
April 1998

DEPARTMENT OF ENERGY

Proposed Budget in Support of the President's Climate Change Technology Initiative





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

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

B-279612

April 10, 1998

The Honorable John R. Kasich
Chairman, Committee on the Budget
House of Representatives

Dear Mr. Chairman:

Increasingly, emissions of carbon dioxide and other heat-trapping “greenhouse gases” from energy production, industry, transportation, agriculture, and other human activities are becoming concentrated in the earth’s atmosphere. Many scientists believe that the buildup of these gases is creating a greenhouse effect that will lead to global warming. Global climate changes could influence weather patterns, including shifts in precipitation patterns that could lead to flooding, changes in crop yields, and changes in ecosystems. In his State of the Union address, the President noted that the United States has agreed with other nations to reduce its greenhouse gas emissions through market forces, new technologies, and energy efficiency. In support of this agreement, the President proposed \$6.3 billion over the next 5 years for the Climate Change Technology Initiative, which would fund research and development (R&D) and the deployment of new technologies to encourage energy efficiency, renewable energy, and technologies to reduce the amount of carbon dioxide emitted into the atmosphere, as well as provides tax incentives. The Department of Energy (DOE) is expected to implement the largest portion of this initiative through its programs and activities.

As requested, we are providing you with (1) information on how DOE plans to alter its climate change R&D spending from fiscal year 1998 to fiscal year 1999 and (2) our observations regarding funding for R&D, based on our previous work in this area. On March 12, 1998, we briefed your staff on the results of our work and agreed to provide you with this report summarizing our findings. (App. I provides our briefing materials.)

Results in Brief

DOE is proposing to increase its spending to about \$1.06 billion for R&D in fiscal year 1999 to support the Climate Change Technology Initiative, a \$331 million increase from funding in fiscal year 1998 for programs related to climate change. The \$331 million increase as well as the remaining \$729 million will continue to support and expand existing R&D programs in energy efficiency and renewable energy as well as other programs related to climate change. Total funding, according to DOE, will address multiple

energy and environmental goals, including decreasing the United States' dependence on foreign oil, improving air quality, decreasing energy costs for consumers and businesses, increasing economic competitiveness, and cutting greenhouse gas emissions.

From reviewing our previous reports on R&D, we have drawn five common themes, stated here as questions, that the Congress may want to consider as it deliberates DOE's budget proposal: (1) Would the private sector do the research without federal funding?; (2) Will consumers buy the product?; (3) Do the benefits exceed the costs?; (4) Have efforts been coordinated?; and, (5) Have implementation concerns been addressed?

DOE's Climate Change R&D Funding

Overall, DOE is proposing to increase its budgetary authority of \$729 million in fiscal year 1998 to about \$1.06 billion for R&D in fiscal year 1999 in support of the Climate Change Technology Initiative. The \$331 million increase in R&D funding will, according to DOE, expand the most promising R&D programs and accelerate the development of energy technologies in six organizations of the Department: Energy Efficiency, Renewable Energy, Fossil Energy, Nuclear Energy, Energy Research, and the Energy Information Administration. The largest increase in DOE's climate change R&D funding would occur in Energy Efficiency and Renewable Energy, where the combined fiscal year 1999 funding would be increased by about \$261 million over the fiscal year 1998 level—from about \$729 million to about \$990 million. Increased R&D funding in these areas will, according to DOE, help to develop high-efficiency vehicles; alternative vehicle fuels, such as "biofuels" from plants or waste; more energy-efficient buildings; higher-efficiency industrial processes; and solar and wind systems; among other projects. DOE officials said that the use of these technologies will help to reduce carbon dioxide emissions into the atmosphere as well as satisfy other energy and environmental goals.

The remaining \$70 million will increase funding in the other four organizations, with Fossil Energy and Energy Research receiving the next largest shares of about \$30 million and \$27 million, respectively. A key effort in fossil energy R&D will be the Department's Vision 21 Program, which will focus on combining several energy technologies into a single ultra-high-efficient system that is expected to reduce energy consumption and emissions. The increase for Energy Research will fund a broad range of basic scientific research focused on long-term solutions to climate change. Nuclear Energy and the Energy Information Administration will receive the remaining increase in funding.

Observations Regarding Federal R&D

According to DOE, it has historically supported a wide range of energy R&D in eight program areas—with funding of about \$61.8 billion from 1978 through 1995.¹ As we have reported previously, while the amount of money spent on R&D is useful as a measure of how much research is being performed, it is not a good indication of the results of research.² From reviewing our previous reports, we have drawn the following five common themes, stated as questions, that may help the Congress consider DOE's proposed R&D budget:³

Would the private sector do the research without federal funding? Our work suggests federal R&D programs sometimes displace research that private industry may have done without government funding. For example, in our 1996 report on the Department of Commerce's Advanced Technology Program, we found that about 40 percent of the award recipients said they would have conducted the research without assistance from the program.⁴

Will consumers buy the product? One of the keys to successful research is that the resulting technology will be competitive in the marketplace. In our 1995 report on the United States Advanced Battery Consortium's development of batteries for electric vehicles, we found that, although the consortium may reach its technological midterm goals for the batteries, the vehicles that use them will be too expensive and will not perform well enough to compete with traditional automobiles. Moreover, members of the consortium from the automobile industry believed large subsidies would be needed to sell cars with midterm batteries. These members also doubted that vehicles with midterm batteries would achieve any significant market penetration.⁵

Do the benefits exceed the costs? Our previous work suggests the federal government has a mixed record in estimating the costs and benefits of federally funded R&D. In our 1996 review of DOE's Success Stories report, we noted that the Department had made valid claims about the benefits of

¹This figure is in constant 1995 dollars.

