The Importance of Research and Development (R&D) for U.S. Competitiveness and a Clean Energy Future

Michael Greenstone
3M Professor of Economics, MIT
Director, The Hamilton Project
Senior Fellow, The Brookings Institution

Thank you Chair Maloney, Ranking Member Brownback and members of the Committee for inviting me to testify today. I believe it is critically important that we give greater priority to new and better research and development (R&D) investments, to help ensure our country's future competitiveness and to pave the wave for clean energy innovation.

I am grateful for the opportunity to speak today about two interrelated challenges that our country faces. The first is the stagnation in economic opportunity for many families that dates back at least three decades. The second is the economic, national security, and environmental risks posed by our continued reliance on fossil fuels. The key purpose of my testimony is to discuss how R&D can enable us to begin confronting these dual challenges by creating new jobs for American workers, and fundamentally altering the way we produce and consume energy.

I. CHALLENGE 1: UNITED STATES COMPETITIVENESS

Even before the Great Recession's arrival, there were legitimate concerns about U.S. competitiveness. A recent study by my colleague David Autor, a professor at MIT, highlights the fact that since the 1980s, the American job market has become polarized between high-skilled, high-wage jobs and low-wage, low-skilled jobs. At the lower end of the labor market wages have stagnated or declined. Between 1979 and 2007, real earnings for high school graduates with no further education declined by 12%, and earnings for high school dropouts declined by 16%.[1] During the same period, earnings for those with a college degree or better have increased by 10% to 37%.

At the same time, male labor force participation rates declined between 1979 and 2007 for all education levels, but especially among less-educated men. Employment to population ratios for high school dropouts and graduates declined by 12% and 10% respectively.[2] In many cases, this detachment from the labor force reflects a judgment that individuals cannot earn enough to support their families.

The economic impact of this wage stagnation has been compounded by reduced rates of increases in educational attainment. Thus, at the same time that the market was sending a message about the increased importance of skills, the rate of increase of accumulation of skills

[1] David Autor, "The Polarization of Job Opportunities in the U.S. Labor Market," Hamilton Project and Center for American Progress Joint Paper, April 2010, pp. 3-6.
[2] Autor, 20.

was declining. (Women are an important exception as their college completion rates increased dramatically in this period.)[3]

The troubling trends are also evident in our ability to compete in international markets. Our world market share of exports produced by high technology industries dropped from 20% to 12% between the 1990s and 2005. In contrast, from 1999 to 2005, China's market share has more than doubled from 8% to 19%. Additionally, the U.S. trade balance in advanced technology products shifted from a surplus to a deficit in 2002.[4]

These trends threaten the social fabric of our nation. A defining feature of our history is that each generation of American has enjoyed a higher standard of living and has had access to opportunities that were not available to their parents. This pattern of advancement is under assault. For our political and economic systems to work well, it is vital that all Americans feel that they are able to participate in our nation's economic growth. Indeed, one of The Hamilton Project's (an economic policy group at Brookings that I direct) core principles is that economic growth is stronger and more sustainable when it is broad based.

II. CHALLENGE 2: FOSSIL FUEL DEPENDENCE, ENERGY SECURITY, AND CLIMATE CHANGE

The United States and the world rely on the Persian Gulf countries for petroleum. This region is not always politically stable and can be hostile to our interests. Thus, our need for access to reliable and affordable petroleum constrains our foreign policy objectives, especially our national security ones. This is the essence of our energy security challenge.

At the same time, climate scientists tell us that the warming of the climate is unequivocal, and "very likely" due to increases in greenhouse gas concentrations from burning of fossil fuels, such as petroleum.[5] Indeed without a change in policy, the state of the art climate models predict that the mean global temperature will increase by more than 7 degrees Fahrenheit over the course of this century.[6]

In addition, the models predict a startlingly large increase in the number of very hot days. For example, one model predicts that by the end of the century the typical person in the United States is predicted to experience 31 additional days where the mean daily temperature exceeds 90° F.[7] Currently, the typical person experiences just 1.3 days per year where the mean

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[3] Autor, 25.

[4] National Science Foundation, Chapter 6: Industry, Technology, and the Global Marketplace in *Science and Engineering Indicators 2008* (2008).

[5] Intergovernmental Panel on Climate Change (IPCC). "Climate Change 2007: Synthesis Report, Summary for Policy Makers," (2007). The IPCC defines "very likely" as at least 90% certain.

