MASSACHUSETTS INSTITUTE OF TECHNOLOGY

77 Massachusetts Avenue
Cambridge, Massachusetts 02139–4307
Phone 617–253-3206
Fax 617–253-3193

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To: Under Secretary for Science Steven Koonin
Department of Energy
1000 Independence Ave., SW.
Washington, DC 20585.

Submitted Through: DOE-QTRmailbox@hq.doe.gov

From:
Claude Canizares
Vice President for Research and Associate Provost
Bruno Rossi Professor of Physics
Massachusetts Institute of Technology (MIT)

Ernest J. Moniz
Director, MIT Energy Initiative
Cecil and Ida Green Distinguished Professor of Physics and Engineering Systems
Director, MIT Laboratory for Energy and the Environment

Subject: Request for Public Comment on the Department of Energy-Quadrennial Technology Review (QTR)

Dear Under Secretary Koonin:

We are writing in response to the Department of Energy's Request for Comment on the Quadrennial Technology Review (QTR), issued in the March 14, 2011 Federal Register. MIT submitted an initial response on April 15, 2011, and this submission serves as a follow up with additional information pertaining to the specific questions outlined in the Request for Information (RFI). The organization of this document follows that of the questions posed in the RFI.

Energy is a significant focus area at MIT. Through MIT's Energy Initiative (MITEI), over 20% of Institute faculty members participate in research and education related to energy, and the MIT Energy Club has over 2,800 members. MITEI, established in November 2006, serves MIT as an umbrella organization for research, education, campus energy management, and outreach activities that cover all areas of energy supply and demand, security, and environmental impact. It has also supported a series of major energy policy studies in recent years (see MIT's previous submission to the DOE QTR RFI).

Based in part on MIT's experience, and after consultation with those involved with energy across the Institute, this submission provides input on four of the topic areas outlined in the RFI: "U.S. Energy Framework," Clean Energy Leadership," "Program Definition and Leadership," and "Technology Leadership." Each topic is reviewed in succession below.

I. Comments on "U.S. Energy Framework":

MIT applauds the Department for initiating the QTR, and for considering input from stakeholders at the outset of the process. We hope that the QTR will ultimately develop into a broad energy technology strategy, built and continuously informed through a coordinated, ongoing, public-private process. We also hope that the QTR can work in concert with the recently released DOE Strategic Plan, and that these will be well integrated in the future.

A public-private partnership. As outlined in the QTR framing document, the DOE QTR is different from similar reviews at the Departments of Defense (DoD) and Homeland Security (DHS), in that "the deployment, ownership, and operations of energy technologies are almost entirely nongovernmental functions that are determined by government policies and investment." This reality will require that the QTR become a living document continuously informed by outside stakeholders. The QTR should function as an active public-private partnership, with private sector leadership, academic inputs, and transparency throughout the process.

Team B. Another recommendation would be to institute a non-partisan, independent review panel for the QTR, a "Team B", comprised of outside experts who regularly assess the progress of the QTR. The members of such a panel should be recognized experts drawn from industry—both established and new entrants—and academia, as well as other appropriate sectors. A potentially useful model for this panel could be the National Defense Panel, as proposed in the Military Force Structure Review Act of 1996, to review and assess the Quadrennial Defense Review (QDR). The participation of such a panel in an ongoing energy strategic process will not only drive a more comprehensive strategic planning process, but will also help build a constituency to support the Department, both intellectually and politically.

II. Comments on "Clean Energy Leadership":

Stable, sustained, and predictable investments in R&D. In order to ensure the nation's clean energy leadership, the Department should support stable, sustained, and predictable investment in energy research and development (R&D) across the energy technology innovation system. The importance of this investment in building and maintaining the nation's leadership in clean energy cannot be overstated, particularly given that clean energy technology innovation may drive a major global business opportunity and U.S. leadership is by no means assured.

The Department's recent introduction of innovative research programs at the "front end" of the energy innovation system, particularly Energy Frontier Research Centers (EFRCs), the Advanced Research Projects Agency-Energy (ARPA-E), and Energy Innovation

Hubs are promising efforts to identify and overcome some of the most significant barriers to the front end of energy innovation. The robust and complementary portfolio these programs offer, in addition to the Office of Science's basic research programs, help maximize the nation's ability to achieve energy breakthroughs. Our view is that the Department's energy R&D program should be weighted even more towards sustained support for multidisciplinary teams focused on key science and technology barriers to lower cost clean energy.

