Statement of
Steven E. Koonin
Under Secretary for Science
U.S. Department of Energy

Before the

Committee on Energy and Natural Resources
United States Senate

Department of Energy's Quadrennial Technology Review,
S. 1703 – Quadrennial Energy Review Act of 2011, and
S. 1807 – Energy Research and Development Coordination Act of 2011

November 15, 2011

Chairman Bingaman, Ranking Member Murkowski, and Members of the Committee; thank you for the opportunity to appear here today to report on the Department of Energy's (DOE) first Quadrennial Technology Review (QTR). It has been a great honor and privilege to lead this review. Secretary Chu and I greatly appreciate your interest in it.

Access to clean, affordable, secure, and reliable energy has been a cornerstone of America's economic growth. And yet, the security of energy supplies, U.S. competitiveness, and energy's environmental impacts are long-standing challenges. All remain pressing national issues.

The President's Council of Advisors on Science and Technology (PCAST) recognized the importance of a coordinated approach to federal energy policy and called for a QTR in its November 2010 *Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy.*[1] The Review we prepared in response sought to define a simple framework for understanding and discussing the challenges the energy system presents and to establish a shared sense of priorities among activities in the Department's energy technology programs; and to explain to the Department and its stakeholders the roles that the DOE plays in innovation and energy transformation. To holistically address our national energy technology challenges, the QTR highlights six strategies: three in the transportation sector and three in the stationary sector.

Transportation

In transportation, our challenges are energy security – each day we send $1 billion out of the country to pay for oil – and environmental concerns over greenhouse gas emissions and other pollutants. Because oil markets are global and we import nearly 50% of our oil, we face issues with high prices and security of supply. Globally, demand for oil is growing which will continue to exert upward pressure on oil prices. Increased domestic production will allow for domestic

[1] Executive Office of the President–President's Council of Advisors on Science and Technology. (2010). *Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy, Washington, DC.* Accessed at: http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf

job growth, will increase security. However, domestic production will not affect the price of oil because as a nation we cannot produce enough fast enough to significantly affect the global market. Due to the scale of OPEC's supply relative to other producers, it is able to distort the global market through cartel power. Other fungible liquid fuels (i.e., unconventional crude, biofuels, or gas-to-liquids) will also help reduce our dependence on oil but will be subject to the same market pressures.

Going beyond supply measures, reducing oil consumption will mitigate the impact of global oil price dynamics on the Nation's economy. Therefore, we will also reduce our crude demand through efficiency and then by progressive electrification of the light-duty fleet. Research in advanced biofuels is also necessary to supply those vehicles that cannot practically be electrified (i.e., long-haul trucks, aircraft). Our three recommended strategies, ordered by cost-effectiveness and time-to-impact, are:

Vehicle Efficiency: Improving vehicle efficiency is one of the most effective short-term routes to reduced liquid fuel consumption. This has been an administration priority, as the Department of Transportation and the Environmental Protection Agency have set new Corporate Average Fuel Economy (CAFE) and greenhouse gas emissions standards for model year 2012-2016 light duty vehicles, and the President announced a framework in July for standards for MY 2017-2025 light duty vehicles. DOE will focus on internal combustion engine improvements, lightweighting, and aerodynamics. DOE's highest leverage contributions in this area include convening consortia, such as the United States Council for Automotive Research (USCAR), and providing unique facilities and capabilities in the national laboratories, such as the Combustion Research Facility.

Vehicle Electrification: Hybridization of the vehicle fleet can help reduce oil consumption at the pump in the near- and mid-term; full electrification would decouple light-duty vehicles from the global oil market. DOE will focus on batteries, electric motors, and power electronics that can improve hybrids and plug-in hybrids. DOE will maintain a limited program of fundamental research and development (R&D) in fuel cells for transportation and in hydrogen production and storage.

Alternative Hydrocarbon Fuels: Since the heavy-duty vehicle sectors face significant barriers to electrification, this part of the fleet will always rely to some extent on portable, high energy density fuels. DOE will focus on drop-in biofuels for the heavy duty vehicle, air, marine, and train markets because of the ease of deployment. The negative environmental impacts of fuels made from non-petroleum fossil fuels without carbon capture & storage currently outweigh their possible energy security benefits. We also note that compressed or liquid natural gas, although a potential alternative, would require significant investment in infrastructure.

Stationary Heat and Power

The challenges we face in the stationary sector are very different than in the transportation sector. In our residential, commercial and industrial sectors, our challenge is to provide heat and power in environmentally responsible ways that strengthen domestic innovation and

manufacturing capabilities. The stationary sector is complicated by the fact that generation, transmission, and demand are interdependent. Our three recommended strategies, ordered by cost-effectiveness and time-to-impact, are:

Energy Efficiency in Buildings and Industry: Increasing energy efficiency has net economic advantages because energy expenditures decrease for the same level of service. In both buildings and industry, a lack of accessible, actionable information is a major market barrier. For building efficiency, DOE will pursue technology and information availability improvements on both a component and system level. For industrial efficiency, DOE will pursue improvements in both existing and innovative manufacturing processes.

