Public Sector Funding Mechanisms to Support the Implementation of an Advanced Technology Strategy

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Preface: The Global Technology Strategy Program

The Battelle Memorial Institute's Global Energy Technology Strategy Program (GTSP) is an ongoing research effort investigating the potential of new energy technologies to address global climate change. Through its findings and analyses, the Program aims to contribute to the stabilization of atmospheric concentrations of greenhouse gases at levels that would prevent dangerous anthropogenic changes to the Earth's climate. The GTSP recognizes that achieving atmospheric stabilization will require fundamental changes in the ways that people use energy. While changes in human behavior and attitudes can play important parts in altering predominant patterns of energy use, technological change is a powerful lever for reducing the impacts of human activity on the global environment. Thus, new energy technologies and systems that emit little or no carbon waste will play an important role in shaping the response to climate change.

The GTSP's emphasis on technology as a primary tool in controlling carbon emissions is supported by the widely cited equation known as the Kaya Identity, where:

Carbon dioxide emissions = (carbon intensity of energy) x (energy intensity of the economy) x (per capita GNP) x (population)[1, 2]

According to the Kaya Identity, total carbon dioxide (CO_2) emissions are a function of demographic, macroeconomic, and technological factors. Given the complexity and number of variables that influence the population and per capita GNP terms of the equation, the remaining technological terms (carbon intensity and energy intensity) may offer more tractable intervention points in the near to mid-term. Both the carbon intensity of energy and the energy intensity of the economy are in many respects technologically-determined and, thus, may be influenced by policies designed to encourage the development and adoption of carbon-mitigating energy technologies. Moreover, the importance of these terms as focal points of climate change policy is augmented by expectations of continued growth in both global population and the global economy through 2050 at least.

In its scale, scope, and urgency, this technological challenge is unprecedented in human history. The buildup of anthropogenic CO_2 and other gases has occurred over more than a century, and is

[1] See Y. Kaya, "Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios." Paper presented to the IPCC Energy and Industry Subgroup, Response Strategies Working Group, Paris (1990).
[2] The Kaya Equation has been modified by researchers associated with GTSP as well as others to include a final term " – sequestration." This term recognizes that soil carbon sequestration, afforestation and geologic storage of CO2 are also ways of decreasing emissions of greenhouse gases that have come to the fore since the original publication of the Kaya Equation in 1990.

likely to intensify in the future without significant changes in global energy use patterns. The rising concentrations of these gases in the atmosphere have been implicated as significant drivers of global climate change. Thus, addressing the problem will require long-term collective action coordinating the mitigation efforts of many governments, industries, and consumers worldwide. The GTSP contributes to the goal of global climate change mitigation through its analyses of energy-related greenhouse gas abatement options and its articulation of alternative pathways for global energy technology change.

The first phase of the GTSP examined the relationships between energy and climate systems, and began to identify critical roles for advanced energy technologies in mitigating some of the long-term risks of anthropogenic climate change.[3] Phase I found that:

- Climate change is a long-term problem, with implications for action today;
- Stabilizing the concentration of CO_2 requires fundamental changes in energy systems;
- Significant improvements in the existing suite of technologies and the development of new technologies are required to achieve stabilization while holding the associated costs to acceptable levels;
- Current investments in R&D into energy technologies that could reduce the cost of climate stabilization are inadequate;
- A strategy to develop and deploy technology is a critical element of a robust response to the climate change issue; and
- Emissions mitigation technology development programs must be complemented by research programs to reduce uncertainty in the climate sciences, to explore strategies and policies to limit cumulative emissions of CO_2, and to better understand robust adaptation options.

Phase II of the GTSP has built on these initial research findings. Among its research objectives, it aims to identify institutional designs, funding and support mechanisms to support the performance of energy research and development over the long-term on a scale that is commensurate with the climate change problem. While Phase II addresses challenges associated with the creation of a stable and effective energy R&D enterprise, it is particularly focused on the hurdles that several new and promising technology classes face in moving from the laboratory to widespread commercial deployment. Key technologies include carbon dioxide capture and storage (CCS) systems, fuel cells and hydrogen systems, and biomass energy technologies. These technologies are collectively referred to in this paper as "gap technologies."

[3] The summary report from Phase I of the study, ***Global Energy Technology Strategy: Addressing Climate Change: Initial Findings from an International Public-Private Collaboration,*** provides highlights of the key findings from the program's first three years. The objectives of the Phase I research effort were to: (1) assess and identify the technology transformation required to stabilize concentrations of carbon dioxide CO_2) in the atmosphere; (2) describe the role that technology can play in achieving atmospheric stabilization; (3) identify the individual (gap) technologies that could play a significant role in stabilizing concentrations of CO_2 in the atmosphere; and (4) evaluate recent trends in public and private energy research & development (R&D) to determine the potential to facilitate the necessary technology transformation. The document also included key findings and general recommendations for those engaged in the climate policy debate as to how to develop and implement a long-term technology development strategy to address climate change.

I. Background: Recent Trends in Energy R&D Investment

Among the factors that forestall the transformation of energy systems is the fact that funding for energy R&D has declined sharply in most industrialized countries over the past two decades. Since a small group of industrialized countries has historically performed the vast majority of the world's energy R&D, their decisions to reduce support for energy R&D amount to a global reduction in energy R&D intensity. The absence of acute energy crises, such as those of the 1970s, the deregulation of the energy industries in many countries, and persistent uncertainties surrounding environmental policies and regulations have played major roles in causing countries to discount the importance of long-term energy R&D. Several countries—including the United States, Germany, and the United Kingdom—have reduced their cumulative public and private investment in energy R&D by more than 65%, since 1980. Thus, there is an urgent challenge in ensuring sufficient, long-term financial and institutional support for the R&D needed to catalyze a global energy technology transformation in response to climate change. As a first step in designing new institutions to support long-term energy R&D, this paper explores potential opportunities and shortcomings of existing public sector financing mechanisms with a focus on

What Is Energy R&D?

Accepting that there are few explicit definitions of energy R&D in the literature, and that no extant definition is universally accepted, the GTSP adopts the following definition, based on that of the U.S. President's Committee of Advisors on Science and Technology (1999):

- Energy R&D refers to a series of linked processes by which technologies for energy supply, end use, or carbon management move from theoretical conceptualization to feasibility testing and, ultimately, to small-scale deployment.

