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Chairman Lummis, Ranking Member Swalwell, and Subcommittee Members, thank you for the opportunity to testify today.

My name is Lisa Jacobson, and I am the President of the Business Council for Sustainable Energy. The Council is a broad-based industry trade group representing companies and associations in the energy efficiency, natural gas and renewable energy industries. Its membership includes independent electric power producers, investor-owned utilities, public power, commercial end-users, equipment manufacturers, project developers as well as service providers for energy and environmental markets. Since 1992, the Council has been a leading industry voice advocating for policies at the state, national and international levels that increase the use of commercially-available clean energy technologies, products and services.

The Council is pleased to be able to share its views at this important hearing on the American energy outlook, focused on technology, markets and policy drivers. The Subcommittee on Energy has a significant role to play in overseeing the country's strategic energy investments, which have contributed to the development and deployment of highly valuable energy technologies and resources that underpin the U.S. economy.

Over the past several years, we have seen real market penetration of a wide range of sustainable energy technologies and resources and we have witnessed the results of policies that work. But our work is not done.

To continue the momentum of growth in these sectors, and to receive their co-benefits, long-term, stable polices will be needed to level the playing field and to provide market access to sustainable energy technologies. We will also need to continue to invest in energy research, development and deployment to increase the efficiency of our energy generation and use and to spur new innovations. This is important for domestic economic growth and for U.S. competitiveness in the energy sector.

I would like to focus my testimony on two areas. First, I would like to share some of the findings from the recently released *Sustainable Energy in America 2013 Factbook*.[1] The Factbook was researched and produced by Bloomberg New Energy Finance and commissioned by the Business Council for Sustainable Energy. It is a quantitative and objective report, intended to be a resource for policymakers with up to date, accurate market information. Its goal is to offer important benchmarks on the contributions that sustainable energy technologies are making in the U.S. energy system today. It also provides information on finance and investment trends in clean energy resources.

The second area I would like to discuss is the valuable and effective role that federal government investments in the energy sector have played, and should continue to play, in the availability of new, innovative energy technologies and practices. These investments in the form of research, development and deployment initiatives as well as federal tax incentives have expanded the energy technologies and resources available for the nation, while helping to save businesses and consumers money, and creating hundreds of thousands of U.S. jobs.

Sustainable Energy in America Factbook Findings

Some of the most significant findings from the *Sustainable Energy in America 2013 Factbook* point to the dramatic changes underway in the U.S. energy sector over the past several years. Traditional energy sources are declining, and natural gas renewable energy and energy efficiency are on the rise.

These changes are increasing the diversity of the country's energy mix, improving our energy security, cutting energy waste, increasing our energy productivity and reducing air pollution and greenhouse gas emissions.

Behind these changes are a portfolio of new energy innovations, technologies, and applications. These include: newly applied techniques for extracting natural gas from shale rock formations; lower-cost and higher-efficiency photovoltaic panels for converting sunlight to electrons; highly efficient, natural gas end-use applications; vehicles fuelled by electricity and natural gas; and 'smart meters' that allow consumers to monitor, modulate, and cut electricity consumption, among others.

The Factbook takes a broad view of sustainable energy technologies and provides data on a wide range of clean energy industries including natural gas, renewable

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[1] Business Council for Sustainable Energy, "Sustainable Energy in America 2013 Factbook," January 2013, at http://www.bcse.org/sustainableenergyfactbook.

energy sources (including solar, wind, hydropower, geothermal, and biomass – but excluding liquid biofuels), distributed power, and energy efficiency.

The Factbook also aims to fill data gaps. For example, data sources and economic models of the U.S. energy industry often fail to capture the full contribution of sectors such as distributed generation. The Factbook seeks to quantify accurately some sectors that are currently small but growing rapidly.

Recent Changes in the U.S. Energy Sector

According to preliminary 2012 EIA data, total energy use fell 6.4% between 2007 and the first nine months of 2012, driven largely by advances in energy efficiency.

Use of natural gas and renewable energy have increased, while other major energy sources such as coal and oil have experienced declines. Natural gas provided the U.S. with 27% of its total energy supply in 2012, and renewables (including hydropower) supplied 9.4%.