²Measuring Performance: Strengths and Limitations of Research Indicators (GAO/RCED-97-91, Mar. 21, 1997).

³We do not intend our five questions as an assessment of DOE's performance in these areas.

⁴Measuring Performance: The Advanced Technology Program and Private-Sector Funding (GAO/RCED-96-47, Jan. 11, 1996).

⁵Electric Vehicles: Efforts to Complete Advanced Battery Will Require More Time and Funding (GAO/RCED-95-234, Aug. 17, 1995).

a few of the technologies. Some of these benefits may be substantial, but, in most cases, DOE did not state how much it spent developing the technologies or had problems with its analyses.⁶

Have efforts been coordinated? Ensuring that DOE's R&D is consistent with other federal R&D efforts and with its mission statement and strategic plan under the Government Performance and Results Act of 1993 is important in order for the Department to limit duplication and focus its funding effectively. Furthermore, because many of the Department's activities, such as the Partnership for a New Generation of Vehicles, cut across a number of other federal agencies, coordination with these agencies is essential.⁷

Have implementation concerns been addressed? Our past work has shown that agencies sometimes do not have the administrative structure needed to implement R&D projects effectively. In a 1995 report on unobligated funds in the Advanced Technology Program, we observed that, in fiscal year 1995, the funding and the planned number of awards for the program about doubled.⁸ However, the National Institute of Standards and Technology (NIST), the agency that administers the program, did not increase its administrative staff at the same rate to make the awards. At the end of fiscal year 1995, NIST had not made all its planned awards and carried over a unobligated balance of \$136.4 million.⁹

In response to our questions, DOE said that it carefully considers each of these questions when it formulates budget proposals. According to DOE, proposals that do not successfully answer these questions are not included in its budget request.

Scope and Methodology

We conducted our review from January 20, 1998, through March 1998 in accordance with generally accepted government auditing standards. We reviewed DOE's fiscal year 1998 estimated discretionary budget authority and compared it to the Department's proposed fiscal year 1999 budget for

⁶DOE's Success Stories Report (GAO/RCED-96-120R, Apr. 15, 1996).

⁷The Partnership for a New Generation of Vehicles is an industry-government cooperative partnership between Chrysler, Ford, and General Motors and 11 federal agencies or entities to (1) develop manufacturing techniques to reduce the time and cost of automotive development, (2) improve fuel efficiency and emissions performance, and (3) develop a vehicle with triple the fuel efficiency of today's midsize cars while maintaining or improving safety, performance, emissions, and price.

⁸NIST's Unobligated Funds (GAO/RCED-95-166R, May 4, 1995).

⁹NIST Carryover Balances (GAO/RCED-97-144R, Apr. 30, 1997).

the Climate Change Technology Initiative. We spoke with DOE officials in each of the major program divisions involved in the Initiative, including Energy Efficiency, Renewable Energy, Fossil Energy, Nuclear Energy, Energy Research, and the Energy Information Administration. To develop our observations about R&D, we reviewed and summarized GAO reports and testimonies on R&D since 1990.

Agency Comments and Our Evaluation

We provided a copy of our report to DOE for its review and comment. We obtained comments on the results of our work from the Department, including the Assistant Secretary, Energy Efficiency and Renewable Energy and one of his directors. DOE agreed with the funding information presented in this report and provided two general comments.

First, DOE said that the report should clearly state that both the base programs and the increases associated with the Climate Change Technology Initiative are designed to meet multiple objectives—not exclusively reducing greenhouse gas emissions. Furthermore, DOE said that the increase is for an expansion of work on the most promising technologies. We modified the text to include DOE’s multiple objectives and to note that DOE’s expanded funding will target the most promising technologies.

Second, DOE agreed that the five questions we raised are appropriate in the consideration of R&D funding. However, DOE said that the report attempts to provide or imply answers to each question that are uniformly negative and are based on marginally relevant examples. We do not intend our five questions as an assessment of DOE’s performance in these areas. Rather, we cite previous reports to illustrate that these are areas that the Congress may want to consider when funding any R&D. Therefore, we provide examples from reports concerning DOE and other agencies. To address this comment, we modified the text to better explain the intent of our questions and the means by which DOE chooses its proposals.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 14 days from the date of this letter. At that time, we will make copies of this report available to others upon request.

If you have any questions or need additional information, please contact me on (202) 512-3841. Major contributors to this report were Daren Sweeney, John Johnson, and Daniel Haas.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Victor S. Rezendes". The signature is written in a cursive style with a large, stylized initial "V".