Grid Modernization: The U.S. needs a 21st Century electrical grid to provide needed stability and to integrate new forms of energy. A modernized electrical grid is essential for, among other things, wide-scale electrification of the vehicle fleet, deployment of demand response, and efficient integration of clean electricity generation. While the most critical advances needed for realization of a modernized grid are not related to technology or R&D, there are technological improvements including improving grid observation, understanding, and operation; improving control of energy and power flow; and developing and deploying energy storage that would be beneficial.

Clean Electricity: Multiple generating technologies with diverse characteristics at varying stages of maturity make it difficult to prioritize the clean electricity research portfolio. The usual metrics of potential for cost-competitive levelized cost of electricity and greenhouse gas intensity do not sufficiently differentiate among technologies. Other factors, including modularity and scalability, water consumption, infrastructure compatibility, and global context, help to stratify the research portfolio. Comparative assessments of these factors over the full life cycle of these technology options will help ensure the cleanest and most cost-effective options for society. Above all, DOE will use the materiality, market potential, and maturity of clean electricity technologies, as described below, to prioritize its activities.

Prioritizing Our Activities

As Secretary Chu noted in his introduction to the QTR, the Department's energy technology strategy has been traditionally organized along individual program lines and based on annual budgets. With this QTR, our goal is to bind together multiple energy technologies, as well as multiple DOE energy technology programs, in the common purpose of solving our energy challenges. In addition, the QTR provides a framework to help inform our multi-year planning. Energy investments, if they are to be effective, must be consistent and flexible, multi-year--, if not multi-decade, investments.

One of the salient facts about energy technology R&D is that there are always many different technical approaches to solving the same problem—and more are being proposed every day. While a testament to the power of human ingenuity, this excess of options creates a practical problem: since we have limited resources and urgent problems to solve, how do we choose which subset of these many approaches to pursue?

The QTR has been, at its core, about developing the principles that will help inform those difficult choices between different technically viable approaches that cannot all be pursued. Mere technical promise—that something could work—is an unjustifiably low bar for the commitment of DOE R&D funds. As every dollar matters, we must give priority in our research portfolio to those technologies that are most likely to have significant impact on timescales commensurate with the urgency of national energy challenges.

The burden of oil imports and the need to reduce greenhouse gas emissions dramatically by 2050 sets a relentless clock on our actions. Because significant changes in energy supply can take 20 years or more, the Department will focus on a portfolio of technologies that can confidently be predicted to be material by 2030. Technologies can be judged by maturity, materiality, and market potential:

- **Maturity:** Technologies that have significant technical headroom yet could be demonstrated at commercial scale within a decade.

- **Materiality:** Technologies that could have a consequential impact[2] on meeting national energy goals in two decades.

- **Market Potential:** Technologies that could be expected to be adopted by the relevant markets, understanding that these markets are driven by economics but shaped by public policy.

Additionally, we will apply two themes to the development of the overall R&D portfolio. First, we will balance more assured activities against higher-risk transformational work to hedge against situations where reasonably assured paths become blocked by insurmountable challenges. DOE will reserve up to 20% of the Department's energy technology R&D funding for "out of the box activities". Second, because the Department neither manufactures nor sells commercial-scale energy technologies, our work must be relevant to the private sector, which is the agent of deployment.

Furthermore, we must clearly acknowledge that even the most carefully planned energy R&D strategy can be upset by unexpected technical advances, changing market conditions, unanticipated environmental challenges, and outside events. For that reason, the QTR found that the Department should maintain a mix of analytic, assessment, and fundamental engineering research[3] capabilities across a broad set of energy technology areas. Such activities in any given technology area should not imply a DOE commitment to additional demonstration or deployment activities in that area. The mix of analytic, assessment, and fundamental engineering research will vary according to the status and significance of the technology.

---

[2] We define "consequential" as roughly one Quad per year of primary energy; such a metric may not be appropriate for all technologies.

[3] Fundamental engineering research is research intended to understand the sensitivity of man-made systems or components to specific laws of nature. The goal of fundamental engineering research is to make better predictions about the behavior of those systems, which will broadly improve our ability to design, build, and maintain engineered products and services for particular purposes. Fundamental engineering research is an essential precursor to technology development.