Further, in the electricity sector, lower- and zero-carbon power sources are growing. Natural gas-fired power plants provided 31% of U.S. electricity in 2012, up from just 22% in 2007. Renewable energy generation has meanwhile grown from 8.3% to 12.1% over that period. These technologies, which include wind, solar, geothermal and hydropower, represented the largest single source of new capacity growth in 2012, with more than 17GW added.

Market Dynamics

Low natural gas prices can both complement and conflict with other energy sources. For wind power in particular, less expensive natural gas has made it difficult to compete economically, though the one-year extension of the Production Tax Credit in 2013 has strengthened the business case for wind in the short term. Yet natural gas generators, which are inherently flexible technologies that can be easily ramped up and down to meet demand, are natural counterparts for variable resources such as wind and solar. Other options, such as combined heat and power (CHP), and fuel cell installations, which draw on natural gas for fuel, have become more competitive as natural gas prices decline.

The levelized costs of electricity for renewable technologies have fallen dramatically. For example, the cost of electricity generated by best in class large solar plant costs have dropped from $0.31 per kilowatt-hour in 2009 to $0.14 per kilowatt-hour in 2012, according to Bloomberg New Energy Finance's global benchmarking analysis based

on already financed projects from around the world. Distributed solar costs have fallen dramatically as well. The investment tax credit and state incentives are clearly working. (These figures exclude the effect of tax credits and other incentives, which would bring those costs down even lower.) Over the same period, the cost of power from a typical large wind farm has fallen from $0.09 in 2009 to $0.08 per kilowatt-hour.

Energy efficiency is making its mark on the grid and in buildings. Since 1980, energy intensity of commercial buildings has decreased by over 40%, propelled by increasingly sophisticated approaches to financing for energy efficiency retrofits, as well as by standards, such as those that apply to heating and cooling units and to thermal building performance (i.e., insulation). Overall, U.S. utility budgets for energy efficiency reached $7 billion in 2011 (the latest available date for which data exists). Demand response capacity, which typically involves the curtailment of electricity consumption at times of peak usage, has grown by more than 250% between 2006 and 2011, allowing major power consumers such as manufacturers to cut their energy costs and utilities to scale back production from some of the costliest power plants. The Factbook finds that 46 million smart meters have been deployed in the U.S., while spending on smart grid roll-outs hit $4.3 billion in 2012, up from $1.3 billion in 2008.

The Impact of Policy on Renewable Energy and Energy Efficiency Growth

Stable, long-term policies at state and federal levels that provide a level playing field and enable market access, combined with targeted investments in research, development and deployment, are needed to sustain the growth in clean energy sectors.

Though the levelized costs of electricity of many renewable generation technologies have fallen drastically, most of these technologies still rely on incentives to compete. State-level mandates have been important drivers for renewable growth in the U.S., though in the case of most states, targets for the next several years have already been satisfied.

Policy measures have also helped further the cause of energy efficiency: Energy Star-certified commercial building floor space has increased by 139% from 2008 to 2012, and the stringency of building air conditioning efficiency standards has increased by up to 34% since 2005.

The value of long-term policies, coupled with public and private investments can be seen in California. California has been able to keep its per capita energy use flat over

the past 30 years with a sustained commitment to energy efficiency. Energy efficiency has significant economic benefits. For example, in 2011, California investor owned utility PG&E's energy efficiency programs helped save customers more than $262 million on their energy bills.[2]

Grid Modernization, Reliability and Resiliency

Ensuring ongoing grid reliability will become a growing concern for electricity market operators and regulators. Dynamics contributing to this focus include declines in the use of coal, the impacts of severe weather events and the increased presence of variable energy resources on the electricity grid. Yet other changes are occurring – including reduced electricity demand through energy efficiency; the introduction of smart grid technologies for improved grid management; and the growing role for dispatchable resources such as natural gas plants, hydropower, and demand response – that can help the electricity industry meet these challenges. Still, many market structures do not yet fully recognize the benefits of some of the technologies offering increased flexibility, such as energy storage.