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

GAO RCED

DOE's Expenditures in Support of the
President's Climate Change
Technology Initiative

GAO Contents

- Background
 - Objectives
 - Results in Brief
 - Scope and Methodology
 - Budget Information
 - GAO's Observations
-

GAO Background

- President's budget requested \$6.3 billion over the next 5 years (1999-2003) for Climate Change Technology Initiative (CCTI).
 - R&D and deployment of energy efficiency, renewable energy, and carbon reduction technologies (\$2.7 billion).
 - Tax incentives (\$3.6 billion).
 - Department of Energy (DOE) expected to implement largest portion of R&D for CCTI.
-

GAO Objectives

- Provide information on how DOE plans to alter its climate change R&D spending from 1998 to 1999.
 - Provide observations regarding R&D based on previous work.
-

GAO Results in Brief

-
- DOE proposes over \$1 billion for R&D to support CCTI for FY 1999. Approximately \$729 million has been recoded as CCTI from previous year.
 - Almost all CCTI dollars are to be expended through existing programs. (One new program.)
 - Concept is to accelerate technology-- "more faster."
-

GAO Results in Brief

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- Prior to funding proposed increase, the Congress may want to consider five themes from GAO's previous work:
 - Would private sector do the research?
 - Will consumers buy the product?
 - Do benefits exceed costs?
 - Have efforts been coordinated?
 - Have implementation concerns been addressed?
-

GAO Scope and Methodology

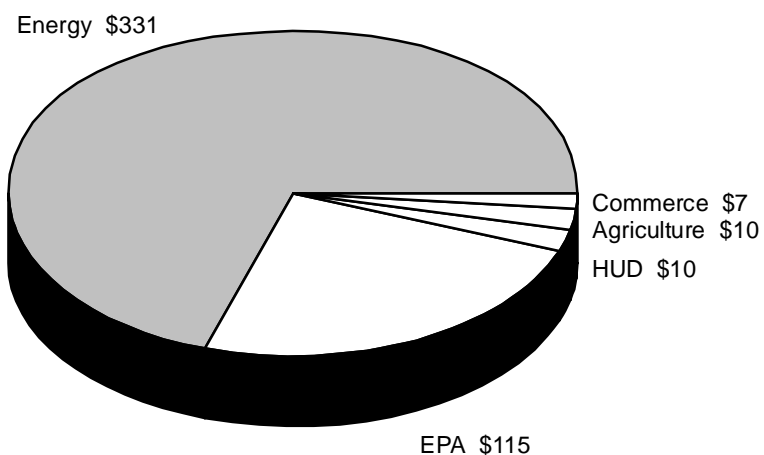
- Reviewed DOE's budget for FY 1998 and proposed budget for FY 1999.
 - Reviewed our prior work in related R&D program areas.
 - Discussed R&D changes with DOE program officials.
-

GAO RCED

Budget Information

GAO Climate Change Technology Initiative:
Governmentwide Increase (FY 1999)

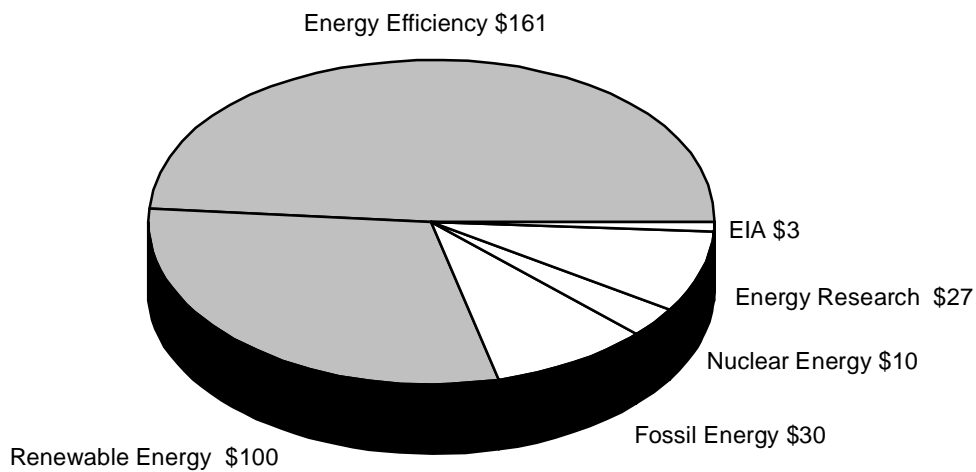
\$473 million



Note: Does not include tax incentives.
Source: DOE.

GAO Climate Change Technology Initiative:
DOE Increase (FY 1999)

\$331 million



Note: Dollar amounts rounded.
Source: DOE.

GAO DOE Climate Change R&D
(FY 1998-99 funding)

