and types of energy projects**, has broad flexibility (a variety of innovative finance techniques), and leverages federal funds with private dollars.
- Take advantage of currently healthy financial condition of nuclear utilities to devise best levels, means of assistance. Financings may be "on balance sheet".
- **Pursue other important mechanisms to create level playing field for nuclear energy** (e.g., include clean nuclear power in future U.S. emissions programs).

Achieving a Sustainable Future for Nuclear Power

Longer Term Goals

- Sustainability
- Economics
- Safety and reliability
- Proliferation resistance
- Physical protection

Sustainable Nuclear Energy

- The ability to meet the needs of the present generation while enhancing the ability of future generations to meet society's needs indefinitely into the future.
- Having a positive impact on the environment through the displacement of polluting energy and transportation sources by nuclear electricity generation and nuclear produced hydrogen.

Sustainability (cont)

- Allow geologic waste repositories to accept the waste of many more plant-years of nuclear plant operation through substantial reduction in the amount of wastes and their decay heat.
- Greatly simply the scientific analysis and demonstration of safe repository performance for very long time periods (beyond 1,000 years), by a large reduction in the lifetime and toxicity of the residual radioactive wastes sent to repository.

Sustainability (cont)

- Extending the nuclear fuel supply into future centuries by recycling used fuel to recover its energy content, and by converting U-238 into new fuel.

Competitive Nuclear Energy

- Achieving economic life-cycle and energy production costs through a number of innovative advances in plant and fuel cycle efficiency, design simplifications, and plant sizes.
- Reducing economic risk to nuclear projects through innovative advances that may be possible with the development of plants using innovative fabrication construction techniques and modular plants.

Competitive (cont)

- Allowing the distributed production of hydrogen, fresh water, district heating, and other energy products to be produced where they are needed.

Safe and Reliable Systems

- Increasing the use of inherent safety features, robust designs, and transparent safety features that can be understood by nonexperts.
- Enhancing public confidence in the safety of nuclear energy.

Proliferation Resistance

- Providing continued effective proliferation resistance of nuclear energy systems through the increased use of intrinsic barriers and extrinsic safeguards.
- Increasing physical protection against terrorism by increasing the robustness of new facilities

Where Are We Today?

Revitalization of Nuclear Research in the U.S.

FY 2004 Nuclear Energy, Science and Technology Budget Request

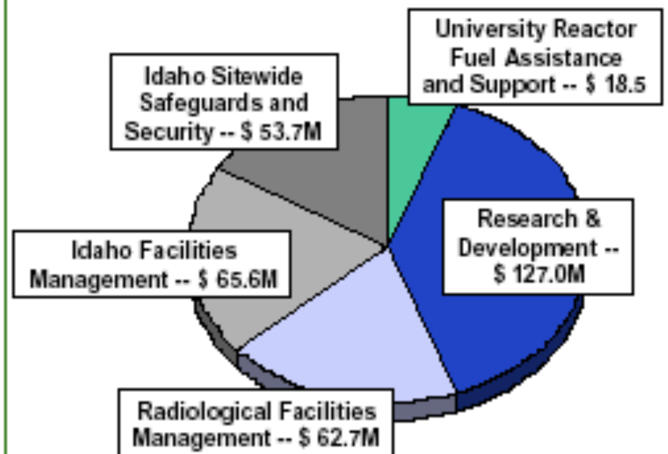
William D. Magwood, IV, Director
Office of Nuclear Energy, Science and Technology
U.S. Department of Energy

February 3, 2003

FY 2004 Nuclear Energy, Science and Technology Budget Request

(dollars in thousands)

	FY 2002 Comparable Approp.	FY 2003 Comparable Request	FY 2004 Request to Congress	FY 2004 vs. FY 2003	
University Reactor Fuel Assistance and Support..	17,500	17,500	18,500	+1,000	+6%
Research and Development					
Nuclear energy plant optimization........................	6,293	—	—	—	—
Nuclear energy research initiative........................	31,081	25,000	12,000	-13,000	-52%
Nuclear energy technologies..............................	11,867	46,500	48,000	+1,500	+3%
Advanced fuel cycle initiative.............................	77,219	18,221	63,025	+44,804	+246%
Nuclear hydrogen initiative.................................	—	—	4,000	+4,000	—
Infrastructure					
Radiological facilities management......................	58,933	54,180	62,655	+8,475	+16%
Idaho facilities management................................	63,289	68,425	65,560	-2,865	-4%
Idaho sitewide safeguards and security................	40,295	40,215	53,651	+13,436	+33%
Program direction..	57,237	56,834	60,207	+3,373	+6%
Use of PY balances	-818	—	—	—	—
Total..	362,896	326,875	387,598	+60,723	+19%



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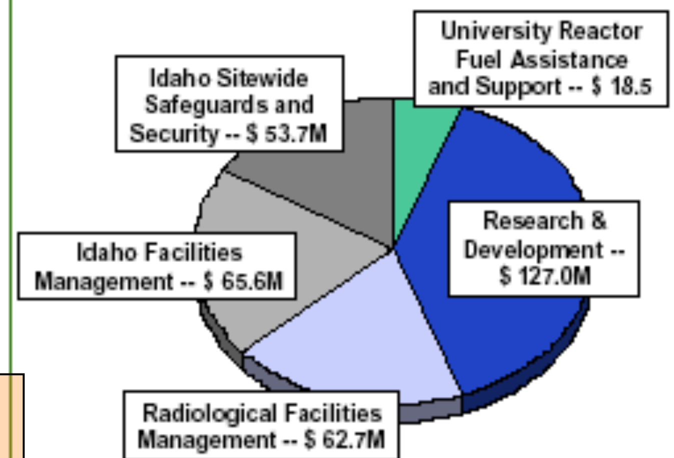
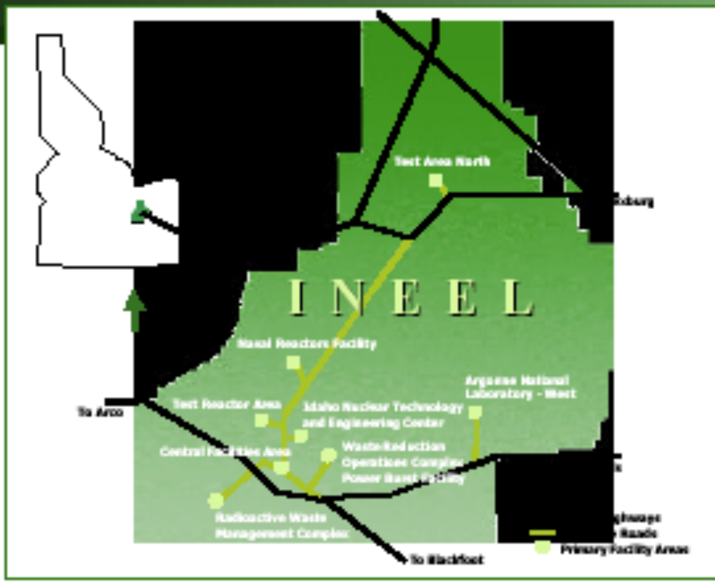


