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# Superconducting Magnet Energy Storage System with Direct Power Electronics Interface


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## Project Team

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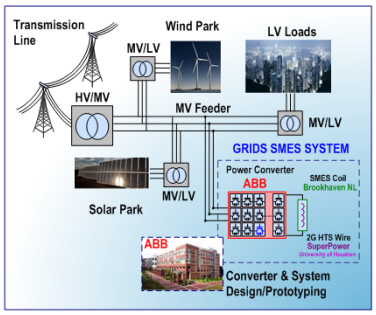
### Project Goal

- Competitive, fast response, grid-scale MWh superconducting magnet energy storage (SMES) system
  - Demonstrated through a small scale prototype, (20 kW, 2.5 MJ) and direct connection power electronics converter (with Si-based devices)




### Conductor Manufacturing and Process Modeling

- About 8.4 km of 12 mm wide HTS tape delivered
- Achieved record-high single-pass critical current in PA-MOCVD processed 2G-HTS sample of 950A/12mm
- Successful film deposition of (RE)BCO up to 2 µm
- Potential for growth of very thick films with no performance or $J_c$ degradation
- Achieved up to 4 µm thick film

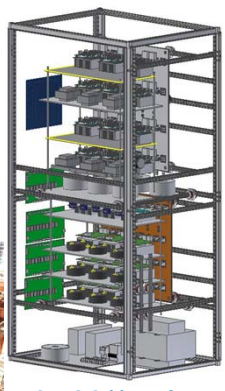
Enhanced MOCVD system

### Power Electronics Interface

**700 A dc output, 230 $V_{ac}$ input**
**15 kW max**

- Complete performance verification of AC/DC and DC/DC converters' individual sub-modules
- Totality of converter modules in fabrication
- Converter mechanical and electrical integration is ongoing
- Issues with the integration and scalability of quench protection system: Devised alternative solutions

Partially built AC/DC converter DEMO



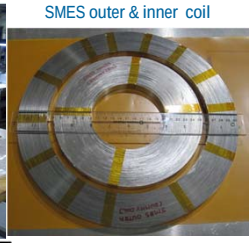
SMES Grid Interface Converter DEMO

### Project Update

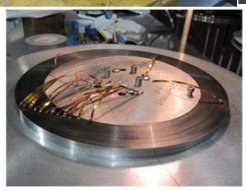
- Coils for magnet built; final tests under way. Novel bypass switch built and successfully tested
- Power electronics converters built and successfully tested
- Capabilities of new PA-MOCVD successfully demonstrated

### SMES Magnet Coil Design and Testing

- 28 inner coils and 16 outer coils have been fabricated (for a 1.7 MJ demo unit).
- All inner coils and 5 outer coils have been tested at 77 K.
- Extensive QA test of each coil shows construction and splicing techniques are acceptable for both inner & outer coils



SMES outer & inner coil



SMES outer coil

Made with ~210 m of 12 mm tape with 65 µm copper 25 µm of SS tape between turns (No. of turns = 258).

### Quench detection and protection system

- Hybrid approach: IGBT+ Contactor for low loss and reliable operation.


### SMES bypass switch

- Fast and efficient superconducting switch designed and tested ( 77 K, > 650 A)
- Innovative SC switch concept; all solid-state electronics developed and tested as able to be scaled up for high off-resistance
- Demonstrated long-term ( > 13 hrs) energy storage in SC coils at 77 K. Round trip efficiency > 99%

SC bypass switch prototype with RF control