[6] Congressional Budget Office. "Potential Impacts of Climate Change in the United States," (Pub. No. 3044, May 2009), p. 7

[7] For example, a day with a high of 100° F would need a minimum temperature greater than 80° F to qualify.

exceeds 90° F. To be clear, a day with a mean temperature exceeding 90° F is very hot because the mean daily temperature is calculated as the average of the high and the low.[8]

There are likely to be other changes in climate, including higher sea levels, changes in rainfall patterns, and increased storm intensity. The consequences of climate change for health, economic growth, innovation, and well-being are not well understood, but include quite negative possibilities.[9]

Further, two interrelated factors increase the odds that such dramatic changes in temperature will occur. First, fossil fuels, like coal and petroleum, are the cheapest sources of energy available today. Additionally, there appear to be bountiful supplies of fossil fuels -- meaning that they are likely to remain inexpensive. At our current consumption level, there are more than 245 years worth of proven coal supplies in the United States.[10] There are also large reserves in India and China, where much of the increase in future demand for energy is projected to occur.[11]

The second factor is that a substantial share of the world's population remains very poor. These economies are likely to pursue cheap energy sources as they grow in the coming decades. Indeed, for the leaders of these nations, pulling their citizens out of poverty is a policy priority that exceeds reducing greenhouse gas emissions in importance.

Some basic statistics help to underscore why developing countries will be focused on growth. Today, per capita income is about $46,000 in the United States. In China and India, it is $6,500 and $3,100, respectively.[12] These differences in income have consequential impacts on people's lives. India's infant mortality rate is nearly eight times higher than the U.S. rate. The China infant mortality rate is three times higher than ours.[13]

The bottom line is that for a substantial period of time, developing countries are likely to be focused on increasing their incomes and using the cheapest energy sources available to do so. Without a change in the cost of low carbon fuels, this will mean increased demand for fossil fuels. In fact, the latest reference case projections from the U.S. Energy Information Administration reveals that non-OECD countries will increase their CO_2 emissions from 14.7

[8] Olivier Deschenes and Michael Greenstone. "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the U.S." (MIT Joint Program on the Science and Policy of Global Change, 2007).

[9] Olivier Deschenes and Michael Greenstone. "Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the U.S." (MIT Joint Program on the Science and Policy of Global Change, 2007).

[10] BP, "BP Statistical Review of World Energy," (June 2010).

[11] Due to the peculiarities of how proven reserves are calculated in the energy industry, my expectation is that current estimates of reserves are underestimates of the total reserves of coal and petroleum. In particular, proven reserves are frequently calculated at current prices and thus do not reflect the likely increase in reserves at higher prices.

[12] Central Intelligence Agency, "The World Factbook."

[13] World Health Organization, "World Health Statistics 2010," (2010).

billion metric tons in 2007 to 28.2 billion metric tons in 2035.[14] As a point of comparison, U.S. emissions are projected to increase to 6.3 billion metric tons of CO_2 in 2035 from 6.0 billion metric tons in 2007.

III. WHAT IS THE CONNECTION?

Why are these challenges -- U.S competitiveness and fossil fuel dependence-- connected?

The need to find new sources of energy that do not constrain our foreign policy objectives nor imperil our planet is real and will not go away without significant breakthroughs in energy innovation.

This creates an opportunity for the countries, firms, and workers that can provide a solution. Specifically, the innovators that reduce the cost of low carbon energy sources or otherwise reduce the build-up of greenhouse gas concentrations will be able to sell the technologies and equipment to countries around the world. This will produce new industries and jobs and could be an important part of strengthening future U.S. competitiveness.

The tough question is how to get from here to there.

IV. A NEW AND IMPROVED ENERGY R&D SYSTEM AS A SOLUTION

I believe that the solution lies in undertaking a new program of energy R&D that is narrowly focused on funding research that the private sector will not undertake. Further, such a new R&D program must have higher levels of investment than we have seen in recent years.

A. Why is R&D so Important?

Let me provide some brief background on the historical importance of R&D. It has been apparent for at least a century that future economic progress will be driven by the invention and application of new technologies. R&D is one category of spending that develops and drives these new technologies. However, private sector firms are prone to focus their R&D on "applied" projects, where the payoff to their bottom line is likely to accrue only to them. Their role is not to undertake broad R&D for the general benefit of our nation.