Given these factors, research, development and deployment investments are needed in this area to improve efficiency, demonstrate performance and to spur the new innovations that will be required to meet the evolving needs of the power grid. For example, investment being made in smarter and more efficient technologies such as voltage sensors and distribution circuits can help utilities better pinpoint what is happening on the grid and speed power restoration efforts when outages occur.[3]

Federal Investments in Research, Development and Deployment Foster U.S. Competitiveness, Energy Security

With regard to federal energy investments, BCSE strongly supports the continued funding of basic and applied research and development for clean energy technologies. This must be balanced with work on commercialization, market transformation and other efforts to ensure that products do not sit on laboratory or university shelves, but are transferred to the private sector to achieve the intended public benefit of the research and development.

While the U.S. Department of Energy (DOE) is primarily a research and development institution, it is uniquely positioned to address barriers in the marketplace that

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[2] PG&E Corporation, "Customer Energy Efficiency," at http://www.pgecorp.com/corp_responsibility/reports/2011/co04_ee.jsp.

[3] PG&E Corporation, "Fewer Outages for PG&E Customers with Help from High Tech Upgrades," December 2012, at http://www.pgecurrents.com/2012/12/14/thanks-to-technology-and-electric-system-upgrades-pge-customers-are-seeing-fewer-outages/

inhibit the successful deployment of clean energy technologies and should dedicate significant resources to these market efforts, especially for technologies that are ready to progress out of the "innovators" area of the technology adoption cycle and into "early majority" stage.

There are strong analytical findings that show the overall return on investment that has resulted in federal energy research, development and deployment (RD&D) investments. Such investments jumpstart private sector innovation critical to our long-term economic growth, energy security, and international competitiveness. DOE has supported effective programs, many in partnership with the private sector, that have resulted in the availability of new, more efficient energy technologies.

As part of a comprehensive review that was released in 2001, the National Research Council's Committee on Benefits of DOE R&D on Energy Efficiency and Fossil Energy found that "DOE's RD&D programs in these areas have yielded significant benefits (economic, environmental, and national security-related), important technological options for potential application in a different (but possible) economic, political, and/or environmental setting, and important additions to the stock of engineering and scientific knowledge in a number of fields."[4]

Although the committee was not always able to distinguish the DOE contribution from that of others, the net realized economic benefits in the programs studied were viewed to be substantially larger than the DOE investment. Energy R&D is also being undertaken by NASA and DOD, and there is solid collaboration between the efforts of DOD and DOE in the area of renewable energy.

The value of federal investments in RD&D is especially important given current market conditions. According to Bloomberg New Energy Finance, the near term trend is reduced private sector investment from venture capital and private equity investors in early stage clean energy companies. This is due to challenges with fundraising and difficulties in taking private firms onto public stock exchanges. This is a troubling development given the importance of innovation in the energy sector.

Venture capital and private equity investment shrank by a third in 2012 to $5.8 billion from $8.7 billion in 2011. The third and fourth quarter 2012 figures were the lowest since 2006. Down also is the number of venture financings. Bloomberg New

[4] Committee on Benefits of DOE R&D on Energy Efficiency and Fossil Energy, Commission on Engineering and Technical Systems, National Research Council. "Executive Summary." *Energy Research at DOE: Was It Worth It? Energy Efficiency and Fossil Energy Research 1978 to 2000*. Washington, DC: The National Academies Press, 2001.

Energy Finance tracked 421 investments made in early-stage companies in 2012, down 22% from the 543 in 2011.

Finally, in our current constrained budgetary environment, support for energy RD&D might be questioned. In response, I would argue that the energy sector, like the transportation sector for example, involves technologies that have been transformed over the course of a century. Just as the government should not stop investing in automotive R&D – improving fuel efficiency and economy, safety, incorporating new materials, etc., it is critical that the U.S. government continue to investment in advancements in the energy sector.

Sustainable Energy RD&D Investments

Natural Gas

The technological advances allowing for the low cost extraction of natural gas from shale occurred due to more than three decades of federal government and Gas Research Institute investment in research, demonstration, and production. According to a 2011 Breakthrough Institute report, both directly and indirectly, the government supported critical moments and tools in the shale gas revolution - massive hydraulic fracking (MHF), 3-D mapping, horizontal drilling, and horizontal wells.[5] These technological advancements offers the potential for stable natural gas prices in the $4 to $6.50 per million BTU range.[6] According to the American Gas Association, at these price ranges, the country's natural gas resource base can support significant expanded use of natural gas during the next decade and beyond. This provides the potential for natural gas to provide an abundant, clean and domestic fuel source for direct use applications, transportation and power generation at affordable prices.

