



# Status of HTS Projects in the US

International Workshop on HTS Power Applications  
Nagoya University - November 26, 2007

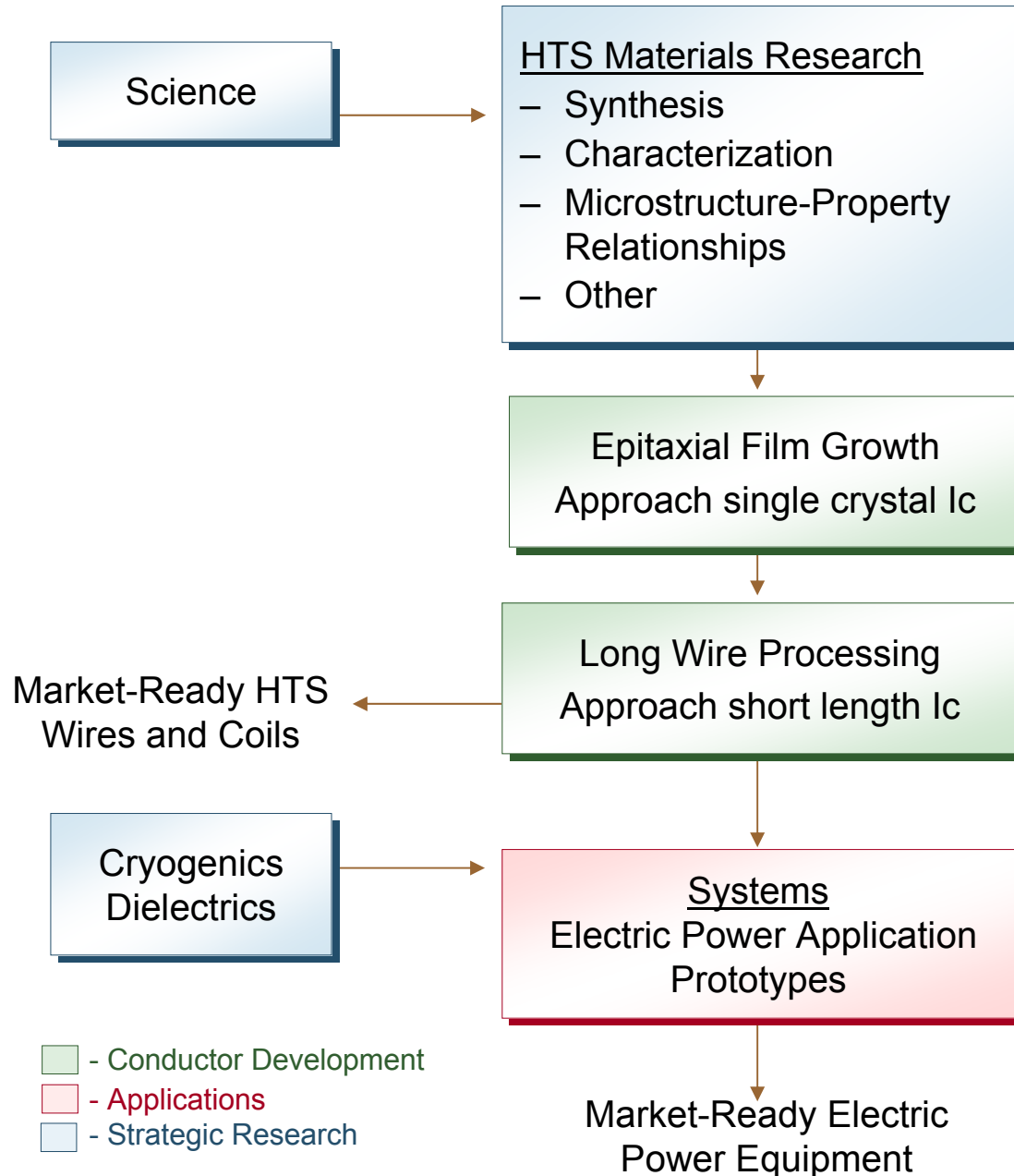
C.S. Weber



