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SUSTAINABLE ENERGY STUDY #5

MIT-Led Panel Backs Geothermal 'Heat Mining' as a Key U.S. Energy Source:

A study sponsored by the U.S. Department of Energy and conducted by the Massachusetts Institute of Technology has found that geothermal energy in the United States could achieve a capacity of 100,000 megawatts -- enough to supply about 25 million homes -- in 50 years at an eventual cost of just \$40 million a year. That would represent about 6 percent of the current U.S. electricity supply - replacing aging nuclear and coal plants with an environmentally friendly alternative. The proposed program would require a combined public and private investment of \$800 million to \$1 billion in the first 15 years -- about the same money needed to build one new clean-coal power plant, the study said. The study is described by the researchers as the most far-reaching on the subject in 30 years.

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The Future of Geothermal Energy - Impact of Enhanced Geothermal Systems on the United States in the 21st Century:

<http://web.mit.edu/newsoffice/2007/geothermal.html>

A comprehensive new MIT-led study of the potential for geothermal energy within the United States has found that mining the huge amounts of heat that reside as stored thermal energy in the Earth's hard rock crust could supply a substantial portion of the electricity the United States will need in the future, probably at competitive prices and with minimal environmental impact.

An 18-member panel led by MIT prepared the 400-plus page study, titled "The Future of Geothermal Energy," and released it on January 22, 2007. Sponsored by the U.S. Department of Energy, it is the first study in some 30 years to take a new look at geothermal, an energy resource that has been largely ignored.

The goal of the study was to assess the feasibility, potential environmental impacts and economic viability of using enhanced geothermal system (EGS) technology to greatly increase the fraction of the U.S. geothermal resource that could be recovered commercially.

Although geothermal energy is produced commercially today and the United States is the world's biggest producer, existing U.S. plants have focused on the high-grade geothermal systems primarily located in isolated regions of the west. This new study takes a more ambitious look at this resource and evaluates its potential for much larger-scale deployment.

"We've determined that heat mining can be economical in the short term, based on a global analysis of existing geothermal systems, an assessment of the total U.S. resource and continuing improvements in deep-drilling and reservoir stimulation technology," said panel head Jefferson W. Tester, the H. P. Meissner Professor of Chemical Engineering at MIT.

"EGS technology has already been proven to work in the few areas where underground heat has been successfully extracted. And further technological improvements can be expected," he said.

The expert panel offers a number of recommendations to develop geothermal as a major electricity supplier for the nation. These include more detailed and site-specific assessments of the U.S. geothermal resource and a multiyear federal commitment to demonstrate the concept in the field at commercial scale.

The new assessment of geothermal energy by energy experts, geologists, drilling specialists and others is important for several key reasons, Tester said.

First, fossil fuels--coal, oil and natural gas--are increasingly expensive and consumed in ever-increasing amounts. Second, oil and gas imports from foreign sources raise concerns over long-term energy security. Third, burning fossil fuels dumps carbon dioxide and other pollutants into the atmosphere. Finally, heat mining has the potential to supply a significant amount of the country's electricity currently being generated by conventional fossil fuel, hydroelectric and nuclear plants.

The study shows that drilling several wells to reach hot rock and connecting them to a fractured rock region that has been stimulated to let water flow through it creates a heat-exchanger that can produce large amounts of hot water or steam to run electric generators at the surface. Unlike conventional fossil-fuel power plants that burn coal, natural gas or oil, no fuel would be required. And unlike wind and solar systems, a geothermal plant works night and day, offering a non-interruptible source of electric power.

Prof. Tester and panel member David Blackwell, professor of geophysics at Southern Methodist University in Texas, also point out that geothermal resources are available nationwide, although the highest-grade sites are in western states, where hot rocks are closer to the surface, requiring less drilling and thus lowering costs.

The panel also evaluated the environmental impacts of geothermal development, concluding that these are "markedly lower than conventional fossil-fuel and nuclear power plants."

"This environmental advantage is due to low emissions and the small overall footprint of the entire geothermal system, which results because energy capture and extraction is contained entirely underground, and the surface equipment needed for conversion to electricity is relatively compact," Tester said.