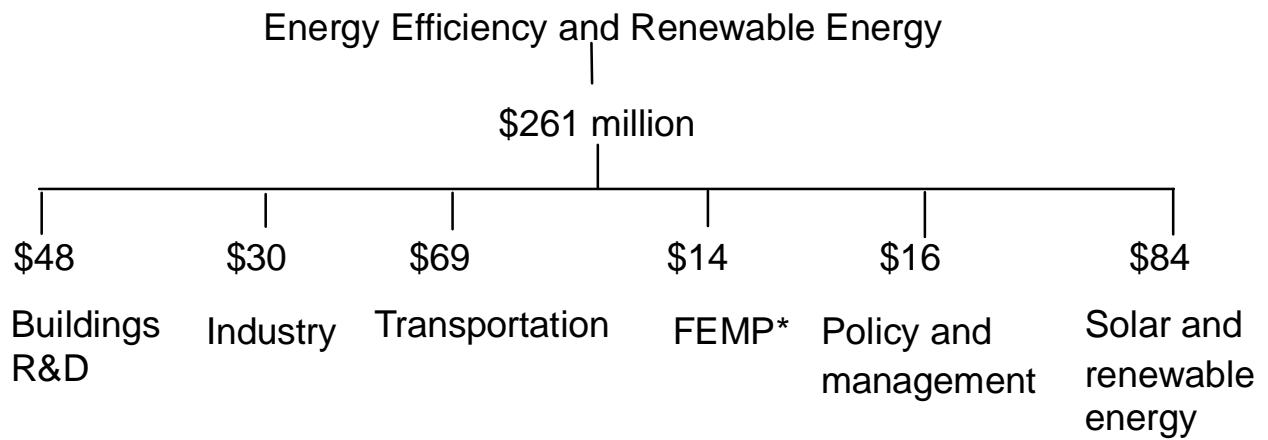
Dollars in millions

DOE organization	FY 1998 estimate*	FY 1999 request*	Change
Energy Efficiency	\$456.6	\$617.4	\$160.8
Renewable Energy	272.2	372.3	100.1
Fossil Energy	0	30.0	30.0
Nuclear Energy	0	10.0	10.0
Energy Research	0	27.0	27.0
EIA	0	2.5	2.5

*Estimate is discretionary budget authority.

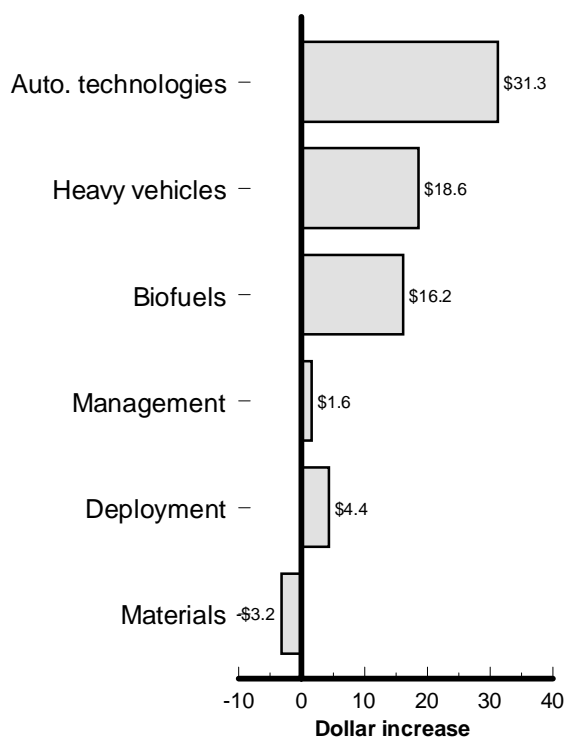
Source: DOE.

GAO Breakout of Increase for Energy Efficiency and Renewable Energy



*FEMP = Federal Energy Management Program.

GAO Energy Efficiency and Renewable Energy--Transportation



Examples

Advanced Automotive Technologies
R&D for PNGV*

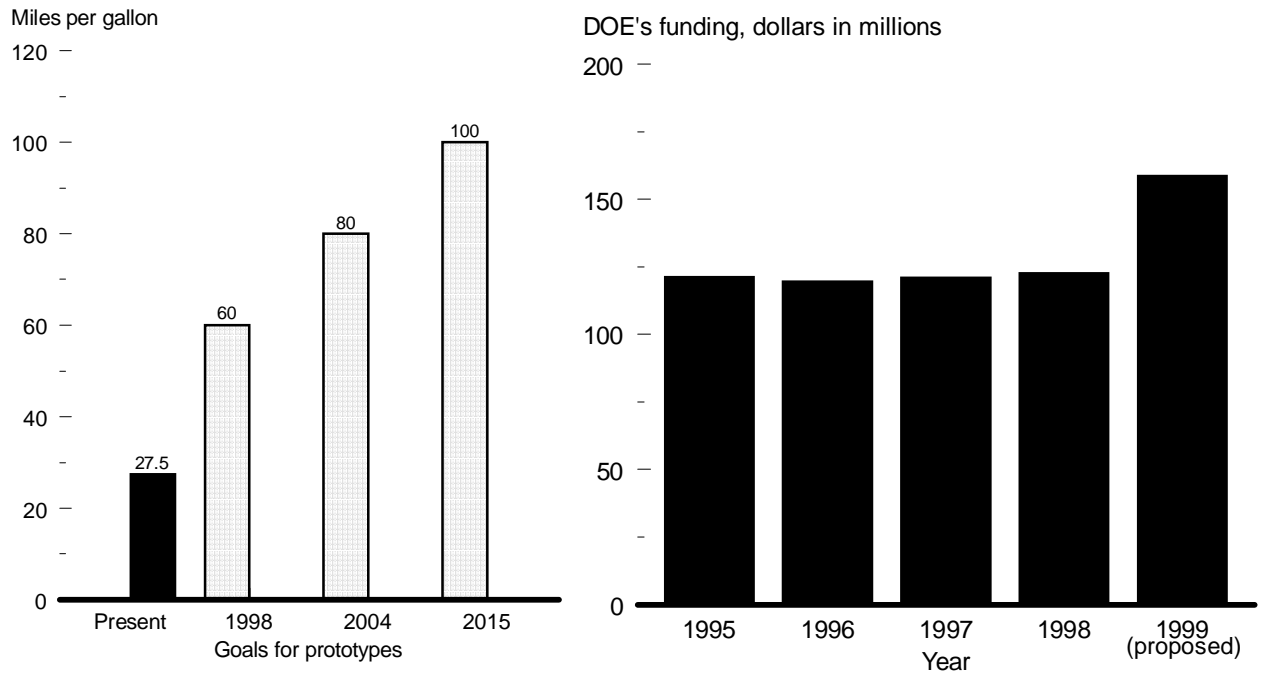
Advanced Heavy Vehicle Technologies
R&D for truck fuel economy
(DOT-DOE program)

Biofuels Energy Systems
Accelerate first commercial-scale
demo. for ethanol from biomass
waste

*Partnership for a New Generation of Vehicles.