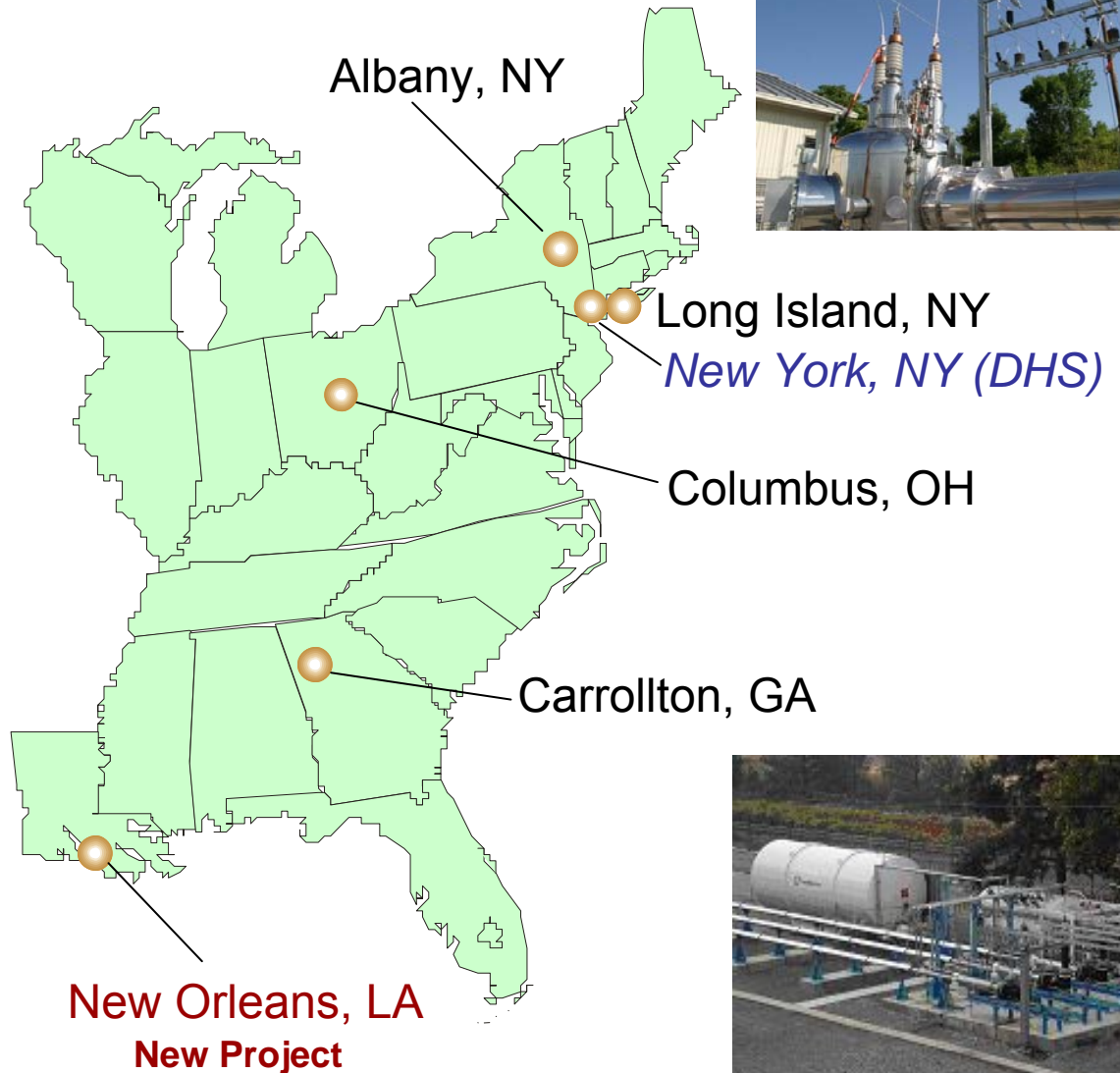
*Providing HTS Solutions for a New Dimension in Power – TODAY!*

A horizontal strip of yellowish-gold HTS tape with a diagonal ribbed texture is positioned at the bottom of the slide.