Conclusions of the Review

As a result of the Review, we found that looking just at DOE:

- the Department is underinvested in the transportation sector relative to the stationary sector (energy efficiency, grid, and electric power). Within our transportation activities, we conclude that DOE should gradually increase its efforts on vehicle efficiency and electrification relative to alternative fuels.

- the Department is underinvested in activities supporting modernization of the grid and increasing building and industrial efficiency relative to those supporting development of clean electricity.

There are several other criteria to consider when balancing the energy R&D portfolio. There is tension between supporting work that industry won't, which biases the Department's portfolio toward the long-term, and the urgency of the Nation's energy challenges. The appropriate balance requires the Department to focus on accelerating innovation relevant to today's energy technologies, since such evolutionary advances are more likely to have near- to mid-term impact on the Nation's challenges. We found that too much effort in the Department is devoted to research on technologies multiple generations away from practical use at the expense of analyses, modeling and simulation or other highly relevant fundamental engineering research activities that could influence the private-sector in the nearer term.

Another important finding of this Review is that the Department impacts the energy sector and energy technology innovation through activities other than targeted technology-development initiatives – the most commonly thought-of approach for organizing DOE's effort. Public comments indicated that DOE's informational and convening roles are among its most highly-valued activities. Information collected, analyzed, and disseminated by DOE helps shape the policy and decisions made by other governmental and private sector actors. That expertise in energy technology assessment gives DOE the standing to convene participants from the public and private sectors to coordinate collective effort. The Department's energy technology assessments are founded upon our extensive R&D capabilities. By supporting pre-competitive R&D and fundamental engineering research, DOE builds technical capabilities within universities and our national laboratories and strengthens those capabilities in the private sector.

Also heard clearly from external stakeholders was that DOE's technology development activities are not adequately informed by how consumers interact with the energy system or how firms decide about technologies. As a result, DOE will integrate an improved understanding of applied social science into its technology programs to better inform and support the Department's investments.

Fundamental to improving Departmental strategy, to implementing the outcomes from this process, and to future QTRs will be the development of strong internal capabilities for integrated technical, economic and policy analysis. The Department needs an enduring group to provide an integrated understanding of technology, markets, business, and policy for the planning and execution of technology programs. This professional group would integrate the major functions

of technology assessment and cost analysis; program planning and evaluation; economic impact assessments; industry studies; and energy and technology policy analysis. Such a group would harmonize assumptions across technologies and make the analyses transparent. Previous attempts to establish such capability within the Department have resided within support offices, rather than at the leadership level, and so have had limited impact.

It is important to state that the QTR is not a substitute for the annual budget process; however, it should inform the development of those budgets as well as internal planning over a longer horizon. Further, the QTR is focused on energy technologies, but it is not, standing on its own, a national energy strategy. In March 2011, the Obama Administration released the *Blueprint For A Secure Energy Future,* a roadmap to guide the pursuit of key energy policy objectives, such as the President's goal of reducing oil imports by one-third by 2025.

When the PCAST, as an external advisory board to the President, recommended the QTR, it also identified its most important recommendation as the development of a multi-agency QER that would forge a more coordinated and robust federal energy policy, engaging many agencies and departments across the Executive Branch. As envisioned by the PCAST, the emphasis of the QER would be on establishing government-wide goals, and identifying the non-budgetary resources needed for the invention, translation, adoption, and diffusion of energy technologies. The PCAST found that because the responsibility for setting these goals goes well beyond the reach of the DOE, the QER would serve as a mechanism for managing this crosscutting challenge.

I would like to briefly describe how we carried out this Quadrennial Technology Review. Public engagement was a central tenet of the QTR. Nearly 700 stakeholders supplied input over the course of the six-month review. The process began officially in March when we released the QTR Framing Document along with a Request for Information in the *Federal Register*. The framing document established the framework, scope, key questions, and process for the review. The QTR team received approximately 60 submissions during the 30-day public comment period. The Framing Document also served as a foundation for five stakeholder workshops across the country. Divided along the six strategies, these workshops solicited input from hundreds of energy experts from industry, national labs, academia, and government agencies. The Capstone workshop hosted in Washington, DC, in mid-July enabled us to summarize what we had learned from the public comments and topical workshops while provoking discussion on the substance of what would become our findings and conclusions. Throughout the process, the team consulted with officials within the Department, our sister federal agencies, and the Executive Office. That public and interagency engagement was vital to the quality and clarity of the final document.

DOE appreciates the support received from Congress during the QTR process as well as the interest from Chairman Bingaman and Senator Pryor in establishing a broader QER. The Administration is currently reviewing S. 1703 and S.1807 and does not have a position on the legislation at this time. The Administration is also currently reviewing its capacity to carry out a QER under existing authorities. We look forward to working with the Committee to address these important questions. Thank you and I am happy to take any questions.