NIST / DoE Workshop: Superconductor Price / Performance Improvements
SuperPower Conductor Price/Performance

• The success of the ARPAE REACT project has laid the groundwork for future advancements towards commercialization of 2G HTS in critical energy related technologies.
  – ARPA-E funding enabled conductor improvements in Ic performance, increased single piece length output and improved lift factor.
  – R&D efforts now focused on improving the conductor production consistency while maintaining high Ic’s and lift factors.
• Multiple tapes with 15% Zr were produced with Ic levels above 1500A (30K, 2.5T) over 100+ meters

Tape length : 550m, ~400A

Piece samples from the long tape show an Ic of over 1700A at 30K/2.5T
From the laboratory into manufacturing

- **Developments at UH**
  - 15% Zr doping & process improvements
  - 20%+ Zr doping & process improvements
  - Next step pinning & process improvements

- **Implementation at SP**
  - Long (500m) length
  - 15% Zr demo leading to introduction to market
  - Long length
  - 20%+ Zr demo leading to introduction to market
  - Samples
  - Long length production
  - Incorporation of process improvements to standard mfg. practices,
  - next generation mfg. equipment

**ARPAE REACT**

**FOLLOW ON EFFORT**

Coupled with R&D improvements being proven at UH under Dr. Venkat Selvamanickam, a 4X improvement over 2012 baseline in conductor $ per kA-meter is expected by 2017 (30K, 2.5T)
ARPA-e REACT – SuperPower Conductor Improvements

• Price / Performance results:
  • SuperPower believes that the following table remains true thru 2017.

<table>
<thead>
<tr>
<th>Production conductor cost analysis</th>
<th>2012</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base (12mm width)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I_c) (77K, sf) - (A)</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Price $/kA-m (77K, sf)</td>
<td>$384</td>
<td></td>
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<tr>
<td>(I_c) (30K, 2.5T) after 2x standard lift factor</td>
<td>600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price at operating conditions (30K, 2.5T) w/ 2x lift factor $/kA-m</td>
<td>$192</td>
<td></td>
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<tr>
<td><strong>Improvements</strong></td>
<td></td>
<td></td>
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<tr>
<td>Base (I_c) (77K, sf)</td>
<td>400</td>
<td>500</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Price $/kA-m (77K, sf)</td>
<td>$288</td>
<td>$230</td>
<td>$192</td>
<td></td>
</tr>
<tr>
<td>(I_c) (30K, 2.5T) after 4x REACT lift factor and base (I_c) improvement - Amps</td>
<td>1600</td>
<td>2000</td>
<td>2400</td>
<td></td>
</tr>
<tr>
<td>Price at operating conditions (30K, 2.5T) – 4x lift factor - $/kA-m</td>
<td>$72</td>
<td>$58</td>
<td>$48</td>
<td></td>
</tr>
</tbody>
</table>

Higher manufacturing materials costs are expected to be offset by yield improvements and market pressure on price.
SuperPower has developed its own internal IcBT measurement system to support routine production of higher Zr content tapes targeted for 30K 2.5T operation. Recently upgraded to be able to measure routinely 30K-77K, 0-2.5T over ~150 degrees. Uses a 2G HTS background coil operated in LN2 at ~ 65K which can be rotated around the sample.
Studies on Mechanical / Electromechanical Properties

- Mechanical behaviors under various stress conditions at RT and/or 77K
- Electromechanical testing for stress (strain) dependence of \( I_c \) at 77K
- Electromechanical strength determined by critical stress with 95% \( I_c \) retention

Axial tensile
RT or 77K w/ \( I_c \)

Transverse tensile
Stud method
RT or 77K w/ \( I_c \)

Fixture for mechanical/electromechanical testing
THANK YOU