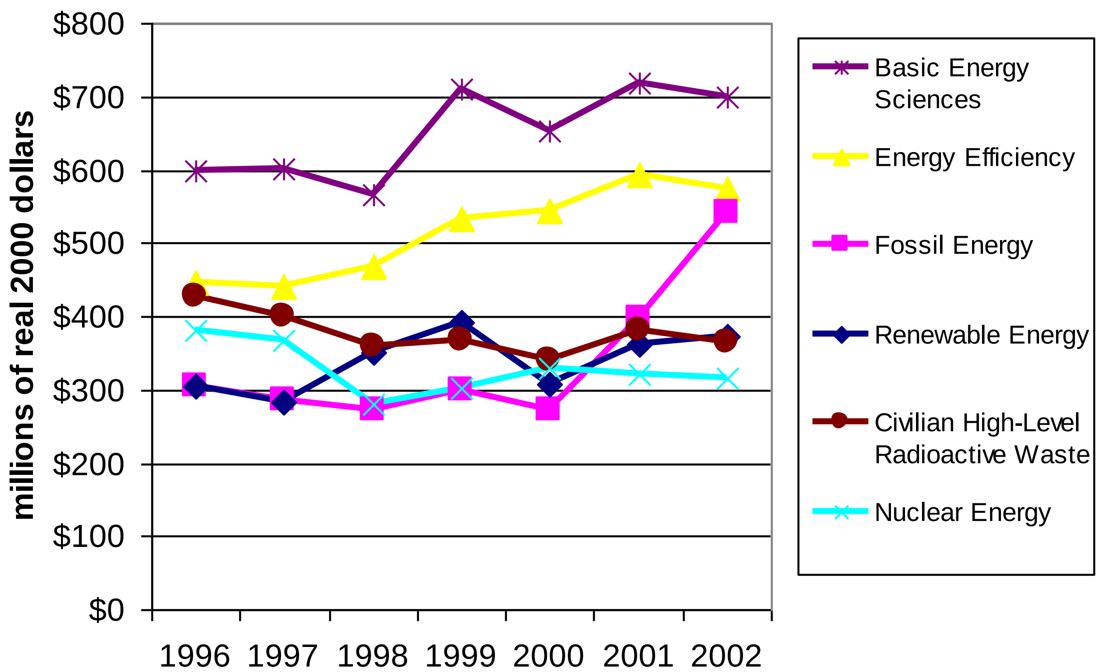
- Energy R&D encompasses both basic and applied research, technology development, and demonstration associated with each phase of the energy lifecycle including: production (e.g., mining and drilling), energy conversion and power generation (e.g., nuclear fission and fusion, fossil and renewable energy systems, bioenergy, and hydrogen production), transmission, distribution, energy storage, end-use and energy efficiency, and carbon management.

- Energy R&D includes efforts to develop carbon management technologies to manage anthropogenic releases of greenhouse gases such as those associated with the combustion of fossil fuel use, in an effort to mitigate the potential impacts of these emissions on climate systems. Carbon management technologies include advanced agro forestry practices aiming to enhance the capacity of soils, trees, and other standing biomass to absorb atmospheric carbon dioxide; engineered pre- and post-combustion carbon capture systems and technologies for geologic and ocean carbon sequestration.

***References**: President's Committee of Advisors on Science and Technology, Federal Energy Research and Development for the Challenges of the Twenty-First Century, Washington, DC, November 1997, p. ES-9; Paul J. Runci and James J. Dooley, "Research and Development Trends for Energy," in Culter J. Cleveland (ed.), Encyclopedia of Energy (Elsevier Press, 2004).*

the United States. Although climate change necessitates a global transformation of energy systems, each country presents a unique environment for technology development and use. As the world's largest energy consumer and carbon emitter, the United States offers an important case study, in this regard. Moreover, findings from an analysis of U.S. public sector funding mechanisms may yield insights useful in the development of funding mechanisms in other countries as well.

Figure 1. U.S. Government Support for Energy R&D, 1996-2001



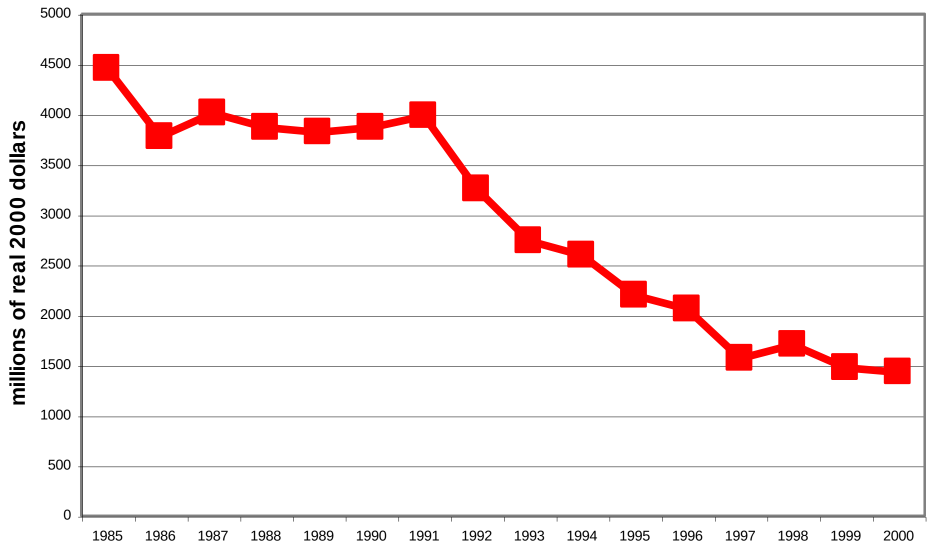
Modifications of, and alternatives to, the predominant direct funding model of public energy R&D support in the U.S. are needed, since U.S. energy R&D investment declined in the aggregate by 68% between 1980 and 1999, while the public and private sectors respectively reduced their energy R&D investments by 63% and 74%.[4] The structure of the remaining energy R&D support in the U.S. may also be in need of redirection in the light of climate change, since the majority of public funds now support basic energy research projects and, increasingly, fossil energy, as shown in Figure 1. Energy efficiency, nuclear fission and fusion, and renewable energy technologies have historically received less federal government support than basic energy science and that funding gap has widened since the mid-1980s.

Private sector energy R&D data, to the extent that they are available, indicate that fossil fuel exploration and production technologies account for the majority of historic and current expenditures. In recent years, private investment in hydrogen and fuel cell technologies has risen sharply, although the magnitude of these expenditures is not known. However, most U.S. auto

[4] See J.J. Dooley, "US National Investment in Energy R&D: 1974-1999," Pacific Northwest National PNWD-3108 (July 2001).

manufacturers have made major investments in the development of fuel cells for transportation applications, while several new firms have emerged as developers and vendors of stationary fuel cells. Nonetheless, available data indicate that private sector investments in energy R&D continue to decline in the aggregate, as Figure 2 shows.[5]

Figure 2. Estimated Aggregate Private Sector Energy R&D Investment, 1895-2001[6]



As the following section discusses, the public sector remains a key player in energy R&D and has a critical role to play in reinvigorating the overall energy R&D enterprise and in elevating awareness of its linkage to climate change mitigation strategies.

