5. Analysis of Energy R&D Programs

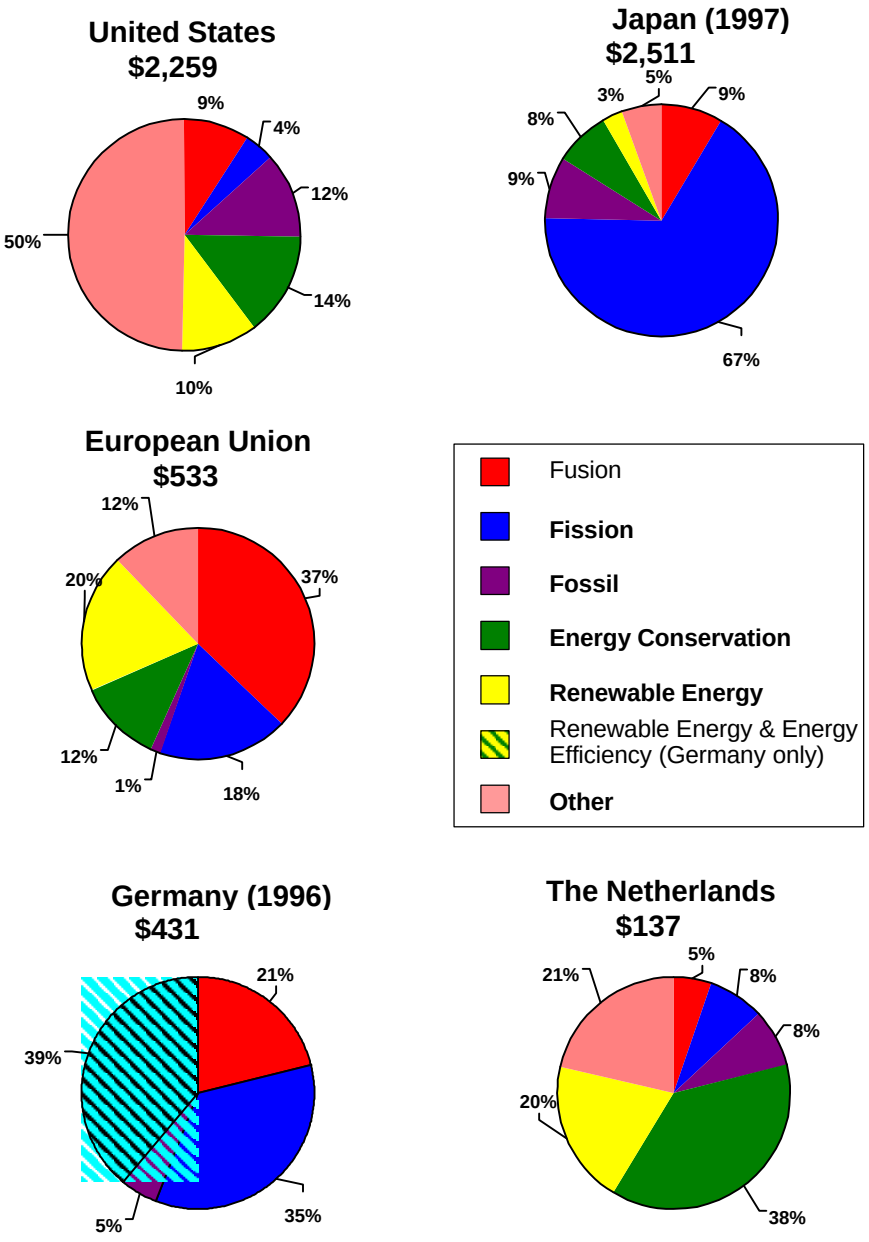
Significant changes are also occurring in the major energy R&D program areas: fossil energy, energy efficiency, renewable energy, and nuclear energy.