In contrast, government can sponsor the kind of "basic" research projects that seek wide-ranging scientific understanding that can affect entire industries, rather than individual firms. For example, government research funding has been critical to many technologies of everyday importance. Just a few examples would include the development of plant genetics, fiber optics, magnetic resonance imaging, computer-aided design and computer-aided manufacturing (CAD/CAM), data compression technologies that make all manner of electronic devices more

[14] Energy Information Agency, Appendix A: Reference Case Scenario in *International Energy Outlook,* (May 25, 2010), p. 13

powerful, progress toward edible vaccinations, and the "eye chip" that might help 6 million blind Americans see.[15]

From the perspective of U.S. competiveness, many of these government-sponsored technological advances have been instrumental in driving economic growth and raising living standards for American families. They have created new industries and high paying jobs that have benefitted a wide-range of regional, state, and local economies.

B. An Abridged History of the Track Record of U.S. R&D Funding

Two of the most notable vehicles for supporting R&D in the United States are the National Institutes of Health (NIH) and the National Science Foundation (NSF). They both have impressive track records that you may already be familiar with.

The National Institutes of Health is funded at about $30 billion per year through the federal budget. This constitutes around 75% of global spending in basic medical science. The NIH has been instrumental in keeping the United States at the forefront of medical innovation: NIH-funded scientists have won 93 Nobel Prizes, and 15 of the 21 most important new drugs between 1965 and 1992 were developed using NIH-funded research.[16] A key to the NIH's continued success has been its internal funding process—while decisions on the establishments of new NIH Institutes and Centers are subject to outside budgetary approval, decisions on research funding within specific fields are made based on a competitive peer-review process.[17]

Another major U.S. success story in the field of basic research and R&D is the National Science Foundation. The NSF supports basic research in a variety of fields and also awards grants through a competitive peer review process. It had a budget of $6.49 billion in 2009. Basic research funded by the NSF has resulted in the development of a diverse set of technologies that have had significant impacts on both quality of life and economic growth, including American Sign Language, bar codes, Doppler Radar, and web browsers.[18]

The Government Accounting Office (GAO) has found that peer review scores at the NSF and the NIH were unrelated to any measured attributes of reviewers or applicants. This suggests that the quality of the proposal was the most important factor in peer reviewers scoring.[19] It seems reasonable to conclude that high levels of funding for basic research coupled with a competitive grant-allocation process played instrumental roles in the success of their R&D programs.

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[15] National Science Foundation, "NSF History: Nifty Fifty."
[16] Joint Economic Committee (Office of the Chairman, Connie Mack), "The Benefits of Medical Research and the Role of the NIH," (May 2000).
[17] U.K. National Endowment for Science Technology and the Arts, "Technology Policy and Global Warming: Why new policy models are needed," (October 2009), p 13.
[18] National Science Foundation, "NSF History: Nifty Fifty."
[19] General Accounting Office, "Peer Review: Reforms Needed to Ensure Fairness in Federal Agency Grant Selection," (GAO/PEMD-94-1, June 1994).

