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To: Under Secretary for Science Steve Koonin
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Submitted Through: DOE-QTRmailbox@hq.doe.gov

From: Claude Canizares
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Date: April 15, 2011

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

Dear Under Secretary Koonin,

I am 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.

Energy is a significant focus area at MIT. Through MIT's Energy Initiative (MITEI), over 20% of Institute faculty members participate in research related to energy, and the MIT Energy Club has over 2,800 members. MITEI, established in September 2006, is an Institute-wide initiative designed to help transform the global energy system to meet the needs of the future and to help build a bridge to that future by improving today's energy systems. MITEI 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.

MIT looks forward to commenting on the QTR more extensively in the coming weeks, however before the April 15, 2011 deadline I would like to draw your attention to a number of reports issued by MITEI in recent years.

Recent Multidisciplinary Studies and Symposia Reports:
MIT faculty members have conducted in-depth multidisciplinary energy studies designed to inform future energy options, research, technology choices, and policy development.

These studies have been grounded in science and engineering, supported by objective analysis, and attempt to be comprehensive in scope and input on critical energy technology policy issues. MITEI has also held a number of symposia that gather experts from academia, industry, and government, and have generated reports representing a wide array of perspectives on topics of interest to policy leaders.

A number of these multidisciplinary studies and symposia reports are highlighted below, including:

- The Future of Nuclear Power (July 2003, updated in March 2009)
- The Future of Geothermal Energy (November 2006)
- The Future of Coal (March 2007)
- On The Road in 2035: Reducing Transportation's Petroleum Consumption and Greenhouse Gas Emissions (July 2008)
- Retro-Fitting of Coal-Fired Power Plants for CO2 Emissions Reductions (March 2009)
- An Action Plan for Cars (December 2009)
- The Electrification of the Transportation System: Issues and Opportunities Symposium (April 2010)
- Critical Elements for New Energy Technologies (April 2010)
- The Future of Natural Gas Interim Report (June 2010)

The Future of Nuclear Power (July 2003, updated in March 2009)
An interdisciplinary MIT faculty group decided to study the future of nuclear power because of a belief that this technology is an important option for the United States and the world to meet future energy needs without emitting carbon dioxide and other atmospheric pollutants. This study discusses the interrelated technical, economic, environmental, and political challenges facing a significant increase in global nuclear power utilization over the next half century, and what might be done to overcome those challenges. In March 2009, MITEI issued an Update to the 2003 report. This Update reviews what has changed from 2003 to today with respect to the challenges facing nuclear power mentioned above. A second purpose of the Update is to provide context for the MIT study, *The Future of the Nuclear Fuel Cycle*, also summarized below.

The 2003 full report can be found here:
http://web.mit.edu/nuclearpower/

The 2009 update can be found here:
http://web.mit.edu/mitei/docs/nuclearpower-update2009.pdf

The Future of Geothermal Energy (November 2006)
An 18-member panel led by MIT and supported by the National Renewable Energy Laboratory (NREL) carried out a comprehensive assessment of enhanced, or engineered, geothermal systems to evaluate the potential of geothermal energy becoming a major energy source for the United States. Geothermal resources span a wide range of heat sources from the Earth, including not only the more easily developed, currently economic hydrothermal resources, but also the Earth's deeper, stored thermal energy, which is

present anywhere. Although conventional hydrothermal resources are used effectively for both electric and nonelectric applications in the United States, they are somewhat limited in their location and ultimate potential for supplying electricity. Beyond these conventional resources are enhanced geothermal systems (EGS) resources with potential for primary energy recovery using heat-mining technology, which is designed to extract and utilize the earth's stored thermal energy. Because EGS resources have significant potential for the long term, the study team focused its efforts on evaluating what it would take for EGS and other unconventional geothermal resources to provide 100,000 MWe of base-load electric-generating capacity by 2050.

