HIGH TEMPERATURE SUPERCONDUCTIVITY

Bringing New Power to Electricity

SUPERCONDUCTIVITY NEWS UPDATE
29 August 2006

In this issue:

2006 Superconductivity Peer Review Showcases R&D Activities and Demonstration Projects

—Progress of four "real-world" superconductivity projects highlighted

The 2006 Superconductivity Peer Review was held near Washington, D.C. from 25 to 27 July. Attracting nearly 200 leaders in the field from around the world, the presentations at this annual event underlined the ongoing progress of research into high-temperature superconductivity as it edges closer to market readiness.

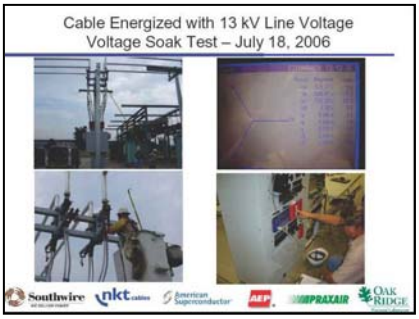
During each year's Superconductivity Peer Review, reviewers score each project, with half the score determined by an assessment of the project's performance versus plans for the year, as well as research integration with other institutions. The other half is

determined by productivity — whether world-class results were produced in the past year.

A glance at the many various technical presentations on the 2006 Peer Review's agenda, available at http://www.energetics.com/meetings/supercon06/agenda.html, shows how the superconductivity community is systematically addressing each of the many technical issues surrounding the full commercialization of this promising new electric power technology.

As superconductivity moves toward adoption by electric utilities, attention focuses on demonstration projects where the superconducting power equipment undergoes rigorous testing in real-world conditions. Four such projects from the Superconductivity Partnership with Industry (SPI) program were highlighted at this year's Peer Review: the Columbus cable project, the Albany cable project, the Long Island cable project and the fault current limiter project. Each one of these SPI projects is described below.

- **SPI Project: Columbus Bixby Substation Power Line**



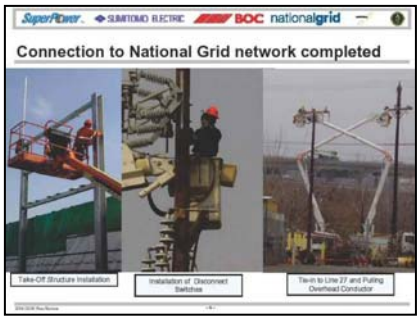
Led by Ultera (a joint venture between Southwire and nkt cables), this project is a 200-meter, 13.2 kV, 3.0 kAmps (69 MVA) superconducting power line at AEP's Bixby substation in Columbus, Ohio. The Bixby project is the highest-current superconducting power line project in the world, and its cable was energized with 13 kV line voltage in a voltage soak test on 18 July.

At the Peer Review, Ultera's David Linsday gave an overview of the project's status. Members of the Columbus Bixby Substation Power Line Project team are: Ultera, AEP, Oak Ridge National Laboratory, Praxair and American Superconductor.

View Ultera's slides by David Lindsay from the 2006 Peer Review

- **SPI Project: Albany Power Line**

Led by SuperPower, Inc., this project uses 350 meters of superconducting power line to link two Niagara Mohawk substations (Riverside and Menands). This superconducting power line parallels a new 34.5kV installation and has been added to handle load growth (i.e., it is not used solely for demonstration purposes).



At the Peer Review, Niagara Mohawk's Chuck Weber described the project team's progress, which led to a ribbon-cutting shortly after the Peer Review on 2 August.

Members of the Albany Power Line Project team are: SuperPower, Sumitomo Electric, BOC, National Grid (Niagara Mohawk), NYSERDA and the U.S. Department of Energy.

View Niagara Mohawk's slides by Chuck Weber from the 2006 Peer Review

News item: "New superconducting system beneath I-90 said to boost electrical capacity"

Richard A. D'Errico writes in the 25 July edition of the (Albany) Business Review:

> "Newly installed superconducting wire running between National Grid's Riverside and Menands substations is providing enough extra power through increased efficiency for more than 70,000 households, according to industrial gas supplier BOC.
>
> […]
>
> "The project is considered the first in-grid, high temperature superconductivity cable project in the United States, and will be officially commissioned on Aug. 2. High temperature superconductivity wire reduces the amount of electricity lost during transmission."
>
> […]
>
> "The project is particularly timely at a time when the U.S. Department of Energy is projecting world electricity demand to grow 2.6 percent per year, according to Garcia. With the technology, utilities can keep up with demand without having to add multiple distribution lines, he said."