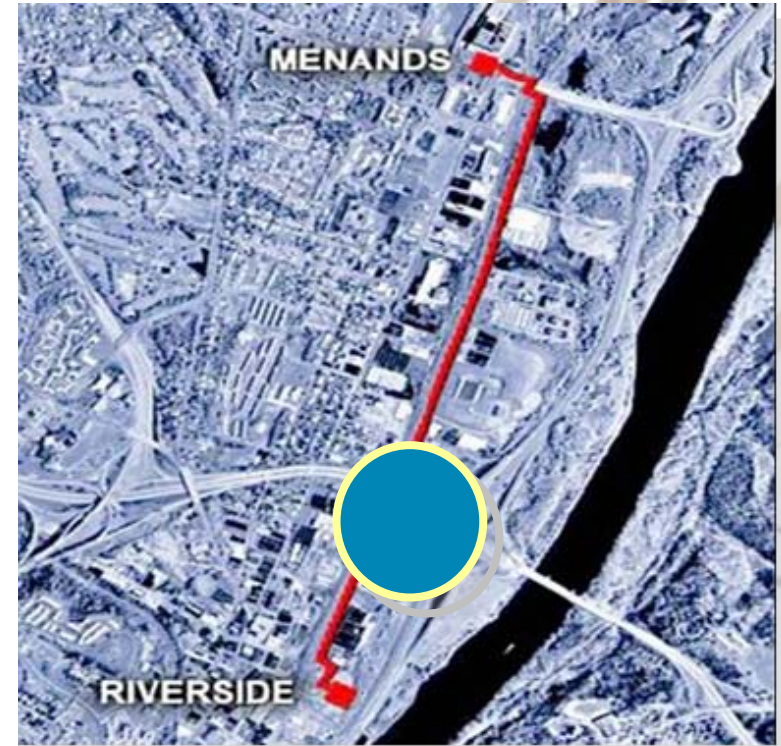
# DOE HTS Program R&D Activity Flow



# U.S. HTS Cable Installations



# Albany Cable Project: 350 m HTS Cable Energized July 2006 and serving the equivalent of 25,000 homes



- **Demonstration of technical & commercial viability of underground HTS cable operation between two National Grid substations**
- **Connects two lengths of 1G cable totaling 350m with the world's first HTS cable-to-cable joint, required for long cable runs**

# Albany HTS Cable Project Status Report: November 2007

## Project Phase I – 350 m 1G HTS Cable system in 2 sections (320 m and 30 m)

**Operated without incident or interruption from July 20 - November 11, 2006**

- 114 days or >2,700 hours of continuous operation

**Experienced 1st fault current event on November 12, 2006 @ 9:32AM**

- Breaker in nearby substation had an external flashover
- ~ 7.3 kA peak current on HTS cable
- Cable survived without damage
- Back online on Thursday (11/16) @ 12:30pm

**System de-energized and began cool-down: May 1, 2007**

- Total accumulated run time: > 280 days (>6,720 hours)
- Maintenance work performed on cryocooler, chillers, other equipment without interruption to cable operations

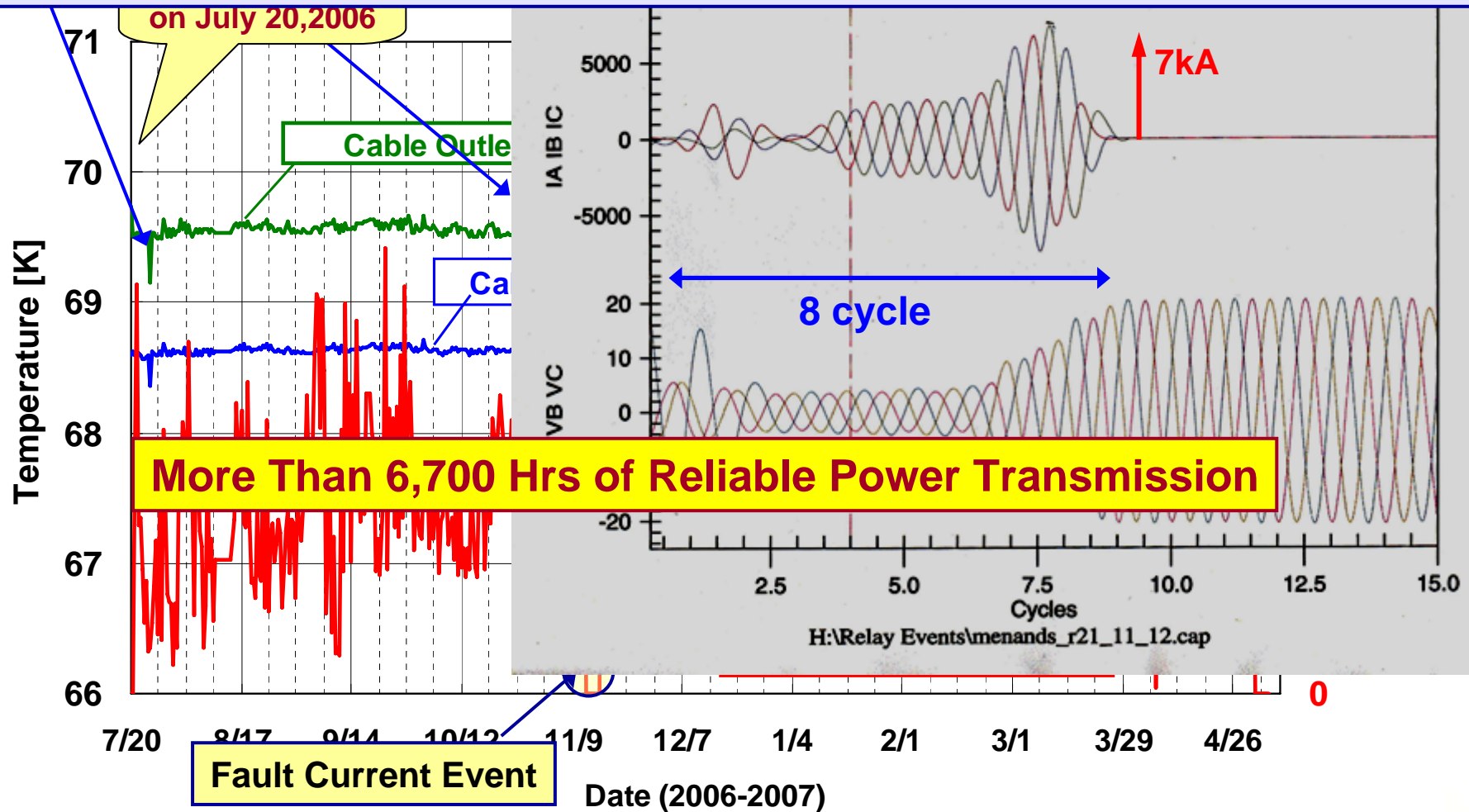
## Project Phase II – 320 m 1G HTS Cable joined to 30 m 2G HTS Cable