This will also have a major impact for U.S. job creation, for instance, in Wyoming gas shale development is expected to support about 23,000 jobs in the state by 2020.[7]

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[5] Michael Shellenberger et al., "Where the Shale Gas Revolution Came From: Government's Role in the Development of Hydraulic Fracturing in Shale," Breakthrough Institute, May 23, 2012, at http://thebreakthrough.org/index.php/programs/energy-and-climate/where-the-shale-gas-revolution-came-from.

[6] American Gas Association, *Rethinking Natural Gas, A Future for Natural Gas in the U.S. Economy* (Washington, DC: 2012), p. 6.

[7] *Casper Star-Tribune.* "Wyoming Shale Gas to Support 23K Jobs by 2020," December 23, 2012, at http://trib.com/business/energy/report-wyoming-shale-gas-to-support-k-jobs-by/article_09b5f2e4-bf68-5953-90e4-fbc94c19d81e.html

In terms of private sector research, the Gas Research Institute (GRI) developed the world's first high efficiency fully condensing natural gas furnace in 1983. This product now has 50 percent of the furnace market and 90 percent of the new furnaces purchased in places like Wisconsin. GRI estimates that this sped up the introduction of the high efficiency furnace by at least ten years.

To help realize this potential, DOE should consider undertaking more RD&D into efficient natural gas technology, ensuring that businesses and consumers utilize natural gas wisely and efficiently. Specific technology areas for increased focus would include: fuel cells, micro combined heat and power, natural gas fired cooling and heat pumps, solar/gas hybrid systems, gas water heaters and natural gas vehicles.

Further, in 2011, the American Gas Association, Gas Technology Institute and Navigant consulting released a white paper that offered a vision of a smart energy infrastructure integrating natural gas with electricity from multiple sources, including renewable energy. To achieve this vision, several RD&D areas were recommended. I note a few below.

- Include natural gas in advanced metering infrastructure development to optimize common infrastructure, interoperability and cross-compensation among all utility infrastructures including electricity and water;

- Ensure that future federal funding programs including Smart Grid encourage and allow the use of funding for dedicated natural gas projects and combined electric/natural gas projects; and

- Increase governmental funding for basic as well as applied research in natural gas safety and reliability and smart energy infrastructure technology.[8]

Hydropower

The DOE Water Power Program is growing the nation's global position by funding cutting-edge research to produce the next generation of conventional hydropower and marine and hydrokinetic (MHK) technologies, and by accelerating the development of markets for those technologies. The main objectives of the Water Power Program are to improve hydropower technologies and to gather critical industry, operational and environmental impact data.

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[8] Gas Technology Institute and Navigant Consulting, Inc., *Natural Gas in a Smart Energy Future* (Des Plaines, IL: 2011), at http://www.gasfoundation.org/ResearchStudies/natural-gas-smart-energy-future.htm.

Currently, the conventional hydropower industry employs more than 300,000 workers in the U.S., making it the largest renewable electricity production workforce in the nation. With the Water Power Program's goal for water power technologies to provide 15% of the nation's energy by 2030, hydropower can provide hundreds of thousands of new jobs and economic development benefits for communities.[9]

Further, increasing hydropower generation provides more clean energy megawatts to the grid, and also increases the amount of grid reliability, stability and integrations services to enhance the penetration of variable energy resources. While hydropower and pumped storage projects can provide regional and grid-scale energy storage and other ancillary services, doing so will require projects to operate in new ways and modes, and in some cases, utilize new technologies. This makes continued federal research investments vitally important.

Energy Efficiency

On February 7, 2013, the Alliance Commission on National Energy Efficiency Policy, convened by the Alliance to Save Energy released at its Energy2030 vision. The Commission's report includes a goal of doubling U.S. energy productivity by 2030 and a set of recommendations to achieve this goal, which includes continued support of energy productivity RD&D. Achieving the goal could save $327 billion annually and add 1.3 million jobs.[10]

The Commission noted that private sector R&D budgets are limited in many energy efficiency sectors. Market barriers also prevent adoption and commercialization of new innovations. Thus government support both for R&D and for a wide range of deployment programs has been critical to advances in energy productivity. Looking forward, the Commission recommends increased federal investment in basic and applied research, development, demonstration, deployment, and technical assistance at DOE, the Environmental Protection Agency, and other agencies. The federal government should also encourage private R&D through other policy approaches such as public-private consortia, the R&D tax credit, and supporting challenges or contests.

