superior performance. powerful technology.

Capture the Energy

Superconducting Magnetic Energy Storage

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SuperPower – focus on 2G HTS wire technology

- Formed in 2000 to develop 2G HTS technology for Energy Technology applications
- Ownership:
  - 2000-2006: Intermagnetics General Corporation
  - 2006-2012: Subsidiary of Royal Philips Electronics
- Facilities:
  - Headquarters and manufacturing operation in Schenectady, NY
  - Research & Development organization in Houston, TX
- ~65 employees
  - Highly skilled workforce
  - World recognized experts in their fields
SuperPower® 2G HTS wire and coils

- A superconductor is an electrical conductor which, when cooled to very low temperatures loses all resistance.

- Two types: Low Temperature Superconductors (LTS) and High Temperature Superconductors (HTS)
  - HTS and can achieve their critical temperature (77 K) using inexpensive liquid nitrogen, rather than the more expensive liquid helium required for LTS (4.2 K)
  - HTS demonstrates superior performance in a magnetic field compared to LTS

- Our focus is world leading development and commercial manufacture of 2G HTS wire for applications in energy, medical, transportation, research and other sectors
- Design and fabrication of HTS-based coils

HTS Wind Turbine Generator

HTS Power Cable

HTS Transformer

HTS SFCL

HTS Motor & Generator
Advantages of 2G HTS wire for energy technology applications

Enabling Clean, Green and Smart Technology

- 2G HTS offers excellent performance for all electrical device operating ranges
- Demonstrates superior performance in a magnetic field
- Has superior mechanical properties and is very robust
- High engineering current density: smaller, lighter, easier to site devices
- Improved efficiency, reliability and power quality
- Form fit replacement for copper
- Environmentally friendly and safe (no oil)

SMES: Superconducting Magnetic Energy Storage
SMES is a large superconducting coil capable of storing energy in a magnetic field \( (B) \) generated by dc current. Energy stored scales as \( B^2 \).

Components and operation of a SMES unit

- A typical SMES system includes three parts:
  - superconducting coil
  - power conditioning system
  - cryogenics

- To charge the coil, the power conditioning system uses an inverter/rectifier to transform AC power from the grid to direct current to power the magnet (nearly infinite cycling capability of coil once charged)

- The stored energy can be released back to the network by discharging the coil using the power conditioning system to convert DC back to AC power

- The inverter/rectifier accounts for about 2-3% energy loss in each direction. SMES loses the least amount of electricity in the energy storage process compared to other methods of storing energy
SMES usage

- SMES systems (utilizing LTS) are already commercially available and are currently used for short duration (seconds) energy storage for improving power quality
- In a utility situation SMES could be used for either:
  - diurnal storage (hours), charged from base load power at night and meeting peak loads during the day
  - medium term storage (minutes) to level out variations in renewable generation (solar, wind)
Why SMES?

Provide grid stability to challenges posed by renewable energy sources

- Power is available when needed, not only when generated
- Rapid response for charge or discharge (Power Quality)
- High round trip efficiency (>85%)
- Minimal energy losses (2-3 %)
- Main parts are motionless, which result in high reliability

- However, performance limitations in LTS technology have prevented SMES from developing into a viable grid level storage option
2G HTS enables advancement of SMES

- Superior HTS wire performance characteristics allow for high field operation of a compact, high energy density, grid level storage system.
- Enables device to operate up to 4 times higher field than LTS (NbTi), driving coil size down and performance up.
- Ability to operate at higher temperatures (20-70 K vs. 4.2 K for LTS) = reduction in overall system cost.
- No chemical reaction, no toxins produced.

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### Energy Storage Options

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<th>Discharge Time at Rated Power</th>
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<td>Seconds</td>
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<th>System Power Rating</th>
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<td>1 kW</td>
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Challenges

• High performance conductor required for economics to be competitive with advanced batteries (need to be in the $50/kAm range)
• Persistent current joints / switches highly desirable to reach loss targets
• High fields equate to high stresses
  - mainly hoop stress <<SP 2G HTS can handle up to 700 MPA hoop stress>>
• Long 2G HTS wire lengths will be required to minimize / eliminate splices / joints (each splice is a loss source)
• Continued R & D is necessary to bring price down and demonstrate SMES as an attractive grid level storage option
Advanced Research Projects Agency-Energy (ARPA-E) SMES Project

• ARPA-E Objectives:
  – bring freshness, excitement, and sense of mission to energy research to attract best and brightest minds in the US
  – focus on creative “out-of-the-box” transformational energy research that industry by itself cannot or will not support due to high risk, but where success would provide dramatic benefits for the nation
  – create a new tool to bridge the gap between basic energy research and development/industrial innovation
Program overview / deliverables

Program Duration: 36 Months (2011-2013)
Funding: $5.25M overall cost ($4.2M from Department of Energy’s ARPA-E)
Objective: ~2.5 MJ / 20 kW ultra-high field SMES module, and enhanced power electronics. Demonstrate proof of concept, risk reduction studies and conductor cost reductions

Partners:

ABB Inc. – project lead, grid-interface power converter, system integration and lab demonstration

Brookhaven National Laboratory (BNL) – SMES magnet design, construction, protection, and test; superconducting joints and switches

SuperPower Inc. – Supply high performance 2G HTS wire, assist BNL with coil development, HTS wire cost reduction plan

University of Houston, TcSUH – 2G HTS manufacturing improvements for wire cost reductions

Success in this technology enablement project will facilitate the development of a blueprint for the deployment of cost-efficient SMES systems for energy storage
Thank You

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