Connected science. In order to benefit fully from the fruits of this research and bring them to market, the Department also needs to focus on strengthening the "back end" of the innovation system. This will require an effort to break down barriers between the basic and applied research programs, thus helping to more effectively move technologies to market. Too often, stovepipes put in place between basic and applied programs make it difficult to identify advances in one that could benefit the other. Energy innovation in today's world eschews this linear and compartmented view of the energy innovation pathway, from the most basic research to the broadest technology deployment. As outlined in the 2005 National Research Council report, *Assessment of Department of Defense Basic Research*, basic and applied research are often intertwined and rely on each other for advancement. This report describes the interconnectedness as follows:

> "It is also important to note that the need for discovery from basic research does not end once a specific use is identified, but continues through applied research, development, and operations stages. Basic research is not part of a sequential, linear process from basic research, to applied research, to development, and to application. DOD should view basic research, applied research, and development as continuing activities occurring in parallel, with numerous supporting connections throughout the process."[1]

Technology transfer. A critical step in this effort will be facilitating technology transfer across all DOE research areas. While university partners of DOE have traditionally focused on conducting basic research and training the next generation workforce, many universities—MIT is just one of many examples—are also increasingly incubators of scientific and technical innovation. With the demise of large industrial research laboratories, universities are home to the great majority of basic scientific research conducted in the U.S., as well as a growing level of applied research. This combined fundamental science and engineering is a prerequisite to creation of new technologies, new businesses, and new jobs that fuel the nation's long-term economic competitiveness. DOE programs need to better reach this capability.

Cost sharing. Unfortunately, university efforts to partner with DOE on applied research are currently stymied by the 20 percent cost-share requirement across its applied programs. ARPA-E recognized this problem when, after its first funding opportunity announcement, it took advantage of flexibility in statute to reduce the cost share to 10 percent, thus improving universities' ability to compete. While a positive development, even a 10 percent cost share requirement is difficult for universities to meet, especially in

[1] National Research Council report; "Assessment of Department of Defense Basic Research" *(2005)*, available at: http://books.nap.edu/catalog.php?record_id=11177

these challenging fiscal times. Cost sharing is made for profit-making entities but does not fit with non-profit university financing. Research universities receive revenues from three main sources—federal support for research, tuition applied to offset the costs of education, and endowments and gifts, which are usually highly restricted in their use. Many public institutions also receive State funding, although this is generally aimed at making education more affordable for in-state students. In our estimation, neither state governments nor private donors would be inclined to support cost-sharing for federally funded research.

Without access to independent financing to support the cost-share requirement, universities are sometimes unable to partner with the DOE in this important component of the energy innovation system. DOE should use its cost sharing flexibility to waive these requirements for universities. This recommendation is also echoed in the recently issued President's Advisory Council on Science and Technology (PCAST) report entitled "Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy"[2]: "…the Administration should work to eliminate the 20 percent matching requirement for applied energy research programs for universities and non-profit entities."

Collaboration with other federal agencies. Another avenue the DOE should pursue to strengthen the back-end of the innovation system is collaboration with federal agencies. As DOE is recognizing, the DoD, for example, offers an excellent opportunity for partnership, with its more than 500 major military installations and over 300,000 buildings all over the world, and varied operational units reliant on all forms of energy for their success.[3] DoD installations and units located in various geographies and climates could serve as excellent test beds for implementation of new technologies coming out of the DOE. The DOE should build on the success of the recent Memorandum of Understanding (MOU) signed with the DoD, to create and staff a permanent joint program office shared by both departments to facilitate implementation of principles outlined in the MOU, including those related to technology development and deployment. While the MOU is significant and represents a commitment on the part of the two Department Secretaries, true success in this endeavor will only be met if there is a complementary "bottom up" connection and effort at the program manager level; a joint program could be designed to facilitate this.

Developing the next generation energy workforce. Another key driver behind clean energy leadership is the development of the next generation of energy technology leaders. Effective and adaptable solutions to energy challenges will require that workforce members not be locked into narrow ways of thinking. Members of the energy workforce must have the capacity to appreciate, absorb, and work effectively with information, individuals and organizations from outside of their own area of expertise. Three areas of opportunity are discussed below.