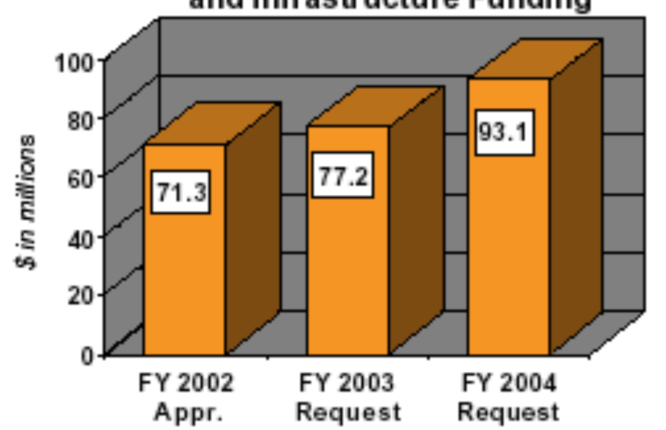
Office of Nuclear Energy, Science and Technology

Revitalization of Idaho National Engineering Laboratory

EM U.S. Department of Energy Office of Environmental Management



Nuclear R&D, Safeguards & Security, and Infrastructure Funding



? **On July 15, 2002, Secretary Abraham announced a major mission realignment for INEEL**

? **INEEL will become a world-class nuclear laboratory focusing on R&D such as:**

- Generation IV nuclear energy systems and advanced fuel cycles
- Advanced space nuclear power and propulsion systems

? **Success in environmental cleanup will be essential to the growth in the nuclear program at Idaho**

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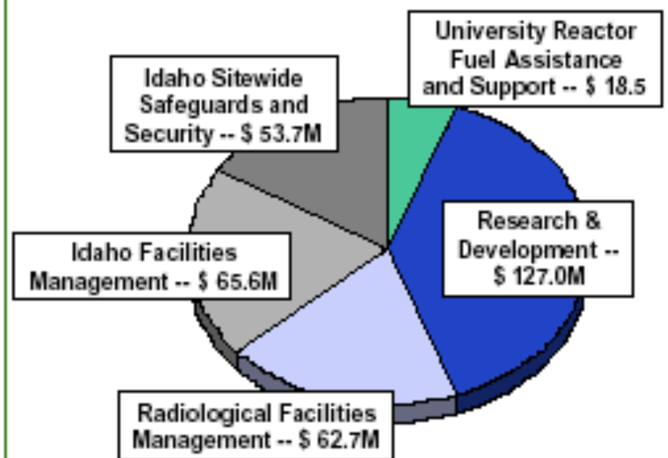

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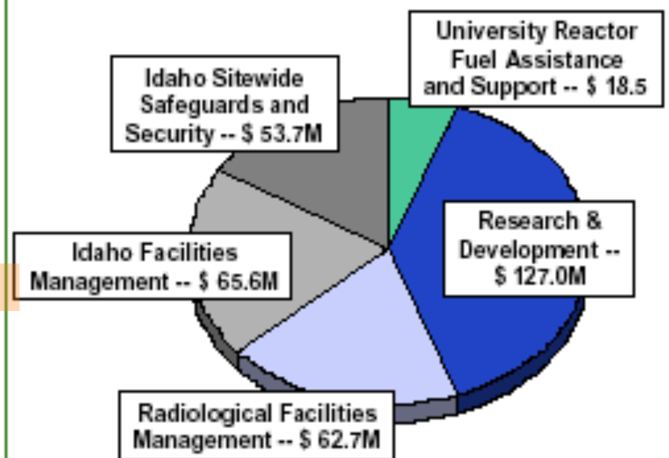
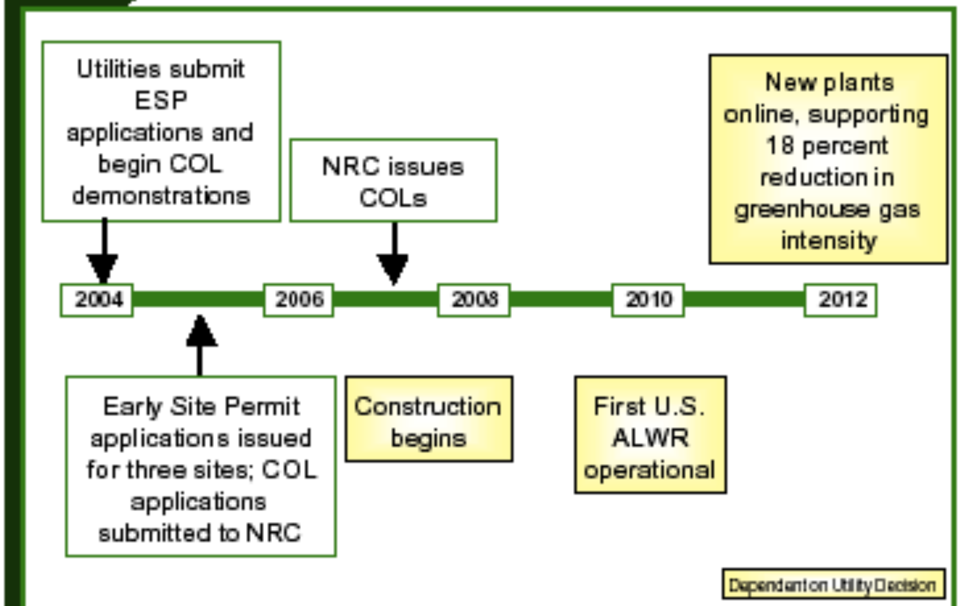
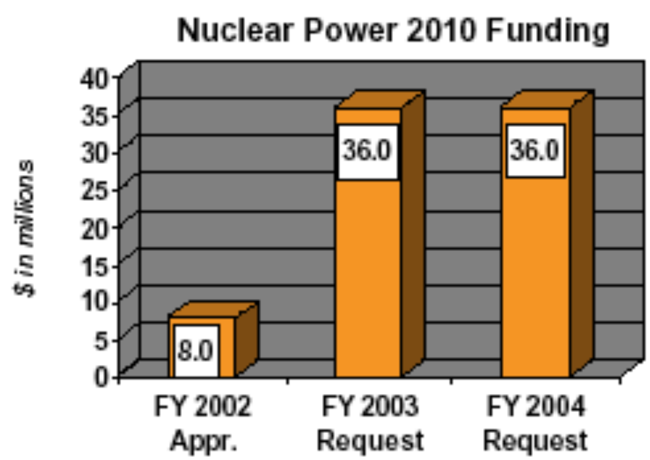


Nuclear Power 2010:
Paving the Way for New Nuclear Power Plants





? U.S. utilities are examining the business cases for new nuclear plants in the U.S.

? Cost-shared regulatory demonstrations and R&D on advanced technologies underway aimed at deploying new plants by 2010

Planned Accomplishments -- FY 2004

? In FY 2003 and FY 2004, DOE will select industry partners for demonstration of Combined and Operating License (COL) processes

? Advanced gas cooled reactor fuel development program continues in FY 2004

Nuclear Power 2010

Nuclear Power 2010
is a new R&D initiative announced by Secretary Abraham on February 14, 2002. This initiative is designed to clear the way for the construction of new nuclear power plants by 2010.