The full report can be downloaded here:
http://www.inl.gov/technicalpublications/Documents/3589644.pdf

The Future of Coal (March 2007)
An interdisciplinary MIT faculty group examined the role of coal in a world where constraints on carbon dioxide emissions are adopted to mitigate global climate change. This report evaluates the technologies and costs associated with the generation of electricity from coal, along with those associated with the capture and sequestration of the carbon dioxide produced coal-based power generation. Growing electricity demand in the U.S. and in the world will require increases in all generation options (renewables, coal, and nuclear) in addition to increased efficiency and conservation in its use. Coal will continue to play a significant role in power generation and as such, carbon dioxide management from it will become increasingly important. This study, addressed to government, industry and academic leaders, discusses the interrelated technical, economic, environmental and political challenges facing increased coal-based power generation while managing carbon dioxide emissions from this sector.

The full report can be downloaded here:
http://web.mit.edu/coal/

On The Road in 2035: Reducing Transportation's Petroleum Consumption and Greenhouse Gas Emissions (July 2008)
This report summarizes the results of a research program that assessed the technology of light-duty vehicles and fuels that could be developed and commercialized during the next 25 years. The study group's objective was to assess and compare options for reducing fuel consumption, especially fuels from petroleum and greenhouse gas (GHG) emissions, during the production and use of both fuels and vehicles. The research for this report was confined to industrialized countries, with an emphasis on the United States but also including some western European countries. The study first assessed the application of new vehicle and fuel technologies to the performance, cost, and lifecycle emissions of individual vehicles; and then considered the effects on the total on-the-road fleet of introducing those technologies using plausible assumptions about how rapidly they could be developed, manufactured, and sold to buyers to replace existing vehicles and fuels or to add to the total fleet.

The full report can be downloaded here:
http://web.mit.edu/sloan-auto-lab/research/beforeh2/otr2035/

Retro-Fitting of Coal-Fired Power Plants for CO2 Emissions Reductions (March 2009)
On March 23, 2009, MITEI sponsored a symposium on the retrofitting of coal-fired power plants to capture carbon dioxide emissions. This report summarizes the views of symposium participants and identifies many key issues, opportunities, and possible "next steps" associated with retrofitting coal-fired power plants for carbon capture. It is important to note that this is a report on the proceedings and papers that informed those proceedings; it is not a study. The report represents a range of views from those at the symposium and where possible, includes consensus or general recommendations from the presenters and participants; it is not intended to represent the views of all the participants. Participants represented the range of stakeholders with expertise, equities, and interests in the topic and included 54 representatives of utilities, academia, government, public interest groups, and industry. The report includes four papers, three commissioned for the symposium, to start discussion of current and long-range technologies and research management objectives and strategies.

The full report can be downloaded here:
http://web.mit.edu/mitei/research/reports.html

An Action Plan for Cars (December 2009)
This report describes a portfolio of policies, which, in the view of the authors, is needed to put personal vehicle transportation on the road to sustainability in the longer term. Reducing petroleum consumption and greenhouse gas (GHG) emissions from cars and light-duty trucks in the United States over the next several decades will require that the country implement a clear and coordinated set of policies now. To incentivize adoption of more fuel-efficient vehicles, the study proposes coupling existing near-term fuel economy standards with a feebate incentive program and gradual increases in fuel taxes. The study further proposes driver education initiatives that would give vehicle owners information on how to maximize fuel savings in their purchase and driving decisions. Finally, the study underscore the need for a long-term strategy for fuels that evaluates fuels-related programs based on their contribution to reducing life-cycle petroleum consumption and GHG emissions.

The full report can be downloaded here:
http://web.mit.edu/mitei/docs/research/actionplan.pdf

The Electrification of the Transportation System: Issues and Opportunities (April 2010)
On April 8, 2010, the MIT Energy Initiative, together with Ormat, Hess, Cummins and Entergy, sponsored a symposium on the electrification of the transportation system. The symposium's 68 participants, all experts with wide-ranging backgrounds and points of view, helped to frame the issues, opportunities, and challenges associated with vehicle electrification. The symposium was organized into four panels that addressed key issues: (1) why vehicle electrification matters, (2) vehicle technologies, (3) infrastructure, and (4) policy options. This report reflects the major points of discussion, and presents a range of possible "next steps" for the consideration of policy makers and other interested individuals and entities. It is important to note that this is a report on the proceedings and

papers that informed those proceedings; it is not a study. The report represents a range of views from those at the symposium and, where possible, includes consensus or general recommendations from the presenters and participants; it is not intended to represent the views of all the participants.

