High-Temperature Superconductors: Meeting Global Electricity Demands

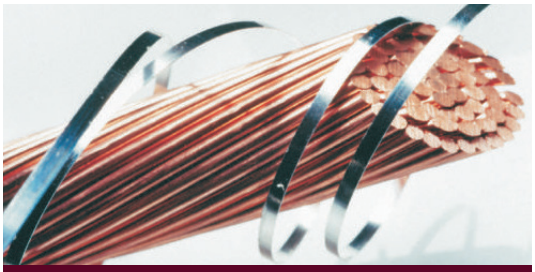
The International Energy Agency's (IEA's) **Implementing Agreement for a Co-Operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector** conducts detailed studies and provides a venue for expert discussion of its topic. Because economic alternatives to conventional technology are urgently needed and the promise of superconductivity is growing, the IEA Agreement prepared this document for ready reference by citizens and policy makers in the Agreement's member countries.

The world depends on electricity not only for light and power, but increasingly, to enable communication, computation, information retrieval and record keeping for all aspects of business, finance and medicine, as well as in our personal lives. Personal computers, mobile phones and the internet would not be ubiquitous without inexpensive and reliable electricity. All these uses drive the demand for more electric power in both the developing and the developed worlds. (For example, the internet's digital warehouses – the cloud's hardware – consume about 30 GW of electric power world-wide, equivalent to 30 nuclear powerplants.)

The International Energy Agency and the U.S. Department of Energy both project global electricity consumption will double by 2030-2035, with much of the increase occurring in the developing world, where present-day capacity falls short. The electrical shortages that drive China's continuing investment are well known. India's power sector, too , has long been considered a great hindrance to the country's economic prospects. Part of the problem is access; more than 300 million people in India still have no electricity. The other part is related to inadequate equipment. In July 2012, an overloaded transmission line precipitated the collapse of India's northern power grids, blacking out some 670 million people, or roughly 10% of the world's population.

To support the projected doubling of world capacity, more than one trillion dollars of new electrical equipment must be built, sold and installed—an important commercial opportunity. Not just more, but better, electrical equipment is wanted to address problems of uncertain reliability, fears of near- and long-term environmental impacts, and unavailability of infrastructure and fuel, as well as plans in some countries to shift from nuclear to renewable generation (stimulated by the 2011 nuclear meltdowns in Japan).

Photovoltaic arrays and wind turbines offer promise for harnessing power from renewable resources. Superconducting magnets and current leads have been incorporated in equipment offered by Bruker to improve the quality of silicon



A tiny HTS wire, colored silver as shown, may replace the bulky copper in today's equipment, enabling smaller, lighter, safer, more efficient, future power equipment.

intended for solar cells. Off-shore winds could be a steady power source, but today's powerful generators are heavy and so expensive to support off-shore. Superconductors offer the prospect of less expensive electricity by enabling powerful but much lighter off-shore generators.

Many of the world's utilities must cope with increasing fault (short-circuit) currents. Lacking an off-the-shelf solution, they desire new technology. HTS offers the only known approach to high voltage "fault current limiters". If developed, they would offer now-unattainable reliability. Further, superconducting transformers offer increased overload capability, decreased fire hazard, and decreased size and weight, very valuable features in cities. Also, superconducting underground electric power transmission cables promise to transmit more power into densely populated cities where space is limited and concerns with environment, safety and health are paramount. Indeed, prototype high-temperature superconducting transmission cables are being developed and demonstrated in China, Korea, Japan, the EU, Russia and the U.S.

Sumitomo's 66kV, 200 MVA HTS cable was recently installed on TEPCO's grid.

Before completing its in-grid test, AEP successfully operated Ultera's Triax™ HTS cable (3kA, 13.2kV) for six years in Columbus, Ohio. Now, RWE plans to test, in Essen, DE, a similar but much longer (1km), triaxial cable built by Nexans.

Concerns over the environmental impacts of hydrocarbons or fissionable material (i.e., uranium and plutonium), which fuel today's generating stations, prompt governments to fund research and development for the long-term success of magnetically confined fusion, a technology that requires superconductivity.

The benefits of High-Temperature Superconductivity (HTS) have not escaped others' attention. Maritime interests have involved themselves in the development. Under the acronym POSE^{2}IDON, a European consortium of 30 institutions is investigating the commercial potential of using superconductors on ships. Kawasaki, Rolls-Royce, Siemens, Sumitomo and others are working on their own projects to a like end.

Built by Innopower, an FCL meant to protect a 220 kV line is now being tested on the grid in Tianjin, China.

HTS has come a long way since its discovery in 1986. The technology has progressed from basic materials research, to laboratory testing, and, in the past decade, to demonstrations of full-size pre-commercial equipment. Yet much remains to be accomplished. Young engineers and scientists must be recruited to advance the field, improve performance and lower costs before the promise of HTS can be fully realized. Cost-sharing between the public and private sectors will encourage the best use of resources; task-sharing among the private sector, government laboratories and research universities will promote cooperation among researchers with diverse training and complementary facilities. With appropriate investment, HTS technology can address the world's energy, safety and environmental concerns and be commercially attractive.

A 4MVA, 2 Hz generator is the latest result of Siemens long term commitment to developing HTS motors & generators for the maritime industry. The same goal also attracts other HTS machine developers.

In the midst of this activity, the IEA Agreement provides a unique forum. Others focus on particular interests. The IEA group involves people from varied disciplines and organizations around the world in a non-competitive discussion of the status, challenges and prospects for commercial use of HTS. IEA group members call upon each other when desired and twice yearly IEA group meetings include updates by members, presentations by invited experts, in-depth reports on selected topics and guided visits to HTS facilities and their staff.

SUPERCONDUCTIVITY

IEA High-Temperature Superconductivity Agreement

The International Energy Agency's Implementing Agreement for a Co-Operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector **draws its participants from the following countries:**

Canada
Hydro-Quebec, Montreal

Finland
Tampere University of Technology

Germany
KIT, Karlsruhe
Siemens, Erlangen

Israel
Ministry of National Infrastructure, Jerusalem

Italy
RSE, Milano

Japan
NEDO, Kawasaki

Republic of Korea
KEPRI, Taejon

Switzerland
Bundesamt für Energie, Bern

United States
Dept. of Energy, Washington, DC

Bruker
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For an introduction to the Agreement's work, visit http://www.SuperconductivityIEA.org

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