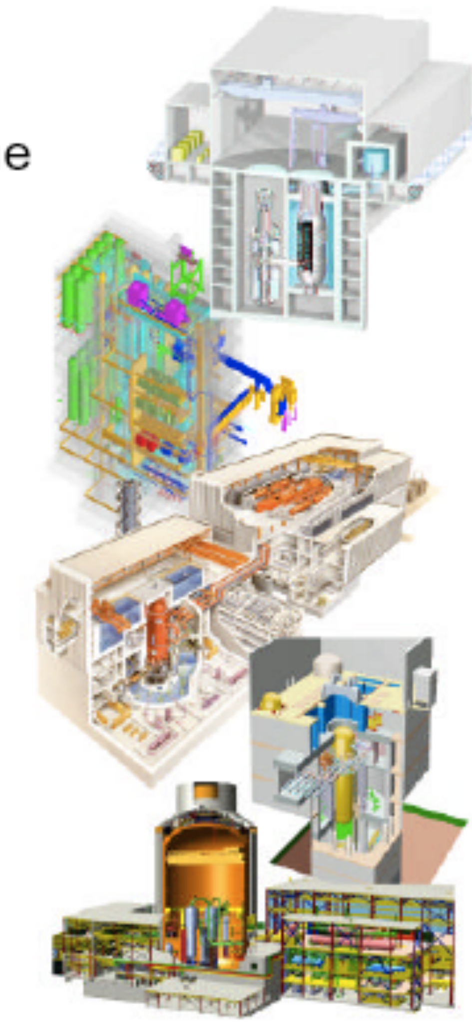
Nuclear Power 2010:
Overview

Goal

- Achieve industry decision by 2005 to deploy at least one new advanced nuclear power plant by 2010

Cooperative Activities

- **Regulatory Demonstration Projects**
  - Early Site Permit (ESP)
  - Combined Construction and Operating License (COL)
- **Reactor Technology Development Projects**
  - NRC Design Certification (DC)
  - First-of-a-kind engineering for a standardized plant
  - Material, component and system testing



FY 2004 Nuclear Energy, Science and Technology Budget Request

(dollars in thousands)

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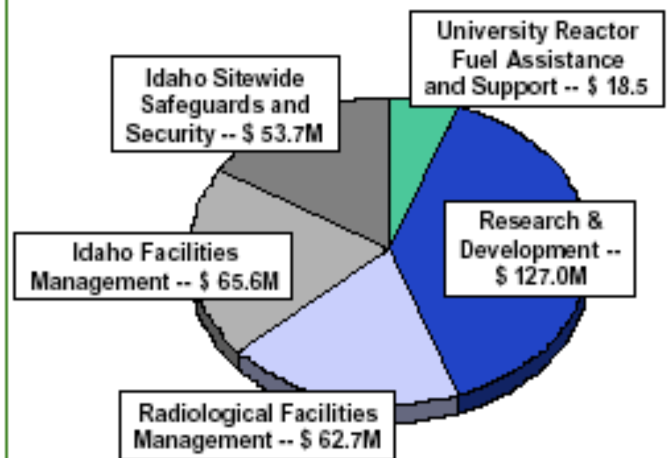
Research and Development					
Nuclear energy plant optimization....	6,293	—	—	—	—
Nuclear energy research initiative....	31,081	25,000	12,000	-13,000	-52%
Nuclear energy technologies....	11,867	46,500	48,000	+1,500	+3%
Advanced fuel cycle initiative....	77,219	18,221	63,025	+44,804	+246%
Nuclear hydrogen initiative....	—	—	4,000	+4,000	—
Infrastructure					
Radiological facilities management....	58,933	54,180	62,655	+8,475	+16%
Idaho facilities management....	63,289	68,425	65,560	-2,865	-4%
Idaho sitewide safeguards and security....	40,295	40,215	53,651	+13,436	+33%
Program direction....	57,237	56,834	60,207	+3,373	+6%
Use of PY balances	-818	—	—	—	—
Total....	362,896	326,875	387,598	+60,723	+19%



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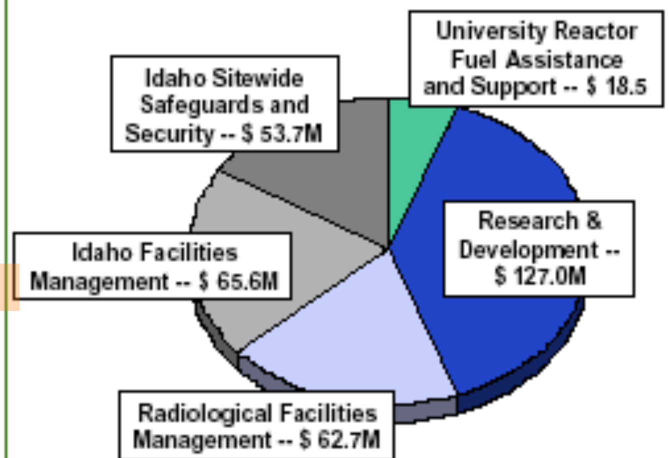
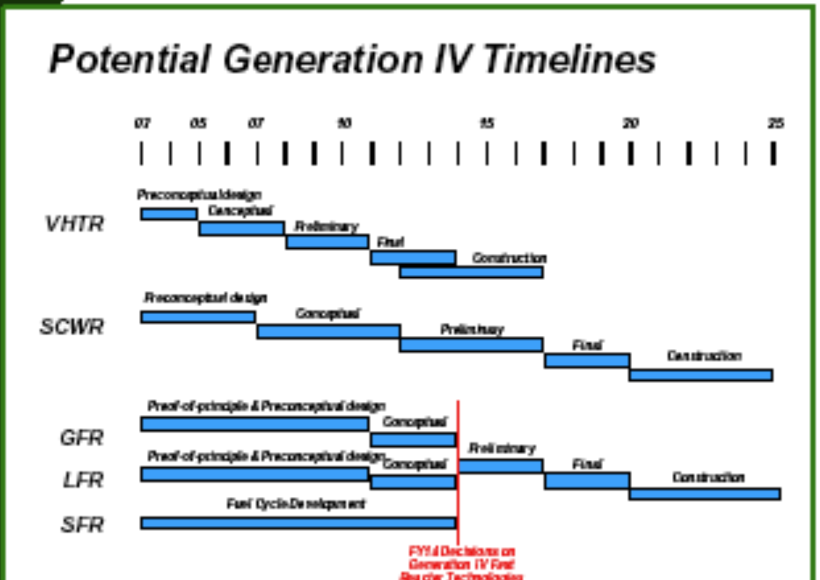
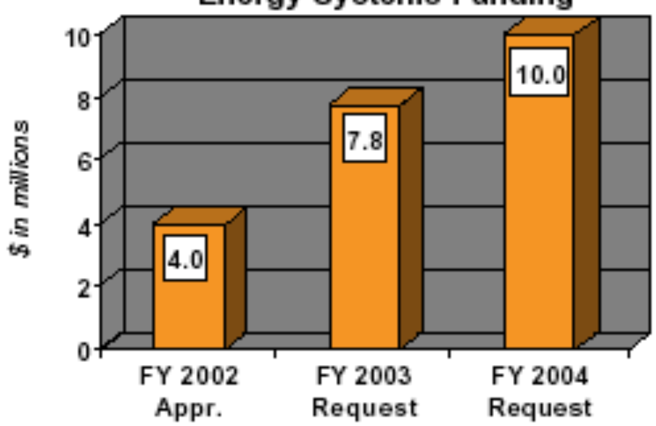