- 2G cable installation complete October 2007
- System electrical and pressure testing completed
- Cool-Down is underway
- System will be energized late December or early January 2008

# Summary of Phase I Operation

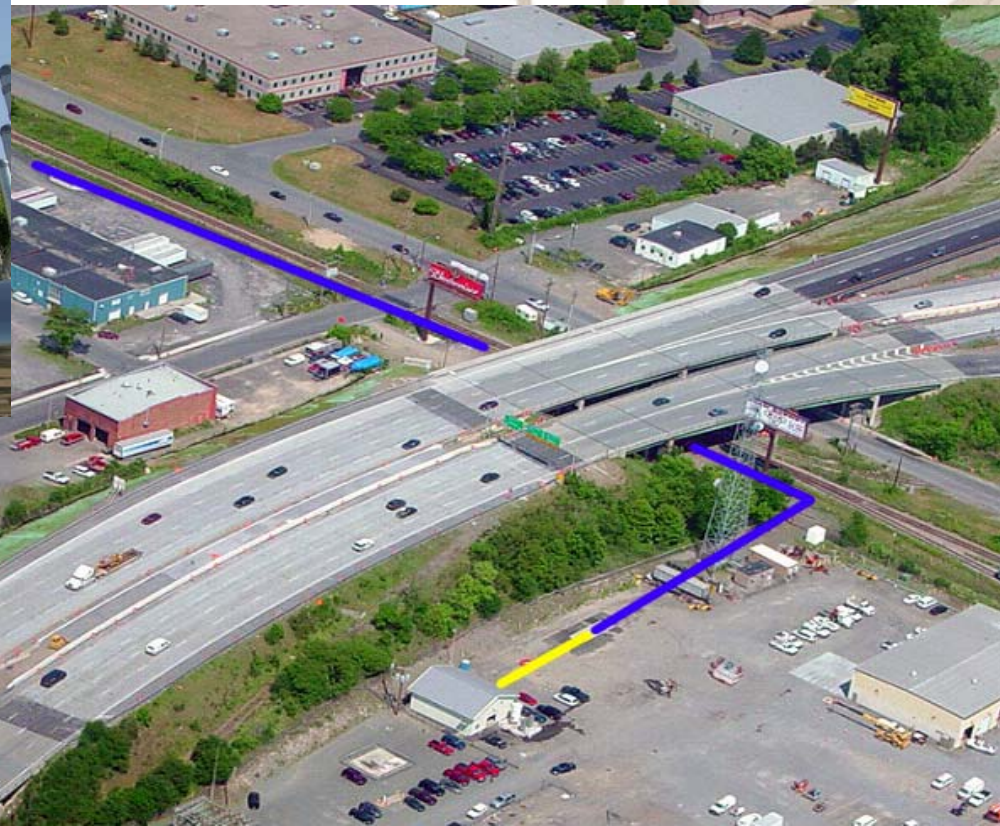
The HTS cable system was checked for damage after the fault event

