

HTS Power Infrastructure for Data Centers: An Overview

High-Temperature Superconductors: From Scientific Discovery to Industrial Reality

Superconductors carry current with effectively zero resistance below a critical temperature. Demonstration projects for HTS cables, fault current limiters and rotating machines have run since the 1990s. What changed recently is manufacturing. Since 2018, billions of dollars in fusion-driven investment have taken HTS wire production from meters per month to kilometers per week, cutting cable costs and building a real supply chain. Systems up to 200 kA now run in industrial settings. The question is not whether HTS works in mission critical power applications. It is how to apply it to data center power delivery.

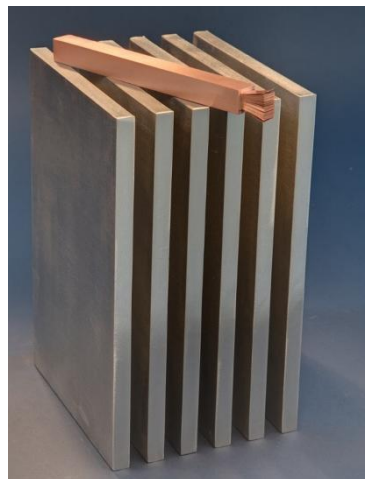


Figure 1 HTS composite conductor on top of aluminum busbar. Both are rated at 20 kA.

Artificial Intelligence Is Redefining Data Center Power

Modern AI clusters require unprecedented power densities, with server rack densities being specified at 600 kW for 2027 (Rubin Ultra) and 1 MW-class racks indicated for the following generation (Feynman), cross-sections, weight and losses of copper and aluminum conductors become a first-order constraint in data center design. These challenges closely align with the strengths of superconducting technology. HTS provides high current density with negligible DC losses while occupying only a fraction of the space required by conventional conductors.

HTS Data Center Use-Cases:

Power Transmission to the Data Center Campus

HTS cables carry significantly higher currents than conventional cables with very low electrical losses, decoupling power and voltage. Conventional cables generate a lot of heat, requiring large corridor sizes to dissipate the heat. HTS cables are not limited in this way. They move more power through a much smaller conductor, cutting the right-of-way needed for a line by up to 80%, civil works cost by up to 60% and easing the permitting that often gates a new build.



Before Using
Superconducting Cables



2 Superconducting Cables Replace **12** Conventional Cables



Figure 2 Image comparing the HTS and conventional cables

It also lets a site run on medium-voltage rather than high-voltage substations, reducing on-site substation land by up to 90%. This gives data center operators a unique tool to bridge gaps in power availability and allow more free site selection. HTS transmission cables have run on live

utility grids for over a decade, including multiple deployments in grids across the US, Europe and South Korea.

TRL: 9

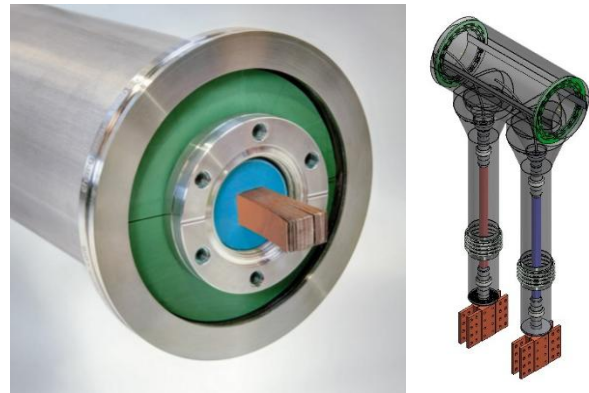
Maturity: proven globally in demanding grid applications.

Power Distribution in the Whitespace

Superconductors can supply high power racks, directly in the whitespace, at low voltage, without excessive copper use. HTS cables and busbars have a small physical footprint, making them particularly relevant for the dense power and crowded space of AI factories.

TRL: 7-8

Maturity: proven components in industry, requires integrated whitespace demonstrations.



Superconducting Fault Current Limiter (SFCL)

SFCLs provide a unique approach to protecting electrical networks against short-circuit currents. Under normal operating conditions, the superconducting element carries current with very low impedance; when a fault occurs and the current exceeds a defined threshold, the material rapidly transitions out of its superconducting state, introducing a significant impedance into the circuit and limiting the fault current. This fast, passive response can reduce the stress on transformers, switchgear, and cables.

TRL: 8-9 deployed in grids / 6-7 specialized for data centers

Maturity: proven on the grid, ready to pilot within data center protection schemes.

Figure 3 Left: HTS Busbar showing the center conductors, liquid nitrogen (blue) and vacuum insulation (green), all encased in stainless steel cryostat. Right: CAD rendering of a cryogenic tap-off box.

Superconducting Magnetic Energy Storage (SMES)

SMES systems store electrical energy in the magnetic field generated by a superconducting coil. Because the superconducting coil has negligible DC resistance, energy can be stored and released with very high efficiency and extremely fast response times (MWs in ms).

TRL: 5-6

Maturity: demonstrated at multiple scales, exploratory for data center power quality.

A Perfect Storm for Superconducting Infrastructure

The convergence of several technological developments has created a unique opportunity for HTS. The combination of new approaches, rapidly increasing power densities, and maturing superconductor technology creates a "perfect storm" in which HTS solutions can deliver significant advantages.

In the FTI Workstream HTS Power Infrastructure we explore this technology. Join us!

Join the workstream and help shape the future of superconducting power infrastructure, collaborate with industry leaders and technology innovators.

Join us at the **OCP Global Summit High Temperature Superconductors Round Table**

Date & Time: **October 13th, 4 – 6 pm,**

Room: **Marriott 3/4**