Generation IV Nuclear Energy Systems: *Nuclear Power for a New Century*





? Developing advanced nuclear energy systems for deployment after 2010 and before 2030

? In September 2002, the 10-Nation Generation IV International Forum agreed on 6 advanced technologies, including:

- Very High Temperature Reactor (VHTR)
- Supercritical Water Cooled Reactor (SCWR)
- Gas Cooled Fast Reactor (GFR)
- Lead Cooled Fast Reactor (LFR)

Planned Accomplishments -- FY 2004

? Conduct major VHTR trade studies

? Complete feasibility study on GFR fuels studies

? Initiate mechanical and irradiation tests on advanced materials

Generation IV Technology Roadmap

NERAC Meeting: Washington, D.C.
September 30, 2002

Generation IV Technology Roadmap

- *Identifies systems deployable by 2030 or earlier*
- *Specifies six systems that offer significant advances towards:*
  - *Sustainability*
  - *Economics*
  - *Safety and reliability*
  - *Proliferation resistance and physical protection*
- *Summarizes R&D activities and priorities for the systems*
- *Lays the foundation for Generation IV R&D program plans*

Generation IV Systems

Gas-Cooled Fast Reactor System	GFR
Lead-Cooled Fast Reactor System	LFR
Molten Salt Reactor System	MSR
Sodium-Cooled Fast Reactor System	SFR
Supercritical-Water-Cooled Reactor System	SCWR
Very-High-Temperature Reactor System	VHTR

- *Each system has R&D challenges ahead – none are certain of success*

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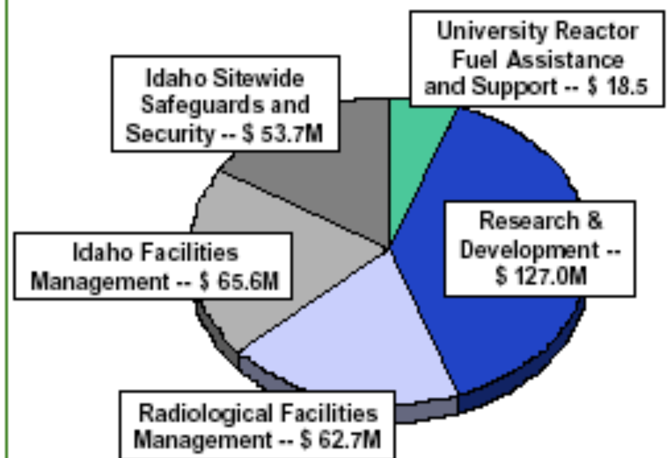

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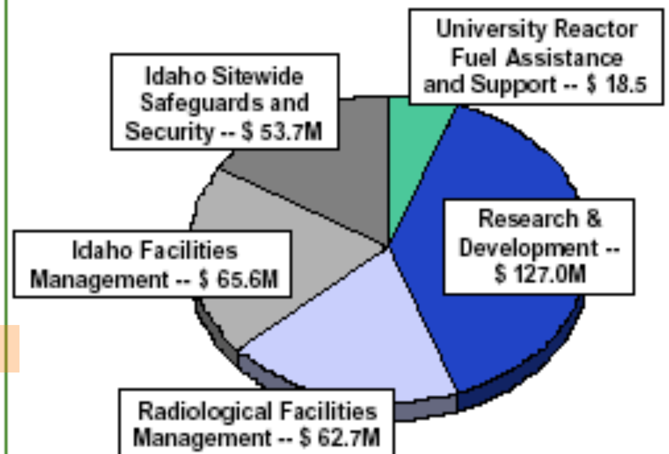
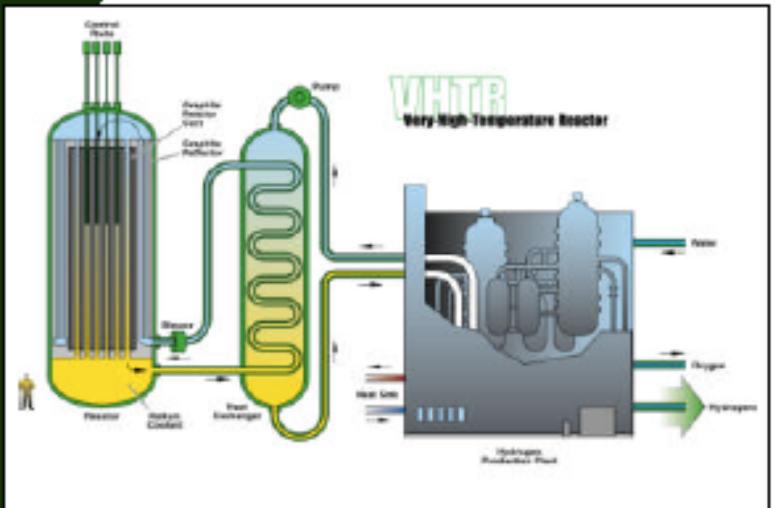
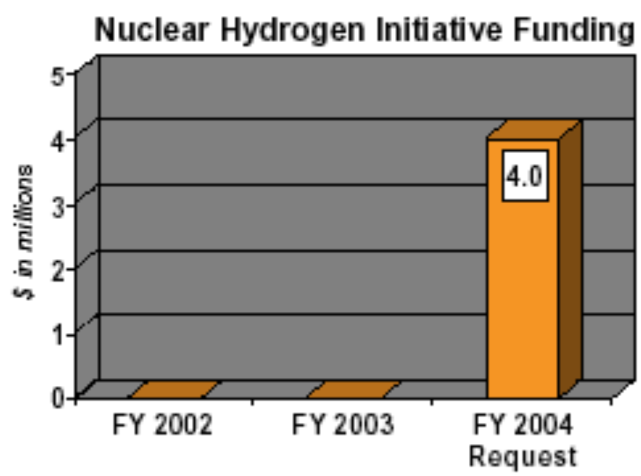


Nuclear Hydrogen Initiative: *Developing Nuclear Energy Systems for Clean and Abundant Hydrogen Production*





? Nuclear energy systems offer opportunity for economical, clean, and abundant source of hydrogen

Planned Accomplishments in FY 2004

? Complete a Nuclear Hydrogen Technology Roadmap

- Built on National Hydrogen Energy Roadmap and inter-office cooperation
- Define R&D required to develop an integrated nuclear hydrogen production plant

