



Abstract

**The Pipetron as an engineering model for 10 GW electricity transmission over
1,000 km
Lance Cooley
Fermi National Accelerator Laboratory
Batavia, Illinois, U.S.A.**

Between 1995 and 2001, concepts, engineering designs, and prototype modules for a Very Large Hadron Collider were developed at Fermilab. This so-called "Pipetron" was capable of producing 100 TeV center-of-mass proton collisions in a small-diameter tunnel 220 km in circumference, using a DC transmission line operating at 100 kA to energize superferric magnets. The engineering effort was successful and magnets could be manufactured today. The Pipetron activity emphasized two aspects relevant for trans-continental electricity transmission. First, supercritical helium at 6 to 10 K provided a cost-performance balance, enabling use of mass-produced Nb-Ti or NbsSn superconductors while reducing the wall-plug electricity load for refrigeration to approximately 0.5 MW per km (including heating at splices). Second, if the superconductor cost is of order \$1 per kA-m at 1 T field, then the cost of the superconductor is not significant compared to costs for civil engineering, refrigerators, and other components. These aspects set the background for a Pipetron-like engineering model for transmitting 10 GW across 1,000 km, which could yield information about the following questions: (1) While installation cost might be similar to that for a LNG pipeline (~ 0.5 M\$ per kM), are cost scaling factors for the cable, splices, and cryogenics modest or large? (2) Can the 100 kA superconductor be operated at common switchgear voltages (100 to 200 kV) without significant impact on the transmission cable design? Switchgear costs can be very high (several hundred M\$) for UHVDC systems. (3) If the Pipetron model considered and upgrade to LH2 cryogenics and MgB2 superconductor, would it be possible to reduce the refrigeration loss per km below 3% (as for UHVDC transmission) without loss of transmission capacity?

Fermilab is operated by Fermi Research Alliance, LLC, under contract DE-AC02-07CH11359 with the United States Department of Energy. Discussions with G. W. Foster, H. Piekarz, P. J. Limon, and J. Tompkins are gratefully acknowledged.