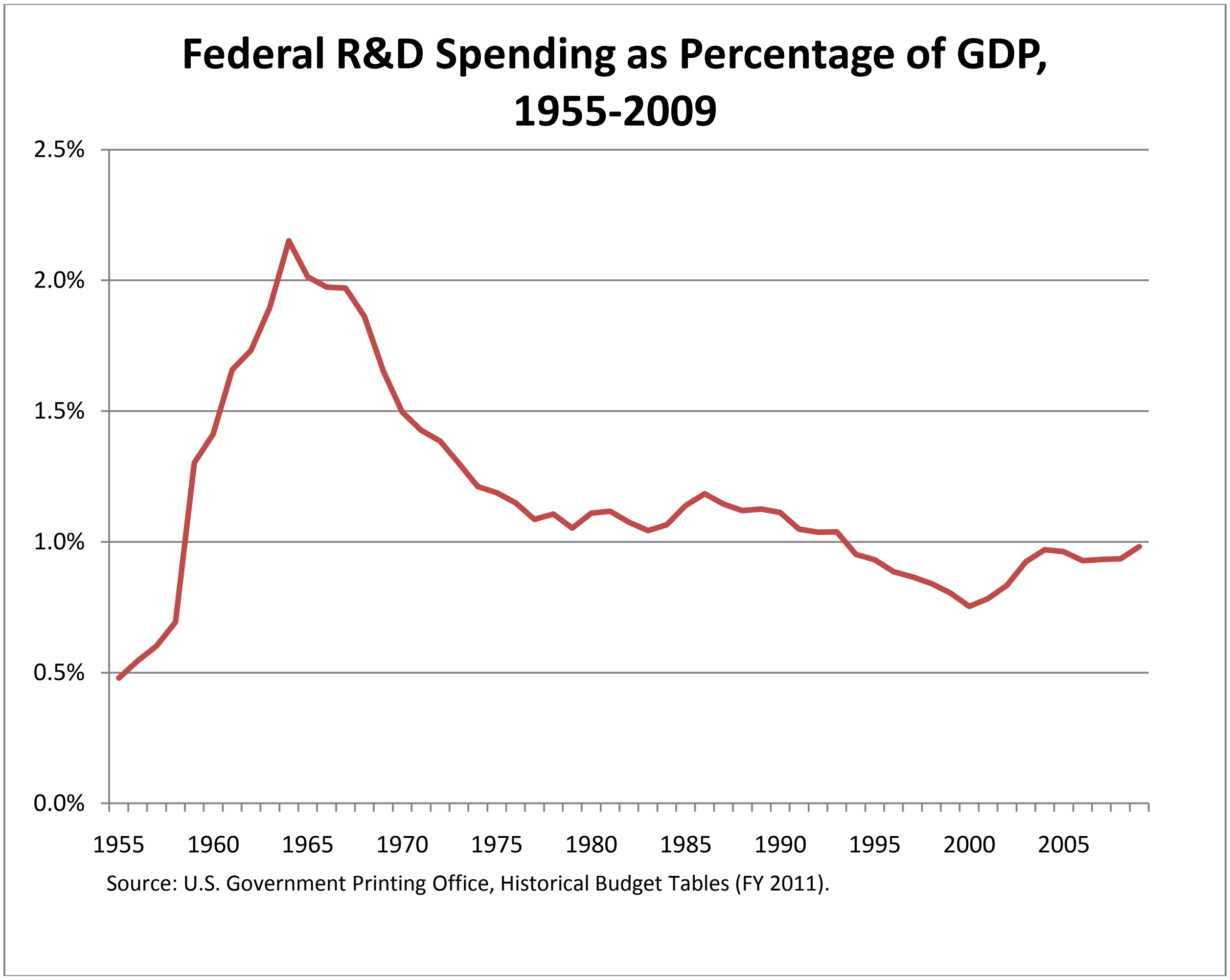
In contrast, the funding for energy research has often been focused on the deployment of existing technologies, rather than the development of new products. In general, deployment of existing technologies is a task that is best left to the private sector. In the cases where the technology is cost competitive, the private sector will deploy it. In cases where the technology is not competitive, the private sector will not allocate resources to its deployment. Further, a lot of energy research is path dependent in that it follows the expertise of the Department of Energy (DOE) laboratories around the country, rather than the highest value added ideas. Finally in general, DOE funding decisions have not been as single mindedly based on peer review as is the case with the NIH and NSF.

The recent creation of the Advanced Research Projects Agency (ARPA-E) shows substantial promise.[20] It is modeled after the Defense Advanced Research Projects (DARPA) agency that led to significant technological breakthroughs including GPS. ARPA-E has worked to develop new technologies that offer progress toward reducing dependence on imported energy, reducing emissions, and increasing energy efficiency.[21] The 2011 budget allocated $300 million for the ARPA-E program, which is about 1% of the funding for the NIH and 5% of the funding for the NSF.

C. How Much Does the United States Spend on R&D?

Our commitment to funding R&D has flagged in recent years. The below chart reveals that the federal government's contribution to R&D spending as a share of GDP has been declining over the last several decades. At its peak during the Cold War, it was more than 2% but it has been on a steady decline and is now less than 1%.

[20] Congressional Research Service,"Energy Provisions in the American Recovery and Reinvestment Act of 2009," (March 3, 2009), p. 5.
[21] Department of Energy (Energy Efficiency and Renewable Energy), "DOE Launches the Advanced Research Projects Agency-Energy, or ARPA-E," (April 29, 2009).