II. The Historical Role of the Public Sector in Energy R&D

Since the 1980s, market-based mechanisms have achieved new popularity among policymakers around the world. Through privatization and deregulation, governments in many countries, including the U.S., have sought to improve the quality of service and overall economic performance by reducing their presence in the marketplace and allowing competition and prices to be the principal arbiters of economic decision-making. Liberalization of several major industries, including telecommunications, airlines, railroads, and banking has yielded many benefits and spurred the rapid and widespread adoption of new breakthrough technologies.

The priority accorded to energy R&D investment by both governments and industry has declined since the early 1980s, due in part to energy deregulation. The "retreat of the state" from energy markets via deregulation has widened an important public goods deficit by shifting a larger share

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[5] See J.J. Dooley, "US National Investment in Energy R&D: 1974-1999," Pacific Northwest National PNWD-3108 (July 2001).

[6] Paul J. Runci and James J. Dooley, "Research and Development Trends for Energy," in Culter J. Cleveland (ed.), *Encyclopedia of Energy* (Elsevier Press, 2004).

of the energy R&D burden to the private sector.[7] Ironically, as government has reduced its regulatory presence in energy markets to allow freer competition, and curtailed its own performance of energy R&D, firms have found less incentive to invest in long-term, high-risk R&D in a more competitive environment.[8] Since the benefits of energy R&D are usually reaped many years after initial investments are made and since those benefits usually cannot be excluded from others, profit-seeking firms in competitive markets often have few incentives to make such R&D investments. Yet the private sector, when given appropriate policy incentives, can play a major role in the provision of public goods. While policy-makers offer some incentives for firms to invest in new technologies (e.g., via a research and experimentation tax credit), these signals have not succeeded in reversing the long-term trend in private energy R&D investment or spurring major new investments in gap technology areas. In the U.S., for that matter, unresolved uncertainties with regard to energy and environmental regulation have sometimes provided potent R&D disincentives, by prompting firms to adopt a "wait and see" approach to investment in new technologies.[9] Considering the major changes in the relationship between the public and private sectors that have occurred in recent decades, a reaffirmation of the importance of both public and private sector roles in the provision of public goods will be essential to effective climate change policy.

Considering its role as a provider of public goods, however, government is uniquely situated to address the need for re-invigorated and sustained investment in energy R&D in general. Historically, government has been the principal sponsor of long-term research in technology areas holding both the greatest breakthrough potential and the greatest financial risk; conversely, the private sector has supported shorter-term R&D projects closer to the marketplace. Yet, designing the institutional mechanisms to support long-term energy R&D in response to climate change is, in itself, a major innovation challenge, especially in an era of deregulation. The established boundaries between private and public sector roles have grown more permeable and are likely to evolve further as both the need and resources available for energy R&D change.

In the public sector, R&D budgets and research programs often ebb and flow with each fiscal year and political season, sometimes independent of their scientific and societal merits. Thus, the development of new public sector energy R&D support mechanisms capable of (1) articulating energy technology needs with respect to climate change, (2) generating financial support for key programs over the long term (50+ years), and (3) moving new technologies from the laboratory bench to wide deployment in the field is among the greatest public goods challenges governments face.

This paper addresses this energy R&D investment challenge by discussing a variety of existing public support mechanisms currently in use to support research activities in a number of industries and economic sectors. This initial cataloguing is a first order analysis of institutional designs that might be used as a foundation for energy R&D support in the future. The paper

[7] See Susan Strange, *The Retreat of the State: The Diffusion of Power in the World Economy* (Cambridge: Cambridge University Press, 1996), 3-16. See also Cullen Murphy, "Feudal Gestures," *The Atlantic Monthly* (October 2003), 135-137.
[8] See President's Committee of Advisors on Science and Technology, *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation* (Washington, DC: The White House, 1999), ch. 2.
[9] See Robert M. Margolis and Daniel M. Kammen, "The Energy Technology and R&D Policy Challenge," *Science* (July 30, 1999), 690-692.

discusses advantages and shortcomings of each model on the basis of observations of its performance to date. The paper's concluding section offers thoughts on the applicability of existing public sector mechanisms to a long-term energy R&D program to mitigate climate change, and discusses modifications or alternative institutional structures that could address problems with existing models.

III. Public Support Mechanisms for Energy R&D

This section examines three fundamentally different approaches the Federal government can take to funding energy R&D: (1) direct federal funding through the Federal budget and appropriations process; (2) regulatory mechanisms, such as wires and pipe charges; and (3) tax incentives, similar to the existing R&E tax credit. Whatever approach policy-makers choose at the Federal level, they will have to grapple with four overarching questions:

- What is the revenue source? The program can be funded from the Treasury, either out of general revenues or from a dedicated tax. Alternatively, it can come from corporate treasuries, either incentivized by a tax credit or compelled by a regulatory requirement.

- How are the revenues disbursed? Disbursements for the program can be provided under the Federal appropriations process (either under annual appropriations or under a mechanism that permits longer-term funding decisions). Alternatively, disbursements can be made entirely outside the Federal budget and appropriations process.

- Who decides what R&D gets funded? As important as where the funding comes from are the questions of who decides which projects are funded and under what criteria. Current Federally-funded R&D leaves these decisions largely in the hands of government decision makers. Once established by law, tax incentives leave these choices in private hands. The regulatory mechanisms we discuss have a range of options for dealing with this question.

- What control does Congress retain? Any approach that entails Federal legislative or regulatory action to fund energy R&D necessarily entails Congressional oversight of the program and ultimate Congressional authority to modify or halt it. A key question in the design of a dedicated R&D funding mechanism is how to put the program on a long-term research path with consistency in funding and research direction, while at the same time assuring Congress that program priorities and management will remain consistent with national objectives. This is a key question because a long-term technology development strategy requires adequate and consistent funding over a significant time period, in contrast to the boom and bust cycles that often characterize congressional support for such activities.

The discussion below reviews alternative funding mechanisms in light of these four questions. As we note below, different mechanisms may be appropriate for different sectors of the energy economy.

A. Direct Federal Funding

The first funding mechanism we review is direct Federal funding – that is, funding the R&D program directly out of the Federal treasury. Under the Constitution, any disbursement by the Executive Branch from the Treasury first requires an appropriation by Congress.[10] The Congressional Budget Control and Impoundment Act of 1974 ("Congressional Budget Act")[11], as well as the parliamentary practices of the House and Senate, overlay this constitutional requirement with a complex set of rules that has important implications for the design of a long-term energy R&D program. The program must either comply with these rules, if it relies on direct Federal funding, or draw on non-government funding sources. The key requirements of the Federal budget and appropriations process are summarized below:

- Division of labor: The rules of the House and Senate prohibit authorizing committees (such as the House Science and Senate Energy Committees) from reporting appropriations measures to their respective houses and prohibit the appropriations committees from reporting authorizing legislation. In addition, the House and Senate Budget Committees set spending and budget authority ceilings for the Appropriations Committees, and give direction to the authorizing committees on revenue and spending measures within their jurisdictions.

