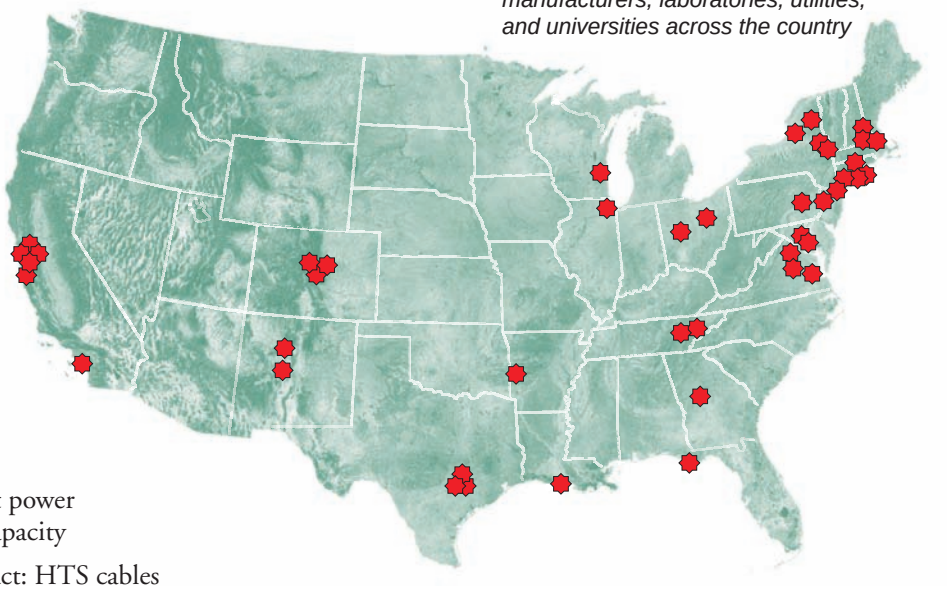
Office of Electricity Delivery and Energy Reliability

High-Temperature Superconductivity for Electric Systems

Plugging America Into the Future of Power

Superconductivity Program Overview

High-Temperature Superconductivity (HTS) has the potential for achieving a more fundamental change to electric power technologies than has occurred since the use of electricity became widespread nearly a century ago. In many ways, the transmission and distribution of electricity are poised for advancement the way that the Internet was poised for its takeoff in the 1990s. Just as fiber optics enabled the "information superhighway" by supplanting lower-capacity copper, superconductivity is enabling an "energy superhighway" by supplanting copper electrical conductors with a ceramic superconducting alternative that has higher capacity while eliminating resistive losses.



The HTS program partners with manufacturers, laboratories, utilities, and universities across the country

Benefits of HTS Power Applications

- Increased grid reliability and security by providing efficient power interconnections with high capacity
- Minimal environmental impact: HTS cables can be readily permitted and installed in dense urban areas
- Low-impedance design enables dynamic control of alternating current power flow, alleviating grid congestion
- Reduced right-of-way requirements (smaller footprint)
- Superconducting fault current limiters do not add impedance to the circuit during normal operation

The Superconductivity Program Has Three Focus Areas:

Superconductivity Applications
Developing HTS-based electric power equipment such as transmission and distribution cables and fault current limiters

Second-Generation Wire Development
Developing high-performance, low-cost, second-generation HTS wire at long lengths

Strategic Research
Supporting fundamental research activities to better understand relationships between the microstructure of HTS materials and their ability to carry large electric currents over long lengths

A spool of HTS tape

"In order to meet President Obama's ambitious energy goals, we must modernize the nation's electrical grid to improve the transmission, storage and reliability of clean energy across the country and help to move renewable energy from the places it can be produced to the places it can be used. By increasing transmission capacity and operators' ability to control the movement of electricity, high-temperature superconductivity will help reduce electricity losses and save energy nationally,"

— Energy Secretary Steven Chu

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Program Mission:

The Office of Electricity Delivery and Energy Reliability's Superconductivity Program's specific mission is to work in partnership with industry to develop HTS wire and perform other research and development activities leading to the commercialization of HTS-based electric power applications by U.S. companies

Program Goals:

By 2020, develop prototype wire achieving 1,000,000 length-critical current (A-m) for second-generation wire

By 2014, produce high-temperature superconductive coil that operates in applied magnetic fields up to 5 Tesla at 65 K for HTS applications

By 2012, verify operating characteristics and reliability of high-capacity HTS cables for distribution-level systems and gain industry acceptability

By 2012, establish design rules based on the full characterization of mechanical and electrical properties of existing and new dielectric materials at cryogenic temperatures

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On June 27, 2007, the Department of Energy (DOE) announced that it will provide up to $51.8 Million to support five Superconducting Power Equipment (SPE) projects. Two of the projects are cables, and the remaining three are fault current limiters.

Superconducting Cables

Superconducting cables are cooled cryogenically to remove the resistance to the flow of electricity, cutting down on the losses that typically occur during transmission. In addition to the three current DOE-funded cable projects located in Albany, NY, Long Island, NY, and Columbus, OH, two new SPE projects were announced:

- Southwire Company (Carrollton, GA) will use a 13.8-kilovolt superconducting cable to connect two existing substation sites and solve a real-world electrical load problem near downtown New Orleans. The cable will connect the LaBarre and Metaire substations, owned by Entergy Corporation of New Orleans, LA, a member of Southwire's project team. The team also includes: DOE's Oak Ridge National Laboratory and nkt cables of Germany.

Cutaway view of an HTS cable system

- American Superconductor Corporation (Westborough, MA) will develop the key components required to commercially deploy second-generation, high-temperature superconductor cables and demonstrate a single-phase prototype cable in the Long Island Power Authority power grid. In addition to the power authority, American Superconductor's team includes: Nexans (France) and Air Liquide Advanced Technologies U.S. LLC (Houston, TX).

Superconducting Fault Current Limiters

Superconducting fault current limiters (FCLs) insert an impedance in a conductor when there is a surge of current on utility distribution and transmission networks. Under normal circumstances, they are invisible to the system, having nearly zero resistance to the steady-state current, but when there is an excess of electricity, otherwise known as a fault current, the FCL intervenes and dissipates the surge, thus protecting the other transmission equipment on the line.

The following are the three new superconducting power equipment FCL projects:

- SC Power Systems (San Mateo, CA) will design, test, and demonstrate a 138-kilovolt, saturable, reactor-type FCL. In this type of limiter, a high-temperature superconductor is used with a direct current power supply to saturate an iron core that interfaces with the line in which the current is to be limited.
- American Superconductor will address the development and in-grid testing of a three-phase, 115-kilovolt fault current limiter, called a SuperLimiterTM, using second-generation wire. The SuperLimiterTM features a proprietary Siemens-developed, low-inductance coil technology that makes the limiter invisible to the grid until it switches to a resistive state.

Fault current limiter testing

- SuperPower Inc. (Schenectady, NY) will design, test, and demonstrate a 138-kilovolt limiter that features a matrix design consisting of parallel, second-generation high-temperature superconductive (HTS) elements and conventional coils.