GAO Energy Efficiency and Renewable Energy--Advanced Automotive Technologies

Partnership for a New Generation of Vehicles



GAO Energy Efficiency and Renewable
Energy--Solar and Renewable Energy

Directly Related Programs

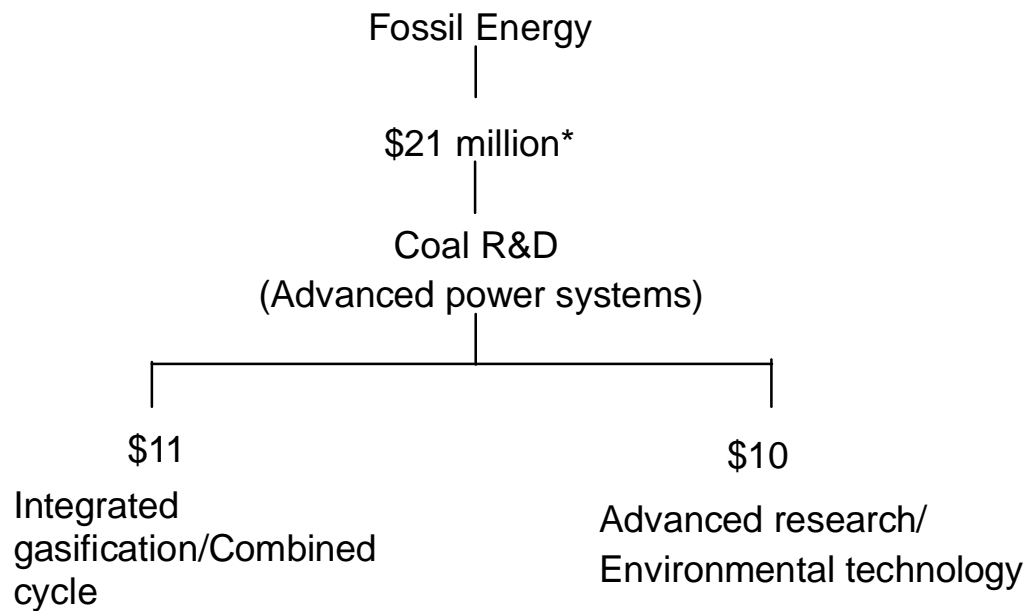
Climate Challenge (\$500,000)

Voluntary program with public-private utilities to encourage the use of pollution-reducing technologies.

U.S. Initiative on Joint Implementation (\$3.4 million)

Worldwide effort to promote less polluting power systems in developing countries (as a precursor to emissions trading).

GAO Breakout of Increase for Fossil Energy



*Does not include \$9 million OMB removed and subsequently returned.

GAO Integrated Gasification/
Combined Cycle

Refocusing Existing Programs

Vision 21 Program (\$11 million)

- Producing energy through the use of high-energy components, such as fuel cells and advanced turbines. New focus will be on achieving ultra-high efficiencies by integrating component parts into a single system. Considered DOE's "showcase" power technology for its 20-year effort.
-

GAO Advanced Research/Environmental
Technology

Expanding Existing Programs

Carbon Sequestration Program* (\$10 million)

Exploring the effects of placing sequestered CO₂ in underground gas and oil wells. Greater focus on practicality, cost, and long-term effects.

*Carbon sequestration refers to the removal of carbon emissions from fossil fuels as they are burned or the capture of carbon emissions from the atmosphere and their subsequent isolation from the atmosphere.

GAO Increase for Nuclear Energy

Nuclear Energy

|

\$10 million

|

Office of Nuclear Energy, Science and
Technology

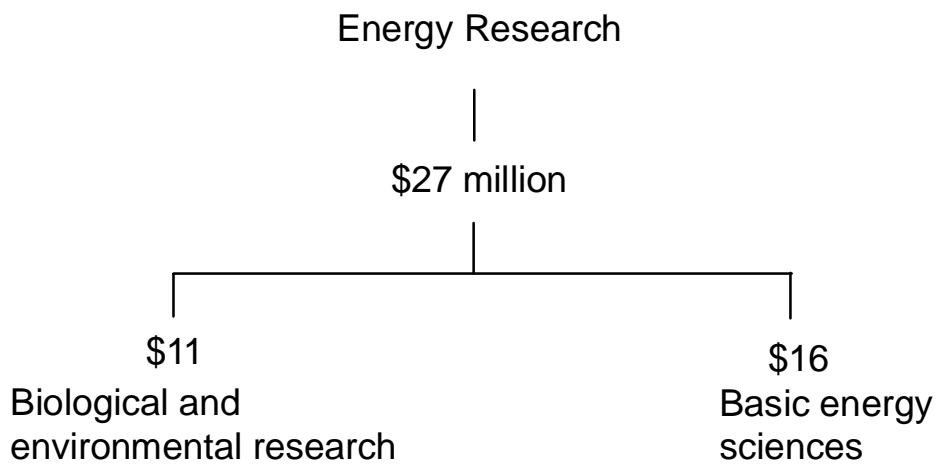
GAO Nuclear Energy

New Program

**Nuclear Energy Plant Optimization Program
(\$10 million)**

Maintaining the operation of existing nuclear power plants. Program will focus on (1) managing the aging of nuclear power plants through development of key monitoring technologies, (2) optimizing capacity by equipping plants with new digital systems, and (3) assisting industry in meeting licensing requirements by working with NRC.