? Develop concept for an integrated nuclear hydrogen production system

? Initiate R&D on high temperature and corrosion resistant materials for thermo-chemical process

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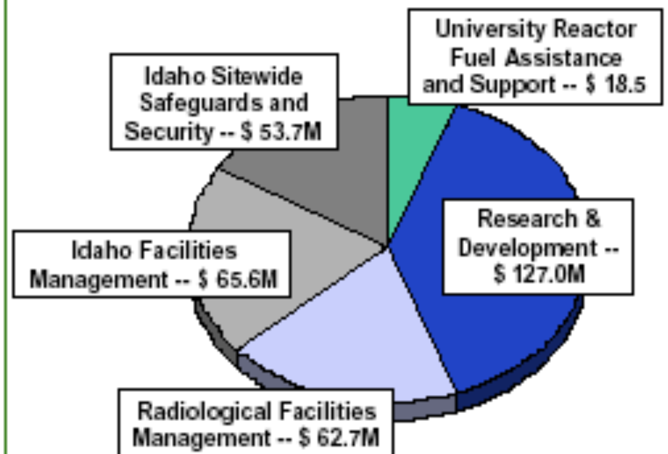

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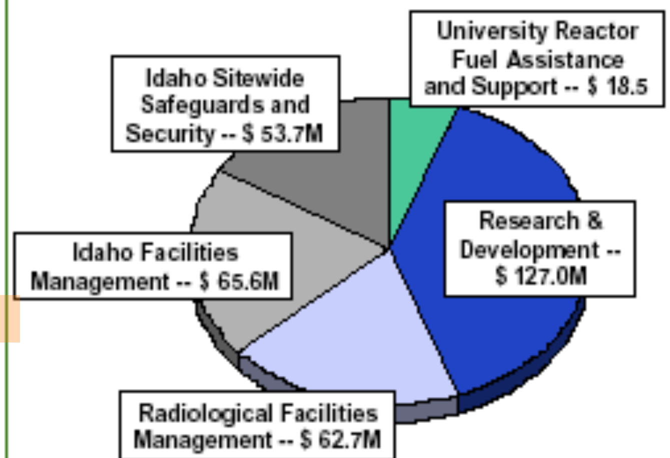
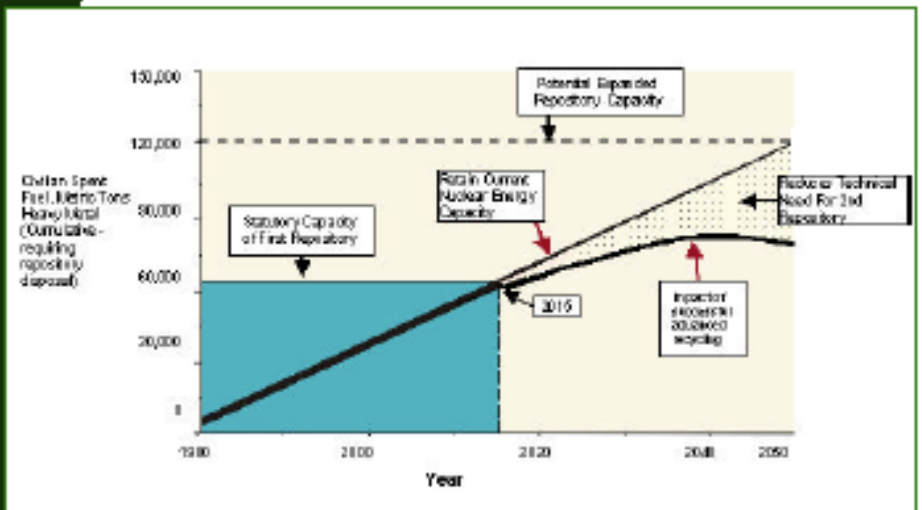


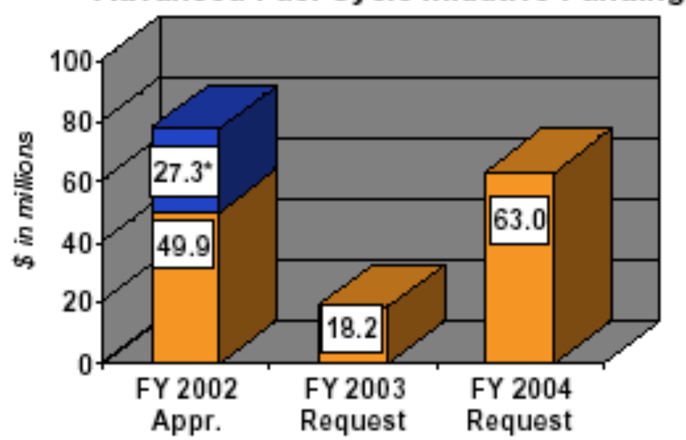
Advanced Fuel Cycle Initiative:
Optimizing Spent Nuclear Fuel Disposition

In cooperation with

OCRWM



Advanced Fuel Cycle Initiative Funding



*Activities related to deactivation of EBR-II.

- Built on international cooperation and collaboration (*e.g.*, France and Russia) and integrated with Generation IV
- *Report to Congress on Advanced Fuel Cycle Initiative: The Future Path of Spent Fuel Treatment and Transmutation Research* issued (January 2003)

Planned Accomplishments -- FY 2004

- Conduct research on proliferation-resistant fuel treatment technologies
- Develop technologies to reduce toxicity and heat load of fuel sent to a geologic repository
- Award additional 10 to 12 transmutation science fellowships to U.S. universities

Report to Congress

on

Advanced Fuel Cycle Initiative: The Future Path for Advanced Spent Fuel Treatment and Transmutation Research

DOE Advanced Fuel Cycle Initiative (AFCI)

While many countries are conducting advanced R&D on the management of spent fuel, the U.S. has done limited work since 1980. It is important for the U.S. to resume this research to ensure that advanced proliferation-resistant technologies become an integrated part of the management of spent fuel.

Advanced Fuel Cycle Initiative

- Reduce spent fuel volume by creating a final high level waste form that is lower in volume than original spent fuel.
- Separate long-lived, highly toxic elements (i.e., actinides such as Pu and Am) that present the most difficult disposition challenge.
- Reclaim spent fuel's valuable energy by providing a method to reclaim the energy value contained in the highly toxic spent fuel elements while providing for their destruction.

AFCI Series One

- Emphasizes advanced technologies applied to current reactor technology. Reduces the volume of material requiring geologic disposition by extracting the uranium (which represents 96% of spent fuel) and reducing the proliferation risk through the destruction of significant quantities of plutonium contained in spent nuclear fuel. These technologies could be deployed today.