The full report can be downloaded here:
http://web.mit.edu/mitei/research/reports/transport-electrification.html

Critical Elements for New Energy Technologies (April 2010)
On April 29th, 2010, MITEI, together with the American Physical Society's (APS) Panel on Public Affairs and the Materials Research Society (MRS), co-sponsored a workshop on critical elements for new energy technologies that took place at MIT. The possibility that important new technologies for the generation, transmission, storage, or use of energy might be constrained by limitations on the availability of certain elements has only recently attracted significant attention. The purpose of the workshop was to bring together experts in the diverse areas that bear on this novel issue and to try to determine the context, scope, complexity, and finally, the seriousness of the problem. The workshop also served as the start for an APS/MRS study of energy-critical elements (released in February 2011) that draws conclusions and recommends policy on this subject. This report summarizes the presentations and discussions that took place at the workshop. The report identifies many of the key issues that will dominate the discussion of energy critical elements in the future. A summary of key issues and themes, from the presentations and discussions, precedes the full rapporteur's report. In keeping with the exploratory nature of the meeting, however, the report refrains from drawing conclusions and making recommendations.

The full report can be downloaded here:
http://web.mit.edu/miteicomm/web/reports/critical_elements/CritElem_Report_Final.pdf

The Future of Natural Gas Interim Report (June 2010)
The *Future of Natural Gas* interim report is the third in a series of MIT multidisciplinary reports examining the role of various energy sources that may be important for meeting future demand under carbon dioxide emissions constraints. The first two reports dealt with nuclear power (2003) and coal (2007). A study of natural gas is more complex because gas is a major fuel for multiple end uses—electricity, industry, heating—and is increasingly discussed as a potential pathway to reduced oil dependence for transportation. In addition, the realization over the last few years that the producible unconventional gas resource in the U.S. is very large has intensified the discussion about natural gas as a "bridge" to a low-carbon future. The report attempts the integrated analysis reported here as a contribution to the energy, security, and climate debate. The study linked below is an interim report on the findings and recommendations, with a full report with additional analysis addressing a broader set of issues expected later this year.

The interim report can be downloaded here:
http://web.mit.edu/mitei/research/studies/naturalgas.html

The Future of the Nuclear Fuel Cycle (September 2010)
In 2003 MIT published the interdisciplinary study *The Future of Nuclear Power* referenced above. The underlying motivation was that nuclear energy, which today provides about 70% of the "zero"- carbon electricity in the U.S., is an important option for the market place in a low-carbon world. Since that report, major changes in the U.S. and the world have taken place as described in the 2009 Update of the 2003 *Future of Nuclear Power* report. Concerns about climate change have risen and a number of countries have adopted restrictions on GHG emissions to the atmosphere. Projections for nuclear-power growth worldwide have increased and construction of new plants has accelerated, particularly in China and India. This study on The Future of the Nuclear Fuel Cycle was carried out because of the continuing importance of nuclear power as a low-carbon option that could be deployed at a scale that is material for mitigating climate change risk, namely, global deployment at the terawatt scale by mid-century.

The full report can be downloaded here:
http://web.mit.edu/mitei/docs/spotlights/nuclear-fuel-cycle.pdf

I hope that you and your staff find these reports useful as you undertake the DOE QTR. One of the complexities of energy is that it includes many technology and resource segments, requiring policies relevant to those segments. MIT's reports referenced above attempt to decipher the energy policy framework with approaches relevant to these segments. While cross-cutting policies across segments should be sought in the QTR process, many policy approaches will inevitably be applicable to particular sectors. We hope the approaches recommended in these reports will be particularly helpful as you consider the latter course. As mentioned previously, MIT looks forward to submitting further comments on the QTR in the coming weeks.

I 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 Abby S. Benson in MIT's Washington, DC Office at (202) 789-1828.

Sincerely yours,

Claude R. Canizares