GAO Breakout of Increase for Energy Research



**GAO Biological and Environmental Research
(long-term solutions)**

Health Effects and Life Sciences (\$5 million)

Sequencing of Microorganisms: Understanding the total genetic makeup of methane- and hydrogen-producing organisms in an effort to explore their possible use as energy sources.

Environmental Sciences (\$6 million)

Carbon Sequestration (\$4 million): Research activities focused on how CO₂ is sequestered in natural forest ecosystems.

Microorganism Research (\$2 million): Exploring the flow of CO₂ from the earth's atmosphere to the ocean and the relationship between CO₂ absorption and marine microorganisms.

GAO Basic Energy Sciences (long-term solutions)

Materials Sciences (\$3.5 million)

Research to support development of higher-performance materials for high-temperature combustion, novel energy-saving magnets and photovoltaic devices. Builds on existing programs but focuses on reducing CO₂ production through greater efficiency.

Chemical Sciences (\$4.5 million)

Research to understand molecular changes primarily during photosynthesis, catalysis, combustion, chemical separations, and energy storage.

Engineering and Geosciences (\$3 million)

Focuses on terrestrial sequestration of CO₂ with goal of assessing the geochemistry, physics, and mechanics to determine how long CO₂ would stay in place and whether it could be stored safely. To be coordinated with Fossil Energy.

Energy Biosciences (\$5 million)

Previously emphasized biochemistry and biophysics of photosynthetic energy capture. Research on CO₂ will focus on genetic engineering and how plants use energy to convert CO₂ into products.

GAO Increase for Energy Information
Administration

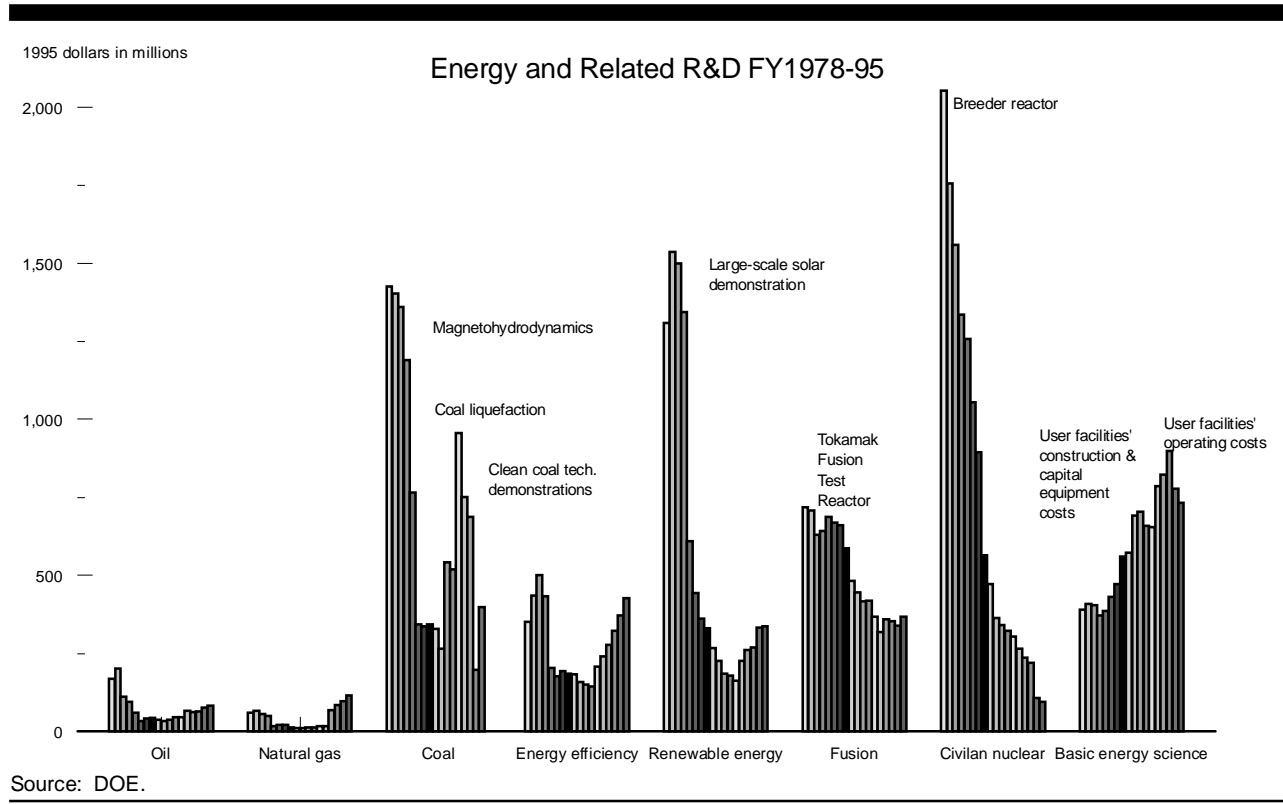
Energy Information Administration
\$2.5 million