- Authorization Requirement: Under House and Senate rules, appropriations may be made only for purposes authorized by law. Absent a waiver, the appropriations committees cannot appropriate funds for an R&D program unless legislation authorizing the program has already been enacted.

- Timing: Appropriations generally cover a single fiscal year, although appropriations can be made available until expended. On occasion, appropriators will permit advance appropriations, *i.e.*, appropriations that are to become available to be used in a later fiscal year. (See discussion below.)

- Limitations on agency commitments. The Anti-deficiency Act[12] prohibits Federal agencies not only from spending Federal funds not appropriated by Congress, but also from entering into any contracts the disbursements for which have not already been appropriated. However, there have been frequent statutory exceptions to this contracting limitation. Both authorizing and appropriations legislation can permit agencies to enter into contracts in advance of appropriations, subject to specific dollar limitations. At present, the Congressional Budget Act has enacted House and Senate rules that preclude authorizing committees from reporting such exceptions.

- Budget ceilings, Pay-go, and scoring. The Congressional Budget Act provides that each year the Congress will set overall fiscal policy by enacting a Budget Resolution which provides the committees of Congress with their individual "budgets" to spend – these are

[10] U.S. Const. art. I § 9, cl. 7.
[11] Pub. L. No. 93-344 (codified as amended in scattered sections of the U.S. Code)
[12] 16 Stat. 251, 16th Cong. (July 12, 1870) (as amended) (codified at 31 U.S.C. §§ 1341, 1342, 1349-1351, 1511-1519).

> called 302 (a) allocations, after the section of the Congressional Budget Act that requires them to be made. In addition, the appropriations committees are required to subdivide their 302 (a) allocations among their subcommittees. These are called the 302 (b) allocations. The Congressional Budget Act also provides that the Budget Resolution may require Congress to enact a so-called Reconciliation Bill to change permanent law (such as entitlements, or existing taxes or fees) with extraordinary procedural advantages in the Senate (it requires only a majority vote to pass, thus it cannot be filibustered). To implement the Congressional budget process, Congress also created the Congressional scorekeeping system. The first thing to note about the Congressional scorekeeping system is that it is designed to control congressional action – and not to control whatever Executive discretion might be available under existing law. Second, the congressional scorekeeping system uses the Congressional Budget Office (CBO) as the analyst, but defers to both Budget Committees for final scoring decisions. Finally, certain procedural safeguards were adopted – such as "Paygo" – that require that any losses in tax receipts, or increases in entitlement spending, would be "paid for" by corresponding increases in tax receipts or cuts in spending.[13]

The cumulative effect of these rules is to impede the practical ability of either Congress or the executive branch to provide stable long-term funding for energy R&D funded through the annual appropriations process. The Office of Management and Budget (OMB), the authorizing committees, and the appropriations committees have an annual opportunity to modify funding amounts or redirect the R&D programs. This opportunity maximizes OMB and committee control of the program, but it also reduces certainty, and complicates long-term planning.[14] The lack of certainty in the energy R&D funding makes it extremely difficult to address a century scale problem like climate change. There are, however, several alternatives to annual appropriations that can permit funding to proceed on a more certain basis. These options are described below.

A.1. Appropriations from General Revenues

a. <u>Annual appropriations.</u>

As outlined above, most Federal appropriations are made on a year-to-year basis and they fund programs during the fiscal year for which the appropriation is made. This is the way much of the current Federal energy R&D is currently funded. Under an annual appropriations process, agencies can enter into multi-year obligations, but only up to the amount of the appropriation for the fiscal year in which the contract is entered into. (Thus, an agency that has an appropriation of $20 million can enter into a 20-year contract under which it could obligate this $20 million in the first fiscal year, even if it disbursed only $1 million each year.)

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[13] The House-Senate conference agreement on the 2004 budget would extend the pay-go requirements to 2008. <u>See</u> http://www.house.gov./budget/04confagrmntleg.pdf.

[14] The Superconducting Super Collider, for example, had about 5 years of appropriations that had provided more than $2 billion when it was canceled in 1993. Once canceled, close-out costs added another $640 million. <u>See</u> Making Appropriations for Energy and Water Development for Fiscal Year Beginning September 30, 1994, and for Other Purposes, H.R. 2445, (Jan. 5, 1993), at p. 15.

b. Advance appropriations.

Another option for energy R&D funding is through advance appropriations – that is, the appropriations act for a specific year will contain an appropriation not only for the year in question, but specific amounts for future fiscal years. For example, in 1987, the Executive Branch requested that Congress provide the Clean Coal Technology program with a $350 million appropriation in fiscal year 1988 and advanced appropriations of $500 million for each of fiscal years 1989 through 1992.[15] Note that the appropriations committees are generally reluctant to provide advance appropriations because they would provide favorable treatment to certain programs over others, and constrain the committees' options when the time came to balance their funding priorities in future years. Where they are used, advance appropriations can provide a modest level of certainty of funding for an R&D program beyond what is available from annual appropriations. But it should be noted that Congress retains the ability to rescind any unobligated advance appropriations. This authority adds an element of uncertainty even to advance appropriations.

c. Lump-Sum Appropriations

Usually, Congress appropriates in any given year funds sufficient to cover the obligations required by a particular program in that fiscal year. Also, some agency practices require major projects be "fully-funded" up front, i.e., that the entire cost of a particular system acquisition be appropriated in the first year, to provide full information to decision-makers before embarking on a major decision, as well as to provide some assurance that the program won't be abandoned on the way to its completion.

A "lump-sum appropriation" differs from an "advance appropriation", even if the same total amount of funding is provided, because under "lump sum" all of the money would be available, and scored, in the year it was enacted, rather than being spread out over a number of years, and not available until that particular fiscal year started.
For example, the original Clean Coal Technology appropriation was made in 1984 in the form of a lump sump appropriation.[16] Congress appropriated money to the Clean Coal Technology Reserve from balances available to the Synfuels Corporation, which received nearly $19 billion in (lump sum) appropriations in 1980.

Lump sum appropriations would provide much more stability than advance appropriations, but they, too, would be vulnerable to being mined for funding other programs or for earmarks. For example, any unobligated funds that were expected to be carried over into a future fiscal year would be vulnerable to legislative diversion in that year's appropriations bill. This would only require that the committee approve language in the new appropriations bill terminating the old use of the money and replace it with a new use**.**

[15] The Appropriations Committees did not accede to this approach. Congress ultimately adopted an approach that relied on annual appropriations; it appropriated $190 million for fiscal year 1988 until expended, $135 million for fiscal year 1989 until expended, and $200 million for fiscal year 1990 until expended. See Pub. L. 100-446, 102 Stat. 1774, 100th Cong. (1988) (modifying Pub. L. 100-202, 101 Stat. 1329-1, 100th Cong. (1987).

