Office of Electric Transmission and Distribution

Superconductivity Partnerships with Industry

Plugging America Into the Future of Power

HTS Cable Projects

"A National Effort to Introduce New Technology into the Power Delivery Infrastructure"

What is being done to modernize electricity transmission and distribution?

In a national effort to introduce new technology into the power delivery infrastructure, the U.S. Department of Energy's Office of Electric Transmission and Distribution is partnering with industry to sponsor projects showcasing the use of high temperature superconducting (HTS) cables in modernizing electricity transmission and distribution systems. Three teams have formed to focus on different aspects of cable design and different electric system needs. This is the most important such effort world-wide and involves equipment manufacturers and suppliers from around the nation.

These projects are hosted by electric utility companies in Albany, New York; Columbus, Ohio and Long Island, New York, where the cables will be installed and operated under typical service conditions.

The planned total investment in the three projects is $68,400,000 (DOE $34,200,000; private sector $34,200,000) appropriated over a four year period.

A team led by American Superconductor will build and demonstrate a power cable on Long Island that will connect two Long Island Power Authority (LIPA) substations nearly half a mile apart. The 138 kV cable will be the first ever application of an HTS cable in the utility grid at transmission voltages.

A team led by SuperPower will demonstrate a 350-meter, 34.5 kV HTS cable connecting two substations along the Hudson River in Albany, New York. A section of the cable will be the first ever grid installation of a device using "Second Generation" HTS wire, a conductor made with new materials that are expected to enable a better cost/performance ratio. Research breakthroughs at Los Alamos and Argonne National Laboratories have contributed to the development of this wire. The Albany cable project will also include the first ever HTS cable splice installed in a utility grid.

ULTERA (a partnership between Southwire and nkt cables) is leading the development of a 200 meter, 13.2 kV HTS cable that will be installed in a substation in the American Electric Power grid in Columbus, Ohio. The cable is being designed to carry 3,000 amps of current and will feature a promising new design in which all three phases will be carried in a single cable through three different concentric layers of HTS wires.

What is Superconductivity?

Superconductivity is a property that only a few materials are known to possess. When cooled to very cold temperatures, these materials are able to carry electricity without resistance, meaning that less

"Promising technologies exist that will improve the transmission, storage, and reliability of renewable energy. An example of the recent technological success that will allow for increased access to all forms of energy, including renewable energy, is the high-temperature superconducting under-ground power transmission cables that the Department of Energy is developing in partnership with industry. The cables will allow a 300 percent increase in capacity without excavation to lay new transmission lines." *–The President's National Energy Policy*

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Study Shows Benefits of HTS Cables

Analysts from Rand Corporation, a non-profit policy research institution, performed a study of the impact of HTS cables on the grid in a heavily-loaded urban network (downtown Chicago) and in a constrained transmission path between major load centers ("Path 15" in California). The study used a complex simulation program to model the respective electrical grids of each area. The results showed that in both cases, the addition of HTS transmission cables could not only increase current carrying capacity, as would be expected, but could do so without sacrificing overall system reliability, since the HTS cables relieved overburdened cables elsewhere in the local grids. *See www.rand.org/publications/MR/MR1531/*

electricity is lost while being conducted through those materials. Prior to 1986, it was thought that materials needed to be cooled to near absolute zero to exhibit superconductivity, but two IBM researchers in that year discovered a class of materials that would superconduct at much "warmer" temperatures, around minus 320ºF. This meant they could be cooled with inexpensive, abundant, and inert liquid nitrogen.

Today the Department of Energy participates in a suite of projects in which electric utility devices using superconducting wires are being demonstrated. Called the Superconductivity Partnership with Industry, this program is matching industry funding with federal funding to demonstrate devices that will typically be half the size and have half the energy losses compared to conventional equipment.

What can HTS cables do for me?

HTS cables, with their increased efficiency, have the potential to reduce the amount of electricity lost in transmission and distribution. The grid in the United States loses an estimated ten percent of all electricity generated before it can be sold to the customer – an amount roughly equal to the electricity generated in the entire continent of Africa. The amount of lost electricity is growing every year, as load centers move further and further away from power plants, and electricity must be conducted for longer distances. The cost of this lost electricity is passed on to the customers of electric utilities. HTS cables have the potential to reduce that cost.

More immediately, HTS cables can pack more current through available spaces. In congested urban areas, expanding the capacity of an underground power line can involve digging up streets and can be expensive and disruptive. HTS cables can be fitted into existing rights-of-way and can provide a three- to five-fold increase in power delivery over conventional copper cables of the same diameter.

In addition to improved efficiency, HTS cables offer additional environmental and safety benefits. HTS cables use liquid nitrogen as a coolant instead of the dielectric oil commonly used in some conventional high-voltage cables. Dielectric oil can be a pollutant and a fire hazard, but nitrogen is environmentally compatible and safe to release into the atmosphere.

Why are public sector dollars funding these projects?

Since the discovery of electricity, systems for generating, transmitting, and using electrical current have been designed with a brute-force approach to overcoming electrical resistance. Since High Temperature Superconductors make it possible to conduct electricity without resistance, they offer the potential to dramatically re-shape the nature of the electrical grid. But the transformation will not occur overnight, or without help.

The materials used in HTS wires are brittle, expensive and often difficult to work with, making HTS research a very high-risk, high-reward endeavor. With energy economics becoming a world-wide focus, it has been difficult for utilities to find funding for large-scale R&D projects. Electric transmission and distribution companies face a growing uncertainty that investments in new technology can be recovered through the rate base. The Department of Energy started the Superconductivity Program in 1992 to assist U.S. industry to become a leader in HTS commercialization.

In 1996, the Superconductivity Program initiated the Superconductivity Partnerships with Industry thrust to enable industry to better fund demonstrations of HTS technology in utility devices. Since then, over $100 million in taxpayer funds has been matched by private industry to deliver first-of-a-kind demonstrations of HTS electrical devices. With the federal government's leadership, HTS research throughout the country has grown and is achieving "world's best" results with regularity.

In recent years, several studies have reinforced the need for transmission and distribution research, including the National Transmission Grid Study and the report on the August 2003 blackout in the northeast. With these three projects, the DOE is addressing that need.