→ No Issues → **Re-connected to Power Grid**



# Phase 2: 30 m 2G Cable Installed

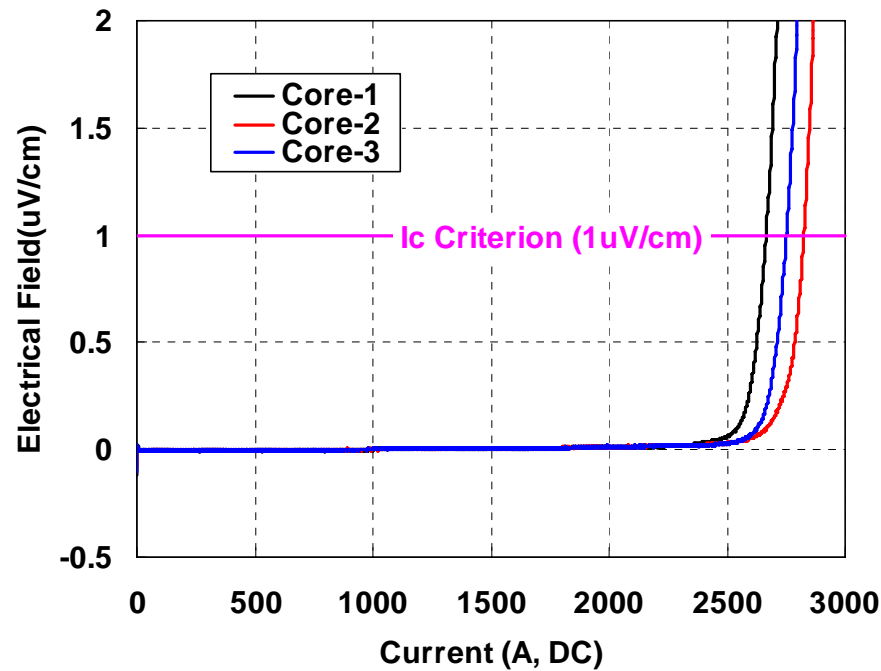
**Cool-Down Begins Mid-Nov. 2007  
Re - Energization planned late  
December or early January, 2008**



***This world's first 2G  
device will  
demonstrate the  
viability of 2G as direct  
replacement of 1G***

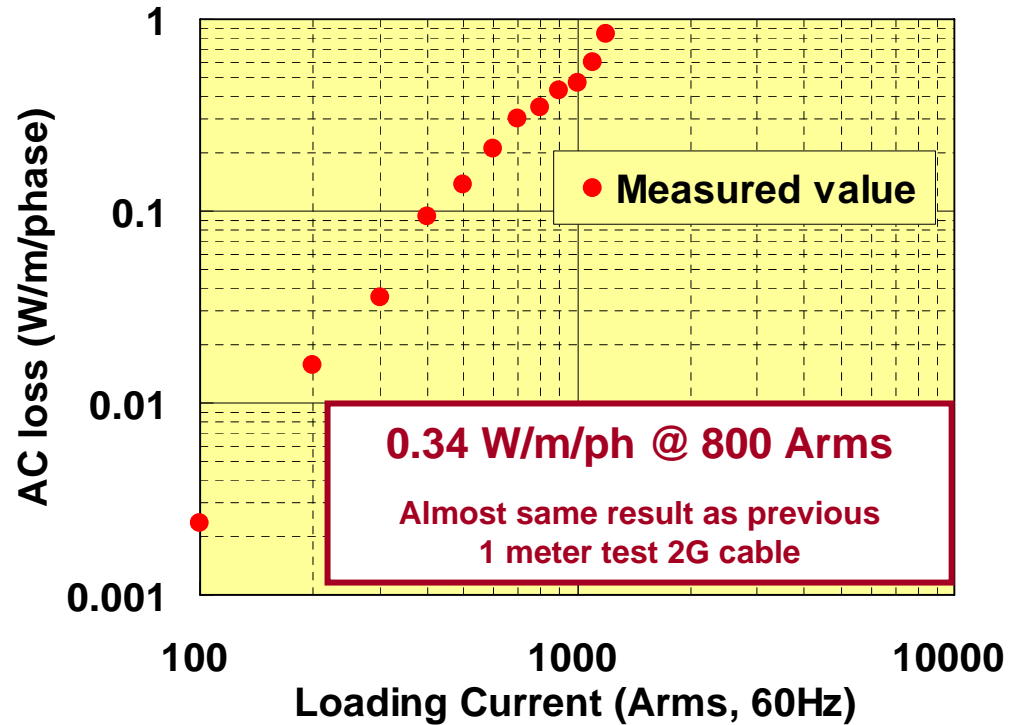


# Excellent overall performance obtained in 2G cable



Ic of conductor layers ~ 2660 – 2820A  
(DC, 77K,  $1 \mu\text{V}/\text{cm}$ )