Fossil Energy R&D –Fossil energy R&D programs in industrialized countries no longer focus, as they did a decade or more ago, on research to locate and characterize new fossil energy resources and to develop new methods of cheaply extracting these resources. To a large extent, fossil energy R&D programs are also moving away from the development of "clean coal technology" programs designed to improve the efficiency and cleanliness of fossil fuel combustion. The beginning of a potentially significant transition in fossil energy research programs is now discernible, wherein programs are seeking to develop zero carbon dioxide emitting fossil fuel technologies. Amid this transition, technologies that are receiving increasing emphasis include methods to "decarbonize" fossil fuels, programs to develop fuel cells capable of making use of the resulting hydrogen-rich fuel streams, and methods to sequester carbon dioxide. Another noteworthy trend is the expansion of fossil fuel research efforts to investigate the potential for developing new, plentiful, and relatively clean hydrocarbon resources such as methane hydrates and coal bed methane reservoirs. Although these non-conventional fossil energy R&D programs are currently small, their emergence signals an expansion of the concept of fossil fuels and an expectation of the continued viability of fossil fuels, even under greenhouse gas constraints, well into the next century. The Netherlands and Japan, for example, have had long-standing research programs examining the efficacy of new fossil energy technologies such as carbon sequestration. Of the industrialized countries surveyed, Japan is the largest supporter of these advanced fossil energy research programs (e.g., carbon sequestration, methane hydrates).[1]

Renewable Energy R&D – In recent years, the focus of industrialized countries' renewable energy R&D programs has become ever more concentrated in the area of solar photovoltaics. Wind energy technology research also receives significant support although it appears that the primary objective of wind energy R&D programs is on technology deployment and commercialization,

[1] Monastersky, Richard. "The Ice that Burns: Can methane hydrates fuel the 21st century?" Science News. November 14, 1998

Figure 3: Public Sector Energy R&D Portfolios



rather than on the development of new systems and components that would fundamentally improve the efficiency or economics of wind power systems. Interestingly, Japan continues to devote significant resources to renewable energy technology programs that no longer receive funding from other industrialized countries such as wave/ocean power and waste-to-energy systems. Also, the Japanese government funds a relatively large amount of geothermal research given the abundance of geothermally active sites in Japan. Perhaps the most significant trend in renewable energy research is the relatively flat budgets of these programs throughout the course of the 1990s, a decade that saw increasing rhetoric from

national governments pledging to do their best to reduce carbon dioxide emissions through, in part, the increased use of renewable energy systems.

Energy Efficiency –Funding for energy efficiency programs has experienced the most consistent growth of all technology areas. In the United States, for example, public energy efficiency R&D has increased by 53% since 1990. Similarly, while Germany's consolidated energy efficiency and renewable R&D budget has grown only slightly over the past decade, its percentage of the total energy R&D budget has grown since 1985 from 9% to 39%. The Netherlands' efficiency programs have also grown steadily, now accounting for some 38% of the Dutch public energy R&D budget. Industrial energy efficiency programs appear to be receiving preference for R&D funds over buildings or transportation-related energy efficiency programs. This preference for industrial energy efficiency R&D likely reflects both a desire to improve competitiveness and to protect the environment.[2]

Nuclear Energy R&D – The future of nuclear energy and related technologies is in a period of uncertainty in many countries. Many nations are decidedly shifting an ever-larger share of their fission energy R&D programs away from the development of new reactors and components to focus on research activities concerned with the nuclear fuel cycle, waste disposal, and reactor decommissioning. In Germany and the United States, for example, the fission research budgets have fallen in real terms by more than 90% over the past decade. With respect to fusion research, Congress' withdrawal of support for U.S. participation in the International Thermonuclear Experimental Reactor (ITER) project and the change in focus of the domestic program from "fusion energy technology development" to "fusion energy sciences" indicates that the commercial availability of fusion energy is still on the distant horizon.