Graduate training program in integrative energy systems. This next generation energy workforce would benefit greatly from a robust cross-disciplinary education, particularly at the graduate education level. This program could be modeled on the

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[2] See "Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy" PCAST, p. 25, available at: http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-health-it-report.pdf
[3] See White House Energy Security Forum, Discussions by the Deputy Secretaries of Defense and Energy, April 24, 2011, available at: http://www.whitehouse.gov/photos-and-video/video/2011/04/26/white-house-forum-energy-security

National Institutes of Health (NIH) Training Grant Program. The NIH Training Grants create "communities of education and research," bringing together faculty dedicated to a shared educational goal, and support graduate student fellowships, seminars, and course development. Eligible institutions would compete to develop the strongest programs, seeking five-year awards to support pre- and post-doctoral trainees enrolled in integrated curricula and research in energy. Institutions would then recruit qualified students who are committed to careers in energy research, and provide mentoring and career development. This approach would enable coherent models of graduate curricula for energy to develop at universities, as opposed to an approach focused on single fellowships for individual students, which would support students engaged in energy research, but would not foster the development of integrated energy curricula. Through training grants, pilot curricula would develop that could be widely circulated among other universities' graduate programs.

Training grant-supported programs can encourage collaboration among departments and provide opportunities to teach new graduate courses at the interface between disciplines. A DOE-sponsored training grant program would contribute to the development of a diverse and highly trained workforce available to assume leadership roles in addressing the Nation's complex energy research and training needs. (The NIH Training Grants have provided powerful and effective incentives for recruiting a diverse community of graduate students.) Establishment of DOE training grant programs is also one of the major recommendations of the PCAST report.[2]

Development of energy curricula. Energy education programs should be multidisciplinary, while including the rigor of deep understanding of the tools and ways of thinking of a core discipline. MIT recently instituted an energy minor for its undergraduates. The Institute chose to develop a minor rather than a major in energy, recognizing that depth of knowledge and specialization are both needed, but are not by themselves sufficient. Members of the nation's energy workforce must appreciate and apply their specialty in the complex and dynamic context of energy systems.

Multidisciplinary education also requires integrative learning. The sheer complexity of global energy and climate challenges requires integrating expertise from many disciplines. This is easy to recognize but difficult to systematically operationalize and measure. Many traditional learning environments are not ideally equipped to foster or to evaluate integrative learning. Several observations on the challenge of integrative learning for energy arising from experience to-date with MIT's Energy Studies Minor are shared in a response to a request for information submitted by MIT to the DOE in 2009.[4]

The DOE could support institutional efforts such as this to encourage universities to implement multidisciplinary and integrative academic programs. In addition to assistance with development of energy curricula, the DOE could help circulate different models, and institute virtual support mechanisms for institutions, faculty, and students.

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[4] MIT response to DOE RFI on Energy Education, available at: http://web.mit.edu/dc/Policy/mit-rfi-response.pdf

Graduate fellowship program. Another exciting program that is worthy of expansion is the DOE Office of Science Graduate Fellowship Program. This fellowship program has garnered significant attention and enthusiasm throughout academia, as the only coordinated fellowship program designed to meet the nation's long-term workforce needs related to the DOE's missions in energy, environment, and scientific discovery.

III. Comments on "Program Definition and Management":

Organizational support for connected science. In order to be successful in conducting fundamental research and gleaning the promise of potential technologies in the market place, the Department must do a better job of integrating the science and energy missions at DOE, thereby increasing the connections between basic and applied research, as discussed above. Creating a single Undersecretary for Energy and Science would better serve the country's energy needs and more effectively align the Department's missions and research portfolios with policy objectives and operational capabilities.

Although such a move may not be universally welcomed, energy technology development is an urgent priority and it will be served better if there is a single individual responsible for the entire energy innovation continuum, from the most basic science problems to issues of wide-scale deployment. Coupled with capable leadership at the top with knowledge of science and technology development, this organizational structure would help rationalize and optimize the performance of DOE's laboratories, and help clarify their mission.

Fuels versus sectors. Another area of improvement could be shifting away from the Department's organization of energy technology offices around fuels (e.g., nuclear, fossil, renewables), with efficiency illogically placed in the renewables office even though its opportunity targets are largely in the fossil fuel arena. This structure perpetuates a growing energy anachronism: fuels with discrete end uses such as oil for transportation or coal for power. In fact—and largely enabled by basic science advances in materials, storage, catalysis, conversion—fuels are much more interchangeable in their end uses. Coal, gas, and biomass to liquids for transportation and electric hybrid vehicles fueled by coal-fired or renewable power generation are just two examples of this growing capability.

This fuel-centric organizational structure is backward-looking and has been overtaken by technology advances. Structuring programs and program leadership around key energy uses—transportation, power, heat, electricity—as opposed to fuels would foster an updated and more comprehensive portfolio approach to energy R&D and related policy development.