Ic of shield layers ~ 2400 – 2500A  
(DC, 77K,  $1 \mu\text{V}/\text{cm}$ )



No Ic degradation and No defect was found at dismantling inspection when bent to a diameter of 2.4 m

Cable withstood AC 69kV for 10 minutes and Impulse  $\pm 200\text{kV}$ , 10 times

# Southwire-AEP, Bixby Station



## Triax Cable Design

### AEP Project:

- Bixby station, American Electric Power, Columbus, OH
- 13.2 kV, 3000 A continuous service = 69 MVA
- 200 m, underground, splice, multiple 90° bends
- In service 8/6/2007
- Peak Load = 2715 Amps
- Max FC experienced = 16,800 Amps



### Cable Pulling



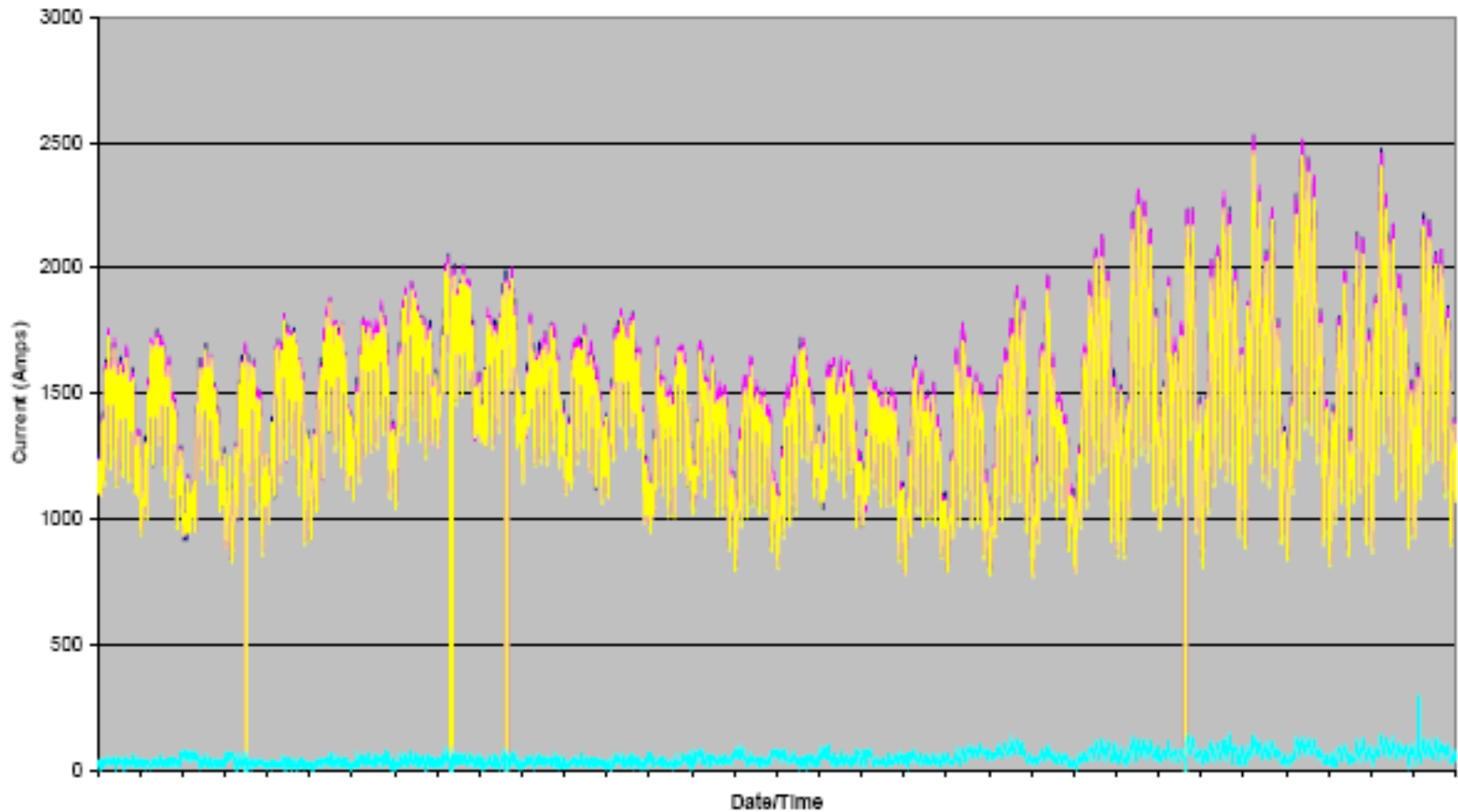
### Terminations



### Underground Joints

# Bixby Load Curve

Bixby HTS Cable Load Curve  
12/10/2006 to 7/22/2007



# Bixby Operating “Events”

## 1. January 3, 2007, ~10am

- AEP station operator error – disconnected wrong lead looking for station battery ground. Dropped entire station and all customers.
- Back-Up cryogenic system operated as designed. Kept cable at normal temperature and pressure during outage.

## 2. February 6, 2007, ~3.30am

- Southwire termination alarm setpoint – conservatively set temperature alarm for “warm” end of termination tripped when ambient dropped below -20 °C. AEP initiated controlled de-energization of cable.

## 3. February 15, 2007, ~8am

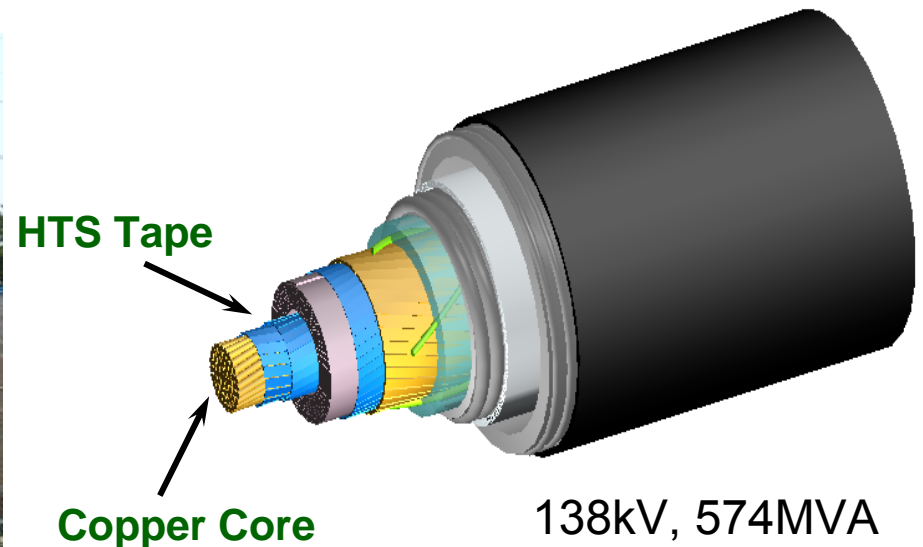