D'Errico's full story is available at
http://albany.bizjournals.com/albany/stories/2006/07/24/daily26.html?jst=b_ln_hl

News item: "Cool cable line put to test"
SuperPower demonstration project designed to cut energy transmission loss

Eric Anderson writes in the 3 August Albany (N.Y.) Times Union:

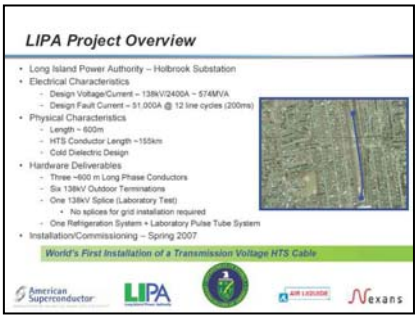
> It's the first of its kind, a high-temperature superconducting cable that one day may find its way into the nation's electric power grid. The "high temperature" is somewhat relative; the wire is chilled to minus 190 Celsius.
>
> On Wednesday, one of the hottest days of the year, utility and industry officials gathered under a tent at one end of the new cable, which connects two National Grid substations in Albany and Menands.
>
> […]
>
> The cable was developed by Schenectady-based SuperPower Inc., a unit of Intermagnetics General Corp. in Latham. The cable is cooled to minus 190 Celsius, allowing electricity to flow with almost no resistance, said Edward L. Garcia, a vice president at BOC Group.
>
> […]
>
> The 7 percent to 10 percent loss due to resistance in traditional copper lines is avoided, said Philip J. Pellegrino, president of SuperPower.

> The technology could ease the pressure on generating capacity, several industry officials said, and potentially avert the failure of overloaded conventional cables. The 14 feeder lines in the New York City borough of Queens that failed last month left tens of thousands of residents without power.
>
> Pellegrino said he expects the cable to be available commercially by 2010, although it will take decades to upgrade the entire electrical system, he added.

Anderson's full story in the Albany Times Union can be viewed at http://timesunion.com/AspStories/story.asp?storyID=505190&category=BUSINESS&BCCode=HOME&newsdate=8/3/2006

- **SPI Project: Long Island Power Line**

Powering LIPA's Holbrook Substation, this 610-meter, 138kV project is led by American Superconductor and is the world's first installation of a transmission-voltage superconducting power line.



James Maguire of American Superconductor provided details on the progress of this project at the Peer Review. Maguire detailed the status of systems and cryogenics tests and reported that the project is on track for commissioning in the spring of 2007.

Shortly after the Peer Review, a groundbreaking ceremony was held during a "scorching" day that served to remind participants of the rapidly growing demand for electricity throughout the country.

Members of the Long Island Power Line Project team are American Superconductor, the Long Island Power Authority, Air Liquide, Nexans and the U.S. Department of Energy.

View American Superconductor's slides by James Maguire from the 2006 Peer Review

> **News item: "American Superconductor and LIPA Bring Largest Superconducting Cable to Long Island"**
> ***—LIPA Chairman says heat wave underscores importance of electric innovations***
>
> "As in the midst of a scorching heat wave, and part of its commitment to ensure economical, safe and reliable electricity to its customers, the Long Island Power Authority (LIPA) held a Groundbreaking Ceremony [on 2 August] in Holbrook to announce the construction phase of the world's largest and highest-voltage superconductor electric transmission cable system. The 138,000 volt (138kV) cable system, nearly one-half mile in length, will be the world's first superconductor cable installed in a live grid at transmission voltages and will carry more power than all previous high temperature superconductor (HTS) cable demonstrations combined."
>
> "The project is being undertaken by a government-industry partnership. Other partners participating in the ceremony included the United States Department of Energy, American Superconductor Corporation (AMSC), Nexans and Air Liquide."
>
> […]

"LIPA is very pleased to be a pioneer in this remarkable technology," said LIPA Chairman Richard M. Kessel. "Superconductivity can provide an invaluable tool to assist LIPA in contributing to provide a high level of reliability to its customers. During this heat wave, innovations like this make more sense than ever."

[…]

"At a time when power grids across the nation are being severely stressed, superconductor technology is being examined by US utilities as a new tool to increase capacity and reliability on their systems. This project is one of three being co-funded by DOE that will demonstrate different designs and applications of high-capacity, low-profile superconducting cable technology. The LIPA project will be the first use of superconductors at electricity grid transmission level voltages. We continue to view superconductivity as a powerful enabler of the next-generation energy delivery system," said Kevin Kolevar, Director of the Office of Electricity Delivery and Energy Reliability at the US Department of Energy."