- Improve projections of energy consumption and prices for International Energy Outlook.
 - Make existing energy data more useful--energy data will be converted to emissions data.
-

GAO RCED

R&D Context

GAO DOE's Historic Funding for R&D



GAO DOE Energy R&D Subject to Opposing Arguments

Orient toward marketplace

Orient toward "basic research"



Advantages

- Near-term results/more measurable
- Enhanced competitiveness for companies

Disadvantages

- May subsidize companies to do what they would do anyway

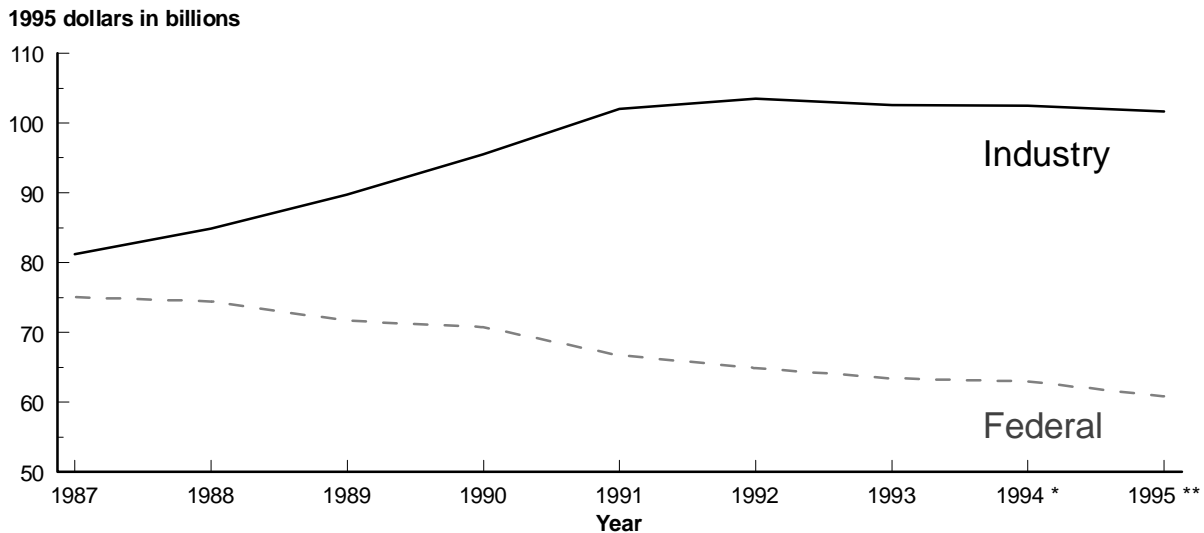
Advantages

- Provide scientific knowledge to support development of new products
- Resource for successful innovation

Disadvantages

- Difficult to measure results/riskier, longer-term investment
-

GAO Investment in Federal and Private Energy R&D



* Preliminary

** Estimate

Source: National Science Foundation.

GAO **It Is Difficult to Measure Outcomes and Performance of Many Types of R&D**

As a result, we are providing several themes from our previous work in R&D that the Congress may want to consider as it reviews DOE's R&D proposal.

GAO Themes From GAO Reports

1. Would private sector do the research?
 2. Will consumers buy the product?
 3. Do benefits exceed costs?
 4. Have efforts been coordinated?
 5. Have implementation concerns been addressed?
-

GAO Displacement of Private Research

Would private industry perform the R&D without government funding?

- Advanced Technology Program
- Clean Coal Technology Program
- Identifying market failures
- Electricity R&D

GAO Displacement of Private Research

Advanced Technology Program (RCED-96-47) (RCED/OCE-98-83R)

ATP funded research that would have been funded by the private sector. 40% of "winners" said they would have continued without funding. Some of the "near winners" financed their projects using private funds only.

National Institute of Science and Technology (NIST) now considers "market failures" when selecting projects. However, it is still difficult to identify where market failures occur.

GAO Displacement of Private Research

Fossil Fuels: Improvements Needed in DOE's Clean Coal Technology Program (RCED-92-17)

In the Clean Coal Technology Program, DOE funded projects that would demonstrate technologies already in commercial use overseas.

These projects may not have been the best use of federal resources because the technologies might have been commercialized without federal assistance.

DOE does not assess whether technologies are likely to be commercialized without federal assistance before selecting projects.

GAO Displacement of Private Research

Federal Budget: Choosing Public Investment Programs (AIMD-93-25)

Public investments like R&D can arise where market failures occur. Market failures include (1) undersupply of public goods, (2) externalities, and (3) excessive risk. Excessive risk is often a problem in large-scale R&D projects.

GAO Displacement of Private Research

**Federal Research: Changes in
Electricity-Related R&D Funding
(RCED-96-203)**

Utilities are cutting R&D budgets in anticipation of greater industry competition. Shift is away from longer-term projects that may benefit many utilities. Shift is toward proprietary R&D with a short-term payback.

GAO Marketplace Competitiveness

Can the technology that DOE develops compete in the marketplace?