- Praxair valve leak – ¼ inch pressure tap valve started leaking with -20 °C temperature with snow/ice. Outdoor -40 °C valve spec'ed into system, but indoor 0°C valve installed. AEP initiated controlled de-energization of cable.

## 4. June 4, 2007, 8am

- **Planned Maintenance** – ½ day for general site maintenance. AEP and SW modifications to instrumentation and sensor setup.

# Long Island HTS Cable Project

- World's first transmission voltage in-grid HTS power cable
  - Design Voltage/Current – 138kV/2400A ~ 574MVA
  - Design Fault Current – 51,000A @ 12 line cycles (200ms)
- Will serve the equivalent of 300,000 homes when energized
- Length ~ 600m (world's longest HTS cable)
- Testing/Commissioning – Fall 2007



# LIPA Project Status Update

As of 2007 DOE Peer Review

- Cable and Termination
  - Two phases in ground
  - Two terminations installed on first phase
  - Two terminations installed on second phase
- Refrigeration System
  - Installation completed
  - Testing on going
- Site Preparation
  - On Schedule



*World's First Transmission Voltage HTS Cable Will Be Operating in 2007*

# New Project: New Orleans HTS Cable

## Problem:

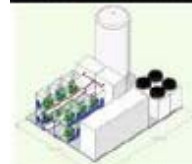
- Load growth in urban area
- Saturated 13 kV distribution
- 230/13 substation to north & south of area
- Need new substation at mid-point