[…]

"With HTS cables gaining broader acceptance by power utilities worldwide, it has become increasingly important to understand the issues surrounding the integration of these cables into existing power grids. In addition to developing a first-of-its-kind HTS cable at unprecedented length and voltage, this project is developing the necessary tools to assure the reliable integration of this technology into the grid. Once the cable system and integration tools are developed, high-capacity superconductor cables will allow utilities to serve much higher power loads than is possible with today's power cables in any given voltage class. This power density advantage translates into easier permitting, smaller rights of way and smaller substations."

[…]

"After an initial operational period and following performance and economic reviews of the cable system, LIPA plans to retain the new superconductor cable as a permanent part of its grid. LIPA and American Superconductor have also discussed plans to install high capacity, low-environmental-impact HTS cables elsewhere in the LIPA grid to address the growing electric power needs on Long Island."

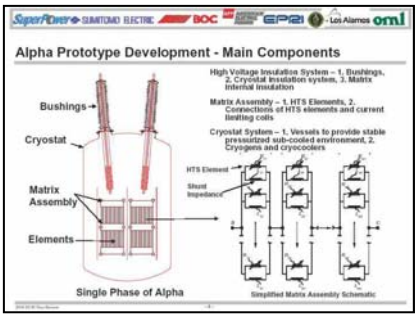
From http://www.azom.com/details.asp?newsID=6217, 2 August 2006

News item: Ken Silverstein of energy**biz *insider* on the LIPA project, 11 August:**

"If the LIPA project performs as expected, it could be a harbinger of things to come in the transmission sector. And with the digital age advancing at a rapid pace, modernization of the grid has become a national priority."

From http://www.energycentral.com/site/newsletters/ebi.cfm?id=190

- **SPI Project: Fault Current Limiter**



A fault current limiter uses superconductors to instantaneously limit electrical surges before they reach a circuit breaker. SuperPower, Inc. is a leader in developing matrix fault current limiters, which would demonstrate the concept at transmission-level voltage of 138kV.

In his update at the Peer Review, project manager Roger Farrell of SuperPower said that his group's goal

was to demonstrate SFCL feasibility at transmission level voltage of 138kV. This project, with a current estimated cost of $23.6 million, is estimated to be completed in June 2009. Farrell noted that the cost is higher and the completion date is later than originally projected because of a switch from melt case BSCCO to second generation (2G) wires and the attendant issues in optimizing the 2G wires for this application.

Members of the Fault Current Limiter Project team are SuperPower, Sumitomo Electric, BOC, AEP, EPRI, the U.S. Department of Energy and two DOE national laboratories: Los Alamos and Oak Ridge National Laboratories.

View SuperPower's slides by Roger Farrell from the 2006 Peer Review

Message from DOE Superconductivity Program Manager Tells of Program Goals and Successes

—Daley highlights high leveraging of DOE funding with private sector dollars

In a message to all participants of the 2006 Superconductivity Peer Review, the U.S. Department of Energy program's team leader, James Daley, lays out his program's goals and accomplishments in an excellent one-page overview:

The U.S. Department of Energy (DOE) Superconductivity Program for Electric Systems has the lead Federal role in developing electric power applications of high-temperature superconductivity (HTS). Superconductivity is the ability of special materials to carry large electrical currents without the resistance energy losses of conventional conductors such as copper wires. In parallel, large-scale electric systems such as transmission cables, transformers, and motors using HTS wire are under development. Effective public/private partnerships are essential to meeting program goals. The U.S. industry provides the leadership needed for future commercialization, while the DOE laboratories and universities address technology barriers.

Wire development activities focus on raising current-carrying capacity and magnetic field tolerance in short samples of wire. Also, the program supports improving the capability of private partners to achieve this high performance in the long lengths needed by applications. The program's "Second Generation Wire" is now scaling up breakthroughs at Los Alamos National Laboratory and Oak Ridge National Laboratory that promise unprecedented performance and low cost by processes that apply HTS coatings to specially prepared metal strips. Several promising manufacturing approaches are being explored in collaborations between national laboratories and the private sector for this important priority.