- Advanced batteries
 - Energy efficiency research
 - Alternative fuels
 - Clean coal technology
-

GAO Marketplace Competitiveness

**Electric Vehicles: Efforts to Complete
Advanced Battery Development Will Require
More Time and Funding (RCED-95-234)**

Advanced Battery Consortium has not proven that batteries meeting long-term technological goals are feasible. Batteries meeting midterm goals may be achievable, but electric vehicles with them not competitive in performance or cost. Carmakers said large subsidies will be needed.

GAO Marketplace Competitiveness

**Full Disclosure of National Energy Strategy
Analyses Needed to Enhance Strategy's
Credibility (T-RCED-91-76)**

DOE's energy efficiency research may be less effective while energy prices are low. Low prices discourage the use of energy-efficient technology. Higher energy prices would encourage research, but administration did not pursue policies to raise prices.

GAO Marketplace Competitiveness

Alternative Fuels: Experiences of Brazil, Canada, and New Zealand in Using Alternative Motor Fuels (RCED-92-119)

Governments became the catalyst for action to encourage industry to promote use of alternative fuels through lower taxes and price subsidies. Providing lower prices through subsidies was most important reason why consumers bought alternative fuels.

Sustained government commitment important because switch to alternative fuels requires long-term financial, technological, and regulatory changes.

GAO Marketplace Competitiveness

Alternative Fuels: Experiences of Countries
Using Alternative Motor Fuels (T-RCED-91-85)

Consumers' acceptance of alternative fuels requires a price advantage over gasoline-fueled vehicles. Government should be catalyst to encourage consumers' use of and industry involvement in alternative fuels.

GAO Marketplace Competitiveness

Fossil Fuels: Outlook for Utilities' Potential Use of Clean Coal Technologies (RCED-90-165).

Without acid rain mandates, utility industry willing to use clean coal technologies at only 5 percent of coal-fired units. With mandates, industry would consider using technologies at up to 50 percent of units to reduce SO₂ and up to 75 percent of units to reduce NO_x.

Technologies may not contribute to acid rain reduction in next 15 years due to uncertainty about when they will be available.

GAO Cost and Benefits/Performance
Measures

Has DOE thoroughly analyzed the costs and benefits of its R&D proposals, and what specific performance measures will it use?

- DOE's Success Stories report
 - Clean Coal Technology Program
 - SEMATECH
 - EPA's voluntary climate change programs
-

GAO Cost and Benefits/Performance
Measures

DOE's Success Stories report
(RCED-96-120R)

DOE made some valid claims about the benefits of its applied research. Some of these benefits may be substantial, but we found problems with the analyses DOE used to support benefits in most cases.

DOE did not report how much it spent on R&D for many of the technologies.

GAO Cost and Benefits/Performance
Measures

Fossil Fuels: Improvements Needed in DOE's
Clean Coal Technology Program
(RCED-92-17)

DOE's selection of some projects, while meeting selection criteria, may not have been the most cost-effective use of federal funds.

Some projects may not have widespread use because they are not expected to reduce emissions as much as existing technology or because they serve a limited market.

GAO Cost and Benefits/Performance
Measures

Federal Research: SEMATECH's Technological
Progress and Proposed R&D Program
(RCED-92-223BR)

SEMATECH appeared to be reaching its
technological goal to produce state-of-the-art
semiconductors using only U.S. equipment.
Domestic semiconductor manufacturers
arrested a decline in world market share.
However, it was unclear how much of this was
attributable to SEMATECH.

GAO Cost and Benefits/Performance
Measures

Global Warming: Information on the Results of Four
of EPA's Voluntary Climate Change Programs
(RCED-97-163)

In assessing the benefits from two of four
climate change action plan programs, EPA
adjusted reductions in greenhouse gas
emissions to account only for the effects of
its efforts. In two other programs, it did not
adjust reported reductions.

GAO Coordination and Consistency

Has DOE assessed whether the proposed research is consistent with its mission statement, strategic plan, and ongoing R&D efforts? Has it coordinated with the R&D efforts of other agencies?

Federal agencies

State and local governments



Industry

International

GAO Administration/Implementation

Does DOE have the administrative structure in place to effectively implement its R&D programs?

- NIST's Advanced Technology Program (ATP)
- Clean Coal Technology Program
 - cost reviews
 - cost-sharing guidelines

GAO Administration/Implementation

NIST's Unobligated Funds (RCED-95-166R)

In FY95, NIST's ATP funding more than doubled from FY94. NIST planned to make about twice as many awards as it did the previous year.

NIST did not increase administrative staff at the same rate as its planned awards.

NIST did not make all awards and carried over \$136.4 million at the end of FY95.

GAO Administration/Implementation

**Fossil Fuels: Ways to Strengthen Controls
Over Clean Coal Technology Project Costs
(RCED-93-104)**

DOE made a good effort to review the reasonableness of sponsors' proposed project costs before projects began. However, after projects started, DOE did not audit costs in a timely manner.

GAO Administration/Implementation

Fossil Fuels: Lessons Learned in DOE's Clean Coal Technology Program (RCED-94-174)

Program shows that government and private sector can work together to develop new technologies.

Lessons learned include (1) obtaining advance funding, (2) using cooperative agreements, (3) establishing federal cost-sharing limits, (4) obtaining early participation of industry, and (5) establishing a comprehensive process to evaluate and select projects.

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