[16] See Joint Resolution Making Continuing Appropriation for Fiscal Year 1985 and Other Purposes, Pub. L. 98-473, Tit. I.

A.2. Appropriations from dedicated revenue sources

A significant part of the Federal budget is funded from dedicated revenue sources, such as user taxes or user fees. Familiar examples include the taxes that support the Highway Trust Fund and the Airport and Airways Trust Fund, as well as the fee that supports the Nuclear Waste Fund. These could be attractive Federal funding options for energy R&D if (i) a politically acceptable revenue source can be found, and (ii) Congress sets up the program in a way that ensures that funds collected are actually disbursed for the program. Both issues are discussed below:

a. Potential revenue sources

(i) Dedicated taxes

Most dedicated taxes are "user taxes," imposed in an amount fixed by statute. User taxes are imposed on the businesses or individuals that will benefit from the program financed by the tax or, alternatively, on the businesses or individuals whose "use" of a resource gives rise to the problem that program is designed to address. For example, highway users pay gasoline taxes, the revenue from which is dedicated to transportation improvements. Under the user tax rationale, a tax for financing energy R&D would be imposed directly or indirectly on energy companies and/or energy consumers. Options for such a tax could include:

- A BTU tax, levied on the BTU content of fuel.
- An *ad valorem* tax, based on the wholesale or retail sale price of the fuel.
- A carbon tax, based on the carbon content of fuel.
- An oil import tax, which is imposed on imported crude oil and/or refined petroleum products.

The recent history of attempts to impose new energy taxes indicates that any substantial tax is likely to meet stiff resistance in Congress unless – like the gasoline taxes dedicated to highway improvement – those on whom the tax is imposed perceive that they will enjoy substantial individualized benefits from the program the tax finances. For example, even at the height of the energy crisis of the 1970s, Congress refused to enact energy taxes proposed by President Carter.[17] The 1993 BTU tax proposed by President Clinton suffered a similar fate.[18]

(ii) User fees

An alternative to dedicated taxes is an "R&D" fee that is authorized by statute and set by the administering agency in an amount that is designed to recover the anticipated costs of the R&D program. This option would be similar to user fees set by agencies like FERC and the NRC to

[17] In 1977, President Carter proposed an omnibus energy program incorporating various taxes on crude oil, "gas-guzzler" cars, and business and industrial users of oil and natural gas. See President James E. Carter, National Energy Plan (April 29, 1977). The tax elements of the Carter plan were not enacted into law. See Congressional Quarterly, Energy Policy 87-A (April 1979).
[18] See Congressional Quarterly, Congressional Quarterly Almanac 1993 107-9 (1993).

recover the cost of the regulatory programs they administer.[19] As described in greater detail below, this approach has significant advantages under the Congressional budget process because it gives appropriators little incentive to reduce funding for the R&D program in order to divert receipts to other uses.

A.3. Disbursement Mechanisms

As noted above, for dedicated taxes or fees to be a workable revenue source, Congress needs not only to provide for the collection of the tax or fee, it must also ensure that amounts collected are actually made available for program purposes. The disbursement mechanisms described below achieve this end with varying degrees of success.

a. Nuclear Waste Fund Model.

The simplest, most common, and least satisfactory disbursement mechanism for a dedicated tax is a trust fund, the disbursements from which are made pursuant to annual appropriations. In theory, the proceeds of the dedicated tax or fee are available only for the statutorily-prescribed purposes (e.g., nuclear waste disposal under the Nuclear Waste Fund[20]) and remain in the Treasury until expended. However, because these revenues are scored as part of the general revenue base of the Federal government, when they are appropriated from the Treasury they count as spending, as if they had come from the General Fund. Thus, if appropriators appropriate less than the entire proceeds of the dedicated tax or fee, the shortfall is available for other purposes. The net result (as the nuclear power industry found with the Nuclear Waste Fund) can be chronic underfunding of the program.

b. Highway Trust Fund model.

A more useful alternative to the Nuclear Waste Fund model is the mechanism used in the Highway Trust Fund.[21] Under the latter, the Federal Highway Administration (FHA) is authorized each year to obligate the estimated receipts into the Trust Fund, subject only to limitations that may be imposed by the Appropriations Committees in that year's Appropriations Act. By obligating the funds, the FHA commits the Federal Government by contract to pay its share of the program. Any appropriations made to liquidate these obligations are not scored in the year in which they are made, since they are only "liquidating" debts that had been legally permitted in an earlier statute. (In this case, the earlier statute is the 5-year highway legislation, which, under budget scorekeeping procedures had been deemed to have provided the required budget authority.)

The Highway Trust Fund is a useful model for purposes of funding energy R&D because it establishes a dedicated funding source that the administering agency can draw down by contract unless constrained by the Appropriations Committees. Until 1998 when the Transportation

[19] See 42 U.S.C. §7178 (authorizing FERC to collect fees in any fiscal year in amounts equal to all of the costs incurred by the Commission in that fiscal year); 42 U.S.C. §2213 (authorizing the NRC to collect charges from its licensees in any fiscal year up to an amount equal to 33 percent of the costs incurred by the NRC in that fiscal year).
[20] See 42 U.S.C. §10222 (2003).
[21] The Highway Trust Fund is set forth in the Internal Revenue Code at 26 U.S.C. §9503 (2003).

Equity Act for the 21st Century (TEA 21)[22] was enacted into law, the Appropriations Committees were able to cut spending authorized under the highway legislation to free up room to fund earmarks as well as to provide room to fund other appropriations. The ability to use highway money to fund other appropriations was shut down by provisions of TEA 21 that create so-called "budgetary firewalls" enforced by procedural points of order against any bill that causes funding to fall below the levels provided in TEA 21.[23] In effect, this made it impossible to accrue savings that could be used for other bills by cutting highway funding. These scoring rules thus prevent the Appropriations committees from constraining highway spending to levels below receipts in order to use the shortfalls for other purposes. However, the Appropriations committees still retain the ability to earmark funds available under the program for particular projects.[24]

c. User Fee Model

A third approach is a variant of the statutory user fees that certain agencies (such as FERC and the NRC) have statutory authority to assess. Under these programs, the agency receives an annual appropriation to cover its operations. It is authorized to assess entities it regulates user fees to recover the amount so appropriated. Appropriators cannot free up spending authority for other purposes by holding program appropriations below receipts (since the agency cannot recover in fees more than the amount appropriated). Importantly, when such a fee is enacted, the fee – as well as any latter appropriations made pursuant to it – is scored as creating zero budget authority, since whatever was "spent" would be "paid for" under the "Paygo" rules.