With regard to future energy R&D scenarios, it is important to note that despite major differences across countries in political culture and choices of policy instruments, countries share an assumption that greater energy efficiency will carry them a significant part of the way toward realizing major carbon emissions reductions in the future. For example in the United States, some have argued that major emissions reductions could be achieved at no cost through the aggressive deployment of new energy efficiency technologies and the creation of an international carbon permit trading regime.[3] This policy trend raises questions about the prospects for future government support for new, advanced energy technology programs that will be needed to stabilize atmospheric CO_2 concentration over the next century.

There is also mounting evidence that the ongoing deregulation of the energy industries in many countries is exerting downward pressure on energy R&D activities, particularly in the private sector.[4] While deregulation often leads to positive outcomes such as lower energy prices and more choice for consumers, the competitive dynamics it introduces also heightens managers' and shareholders' sensitivity to short-term market performance indicators. The pressures on private sector energy firms to reduce costs increasingly compel them to reduce their levels of R&D expenditure and to focus their remaining R&D investments on shorter-term, product-oriented projects. By "privatizing" the governance of the energy industries through deregulation, governments redefine the roles of the public and private sectors in providing energy services to the public. Although privatization may bring higher levels of economic efficiency in the energy

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[2] See Bundesministerium fur Bildung, Wissenschaft, Forschung, und technologie, *4. Programm Energieforschung und Energietechnologien* (Bonn: BMBF, 1997), p. 10; European Commission, EC Research Funding (Luxembourg: Office for Official Publications of the European Communities, 1996), p.15.

[3] Interlaboratory Working Group. 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy –Efficient and Low-Carbon Technologies by 2010 and Beyond* (Berkeley, CA: Lawrence Berkeley National Laboratory and Oak Ridge, TN: Oak Ridge National Laboratory), LBNL-40533 and ORNL-444, September (URL address: http://www.ornl.gov/ORNL/Energy_Eff/CON444), Executive Summary.

[4] Dooley, 1998.

industries, those gains may compromise the ability to take a long view with regard to the energy future and to invest accordingly in energy R&D.

We conclude this overview of trends within the energy R&D programs of the leading energy R&D intensive industrialized nations with the following summary points:

- In stark contrast to overall national R&D (combined public and private sector R&D in all areas) which has flourished over the past decade, national energy R&D efforts have not experienced significant growth over the past decade. In the nations surveyed, the dominant trend has been toward significant reductions in publicly and privately funded energy R&D. For the public sector, energy R&D as a percent of total public sector R&D and as a percent of gross domestic product has also been in decline in all of these nations. Where data are available, it is evident that private sector energy R&D investment is also in decline.
- Budgetary pressures, energy deregulation, and the perceived lack of an "energy crisis" are likely to dampen government energy R&D budgets for the foreseeable future. In the absence of major shifts in the world energy outlook, government energy R&D investments appear unlikely to be restructured and expanded in a way that is optimal for developing the technologies needed in the middle to long term to avoid global climate change.
- The current turmoil in private sector energy R&D programs brought about in large measure by the push to deregulate the energy industries will continue to place downward pressure on private sector investments in longer term energy R&D.
- Public energy R&D is evolving in important ways from the perspective of climate change. Research programs aimed at the development of fuel cells, hydrogen infrastructure technologies, and carbon capture and disposal technologies represent a small but growing percentage of government energy R&D investment.
- There is an increasing gap between governments' aspirations to curb carbon dioxide emissions, as expressed in policy statements, and their funding commitments to energy R&D. Many countries appear to have adopted a *de facto* policy of relying on the further deployment of existing energy efficiency technologies, fuel switching and emissions trading as the primary means of reducing carbon dioxide emissions. While these efforts are important and necessary, they are, in and of themselves, insufficient to address the climate change problem.[5]

Conclusions

The small group of OECD nations that fund the vast majority of the world's energy R&D are defining the world's future energy technology choices. Unless additional countries mount significant efforts to develop energy R&D programs, the energy research currently underway in the OECD will define the energy technology solutions with which the world will be equipped in the next century to address climate change. Considering the long lead times between initial investments in the development of new technologies and the availability of new technologies for commercial deployment, those technologies that exist today and that are already in the R&D "pipeline" are those that will be available over the next few decades to meet global energy challenges. Declining energy R&D budgets in leading industrialized nations bespeak a narrowing range of future technological options.