AFCI Series Two

- Provides for complete resolution of radiotoxicity and heat load issues, by developing fuel cycle technologies for Gen IV systems aimed at enabling the commercial waste stored in a repository to be no more toxic than natural uranium ore after 1,000 years, while providing a very long-term sustainable fuel supply for expanded use of nuclear power (through very high conversion)

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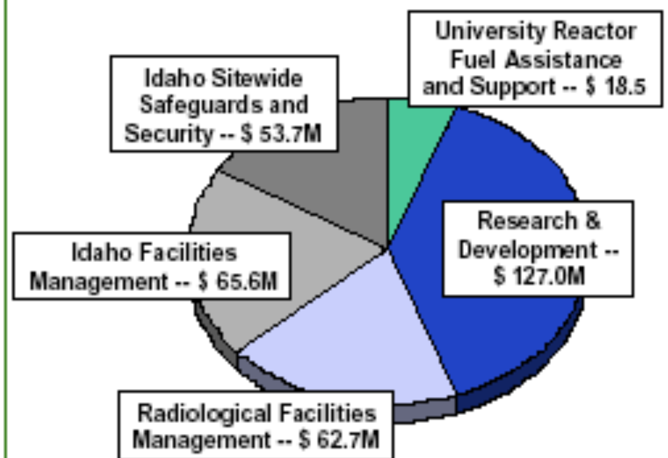

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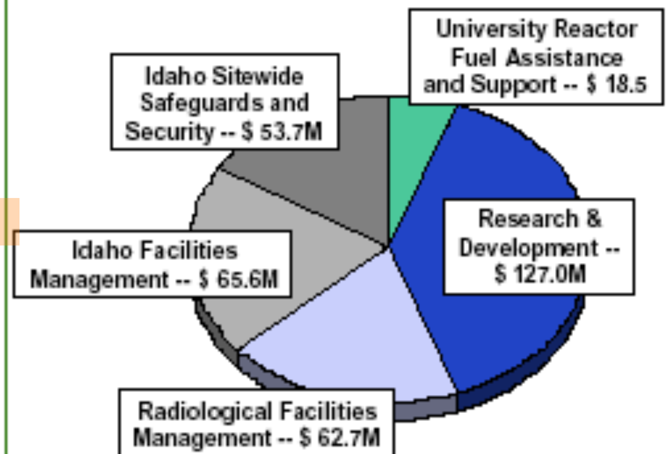

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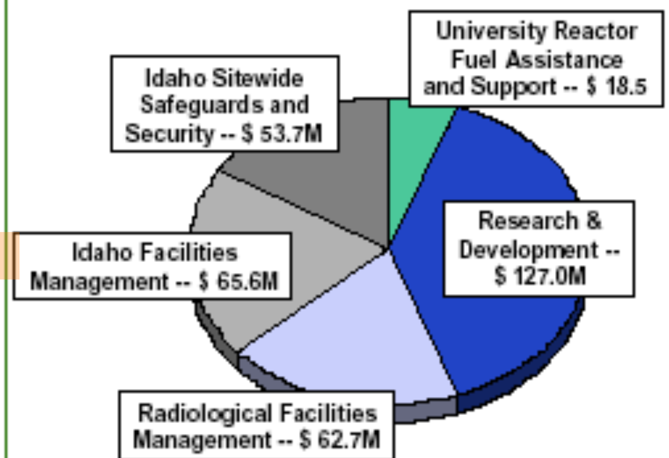

PCAST Recommendations on Nuclear Energy R&D

- A major extramural research program (investigator-initiated, peer reviewed, long range) (NERI)
- A major research program aimed at extending the life of operating plants (NEPO)
- A high level advisory body to DOE (NERAC)

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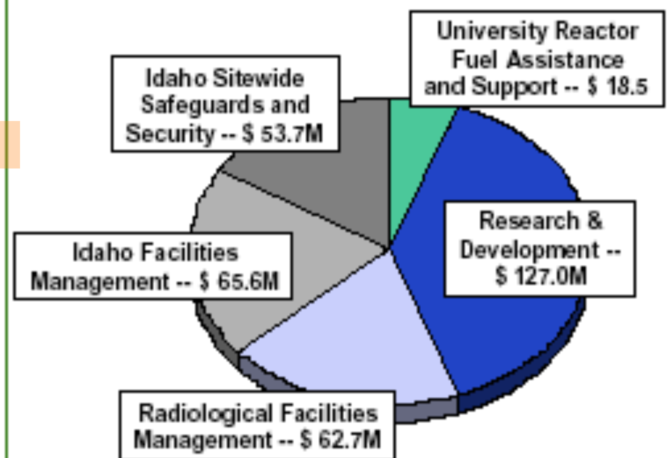


NERAC Recommendations

Nuclear Energy Research Advisory Committee
(NERAC)
Subcommittee on
Long-Term Planning for Nuclear Energy Research

Long-Term Nuclear Technology Research and Development Plan

SUMMARY

June 2000

Long-Range R&D Plan

- Basic Science and Engineering Research
- Nuclear Power
  - Advanced Fuels
  - Instrumentation and Controls
  - Technology and Economics
- Isotopes and Radiation Sources
- Space Nuclear Systems

The importance of investments in …

- Ideas (research)

  "Nation must restore an adequate investment in basic and applied research in nuclear energy if it is to sustain a viable U.S. nuclear power option."

- People (education)
  - "Perhaps the most important role for DOE/NE at the present time is to insure that the education system and its facility infrastructure are in good shape."

- Tools (facilities)
  - "Need for adequate DOE facilities to sustain the nuclear energy research mission (particularly reactor facilities and isotope sources)."