IV. Comments on "Technology Demonstration":

Federally-supported demonstration projects, in theory, aim to provide a set of public goods by demonstrating the commercial viability of key energy technologies that are considered too risky or unsupported by current policy for the private marketplace to fully finance. In exchange for bearing part of the risk of the project, the government gains access to critical data that informs public policy options as well as policy makers, the public, investors, regulators, energy providers, equipment manufacturers, and other key constituencies. Because the ultimate goal is market deployment, information gleaned from such projects should be as "high fidelity" as possible in order to inform commercial practices in project design, construction, operation, and performance.

Challenges of innovating in established sector. Federal involvement in this link of the innovation chain is inherently contentious, raising the specter of government intrusion in private markets in which it arguably picks winners and brands losers. As the energy sector is well-established, however, new entrants face great difficulty without compelling information on cost, efficiency, and performance. Absent this, new technologies will not be deployed, so demonstration becomes absolutely critical. Without strong cost and efficiency information tied to realistic technology options deployment at scale will remain elusive, thus, significant government intervention will be required over the next decade if the marketplace is to have viable, demonstrated options for a future low-carbon world.

In the current environment, DOE is required to manage large-scale demonstration projects under restrictive federal procurement rules and industry match requirements, and do so under the uncertainty of annual appropriations. These untenable conditions—inflexibility bounded by uncertainty—inherently compromise the value of the information obtained. This is highly problematic in today's energy environment, and suggests the need to explore alternative financing mechanisms.

Drawbacks of existing loan guarantee program. Following demonstration, the next stage in the innovation chain involves deployment into initial markets. DOE's current Loan Guarantee program is, in theory, a positive initial step in helping to move technologies past the initial commercialization barrier. However the mandate language in the program's authorizing legislation builds in potential contradictions. It is limited to deployment-ready projects, thereby excluding many emerging technologies as well as the demonstration stage. The "high probability of commercial success" statutory clause, perhaps due to the legacy of failed 1980s synthetic fuels projects, significantly limits the risks that the program can take with innovative technologies, which further rules out emerging technologies. These structural problems in the program, as well as lingering processing problems because of the varying agency perspectives of DOE, Office of Management and Budget (OMB) and the Department of the Treasury, require correction. At lease two alternative mechanisms are under consideration.

Quasi-public corporation model. One model of a creative financing mechanism to support large-scale demonstration projects, which could spur deployment, could be a quasi-public corporation.[5] This corporation would provide indirect incentives to make the demonstration as credible as possible to potential donors, rely on commercial practices free from government procurement rules, and have access to multi-year funding that permits efficient execution of demonstration programs. The corporation would be made up of individuals with direct experience in areas such as industry capability, market needs,

[5] Proposed by former Undersecretary of Energy John Deutch in *What Should the Government Do To Encourage Technical Change in the Energy Sector*; Report No. 120 for MIT Joint Program on the Science and Policy of Global Change; May 2005; available at: http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt120.pdf

and financial incentives. DOE has had difficulty attracting experienced personnel with commercial-scale engineering and finance expertise; a corporation should be able to more easily attract such talent. Such a corporation would not favor particular fuels or supply over end-use, but would require a capital investment derived from a mechanism outside of the annual appropriations process, to reach success.

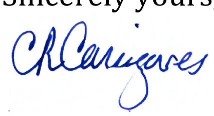
Clean energy deployment administration. Another useful model, in the initial deployment area, could be that of the Clean Energy Deployment Administration (CEDA), as proposed in Title I, Subtitle A of the American Clean Energy Leadership Act of 2009. The CEDA would be an independent administration within DOE, similar to the Federal Energy Regulatory Commission, with strong financial expertise and the goal of creating an environment conducive to investments for development and deployment of new clean energy technologies. CEDA would provide credit to support deployment of clean energy technologies in the forms of loans, loan guarantees (absorbing and rationalizing existing DOE loan guarantee authority), and other support mechanisms, as well as secondary market support to develop alternative products to encourage investment by the private sector.

Collaboration with DoD. Finally, as discussed above, the DOE should pursue potential deployment and demonstration opportunities within the DoD's significant fixed and operational asset base.

IV. Conclusion

We want to express MIT's appreciation for the Department's recognition of the value of outside input into this important undertaking. MIT's faculty and staff stand ready to assist you as you move forward in these efforts. If your offices have any follow up questions, please contact us through Abby S. Benson in MIT's Washington, DC Office at (202) 789-1828.

Sincerely yours,



Claude R. Canizares
MIT Vice President Research and Associate Provost

Ernest J. Moniz
Director, MIT Energy Initiative