The user fee model could be used to fund an energy R&D program. An annual appropriation would be provided (and scored as zero by OMB and CBO), and the administering agency would assess a "research fee" to recover the amount of the appropriation. (The particular fee could be levied on the same base as any of the taxes described above, i.e., it could be a BTU fee, a carbon fee, etc.) This approach, because it is self-financing and links revenues to expenditures, does not provide appropriators with an incentive to constrain spending in order to comply with scoring rules. However, it does not insulate the program from the appropriations process. There is no necessary assurance of year-to-year stability in funding.

B Regulatory Mechanisms

Direct Federal funding and tax incentives (which are discussed below) use the Federal treasury, directly or indirectly, to finance an energy R&D program. Regulatory mechanisms, such as wires and pipes charges, use favorable regulatory treatment or a regulatory mandate to fund the program outside of the Federal budget process.

These regulatory mechanisms are not scored under the Congressional budget process because the budget scorekeeping system is set up to track Congressional spending and tax activity, not

[22] Pub. L. 105-178 (June 9, 1998).
[23] See id., §8101(e).
[24] See, e.g., Department of Transportation and Related Agencies Appropriations Act of 2002 (Enrolled as Agreed to or Passed by both the House and the Senate), H.R. 2299 (earmarking Highway Trust Funds for 72 specifically-named transportation projects listed in alphabetical order – ranging from "$10,296,000 for Alaska or Hawaii ferry projects" to "$400,000 for the Yosemite, CA area regional transportation system project").

regulatory mandates. Congressional action that gives an agency the power to compel regulatory surcharges is not within the scope of the Congressional Budget Act, so long as the funds do not enter or exit the US Treasury.

B.1. Regulatory Incentives

Federal and state regulators since the early 1970's have sought to encourage energy R&D efforts of companies they regulate by permitting energy R&D costs to be passed through to utilities' customers as an operating expense. Much of the current funding for the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) is facilitated by these policies.

Electric utilities founded EPRI in 1973 as an alternative to the proposed establishment of a government trust fund for energy R&D, which would have been financed by a tax on electricity. Over time, support for EPRI – though entirely voluntary – became an industry-wide effort. Funding peaked just above $600 million in 1994. Public utility commissions generally have allowed utilities to pass through all or a part of their EPRI member dues to their customers. This has been a key element of EPRI's support.

GTI's predecessor, the Gas Research Institute (GRI), was founded in 1976 and relied on contributions from firms in the gas industry. Until the 1990s, FERC adopted a somewhat different pass-through policy with regard to GRI funding. Instead of requiring each interstate pipeline to apply for approval of its GRI dues, the Commission allowed GRI to submit its R&D plan and budget along with a single application on behalf of all pipelines. Before the early 1990s, nearly all interstate pipelines belonged to GRI, so FERC-approval of the GRI budget had the character of a mandatory surcharge on pipeline customers.

Restructuring of the gas and electric industries since the mid-1980s has resulted in structural changes in those industries that have made the sales pass-through mechanism infeasible. Gas pipelines are largely out of the gas commodity sales business and wholesale natural gas prices are largely deregulated, wholesale electric cost-of-service regulation has been replaced by competitive markets, and in about half of the states some form of retail electric competition exists.

B.2. Regulatory Mandates

Rather than rely on regulatory incentives to elicit the funding necessary to finance an energy R&D program, Congress could provide for funding through one of the wires and pipe charge, "check-off", or similar regulatory mechanisms discussed in this section. These mechanisms have the advantages of providing a revenue stream that is outside the Federal budget process. However, they present separate legal and political issues that would need to be addressed.

a. <u>Wires and Pipe Charges</u>

The funding mechanisms developed in the 1970s for EPRI and GTI's predecessor, GRI, relied on the pass-through in gas and electric sales rates of voluntary contributions by utilities and pipelines to EPRI and GRI. But, as noted above, restructuring of the gas and electric industries has made the sales pass-through mechanism unworkable. Where gas or electric prices (either at wholesale or retail) are competitively determined, authority to pass through R&D expenses does not ensure these expenses will be in fact recovered. As a result, utilities and regulators have developed as an alternative "wires charges" that recover these costs in electric transmission or distribution rates, or "pipe charges" that recover them in gas transportation rates.

Until the mid-1990s, these charges were largely voluntary – that is, the company that provides the transmission or distribution service decided whether or not to try to include R&D costs in rates. Competitive pressures, particularly in the gas pipeline industry, as well as customer resistance, limit the extent to which companies are able or willing to pass through R&D costs to customers. However, in the context of electricity restructuring, some states, such as California and New York, have mandated surcharges collected by distribution utilities from retail customers. The revenues are used to fund energy R&D and other programs.[25]

Wires and pipe charges set by regulators or Congress can provide a long-term stable source of funding for energy R&D. For example, a $5 billion per year program recovered equally in gas and electric transmission surcharges would require about a 0.7 mill surcharge on electric transmission rates and 10¢/MMBTU surcharge on gas transmission rates. Such charges, if mandated, would be competitively neutral within the gas and electric industries, and would not be large enough to have any effect on inter-fuel competition between gas and electricity. Similar charges could be added to oil pipeline rates.

These surcharges present some design issues. First, wires and pipe charges miss a portion of petroleum use. Some petroleum never sees a pipeline. If all end-use energy consumption were to be assessed a surcharge, the petroleum component would need to be collected as a refiner and importer charge rather than a pipeline charge. Second, allocation of the surcharge among energy sources would need to be addressed (alternative bases for allocation are BTU, ad valorem, carbon). Third, policy-makers would need to address whether these surcharges to be assessed at the distribution level – on end-users – or upstream at the transmission level. Because current Federal regulation leaves retail rates and local distribution largely in State hands, a Federal distribution charge could engender opposition from State regulators. Transmission charges, on the other hand, have their own complications. Gas and oil used in power generation would have to be exempted from the surcharge in order to avoid double charging electric users. Similar adjustments would need to be made to avoid "pancaking" – multiple surcharges imposed on transmission by successive utilities or pipelines.

