

Paris Session 2022



An Evaporative Cooling Approach to Superconducting Cables

SC B1 Insulated Cables - PS2 – Q4

What characteristics of HTS underground systems is
limiting wider application of this technology?

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Group Discussion Meeting



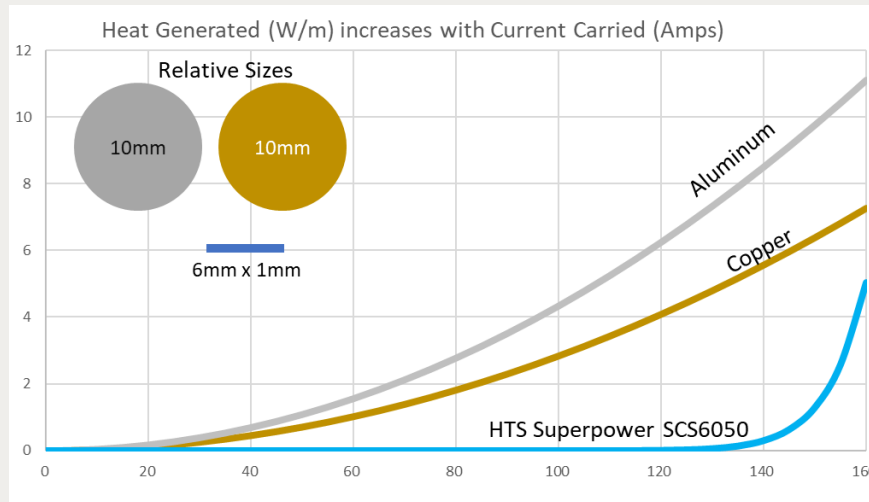
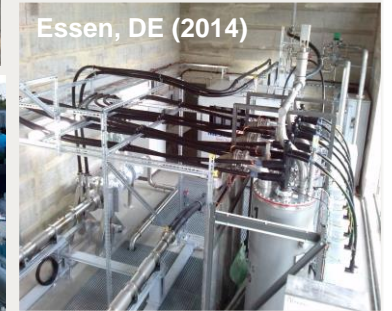
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Superconductors have been perceived to be the holy grail of electricity transmission for decades

- Conventional conductors have non-zero resistance
- Resistance limits conductor ampacity (typically $< \sim 1$ kA) and power capacity
- Superconductors exhibit zero resistance when operating below their *critical current and temperature*, enabling conductors with significantly higher ampacity (> 5 kA)



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- Past grid projects were technically successful, but not commercially viable:
 - Expensive HTS materials; short project lengths drove limited volume
 - Expensive, unreliable mechanical subcooling systems every 5-10 km
 - Underground cables require challenging cryogenic dielectrics
 - Expensive underground line construction

Evaporative cooling unlocks superconducting transmission

A new generation of HTS-based transmission using evaporative cooling can overcome hurdles

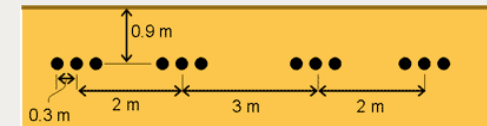
- Open loop, once through coolant flow (nitrogen vapor vented to atmosphere)
- 20x the cooling power per flowing kg of nitrogen*
 - **Improved reliability:** Eliminates mechanical subcooling equipment
 - **Longer distances:** Enables long lines, accelerating HTS cost reduction
 - **Simplified system operation:** Efficient, passive cooling approach that evaporates nitrogen back to the air
 - **Reduced cost:** Smaller pipes, fewer cooling stations (up to every 100 km), simplified installation and repair

* Assumes 5 °C temperature increase limit in conventional HTS transmission approaches.

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Reduced # of cables (reduced UG/OG ROW)

4x 230kV Traditional UG Lines (2,000 MVA)
12 total cables



1x 230kV VEIR UG Line (2,000 MVA)
3 total cables



No heating of nearby UG environment/equipment