The report also notes that meeting water requirements for geothermal plants may be an issue, particularly in arid regions. Further, the potential for seismic risk needs to be carefully monitored and managed.

According to panel member M. Nafi Toksuz, professor of geophysics at MIT, "geothermal energy could play an important role in our national energy picture as a non-carbon-based energy source. It's a very large resource and has the potential to be a significant contributor to the energy needs of this country."

Toksuz added that the electricity produced annually by geothermal energy systems now in use in the United States at sites in California, Hawaii, Utah and Nevada is comparable to that produced by solar and wind power combined. And the potential is far greater still, since hot rocks below the surface are available in most parts of the United States.

Even in the most promising areas, however, drilling must reach depths of 5,000 feet or more in the west, and much deeper in the eastern United States. Still, "the possibility of drilling into these rocks, fracturing them and pumping water in to produce steam has already been shown to be feasible," Toksuz said.

Panel member Brian Anderson, an assistant professor at West Virginia University, noted that the drilling and reservoir technologies used to mine heat have many similarities to those used for extracting oil and gas. As a result, the geothermal industry today is well connected technically to two industry giants in the energy arena, oil and gas producers and electric power generators. With increasing demand for technology advances to produce oil and gas more effectively and to generate electricity with minimal carbon and other emissions, an opportunity exists to accelerate the development of EGS by increased investments by these two industries.

Government-funded research into geothermal was very active in the 1970s and early 1980s. As oil prices declined in the mid-1980s, enthusiasm for alternative energy sources waned, and funding for research on renewable energy and energy efficiency (including geothermal) was greatly reduced, making it difficult for geothermal technology to advance. "Now that energy concerns have resurfaced, an opportunity exists for the U.S. to pursue the EGS option aggressively to meet long-term national needs," Tester observed.

Tester and colleagues emphasize that federally funded engineering research and development must still be done to lower risks and encourage investment by early adopters. Of particular importance is to demonstrate that EGS technology is scalable and transferable to sites in different geologic settings.

In its report, the panel recommends that:

- * More detailed and site-specific assessments of the U.S. geothermal energy resource should be conducted.
- * Field trials running three to five years at several sites should be done to demonstrate commercial-scale engineered geothermal systems.
- * The shallow, extra-hot, high-grade deposits in the west should be explored and tested first.

- * Other geothermal resources such as co-produced hot water associated with oil and gas production and geopressured resources should also be pursued as short-term options.
- * On a longer time scale, deeper, lower-grade geothermal deposits should be explored and tested.
- * Local and national policies should be enacted that encourage geothermal development.
- * A multiyear research program exploring subsurface science and geothermal drilling and energy conversion should be started, backed by constant analysis of results.

Besides Tester, Blackwell, Toksuz and Anderson, members of the panel include: geomechanics expert Anthony Batchelor, managing director of GeoScience Ltd. in the United Kingdom; reservoir engineer Roy Baria from the United Kingdom; geophysicists Maria Richards and Petru Negraru at Southern Methodist University; mechanical engineer Ronald DiPippo, an emeritus professor at the University of Massachusetts at Dartmouth; risk analyst Elisabeth Drake at MIT; chemist John Garnish, former director of geothermal programs of the European Commission; drilling expert Bill Livesay; economist Michael Moore at the University of Calgary in Canada, former California energy commissioner and chief economist at the National Renewable Energy Laboratory; commercial power conversion engineer Kenneth Nichols; geothermal industry expert Susan Petty; and petroleum engineering consultant Ralph Veatch Jr. Additional project support came from Chad Augustine, Enda Murphy and Gwen Wilcox at MIT.

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The complete 372-page report "The Future of Geothermal Energy - Impact of Enhanced Geothermal Systems on the United States in the 21st Century" can be found at:
http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf

An article describing this report appeared in MIT's "Tech Talk" on January 24, 2007 and can be found at <http://web.mit.edu/newsoffice/2007/techtalk51-15.pdf>

A Reuters story on this report appeared in the "New York Times" on January 22, 2007 and can be found at: <http://www.nytimes.com/reuters/news/news-thermal-energy.html>