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[9] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, "Water Power for a Clean Energy Future," at http://www1.eere.energy.gov/water/pdfs/wp_accomplishments_brochure.pdf.

[10] Alliance to Save Energy, "Energy2030: Doubling U.S. Energy Productivity by 2030," at http://ase.org/programs/ee-commission.

Solar

The development of today's robust solar market in the U.S. can be attributed to smart investments in R&D at DOE and national laboratories over the last four decades. Between 1975 and 2008, researchers in industry, academia, and DOE's national laboratories received financial and technical support to hasten the development and market introduction of higher quality, longer lived, and lower cost PV modules. Specifically, PV technologies have benefited from long-term DOE investment that has supported core cell and module technology R&D, manufacturing process development, and the technology infrastructure supporting that R&D. Today, the market is driving most of the cost reductions through economies of scale, manufacturing efficiencies, and innovation throughout the supply chain – but all of this is possible only because of the role of federal R&D in solar to create today's modern solar technologies.

In 2010, DOE released an analysis of these investments over the 1975 to 2008 time period and found important economic, environmental and health, emissions, national security and knowledge benefits. In terms of economic benefits, the study found that $18,734.8 million (2008$) in economic benefits over the period from 1975 to 2008 were quantified, encompassing

- $11,319 million in benefits for PV systems installed in the United States between 1976 and 2008. These benefits included cost savings as well as increases in PV modules' guaranteed useful life.

- $6,773 million in production cost savings for PV companies producing modules destined for non-U.S. markets.

- $630 million from the development of advanced silicon refining processes.

- $12 million from accelerated adoption of wire saw technology by the semiconductor industry for slicing silicon ingots into wafers.[11]

Today, the DOE is continuing its work on solar R&D – both PV and concentrating solar power. The investment in the former is strong, but in the latter it is weak and could use improvement. The three areas that the DOE Solar Program focuses its work are as follows:

[11] "Retrospective Benefit-Cost Evaluation of DOE Investment in Photovoltaic Energy Systems," Department of Energy, Office of Energy Efficiency and Renewable Energy, August 2010, http://www1.eere.energy.gov/analysis/pdfs/solar_pv.pdf

- Solar Technologies—projects that reduce costs related to photovoltaic and concentrating solar power technologies.
- Systems Integration—projects that reduce the costs of connecting high penetrations of solar electricity onto the grid, related to balance of systems, power electronics, and smart grid.
- Balance of Systems Costs—projects that remove market barriers, specifically related to fostering a skilled workforce and standardized permitting and interconnection.

All three of these areas are critical for continued innovation and leadership by the U.S. in the area of solar energy. Although I and the solar industry support work in all three areas, much of the technological cost reduction targeted in the first item will be incremental engineering work supported by companies competing for deployment market share—some in collaboration with federal programs. The second item could be rephrased as preparing our grid for the impending solar success in providing massive amounts of electricity. The third area, although lower in percentage of work that could be called R&D, may be most critical in meeting the policy goals of the last several Administrations and of Congress in its last several major energy bills, in deploying large amounts of solar for national security, environmental, and other policy reasons.

Wind

Past investments in wind have resulted in significant improvements over the past 30 years, such as increased output, improved reliability, and lower costs. Despite this dramatic decrease, there is still plenty of room for further reductions that will be critical for wind energy to compete in an environment of very low electricity costs.

Wind energy is now cost competitive with virtually every other energy source and technology advancements can drive the cost down even more. Already, these technology advances have enabled a typical modern wind turbine to produce 15 times more electricity than the typical turbine in 1990, but further improvements are needed to meet the 20% goal by 2030 as outlined in the DOE's *20% Wind Energy by 2030* report in 2008.