System development activities are carried out by vertically integrated industrial teams composed of a technology user (a power supply company), a manufacturer, and an HTS wire supplier in the "Superconductivity Partnership With Industry" (SPI) part of the program. The project teams usually include a DOE National Laboratory which performs specific supporting activities. Each project is reviewed quarterly at field locations. The SPI portfolio presently includes cryogenic dielectrics, generator, motor, flywheel system, fault current limiter, and cable projects.

The Superconductivity Program leverages HTS research in other Federal programs, chiefly in the DOE Office of Science, as well as in the DOD, and NIST. Work with private companies involves 50% cost-sharing (DOE provides half the funding and the private company provides the remainder). Program funding is thus highly leveraged. Participating companies continue to set most of the world's HTS benchmarks in the electric power field.

Prototype HTS power equipment is beginning to undergo field trials at a critical time for the electric power industry. The electric grid is becoming stressed due to economic growth and changes in delivery pathways as greater competition is introduced. Also, the overall electricity infrastructure is aging (a majority of transformers and other equipment are at or past their design lifetimes) and will need replacement during the

next 20 years. HTS equipment will be more reliable and have higher capacity ratings than conventional alternatives. Commercial versions of the technologies now being developed will become available at a time to meet the needs of a growing economy and a more competitive energy marketplace.

The Annual Peer Review has played an important role in the program's success. You have our sincere thanks for taking the time and effort to assist us again this year.

Argonne's Crabtree Emphasizes Coordination and "Grid Transformation" through Superconductivity

In his remarks at the 2006 Superconductivity Peer Review's plenary session, George Crabtree, Senior Scientist and Division Director at Argonne National Laboratory, pointed out that with the ever-increasing amount of energy devoted to electricity production, the superior performance, higher capacity and greatly increased efficiencies promised by high-temperature superconducting power equipment offer unprecedented opportunities.

Crabtree's comments focused on the importance of continuing to integrate research on superconductivity between DOE's Office of Electricity Delivery and Energy Reliability and DOE's Office of Basic Energy Sciences. He pointed out that such continued coordination would help hasten the breakthroughs in research and development and, ultimately, integration into our nation's electric power infrastructure.

As Crabtree said at the end of his remarks, "the grid cannot meet future challenges of capacity, reliability and quality, but superconductivity has solutions."

View George Crabtree's slides for an excellent overview of superconductivity as a solution to grid issues at
http://www.energetics.com/meetings/supercon06/pdfs/Plenary/02_BES_Collaboration-Crabtree.pdf

What is the Market for Superconductivity?
—Navigant examines market readiness of superconducting power applications

The U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability commissioned a study by Navigant Consulting Inc., of Bedford, Mass., to investigate "the status of HTS technology, the requirements of key applications and barriers to commercial success." The prime authors of this study were Navigant's Stan Blazewicz, David J. Walls, Forrest Small and Steven Tobias.

In its study, Navigant concluded that "government support is critical for advancing HTS technology and bringing it to market" and that commercial success in energy and utility applications will take longer than previously predicted. Navigant pointed out that "each of the technology platforms – wire, cryogenics and dielectrics – must provide sufficient performance at a price that each HTS application can support."

Navigant's study described various R&D programs in the fields of wire, cryogenics and dielectrics, pointing out that improving each of these will help hasten the commercialization of various superconducting power applications. Some of Navigant's key conclusions include:

- "R&D initiatives to improve cryogenics and dielectrics are being led by industry, with some support from the Labs, but more is needed."
- "The most important near term energy and utility markets appear to be fault current limiters and synchronous condensers."
- "HTS cables are likely to enter the market on a commercial basis around 2014, but additional stages of demonstration will be required."
- Bottom line: "We need to do a better job of engaging the utility customers in order to accelerate the adoption of HTS technology."

View Navigant's slides on this study, presented at the 2006 Superconductivity Peer Review

DOE Superconductivity Solicitation Issued
—Replies sought in three primary areas of interest; applications due 7 November

The U.S. Department of Energy has issued a new solicitation for "Superconducting Power Equipment." This funding opportunity (Number: DE-PS26-06NT42874-00) can be viewed at https://e-center.doe.gov/iips/faopor.nsf/UNID/6A77A0672C42024B852571C6005BC82D?OpenDocument.

The solicitation seeks expressions of interest in three primary program areas:

Program Area of Interest 1 – Power Delivery Cables (DE-PS26-06NT42874-01)

"The objective of this area is the development and demonstration of power delivery cables to facilitate the integration of high temperature superconducting wires and cables in existing electric networks to demonstrate improvements to electric system performance, such as power flow control and reliability.