## Challenges:

- Overhead rights of way for 230 or 13 kV very difficult or impossible
- Small footprint available for new substation dictates gas insulated substation 230 kV equipment or expensive station expansion
- 230 kV solution: placing transformer in dense residential area
- 13 kV conventional: Voltage drop, power quality

## Solution:

- 13.8 kV HTS cable to transmit 60 MVA into small footprint station. (2 splices, three sections)
- 1700 meters HTS cable
- Meets load growth needs
- No transformers needed
- Leverage reserve transformer capacity at south end
- Single point cooling station
- *13.8 kV HTS replaces 230 kV underground*
- *Cost-effective with DOE support*



Cooling Plant



13.8 kV, 2.5 kA (60 MVA) Triax HTS Cable



# Project Specs

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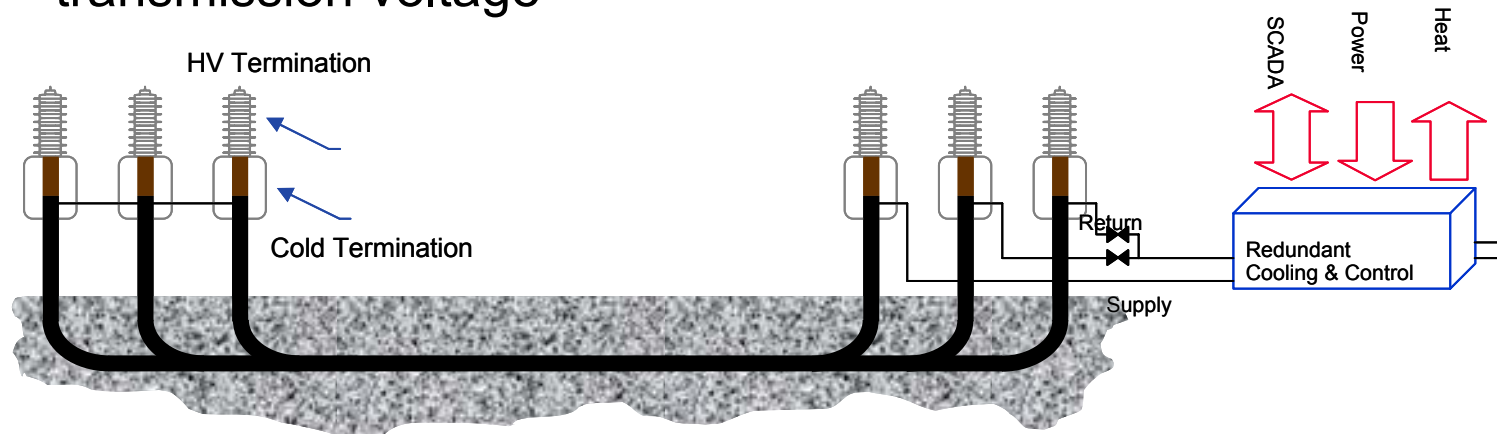
Cable Design	Triax
Length	1760 meters (1.1 miles)
Voltage	13.8 kV
Load	60 MVA
Cooling	Single Point, Closed Cycle
Splices	2
Cable Sections	3
In-Service Date	TBD, 2009-2010



# New Project: AMSC "LIPA 2A" HTS Cable

## LIPA 2A Project Scope:

- Demonstrate cost-effective 2G cable at transmission voltage
  - Use existing system – replace 1G wire with 2G
- Introduce repairable cryostat and cable joint
- Develop low-cost, reliable, and efficient refrigeration system
  - 65K/20 kW Turbo Brayton refrigerator
- Demonstrate inherent fault current limiting capability at transmission voltage



# Project Deliverables

- Phase 1
  - Develop cryostat for easy field repair of cable
  - Develop and prove a 138 kV 2G cable joint
  - Manufacture sample cable using 344 superconductors stabilized for fault current limiting functionality
  - Design a 20 kW turbo Brayton refrigeration system
- Phase 2
  - Final testing and proof of 138 kV 2G cable
  - Manufacture, install, and commission three-phase 138 kV 2G cable system with Secure Super Grids capability
  - Manufacture and demonstrate key components of turbo Brayton refrigeration system

# New Project: "Project Hydra"

(Funded by Dept of Homeland Security)

- 13 kV, 4000 A HTS cables with fault current limiter (FCL) between substations in the Manhattan power grid
- Allow area substations to share excess capacity in emergencies
- Technology Demonstration of inherent FCL HTS cable and stand-alone FCL by FY08
- Integrated System Test and Demonstration by FY10

