SUPERCONDUCTIVITY:

A Breakthrough in Electrical Technology

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Environmental and Energy Study Institute

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The Environmental and Energy Study Institute (EESI) sponsored a Congressional briefing on high temperature superconductivity (HTS) technologies, which promise lower costs, less pollution, more capacity and other advantages in the transmission of an electric current. All of these advantages are crucial as electricity demand increases and the present infrastructure of wires, transformers and generating plants reaches dangerous levels of obsolescence. The burgeoning energy needs of the United States are not likely to be met by simply building more transmission lines and generating plants. According to the panel of speakers, HTS power applications, which are being tested in several U.S. locations, are expensive and must prove themselves in trials, but the future of the technology is very bright.

Superconductors can carry unusually large amounts of electricity without resistance energy losses. Electric power equipment using superconductors typically have double the power capacity with only half the energy losses of the same-sized conventional counterparts. This would have a major impact in reducing the eight to ten percent of power generated that is now lost before reaching the consumer. In addition, HTS has a lower pollution potential because, among other reasons, no oil is needed for transformers and underground cables.

High temperature superconductivity was initially discovered in 1986, and research and development by government and private industry has been devoted to HTS for more than 12 years. It is referred to as high temperature because the cooling necessary for HTS is at the boiling point of liquid nitrogen, which is minus 323 degrees Fahrenheit. For comparison, helium, which is used medically in magnetic resistant imaging (MRI), has a boiling point of minus 452 degrees. Because helium costs about $10 for a two-liter bottle compared to liquid nitrogen costing about 25 cents for the same size bottle, it is unrealistic to contemplate helium for "real world" generation and transmission of electricity.

RESEARCH AND DEVELOPMENT ACHIEVEMENTS

The U.S. Department of Energy (DOE) has co-sponsored much of the research being done on HTS, and panelists at the EESI seminar unanimously saw a need for continued DOE support. Applauding the pace of current developments, Bill Parks, associate deputy assistant secretary of DOE's Office of Power

PANELISTS

Bill Parks
Associate Deputy Assistant Secretary, Office of Power Technologies, U.S. Department of Energy

David Lindsay
Development Engineer, Southwire Company

Jon E. Jipping
Principal Engineer, Power Delivery Planning, Detroit Edison

Shirish Mehta
Vice President of Technology and Development, Waukesha Electric Systems

David Driscoll
Research Manager of the Superconducting Motor Lab, Rockwell Automation

John Howe
Vice President, Electric Industry Affairs, American Superconductor

Technologies (at the time of this writing), noted the beginning of superconductivity research arising from the Nobel Prize winning research of the 1950s. He stated that developments at present are "very, very exciting." At this point, research and development has reached about 80 percent of the goals set by DOE. These goals include:

- Development of HTS wires with 100 times the capacity of conventional copper/aluminum wires of the same size.
- Designing and building generating equipment offering 50 percent reduction in size and 50 percent reduction in energy losses.
- Reducing the costs of HTS wire. Present HTS wiring is available in sufficient quantities to meet present needs, but these wires are about 60 percent silver, making them too expensive for many commercial applications. DOE and private companies are developing new manufacturing processes that eliminate the need for silver and can potentially be made at lower cost.

According to Parks, over the long haul, superconductivity can offer a great contribution to modernizing America's electrical superstructure. If successful, the work offers more efficiency, more reliability and higher capacity.

CABLE: "REAL WORLD" APPLICATION IN TEST

Headquartered in Carollton, Georgia and with annual sales of $1.7 billion, Southwire Company is one of the world's leading wire and cable manufacturers. David Lindsay, development engineer, described the status of Southwire's development of HTS cable. The Southwire Company became the world's first company to provide electricity utilizing high-temperature superconductivity for an industrial use. They installed three 100-foot HTS power cables in February 2000, which provide power to two of Southwire's plants and its machinery division. To date, Southwire has invested $8,150,000 and DOE's investment totals $7,150,000. Asking why a company would invest millions of dollars for this project, Lindsay outlined two answers. First, HTS offers an opportunity to regain some of the power lost in the generation and transmission of electricity. Secondly, HTS can transmit three to five times more power than current lines.

The project has operated flawlessly for more than 8,000 hours so far, and has been running unattended for several months. Advantages emphasized by Lindsay were for comparative ease in replacing underground cables in urban areas, increased carrying capacity and shrinking of size for components. However, huge obstacles to commercialization remain, Lindsay said, pointing out a need for proving reliability and for bringing costs down. The system for refrigeration and cables is very expensive, Lindsay said, although the cost trends are down.