The proposed project may feature cables for AC or DC current. Voltage levels may be distribution-level voltage class or greater. The proposed project may feature Very Low Impedance (VLI) cables.

The goal of the project should be to demonstrate the application of High Temperature Superconductor (HTS) power delivery cables beyond what has already been demonstrated. The project should demonstrate commercial readiness, including how the use of HTS cables could add value to a utility or other end-user."

Program Area of Interest 2 – Fault Current Limiters (DE-PS26-06NT42874-02)

> "The objective of this area is the development and demonstration of fault current limiters (FCL) using high temperature superconductors to control fault-current levels on utility distribution and transmission networks. These fault current limiters, unlike reactors or high-impedance transformers, should limit fault currents without adding impedance to the circuit during normal operation.
>
> The proposed project could involve design, testing and operation of FCLs with the goal to demonstrate FCL for use in transmission; however, it may be appropriate to demonstrate the technology first at distribution level."

Program Area of Interest 3 – Other High Temperature Superconductivity Applications (DEPS26-06NT42874-03)

> "The objective of this area is the development and demonstration of High Temperature Superconductor (HTS) applications not included in Areas of Interest 1 or 2. The goal of proposed projects should be to use HTS devices for more efficient production and use of electricity. Projects would include, but are not limited to, use of HTS technology in synchronous condensers/var generators, storage systems, transformers, large industrial motors and generators. These projects could include other applications of high temperature superconductivity that would result in more efficient production or use of electricity."

Each of the program areas has requirements or preferences specific to each area, and the original solicitation should be reviewed carefully. Due date for applications is 7 November.

American Superconductor announces wire 'breakthrough'

Greg Turner writes in the 11 August edition of the Westborough (Mass.) News:

> "American Superconductor Corp. announced a "major breakthrough" in its development of high-tech wires designed for power transmission cables, ship engines and other electrical systems…The news sent the Westborough company's shares soaring more than 25 percent in late July… American Superconductor said it achieved "commercial levels of electric current for the first time in long lengths" of its second-generation high-temperature superconductor wire - opening up the possibility of moving the technology from the lab to the marketplace."

Read more of Turner's story at
http://www2.townonline.com/westborough/localRegional/view.bg?articleid=554553

"A Power Grid for the Hydrogen Economy"

Paul M. Grant, Chauncey Starr and Thomas J. Overbye have released a paper saying that "cryogenic, superconducting conduits could be connected into a "SuperGrid" that would simultaneously deliver electrical power and hydrogen fuel."

Grant, Starr and Overbye point out that:

> "[a] fundamental limitation of the 20th-century grid is that it is poorly suited to handle two 21st-century trends: the relentless growth in demand for electrical energy and the coming transition from fossil-fueled power stations and vehicles to cleaner sources of electricity and transportation fuels. Utilities cannot simply pump more power through existing high-voltage lines by ramping up the voltages and currents. At about one million volts, the electric fields tear insulation off the wires, causing arcs and short circuits. And higher currents will heat the lines, which could then sag dangerously close to trees and structures…A hydrogen-filled SuperGrid would serve not only as a conduit but also as a vast repository of energy."

Their full article, "A Power Grid for the Hydrogen Economy," from Scientific American via FuelCellWorks.com, is available at http://www.fuelcellsworks.com/Supppage5527.html

September Scientific American Focuses on Energy
—Superconductivity repeatedly cited as enabler of a cleaner, sustainable energy future

The September 2006 issue of Scientific American focuses on "Energy's future beyond carbon," with several articles mentioning superconducting power equipment as a key enabler to a cleaner, more sustainable energy future using all kinds of low-carbon energy technologies.

Particular attention is focused on superconducting wires, with a short feature article by Graham P. Collins on the great promise of second-generation superconducting wires. In his article, Collins points out the significant work left before these wires are fully commercialized, but summarizes the important research and development work being performed by U.S. Department of Energy national laboratories along with companies in the private sector such as American Superconductor and SuperPower.

The September issue of Scientific American is currently on news stands and available for downloading at www.sciam.com.

ABOUT THIS UPDATE

The High-Temperature Superconductivity News Update is compiled by Bob Lawrence & Associates Inc. on behalf of the superconductivity program and is issued periodically as events warrant. Past issues are available at http://www.superconductivitynewsupdate.com/.

Please let me know if you would like more information or story ideas on any of these news items involving high-temperature superconductivity---a clean and capable new

electricity technology for the 21st century. If you have any other comments or questions, please let me know.

Thank you very much.

Craig Cox
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