New Science for a Secure and Sustainable Energy Future

Summary of a report of the DOE Basic Energy Sciences Advisory Committee

The Energy Challenge

For a secure and sustainable energy future, the United States must reduce its dependence on imported oil, reduce its emissions of carbon dioxide and other greenhouse gases, and replace the economic drain of imported oil with economic growth based on exporting a new generation of clean energy technologies.

The cost and uncertainty of imported oil ($700B/yr at the peak, about $200B/yr currently) are major threats to the U.S. economy. Developing new competitive renewable energy resources will help solve our energy problems at home and create economic opportunity to market our solutions to the world.

The Science and Technology Solution

Changing our decades-long dependence on imported oil and unfettered emission of carbon dioxide requires fundamental changes in the ways we produce, store and use energy. This report identifies three strategic goals required to meet these challenges: (1) making fuels from sunlight, (2) generating electricity without carbon dioxide emissions, and (3) revolutionizing energy efficiency and use.

To meet these strategic challenges, the U.S. will have to create fundamentally new technologies with performance levels far beyond what is now possible. Such technologies, for example, may be able to convert sunlight to electricity with triple today's efficiency, store electricity in batteries or supercapacitors at ten times today's capacity, and produce electricity from coal and nuclear plants at twice today's efficiency while capturing and sequestering the carbon dioxide emissions and hazardous radioactive wastes.

Development of these advances will require scientific breakthroughs that come only with fundamental understanding of new materials and chemical processes that govern the transfer of energy between light, electricity, and chemical fuels. *Such breakthroughs will require a major national mobilization of basic energy research.* A working transistor was not developed until the theory of electronic behavior on semiconductor surfaces was formulated. Lasers could not be developed until the quantum theory of light emission by materials was understood. Similar breakthroughs can be achieved for sustainable energy, but only if we invest in basic research now.

Basic science stands at the dawn of an age in which matter and energy can be controlled at the electronic, atomic, and molecular levels. Materials can now be built with atom-by-atom precision, and advanced theory and computational models can predict the behavior of materials before they are made -- opening new horizons for creating materials that do not occur in nature and are designed to accomplish specific tasks. These capabilities, unthinkable only 20 years ago, create unprecedented opportunities to revolutionize the future of sustainable energy. Transformational solutions to reducing imported oil dependency and carbon dioxide emission – from solar fuels, renewable electricity and carbon sequestration to batteries, solid-state lighting and fuel cells – require breakthroughs in the fundamental understanding and control of materials and chemical change.

Recommendations

To achieve these essential breakthroughs we need to fund a bold new initiative focused on solving the critical scientific roadblocks in next-generation carbon-free energy technologies. The solutions are within reach, using advanced materials and chemical phenomena that control matter and energy at the electronic, atomic and molecular level. To develop these solutions, we must recruit the best talent through workforce development and early career programs. We must establish "dream teams" of the best researchers and provide them the resources to tackle the most challenging problems.

Full report: http://www.sc.doe.gov/bes/reports/files/NSSSEF_rpt.pdf

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