In addition to these design questions, mandated wire and pipe charges would require a more fundamental issue to be addressed – who receives the revenues and decides how they are disbursed? If Congress were to adopt a mandatory wires and pipe charge program, it is unlikely

[25] California Assembly Bill AB 1890 (1996) – in addition to deregulating the state's electricity industry – mandated the collection of $540 million from existing investor-owned utility rate-payers from 1998-2002 to support renewable energy technologies. Legislation passed in 2002 updated the California program. See SB 1038 (2002), available at http://www.energy.ca.gov/renewables/index.html. The New York State Energy Research and Development Agency (NYSERDA) was established by law in 1975 as a public benefit corporation for funding research into energy supply and efficiency, as well as energy-related environmental issues. NYSERDA derives its basic research revenues from an assessment on intrastate sales of New York's investor-owned electric and gas utilities, federal grants, and voluntary annual contributions by the New York Power Authority and the Long Island Power Authority. Additional money comes from limited corporate funds. See http://www.nyserda.org.

that it would direct that the proceeds be turned over to the existing private non-profit institutions that currently receive most gas and electric industry funding, EPRI and GTI. Rather, Congress would likely create new institutional arrangements for disbursing the revenues raised in the program. Candidates include:

(1) A Federal agency, such as DOE (which is responsible for the direction of much current Federal energy R&D).
(2) State agencies under an allocation formula. Currently, a number of state agencies such as the California Energy Commission and the New York State Energy Research and Development Administration run energy R&D programs.
(3) A government corporation, such as the 1980s Synthetic Fuels Corporation.
(4) A Federal-State joint board, modeled on the Federal-State Joint Board that sets policy for the Universal Service Fund under the Telecommunications Act of 1996.[26]

Those institutional arrangements would have important consequences for the efficacy of the energy R&D program. The state allocation option could result in a severely balkanized program with little direction or focus. A program administered by a Federal agency could replicate many of the challenges inherent in Federal energy R&D. Government corporations raise similar issues. Joint boards could present a more workable alternative.

b. Check-off

A variant of wires and pipe charges would be a "check off" program under which Congress would direct FERC by statute to impose wires and pipe charges on industry participants agreed to by referendum (subject to an upper limit on the amount). Other examples of surcharges authorized by statute include the "union shop" check-off approved under U.S. labor laws[27] and the various commodity boards established under the nation's agricultural laws.[28]
In 2002, the American Gas Association (AGA) proposed a check-off concept for gas research. Under the proposal, Congress by statute would set up a program that would provide for a referendum within the gas distribution industry on an R&D fee. The fee, which would equal 1 cent/Mcf, would become mandatory for all firm customers if an R&D funding plan were ratified by a 2/3 majority of interested parties. All local distribution companies then would collect the fee, which would correspond to approximately $1 per year per residential customer. For large-volume users, the fee would be capped at $250 per year. The AGA proposed that the R&D program would be administered by a board of directors made up of local distribution companies

[26] See 47 C.F.R. part 54 (2003).
[27] The "Taft-Hartley Act", codified at 29 U.S.C. §158(a)(3), allows an employer and a union to enter into an agreement under which a financial contribution to the union as a condition of employment. Such agreements often take the form of a dues check-off on paychecks.
[28] U.S. agricultural laws authorize the establishment of "commodity boards" for various agricultural products ranging from cotton to peanuts. The authorizing statutes allow the boards to impose a mandatory assessment on producers with the funds to be used for collective marketing efforts, as well as research and development. See, for example, "The Mushroom Promotion Research, and Consumer Information Act," 104 Stat. 3854, 7 U.S.C. §6101 *et seq*. The Act authorizes the Secretary of Agriculture to appoint a Mushroom Council. To fund its programs, the Act allows the Council to impose mandatory assessments upon handlers of fresh mushrooms in an amount not to exceed one cent per pound of mushrooms produced or imported. The assessments can be used for "projects of mushroom promotion, research, consumer information, and industry information." Id. §6104(c)(4). Most monies raised by the assessments are spent for generic advertising to promote mushroom sales.

and industry experts, with input from state regulators and oversight by the Department of Energy. See "NARUC Endorses R&D Funding Partnership for Natural Gas Distributors to Succeed GRI Funding Mechanism," Foster Natural Gas Report (March 7, 2002). This could be a model for a more general funding mechanism.

C. Tax Incentives

The Internal Revenue Code ("Code" or "IRC") provides two types of tax incentives for research and development. First, section 41 of the Code provides a "research and experimentation tax credit" ("R&E credit"). Second, section 174 of the Code allows taxpayers to expense certain qualified research costs. As discussed above, the congressional budget scorekeeping system requires that new tax incentives be "paid for" by closing "loopholes" or increasing other taxes, unless they are accommodated in that fiscal year's Budget Resolution.

C.1. Research and Experimentation Tax Credit

Section 41 of the Code allows a firm to claim a credit against its federal income tax liability for a portion of its increased expenditures on certain kinds of research and development. The R&E credit generally equals 20 percent of the amount by which a firm's research expenses for a taxable year exceeds its historical level of such expenses. Accordingly, the credit lowers a firm's cost of every additional dollar spent on R&D beyond the firm's base amount. Since its introduction in 1981, the R&E credit has been a temporary provision of the Code. Congress has extended it eleven times, and modified the credit on almost as many occasions. Only certain kinds of research are considered "qualified research." In general, "qualified research" must be: (1) undertaken for the purpose of discovering information that is technological in nature; (2) application of the research must be intended to be useful in a new or improved business component of the firm; and (3) consist of activities that constitute elements of a process of experimentation.

Only certain types of qualified research expenditures may be credited. These include wages and salaries of employees undertaking qualifying research, the cost of materials and supplies used in research, 75 percent of payment for qualified research conducted under contract by nonprofit scientific research organizations, and 65 percent of payments for research conducted under contract by certain other organizations. No credit is available for overhead expenses, the cost of structures and equipment used in qualified research, or any expenditures outside the United States.

To promote collaboration between the private sector and universities on research with broad public benefits, section 41 provides a similar 20 percent credit for increases in payments under contract for "basic research." The definition of "basic research" excludes research that has a specific business objective. To qualify, the taxpayer must make its payments to "eligible" organizations, which consist of educational institutions, non-profit scientific research organizations that are not private foundations, and certain grant-giving organizations. Basic research" must be implemented through eligible organizations; "in-house" basic research is not credited.

The R&E credit in its present form has a number of features that limit its general effectiveness as an R&D incentive and its specific effectiveness as an incentive for energy R&D.[29] First, the temporary character of the provision diminishes the ability of firms or research organizations to rely on the subsidy as an element of long-term planning. Indeed, because the R&E credit requires periodic extensions, it entails uncertainties similar to those inherent in the annual appropriations process. Second, only an entity that pays taxes can make use of the credit. As a result, a firm with little or no taxable income in a particular year cannot take advantage of the credit, even if it made significant payments for research in that year.[30]

Critics further assert that the R&E credit has not kept up with dramatic changes in the R&D business environment in the past few years. Increasingly, research partnerships are taking forms that cannot take advantage of the credit. For example, the credit available for "basic research" is perceived as marginal and the provision has been little used. Some observers assert that the prohibition on credits for research that has a "business objective" unreasonably withholds funding for research performed by industry-university partnerships that, while partially motivated by the business objectives of the industry funders, also has significant public benefits. Such partnerships make up an increasing portion of the R&D landscape.[31]

In addition to addressing the above issues, policy-makers could take a number of steps to enhance the effectiveness of the R&E credit as a financial incentive for energy R&D. For example, Congress could increase the credit available for "qualified research" on energy technologies from 20 percent to 30 or 35 percent. Policy-makers also could adjust the R&E credit to reflect the fact that some of the most promising energy R&D is being done through industry partnerships with research consortia, universities, and federal laboratories. Options include: (1) providing that payments to "qualified research consortia" for energy R&D receive the same treatment as "in-house" payments (*i.e.,* 100 percent of such payments may be considered "qualified research expenditures"); (2) increase the credit available for "basic research" on energy; and (3) allow energy research that has a degree of business motivation to qualify for the "basic research" credit so long as the research has the potential to result in substantial public benefits.