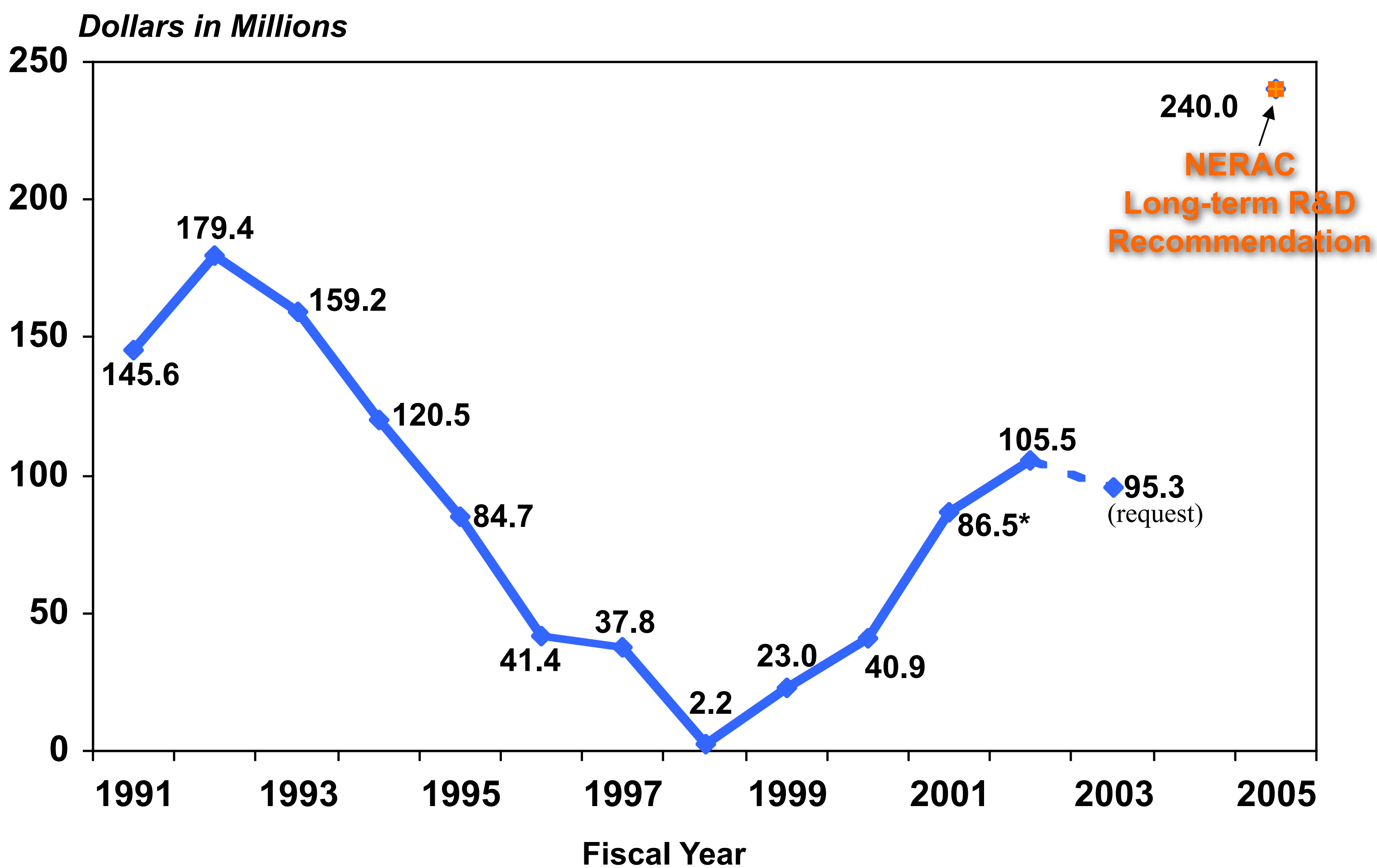
FY2005 NE R&D Budget

Science and Engineering	$60 M	
Advanced Fuels	$42 M	(includes $20 M for TREAT, $10 M for ATR
Instrumentation and Controls	$30 M	
Nuclear Power	$60 M	
Isotopes	$23 M	(does not include funding for a new facility)
Space Nuclear Systems	$25 M	(>$200 M/y for flight qualified systems)
Total	$240 M	

DOE NE Research Budget ($M)

	FY03	FY04	Recommended
NERI	31	12	100 (PCAST)
NEPO	6	0	10(PCAST)
NE Technology	12	30	100 (NERAC)
AFC	77	63	50 (NERAC)
NE Hydrogen	0	4	
NE Education	17	18	33 (HR 238)
Total	136	127	300 (NERAC)

Research & Development Budget History



Does not include $34 million of funding for the APT budget which was funded by DP in FY 2001.

Some Comparisons (FY04, $M)

DOE	23,400
...NNSA	8,800
...ENV	7,800
...Energy Programs	5,400
High Energy Physics	738
Nuclear Physics	389
Renewable Energy	444
Fusion Energy Science	257
Nuclear Energy R&D	127
NE Education	18

Human Resources

"Perhaps the most important role for DOE/NE in the nuclear energy area is to insure the educational system and facility infrastructure are in good health. It is important that the U.S. maintain a strong commitment to the education and training of nuclear scientists and engineers, to support a wide range of nuclear activities.

In support of these roles, one of DOE/NE's primary responsibilities is to assure the country has the supply of nuclear scientists and engineers that will be needed to provide worldwide leadership in scientific, nonproliferation, commercial, and other uses of nuclear science, technology, and materials. This leads to the need to support undergraduate and graduate students, faculty, and both university and DOE infrastructure as well as to fund long-term nuclear-related R&D that is in the national interest.

NERAC Long Range R&D Plan (May, 2000)

THE FUTURE of UNVERSITY NUCLEAR ENGINEERING PROGRAMS

and

UNIVERSITY RESEARCH & TRAINING REACTORS

Michael L.Corradini, Chair
Associate Dean, College of Engineering
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United States Nuclear Regulatory Commission

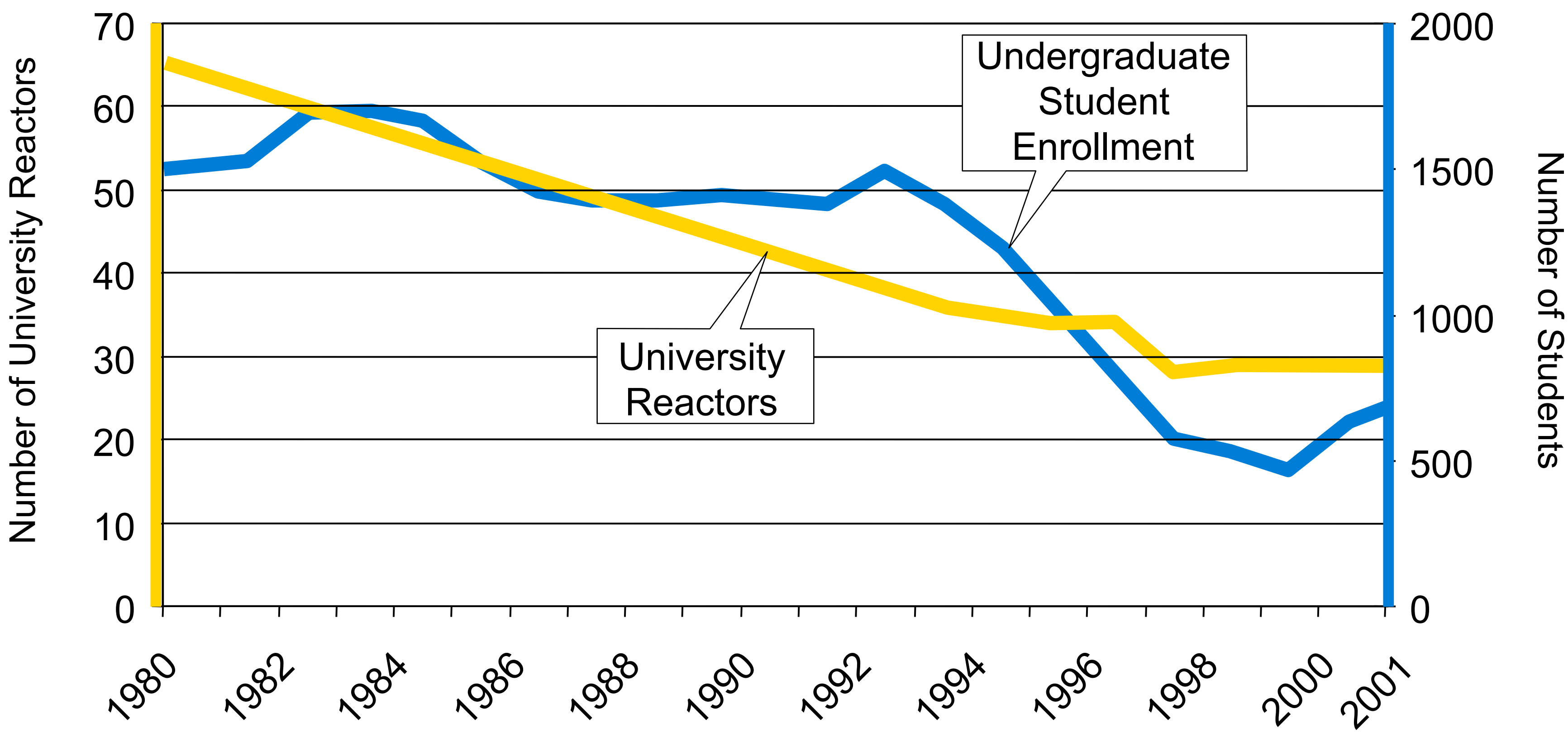
The Future of Nuclear Science and Engineering Education

