EPRI Technology Watch 2010
Superconducting Cables
Fault Current Limiter

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Technology Watch

- EPRI Program Structure
- Application based
  - Generation
  - Power transmission/distribution Cables---transformers
  - Power Delivery
  - System/component protection FCLs---FCCs
- Superconductivity spans various missions in EPRI
- Techwatch publications are a method of providing utility management and staff the status of new developments in specific technical areas.
Technology Watch Areas

• Several ways to segregate the activities.
• Application/Technology
  – Fault Current Limiters---Hassenzahl
  – Power Cables---Young
• Geographic
  – US
  – Europe
  – Asia
• Both will be used to structure the 2010 Document
## Techwatch Past Activities

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<th>HTS Power Cables</th>
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<td>• 2006 HTS Cable Technology Watch</td>
<td>• 2004 FCLs-Utility Needs &amp; Perspectives</td>
<td>• 2004 Cryogenics Primer</td>
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<td>• 2008 HTS Cable Technology Watch</td>
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<td>• 2008 Workshop Proceedings: Specifying and Testing Superconducting Power Equipment</td>
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<td>• 2009 HTS Cable Technology Watch</td>
<td>• 2009 FCL Technology Watch</td>
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The following slides include a part of the international activities addressed in the 2009 Technology watch documents.
Note that much of the effort in the US has been discussed in the PEER review. So here we include some items from other countries.

- Italy ERSA (Resistive)
- U.K./Germany Nexans (Resistive)
- U.K./Germany Zenergy (Saturable-core)
- China (Saturable-core)
- Korea (Hybrid Resistive)
- Japan (SFCL Transformer)
Italy to Install a Resistive Type SFCL

- Project Team: ERSE SpA (research institute) & A2A (power utility)
- Goal: 9 kV, 15 MVA SFCL that can operate on incoming feeders.
- Primary application: incoming feeders (15 MVA) and outgoing feeders (4 MVA).
- 4 MVA prototype is constructed. To be installed in Northern Italy (2010).

Case studies were conducted to determine design parameters and to investigate the effectiveness of the SFCL design.
KEPCO (Korea Electric Power Corporation) plans to upgrade 154/22.9 kV transformers from 60 MVA to 100 MVA.

FCLs are needed to accommodate the increased fault duty.

KEPCO, KERI (Korea Electrotechnical Research Institute), and LS IS have undertaken the development efforts. (Installation TBA)

Hybrid design uses an electromechanical switch to remove HTS component. Current transitions into the driving coil during a fault.
35 kV, 90 MVA unit installed at the Puji Substation in Kunming, China.
Primary Developer: InnoPower Superconductor Cable Company.
Can limit 40 kA fault current down to 20 kA.
HTS DC bias coil cooled by an open-loop system.
Unit was installed in December 2007.

Similar to Zenergy device, but a major difference in operation.

- Fault is detected by the current sensor.
- DC bias is removed from the coil and residual magnetic flux is quickly removed by the energy release circuit.
- Zenergy device maintains constant DC bias as the current peaks drive the core out of saturation.
Japan SFCL Transformer

- Developed by Nagoya University
- Superconducting transformer with integrated resistive type SFCL.
- 22.9/6 KV, 2 MVA prototype constructed in 2009.
- After testing, design will be scaled-up to current levels required for grid installation.

**Combining HTS transformer and SFCL provides:**
- Reduced footprint (two devices combined into one).
- Higher efficiency and lower leakage impedance.
- Increased transmission capacity and higher power system stability.
- Maintenance constrained to only one unit as opposed to two.
Cable Demonstration --- Yokohama, Japan

- 66 kV, 1.75 kA (200 MVA), 250 m (Sumitomo’s triad design)
- Cable will be installed in the TEPCO’s Asahi Substation located in Yokohama (~ 20 km southwest of Tokyo).
- The cable will provide a link between a 154/66 kV step-down transformer and the 66 kV distribution bus.
- Cable system will demonstrate a 180° bend and a splice joint.
- Installation scheduled for 2011.

Furukawa Electric Co., Ltd. in Japan is developing a 275 kV HTS cable system.
Korea --- Cable Demonstration

- Korea to install 500 m HTS cable in Icheon City (~ 50 km south of Seoul).
- 22.9 kV, 1.3 kA (50 MVA) HTS cable will be retrofitted into a space previously occupied by a 10 MVA convention underground cable.
- Installation is scheduled for sometime in 2010.

Layout of 22.9 kV HTS cable at a KEPCO substation in Icheon, South Korea.

154 kV HTS cable with 1 GVA capacity under development.
The Russian Scientific R&D Cable Institute (VNIIKP) and partners have developed a 20 kV HTS power cable for installation in a Moscow-area substation.

- 20 kV, 2 kA (70 MVA), 200 m, coaxial
- Sumitomo was selected as the 1G HTS tape supplier.
- The 200 m cable system was fabricated and assembled for testing at the R&D Center for Power Engineering.
- The 200 m system will be installed in a Moscow area substation site once testing is complete.