POWER LINES: FIRST UNDERGROUND INSTALLATION

Jon E. Jipping, principal engineer for power delivery planning at Detroit Edison, noted that their Frisbie substation has the first underground HTS cable in a utility network. Advantages of the technology as listed by Jipping included an ability to optimize existing infrastructure, thereby reducing the need for new power lines and eliminating a need to dig up existing power lines. Detroit Edison is replacing nine copper cables weighing 20,000 pounds each with three HTS Pirelli cable systems weighing 1,000 pounds. A refrigeration system – which is extremely important – has been commissioned, and three phases of installation and splicing have been accomplished. Jipping projected that the new system could be in operation by the end of 2001. Several companies are following the project with interest and hope to use the retrofit operation, matching the new field to existing power systems.

Development costs are a factor, Jipping said, noting a "strategic opportunity for collaborative research." "It is way too expensive for us to do alone," concluded Jipping. The Electric Power Research Institute and the Department of Energy are co-sponsoring the project. Detroit Edison is the test site provider and utility end user, and other participants include:

- Los Alamos National Laboratory;
- Pirelli Cables & Systems, cable system provider and project management;
- American Superconductor Corporation, HTS tape provider;
- Lotepro Corporation, refrigeration system provider; and
- Electrical Power Research Institute, utilities group expertise, systems studies.

TRANSFORMERS: ENVIRONMENTAL AND SAFETY GAINS WITH DRAMATIC REDUCTIONS IN SIZE AND WEIGHT

Waukesha Electric Systems, based in Waukesha, Wisconsin, is a leading producer of medium and large-size power transformers, with manufacturing plants in Waukesha, Wisconsin; Goldsboro, North Carolina; and Milpitas, California. Shrish Mehta, vice president of technology and development, described their work on transformers, noting the dramatic reductions in size and weight when using HTS technology.

Positive results of using HTS technology include non-flammable installations, environmental desirability and the possibility of indoor siting. In addition to these "siting" benefits, Mehta outlined benefits for power systems: emergency overload capability, without damage to insulation or reduction in lifetime; higher power density; lower operating costs; limiting fault current, and lower impedance and better voltage regulation.

The timing of the introduction of new technology is critical, Mehta said, continuing that the next 20 years will be especially opportune and DOE's continuing support is crucial.

MOTORS: 5,000 HORSEPOWER THE GOAL

David Driscoll, research manager of the Superconducting Motor Lab for Rockwell Automation, described their work at the lab in Euclid, Ohio. Rockwell Automation, a $4.3 billion company headquartered in Milwaukee, Wisconsin, employs approximately 25,000 people at more than 450 locations in more than 80 countries, and is a world-leading provider of industrial automation power, control and information solutions. Their aim is to build and operate a motor with 5,000 horsepower, compared to the present 1,000 hp motor now in test stages. Electric motors consume more than 60 percent of the total industrial demand for power as industry converts electric energy to mechanical energy.

HTS motors, Driscoll noted, will have half the losses of conventional high-efficiency induction motors of the same rating. The motors will be smaller in size and weigh less than conventional counterparts. They will include an adjustable speed drive in order to obtain full benefits from increased efficiency. Significant cuts in sulfur dioxide and ozone releases will benefit the environment.

Navy and commercial ship propulsion systems were seen as a possible application for the new motors. Other potential uses would be in applications requiring continuous operation of large motors, such as boiler feed pumps, induced and forced draft fans and industrial scrubbers. Potential industrial applications include process industries such as chemicals, petroleum, pulp/paper, coal and textiles.

Commercialization will be difficult, however, until reliability has been demonstrated and costs are more competitive. Continued government support is critical, Driscoll said.

COSTS ARE DECLINING

John Howe, vice president of electric industry affairs for American Superconductor, outlined the current status of the "very rapidly developing field." American Superconductor, founded in 1987 and headquartered in Westborough, Massachusetts, is a leader in developing technologies and manufacturing products utilizing superconductor wire and solid-state power electronic switches for electric power applications, such as power cables, motors and generators. HTS is not a distant promise, Howe said, but is in use today. Howe saw a myriad of advantages for plugging HTS into grid systems across the country. An HTS system would include an ability to handle surge loads and increase output where necessary. In the grid systems, one utility or region can provide emergency power to other plants or regions. HTS will be particularly important in replacement of older, inefficient urban systems. Howe saw a potential for greatly decreased costs. Three years ago, the price of production motors was $1,000 per kilowatt hour. This has been reduced to $200, and expectations are for $50 per kilowatt hour in the near future. Howe concluded, "We don't have to wait several years for buyers. The technology is here today."

For more information about superconductivity, including the latest technological developments, please visit the U.S. Department of Energy's website: <www.eren.doe.gov/superconductivity>.

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