Fuel Cells

The DOE's Hydrogen and Fuel Cells Program supports research and development efforts across a range of technical and non-technical areas to enable the widespread commercialization of hydrogen and fuel cell technologies in a range of sectors of the economy. The Fuel Cell Program is coordinated across the DOE, incorporating activities in the offices of Energy Efficiency and Renewable Energy, Science, Nuclear

Energy, and Fossil Energy, and it is aligned with DOE's strategic vision and goals. The Program's efforts have resulted in progress in several areas, including:

- **Fuel Cell Electric Vehicles:** The Fuel Cell Technologies Program reduced the cost of automotive fuel cell stacks by more than 80% over ten years, overseeing a drop from $275/kW in 2002 to $49/kW in 2011. The program is on track to meet its 2017 stack cost target of $30/kW.

- **Hydrogen Production:** The DOE projects a reduced cost for producing hydrogen from natural gas of approximately $3.00/gallon gasoline equivalent (gge), a price competitive with gasoline.[12] Improvements have also been made to the production of hydrogen from renewable resources, such as water electrolysis from wind energy, reforming of bio-derived liquids. Photosynthetic conversion in hydrogen-producing microalgal cultures has improved from 3% efficiency in 2000 to 25% in 2008.

- **Hydrogen Storage:** The DOE's National Hydrogen Storage Project identified several metal hydride materials in which improved hydrogen storage capacity by more than 50% between 2004 and 2006.[13] The DOE also developed a new "cryo-compressed" tank concept in 2007 which further increased the gravimetric and volumetric capacity for hydrogen storage.

- **Hydrogen Delivery:** The DOE projects significant cost reductions have been made for various hydrogen delivery systems. DOE projects a 30% reduction in cost for a tube trailer delivering high-pressure gas from 2005 to 2009, and a 20% reduction for a pipeline delivering high-pressure gas. DOE projects that the cost of delivering liquid hydrogen via a tanker truck has been reduced by 15% over the same time period.

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[12] "Progress and Accomplishments in Hydrogen and Fuel Cells," Department of Energy, Office of Energy Efficiency and Renewable Energy, April 2012, at http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/accomplishments.pdf

[13] Hydrogen and Fuel Cells Program Record, 2006, May 2006, at http://hydrogen.energy.gov/pdfs/5037_h2_storage.pdf

- **Solid-Oxide Fuel Cells:** Program research led to the development of a solid-oxide fuel cell (SOFC) micro-combined heat and power system with an almost 25% increase in system power density between 2009 and 2010. The power density of a fuel cell system is the ratio of power produced by a cell, to the volume of the cell. Increased power density allows for a more than 30% reduction in stack volume and a 15% reduction in stack weight.[14] The electrical efficiency at rated power of SOFCs increased to 34% to 40% between 2008 and 2012. The factory cost for the cells also decreased from $750/kW in 2008 to $650/kW in 2012.

- **Supporting Commercialization of Early Markets:** The DOE received $42 million under the American Recovery and Reinvestment Act of 2009 (ARRA) for the deployment and commercialization of fuel cell and hydrogen technologies. DOE leveraged the funding to gain an additional $54 million in private funding from industry participants. This $96 million in total funding assisted in the deployment of over 1,000 fuel cells in backup power and forklift applications. These initial deployments were used to leverage the deployment of over 3,500 fuel cell forklifts and 1,300 backup power fuel cells without government assistance.

Conclusion

The Sustainable Energy in America Factbook shows with a mix of research, development and deployment initiatives supported by policies and incentives at the state and federal level, the U.S. has experienced a rise in market penetration of a broad range of sustainable energy technologies. The data shows that the policies that have been adopted have worked but the work is not done. To ensure secure, clean, reliable, affordable energy sources in the U.S. we must continue the federal government's partnership in research, development and deployment programs. Council members have specific views on programs that have been effective for their industries and look forward to working with this Committee to identify effective programs that bring a strong rate of return to tax payers while unlocking the vast domestic potential for sustainable energy technologies. Private industry stands ready to work with the federal government to ensure that any and all public investment in these sectors is highly leveraged, effective, and efficient in carrying out the intended policy aims of the investments.

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[14] "Progress and Accomplishments in Hydrogen and Fuel Cells," Department of Energy, Office of Energy Efficiency and Renewable Energy, April 2012, at http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/accomplishments.pdf