The next chart explores the time series of federal R&D in the energy sector. In 2009, federal R&D spending on energy totaled $1.7 billion or a little more than 1/100 of 1 percent of GDP. In constant dollar terms, this is less than one fourth of the peak in energy R&D spending during the 1980s. Alternatively, it is just 55% of the $3.1 billion that will be spent in 2011 providing a tax benefit for employee parking! As a percentage of GDP, it is 1/10 of the peak spending in 1979.[22]

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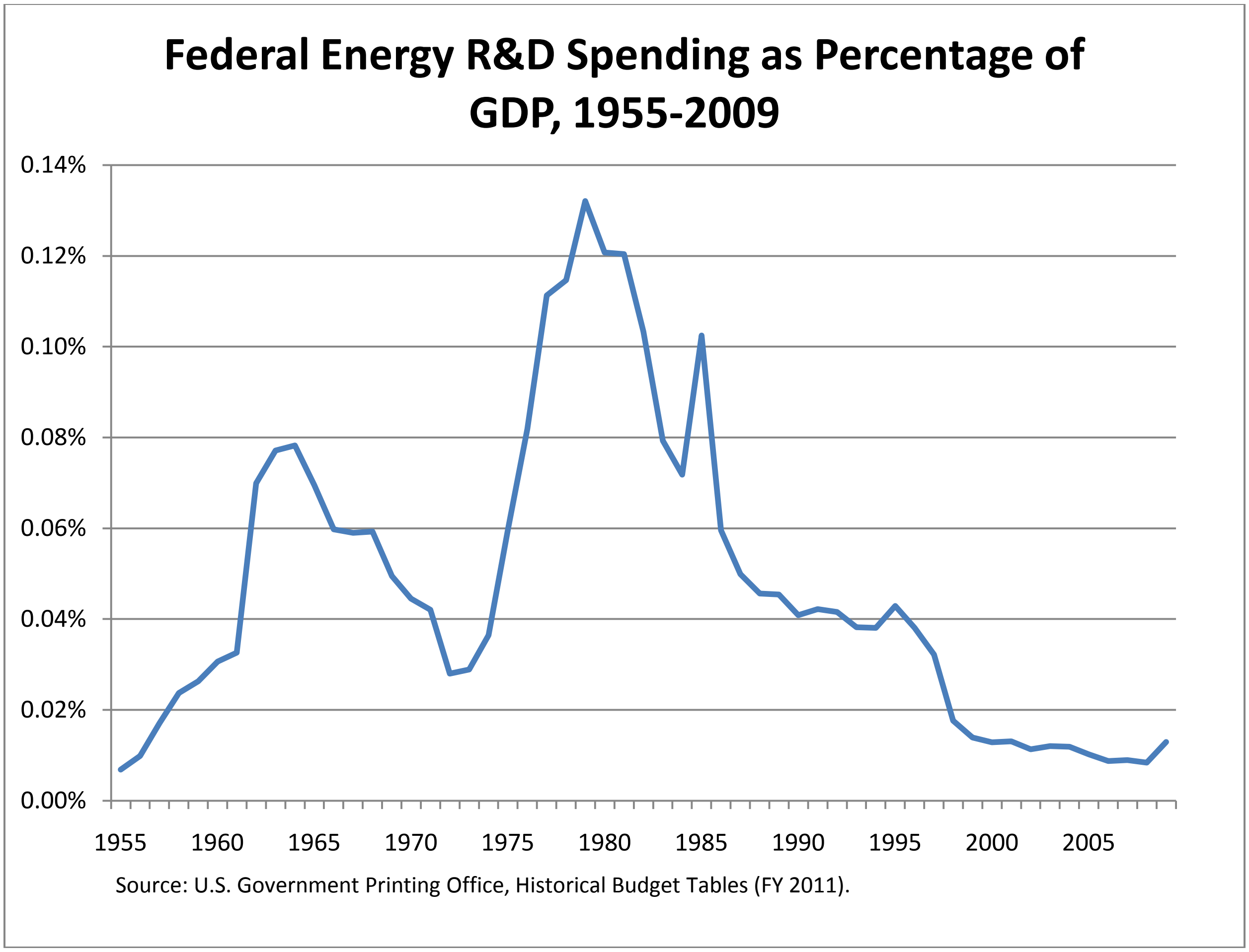
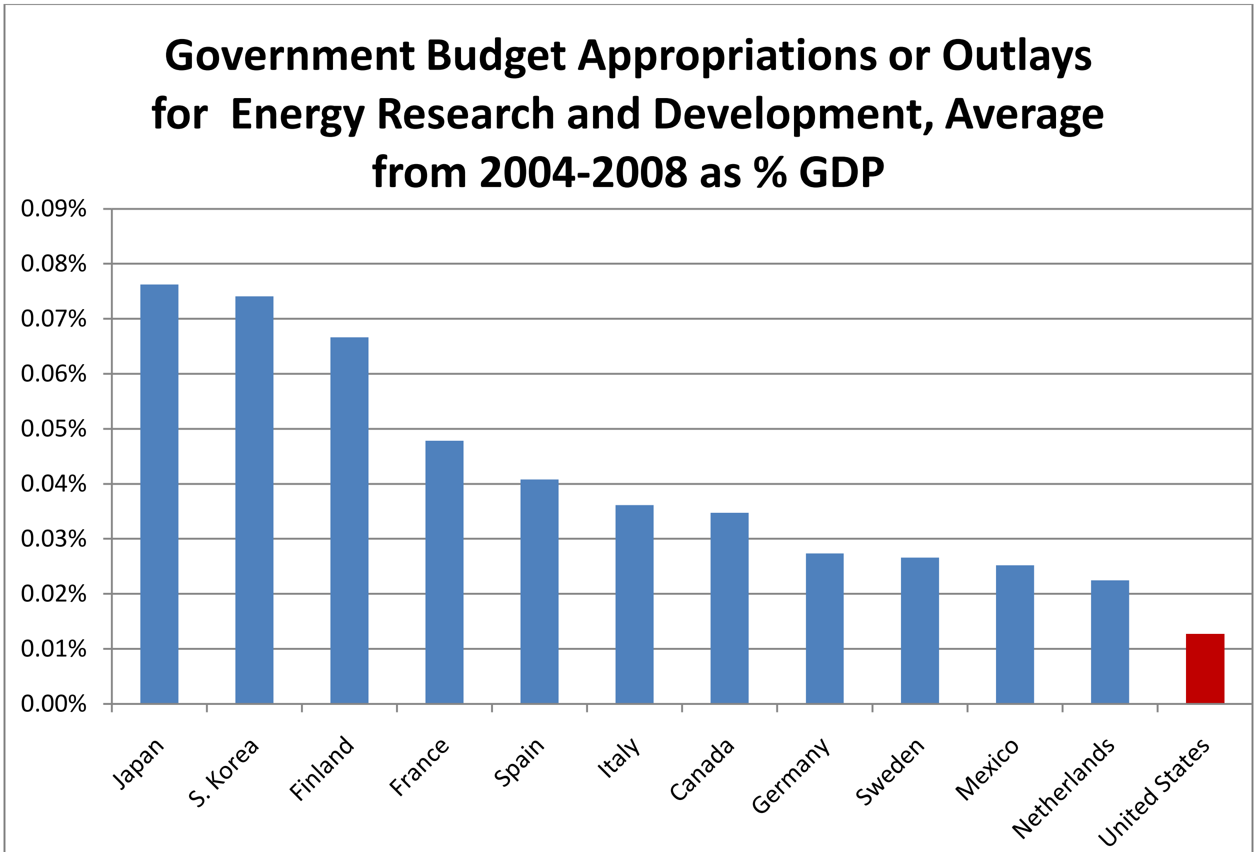
[22] Moreover, private investments in energy R&D have been in decline for some time: energy R&D spending by U.S. companies fell by 50% or about $1 billion between 1991 and 2003. See Gregory Nemet, "U.S. Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion," (Doctoral Candidate at University of California, Berkeley, June 29, 2006), pp. 3-5.