That said, energy technology programs that could have significant impacts in addressing climate change are starting to emerge. For example, the beginning of a potentially significant transition in fossil energy research programs is now discernible, wherein programs are seeking to develop zero carbon dioxide emitting fossil fuel technologies. Key technologies that are beginning to receive budget preference include methods to "decarbonize" fossil fuels, fuel cells, and methods to dispose of or sequester carbon dioxide wastes. The total amount of resources committed to these technology areas is currently small, however.

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[5] National Laboratory Directors, *Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions* (October 1997), p. xiii.

The observed changes in the makeup of national energy R&D portfolios have major implications for three additional aspects of energy technology development as it relates to efforts to meet the challenge of climate change. Each of these is discussed below.

The scale of the world's energy R&D enterprise is contracting. The challenge posed by climate change demands continuing advancements in energy technologies over the course of the next century. The continuing reductions in the scale of national energy R&D programs and the apparent shift to shorter term research suggests that the world is entering the next century with fewer energy R&D options than would be the case had more robust and sustained energy R&D funding levels been maintained. The drastic reductions that have taken place in key countries such as Germany and the United Kingdom have seriously stunted the research capabilities of these countries to carry out energy supply R&D on a scale that is "commensurate in scope and scale with the challenges and opportunities of the twenty-first century."[6]

Collaborative R&D between and among OECD countries is constrained by shrinking public energy R&D investments. In an era of greater fiscal discipline and shrinking government spending, public-private and international R&D cost sharing is increasingly popular among policy makers in major industrialized countries. The Japanese fast breeder reactor program and the International Thermonuclear Experimental Reactor (ITER) are examples of energy technology areas where international collaboration and cost-sharing have succeeded in sustaining "big science" projects. Yet, in countries such as the U.S., the U.K., and Germany, deep energy R&D budget cuts may be having the opposite effect. As both public and private sector energy R&D budgets contract, pressure often intensifies to focus remaining resources "downstream" on shorter-term, applied research aimed at the development of commercial technologies rather than on longer-term and basic research. The proprietary nature of the downsteam end of the technology innovation process imposes disincentives for international collaboration. Since responding to climate change will require both new energy technologies and international collaboration to that end, the shrinking of government R&D budgets may inflict double damages by precluding both of these.

Collaborative R&D between OECD and developing countries is constrained by shrinking public energy R&D investments. In the absence of a significant change in the current incentive structure and in the scale of OECD countries' energy R&D efforts, it is unlikely that collaborative energy R&D programs involving OECD and developing countries will expand substantially. While the energy technology imperatives of climate change argue in favor of long-term collaboration and capacity-building between OECD and developing countries, the shorter-term imperatives of the market currently appear to be taking precedence.

The challenge is for industrialized countries to do more than deploy existing energy technologies and transfer turnkey energy systems to the developing world. Meaningful response to climate change demands that today's energy R&D performing nations adopt the long view, embarking on efforts to engage major developing countries as partners in the climate change solution. Although shorter-term incentives will tempt OECD countries to regard major developing countries as future markets for energy technology exports, the danger of this approach is that it may contain the seed of its own destruction. Economic, political, and security considerations are likely to prompt developing countries to avoid deepening dependence on imported energy technologies. The alternatives for these countries will be either to continue to grow using current generation energy technologies, or to attain a higher level of technological self-sufficiency. Global environmental well-being argues in favor of efforts to extend the world's energy R&D capabilities by helping developing countries to become significant contributors of energy technology.

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[6] Holdren, John, et. al. 1997. *Federal Energy Research and Development for the Challenges of the Twenty-first Century.* Report of the Energy Research and Development Panel of the President's Committee of Advisors on Science and Technology. September 30, 1997. Washington, D.C.