Introduction: Energy R&D in Decline

For well over a decade, the world has enjoyed a period of cheap and abundant energy supplies. Since the oil shocks of the 1970s, a combination of factors, including technological advances, discoveries of new petroleum resources, improved energy productivity, and the creation of futures markets, has alleviated fears that the energy future would necessarily be characterized by scarcity and high prices. The 1990-91 Persian Gulf War, which caused only a brief price spike on international energy markets, ultimately bolstered optimism concerning the world's improved adeptness at managing energy crises.

Amid the general energy optimism that has persisted since the mid-1980s, government investments in energy research and development (R&D) have declined in many advanced industrial countries. To a great extent, the reduction in government commitments to energy R&D reflects the perception that energy has become a matter of lesser urgency, relative to other social priorities.

At the same time, an ideological shift in the industrialized countries toward the deregulation of key industries, such as electric and gas utilities, has placed additional pressures on R&D investments. With the introduction of competitive forces in the energy industries and the elimination of guaranteed returns, firms' (and in particular energy utilities') R&D investments have grown smaller. Remaining R&D resources gravitate more often to lower risk, market-oriented projects than to riskier projects with more distant payoffs.[1]

Yet, while public and private sector energy R&D investments have declined, a major new energy challenge has appeared on the horizon that will demand significant and sustained commitments to the development of new energy technologies. The challenge of global climate change, and actions aimed at its mitigation, will require a transition to fuels and energy technologies that emit less carbon dioxide and other greenhouse gases—substances whose rising concentrations in the atmosphere are thought to be major contributors to global warming and related climatic changes.[2] Also, the costs associated with the reduction of greenhouse gas emissions will depend on the technologies that become available for deployment in the first decades of the next century. Estimated costs span many orders of magnitude, with even best case scenarios showing costs that range from zero, assuming widely available advanced technologies, to 3% of gross world product using 1990 vintage technologies.[3] The challenge is made greater still by virtue of the fact that global energy use is expected to grow by 75% by 2020 and that most of the new demand will be met with fossil fuels.

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[1] JJ Dooley, "Unintended Consequences: Energy R&D in a Deregulated Market," *Energy Policy* (June 1998).
[2] See Intergovernmental Panel on Climate Change, *IPCC Second Assessment: Climate Change 1995*, p. 13.
[3] Jae Edmonds, James Dooley, and Marshall Wise, "Atmospheric Stabilization: The Role of Energy Technology," in *Climate Change Policy, Risk Prioritization, and US Economic Growth* (Washington, DC: American Council for Capital Formation, June 1997).

In December 1997, official delegations from over 150 countries met in Kyoto, Japan, and signed an international treaty aimed at reducing global emissions of carbon dioxide. Under the Kyoto Protocol, the major industrialized countries agreed to reduce their carbon emissions by 6-8% from their 1990 levels within the period 2008-2012. Yet the Kyoto Protocol has not been ratified by any major signatories and its prospects, in the United States especially, are dim. There are indications that, while governments of industrialized countries now view the climate change issue with increasing seriousness, there is still insufficient urgency surrounding the problem to precipitate major political action and new government commitments to energy R&D.

Is the World Prepared for the Emerging Energy Future?

Considering current trends in energy R&D and emerging energy challenges, how technologically well-prepared is the world to cope? This study was prompted by the identification of a gap between likely future technology needs and the R&D investments in the present necessary to meet those needs. Over the period 1985-1995 the nine large OECD countries that support 95% of the public sector R&D in the industrialized world, reduced their budgets for energy R&D by more than 20% in real terms, on average. Some countries, such as Germany, Italy, and the United Kingdom, cut their budgets by 70% or more over this decade.[4]

Even more important, below the first-order similarities in industrialized countries' declining energy R&D expenditures lies a great diversity in the programmatic foci of national energy R&D investment portfolios. While overall funding levels are certainly important, the composition of countries' R&D portfolios may be at least as significant as determinants of future technology options. This study seeks to identify and explain some of these critical second-order differences across countries.

Case Selection and Data Used in This Study

This report presents research findings from case studies of four countries (the United States, Japan, Germany, and the Netherlands) and the European Union.[5] These countries were selected as the initial cases for this study on the basis of their historic roles as sponsors/performers of energy R&D, and in consideration of the composition of their current energy R&D portfolios. This sample set represents the broader population of OECD sponsors of energy R&D. As some of the world's most important sponsors of

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[4] International Energy Agency, *IEA Energy Technology R&D Statistics: 1974-1995* (Paris: International Energy Agency, 1997).

[5] For the purpose of this study, the European Union is treated as a single unit or "country," since it is a major sponsor of R&D and has its own research programs. Although the funding for research is provided by each of the EU's fifteen Member States, the programs are administered at the Community level by officials of the European Commission in Brussels.

energy R&D, they also illustrate the broad diversity of energy R&D funding strategies among leading industrialized countries.[6]

This analysis was prepared using data obtained directly from country sources and avoiding data from third party sources such as the Paris-based International Energy Agency (IEA). The use of official country source data facilitated more accurate and more detailed analysis of energy R&D trends. The use of country source data also enabled the conversion of all currencies into constant 1995 purchasing power parity (PPP) US dollars. In contrast, most third part data sets are converted to US dollars using market exchange rates (MERs). These currency conversion methods can produce dramatically different results from one another.

As the US National Science Board notes in *Science and Engineering Indicators 1998*, purchasing power parities (PPPs) are preferable to market exchange rates (MER) for converting international R&D financial data into a common currency.[7] At their best, MERs represent the relative value of currencies for goods and services traded across borders, measuring a currency's relative buying power at a given point in time. PPPs take into account the cost differences across countries of buying a similar basket of goods and services in numerous expenditure categories including non-tradables. PPPs are particularly well suited to measuring the value of goods and services that are not internationally traded; thus, they are well suited to converting R&D financial data since the vast majority of all nation's R&D investments are for research carried out within the sponsoring countries' borders. PPPs also tend to be much more stable over time and therefore do not introduce the often large day-to-day and year-to-year fluctuations in MERs, which reduce their statistical usefulness for the purpose of comparing R&D expenditures.

As Figure 1 shows, changes in dollar-denominated R&D expenditures converted with market exchange rates can significantly overestimate the true value of the expenditures. The use of MERs can also introduce wild fluctuations into the data being analyzed that are not present in the original local currency denominated figures. For these and many other reasons, MERs are inappropriate for showing trends in these data and will not be used in this research. PPP calculations result in estimates of R&D expenditures that are considerably closer to countries' actual spending patterns. For example, using purchasing power parities, Japan's public energy R&D expenditures in 1995 are estimated at approximately $2.5 billion; using market exchange rates, however, the total effort will be inaccurately inflated to over $4.5 billion (as reported by the IEA).[8] Consequently, the use of MERs would lead to the incorrect assumption that Japanese public energy R&D expenditure is more than twice that of the U.S. government's energy R&D budget (approximately $2.2 billion), whereas the use of PPPs show both countries' investments to be of roughly equal size.

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[6] In the second phase of this project, the energy R&D programs of Canada, France, Italy, Switzerland, and the United Kingdom will be surveyed.

[7] National Science Board, *Science and Engineering Indicators: 1998* (Washington, DC: U.S. Government Printing Office, 1998), p. 4-36.

[8] See International Energy Agency, *IEA Energy technology R&D Statistics: 1974-1995* (Paris: International Energy Agency 1997).