It is also instructive to compare U.S. spending with other countries. This comparison is if anything, even less favorable. During the 5 year period of 2004-2008, the average U.S. federal level of support of energy R&D was equal to about 0.0127% or about 1/100 of 1% of GDP according to OECD calculations.[23] This rate of investment in energy R&D puts the United States in 12th place out of the 12 OECD countries that spent the most on energy R&D during this period.

[23] OECD statistics on energy R&D include a broader set of outlays than do OMB figures.



Source: OECD Government Budget Appropriations or Outlays for R&D (BAORD), Data by Socio-Economic Objective, expenditures on "Production, distribution and rational utilization of energy"
GDP from World Bank World Development Indicators.
Data not available for Canada 2008, Russian Fed. 2004-2006, Mexico 2007-2008.

The conclusion from these figures is simple: without greatly expanded investments in U.S. energy research and development, we will not be poised as a leader in energy innovation. This greatly decreases the chances that we will be able to reduce our dependence on fossil fuels and fundamentally decarbonize the U.S. energy sector. Further, it decreases the chances that the coming revolution in the energy sector will aid our global competitiveness.

D. Principles for Reform of U.S. Energy R&D Program

With this background, I would like to suggest some key principles for research and development that I think the United States should adopt moving forward -- with specific emphasis on energy R&D. Let me provide the caveat that these are broad themes and should be considered a starting point for future discussions on how to best structure an improved federal R&D program. The Hamilton Project is undertaking this challenge and is in the process of commissioning a series of “discussion papers” on this issue that will lay out specific policy proposals for enhancing our nation's R&D capacity. We will unveil this new thinking in 2011.

As I see it, the evidence supports five key principles for R&D that could help transform our energy future:

1. *Increased funding*: Increasing federal energy R&D funding is necessary to stimulate the kind of innovations that we need to reduce our dependence on fossil fuels, increase our energy independence, mitigate the impacts of climate change, and increase our nation's competitiveness. The exact level of funding is a political judgment that must account for the other budget priorities, but it is clear that the current level is woefully inadequate.

2. *Political independence:* As the experiences of the NIH and the NSF demonstrate, one of the keys to a successful R&D policy is ensuring that funding is awarded based on merit through a competitive process that ensures the maximum impact and cost-effectiveness of R&D spending.

3. *Basic Research:* New federal energy R&D should focus on basic research. Private companies do not have incentives to embark on basic research that may not lead to the development of a new product. Additional government funding can compensate for this shortfall and provide basic research that is crucial to developing technologies in high-risk areas that the energy industry is unlikely to pursue on its own. Further, a focus on basic research would keep the government out of the business of choosing winners and losers.

   Some broad areas for potential funding include carbon sequestration, which requires additional development to make it cost effective and useable on a large scale. Another potential area of research is ocean fertilization, which would involve depositing nutrients into the ocean to stimulate the growth of CO2-absorbing phytoplankton. More research also needs to be done on the environmental impact and effectiveness of ocean fertilization and on reforestation.

4. *New R&D Funding Mechanisms*: An area that merits consideration is the use of new funding mechanisms for R&D. One potentially promising area would be the use of advanced market commitments, where a substantial prize would be offered to innovators who develop emission reducing technologies. For example, the government could offer a monetary award to the first firm that successfully captures half of an average power plant's emissions over 10 years and stores it successfully.

5. *Demonstrate Commercialization Potential:* The ultimate objective of federal energy R&D is to develop new technologies that are used in the marketplace. Thus, it is important that an energy R&D program include funding for demonstration – to show that new technologies can be implemented at a commercial scale. At the same time, funding for demonstration should not be expanded to include deployment of new technologies once their viability has been demonstrated, as this would crowd out the private sector.

V. CONCLUSIONS

Substantially increasing the government's focus on R&D, and specifically energy R&D, will meaningfully impact two significant long-run problems facing the United States today. Both our dependence on fossil fuels and economic competitiveness are issues that cannot be resolved through short term solutions, now or in the future. By increasing funding for energy R&D (and R&D in other areas), the United States can start planting the seeds of innovation that will grow into new technologies that we cannot imagine yet, but will potentially reshape our energy landscape and place the our nation as a leader in clean energy.

The key purpose of my testimony has been to describe why R&D is crucial for our future competitiveness and to tackle the problems associated with climate change. Without this investment now, we are saddling future generations to difficult economic and environmental challenges. How to achieve these goals is another step altogether, and one that demands serious deliberation.

As with any long-term policy shift, there are difficult political issues that need to be resolved before this policy could move forward. The source of enhanced R&D funding is a central issue in the current budget context although it is important that the present fiscal situation not blind us to R&D's benefits. Another issue is how the government should manage its energy R&D programs. As I discussed earlier, the track record of the NIH and NSF shows that federal R&D funds are most effective when proposals are funded through an independent, peer-reviewed process by experts with research expertise.

As I mentioned, The Hamilton Project will be developing a specific set of policy proposals that adhere to the principles outlined here and confront some of the implementation challenges. I would welcome the opportunity to return to the Joint Economic Committee and discuss them.

Thank you very much for the opportunity to testify before you today. I would be happy to answer any questions that you might have.