NERAC Blue Ribbon Committee on Nuclear Engineering
(Chair, Mike Corradini, U. Wisconsin)

Charge:

- The intellectual nature of nuclear engineering
- The future of university reactors
- The relationship between university programs and the national laboratories
- The level and nature of federal funding necessary to sustain university nuclear engineering programs.

Trends In University Nuclear Engineering



Decline in Nuclear Engineering

Over the past two decades, there has been a decline in

Nuclear Engineering Programs: 80 --> 40

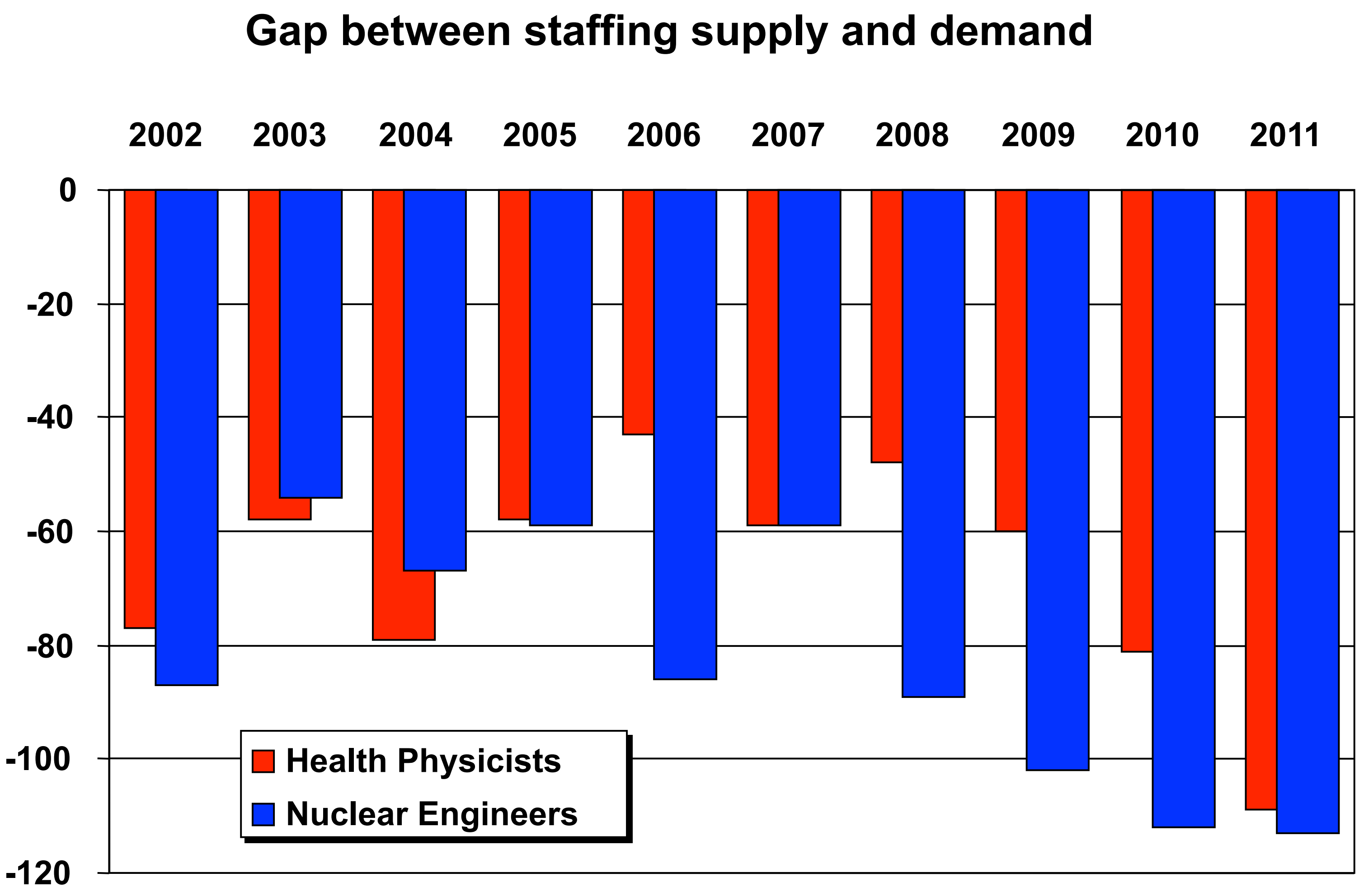
University Research Reactors: 76 --> 26

Undergraduate Enrollments: 1,852 --> 570

M.S. Enrollments: 958 --> 460

Ph.D. Enrollments: 630 --> 490

Actual staffing gap rises to more than 100 HPs and 100 nuclear engineers by 2011



Reference:
Navigant Consulting
12-17-01

Can the pipeline be filled to support both civilian and defense nuclear energy needs?

- Numerous studies (NEI, ANS, NEDHO, …) for U.S.
- All come to the same conclusion:
  - **HUGE need for nuclear professionals**
  - **90,000 new nuclear workers needed in next 10 years**
  - **In next 10 years, need**
    - **~ 2400 new nuclear engineers**
    - **~ 1300 new health physicists**

Facilities

- NERAC NS&T Infrastructure Roadmapping
- On the positive side:
  - **INEEL –> NE**
- On the negative side:
  - **- FFTF**
  - **- HFBR**
  - **- University Research Reactors**
- NERAC Warning:
  - **Without an adequate investment in research programs and human resource development, facilities are useless …**

Some Final Concerns

Some Final Concerns

- Does DOE have the vision and the will to make the investments in research, education, and facilities today (ideas, people, and facilities) to provide the nuclear energy option for tomorrow?
- Does a "mission-focused" office such as NE have the capacity to build and sustain high quality basic research programs?

Some Final Concerns (cont)

- Does the Administration (particularly OMB) understand the investments that will be required to restore nuclear power as a sustainable component of the national energy strategy?
- If the Administration is unwilling to provide the leadership necessary to sustain the nuclear option, who else can?

Nuclear Energy's Guardian Angel:

Senator Pete Domenici!!!