C.2. Expensing of Research and Development Expenditures

The second type of tax incentive for R&D is the expensing of R&D expenditures pursuant to section 174. Section 174 provides that a taxpayer may treat research or experimental expenditures that are paid or incurred by him during the taxable year in connection with his trade or business as expenses that are not chargeable to a capital account. This treatment provides two benefits. First, these payments can be deducted from taxable income. Second, as an expense, all

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[29] See generally Gary Guenther, Congressional Research Service, Research Tax Credit: Policy Issues for the 107th Congress (Nov. 9, 2001).

[30] Not all tax credits are available only to taxpayers with taxable income. For example, the Earned Income Tax Credit is available to an otherwise qualifying taxpayer, regardless of whether the taxpayer reported taxable income in the given year. See 26 U.S.C. §32 (2003).

[31] See Kenneth C. Whang, Fixing the Research Credit, Issues in Science and Technology Online (Winter 1998), available at http://www.nap.edu/issues/15.2/whang.htm.

of the payments for a particular year can be deducted in the year that they are incurred. Capital expenditures, by contrast, must be amortized over time.

The types of research for which payments may be expensed pursuant to section 174 essentially correspond to what constitutes "qualified research" for purposes of the R&E credit under section 41.

The incentive provided by section 174 is characterized by some of the same drawbacks as the R& E credit. For example, only entities that have taxable income can take advantage of the provision. In addition, section 41 is even more limited than the R&E credit in promoting partnerships between industry and universities or research consortia. A taxpayer currently is not entitled to deduct payments for research if the taxpayer does not himself direct or control the research.[32] Also, a requirement that the funding contribute to research that could be exploited in the taxpayer's trade or business implies that payments for "basic research" may not be expensed. Policy-makers could improve section 41 as energy R&D subsidy by relaxing these requirements.

Such modifications to section 174 could be particularly important because, in any given year, many potential industry funders of energy R&D would otherwise not be able to take advantage of the R&E credit, e.g., because (1) they already have reached their "general business credit" cap, or (2) their outlays for R&D (relative to gross receipts) have not increased from the previous year.

IV. Conclusions

Climate change represents a new class of problem in environmental policy, in energy policy, and in international relations. Considering the unprecedented scale and scope of the challenge, effective response strategies must include innovative approaches to the funding of energy R&D and to the design of R&D support mechanisms. Clearly, traditional approaches to energy R&D, including direct government funding and corporate R&D sponsorship, remain necessary parts of the global response to climate change; yet the continuing decline in support from these sources and the historical variance in funding levels and programmatic focus from year to year demands the creation of additional institutions to conduct climate-related energy R&D more intensively and consistently.

Considering the need for new institutions to support climate change-related energy R&D, three key questions must be addressed. (1) What design features might new support mechanisms incorporate to make them resilient and effective sources of new energy technologies over the long term? (2) What funding sources and arrangements could be envisioned to support long-term, climate-related energy R&D? (3) Who would have the authority to make decisions regarding the funding levels and direction of energy R&D as performed in new institutional structures?

Congress would likely need to create new institutional arrangements for disbursing the revenues for the performance of energy R&D addressing climate change. But what might such an

[32] See Research & Dev. II v. Commissioner (1997, CA10) 124 F.3d 1338, 97-2, USTC ¶ 50643, 97 Colo J C A R 1853, 80 AFTR 2d 97-6548.

institution look like and how would decisions be made regarding R&D program support? Candidates include:

(1) A new federal agency.
(2) Existing state agencies, funded under a federal allocation formula. Currently, a number of state agencies, such as the California Energy Commission and the New York State Energy Research and Development Administration, run energy R&D programs.
(3) A government corporation, such as the 1980s Synthetic Fuels Corporation.
(4) A public-private institution, such as FutureGen.
(5) A federal-state joint board, modeled on the Federal-State Joint Board that sets policy for the Universal Service Fund under the Telecommunications Act of 1996.[33]

Whatever institutional architecture may be envisioned in theory to address future energy technology needs, it is already clear that institutions for the performance of energy R&D are now evolving to meet the demands and realities of the changing market and policy environments. In recent years, for example, the role of public-private sector partnerships has grown as a means of leveraging the resources and increasingly scarce funds of both sectors. A noteworthy example is the FutureGen project, a $1 billion government/industry partnership to design, build and operate an emissions-free, coal-fired electric power plant incorporating key "gap technologies" such as hydrogen separation and carbon dioxide capture and storage in deep geologic reservoirs. The 275-megawatt prototype plant will serve as a large-scale public-private engineering laboratory for testing new clean power, CO_2 capture, CO_2 storage technologies along with a broad research program aimed at measurement, monitoring and verification of injected CO_2, and coal-to-hydrogen technologies.[34]

While initiatives such as FutureGen are indicative of ongoing innovation in institutional design and on the great potential of public-private partnerships, it is also important to note that the viability and success of such partnerships are constrained to some extent by statutory limitations and rules regarding federal appropriations. For example, Congressional restrictions on the appropriation of out-of-year funding could heighten perceptions of financial risk to private sector participants in public-private partnerships. History suggests that these perceptions are not entirely unfounded. Changes in the rules and processes governing multi-year appropriations appear necessary if public-private partnerships are expected to play an increasingly prominent role in energy R&D performance in the future.

In an era of deregulation, government and industry each have new roles to play in the provision of key public goods including those that flow from energy R&D. While the growth of public-private partnerships highlights a tacit acknowledgement of these changes, a more explicit dialogue between government and industry on their evolving relationships, responsibilities, and expectations would be a useful first step toward the development of new R&D institutions. A collaborative discussion of the strengths and shortcomings of traditional energy R&D support mechanisms, and of the range of possibilities for new arrangements could make a valuable contribution. Such a discussion would necessarily address the three key questions outlined

[33] See 47 C.F.R. part 54 (2003).
[34] See National Energy Technology Laboratory, "FutureGen" available at http://www.netl.doe.gov/coalpower/sequestration/partnerships/index.html.

earlier in this section—what mechanisms, whose money, who decides—and would be the opening words of an ongoing and evolving discourse. Fostering strong and innovative relationships among the key R&D players in this manner could be as important as the technologies themselves in mitigating climate change.