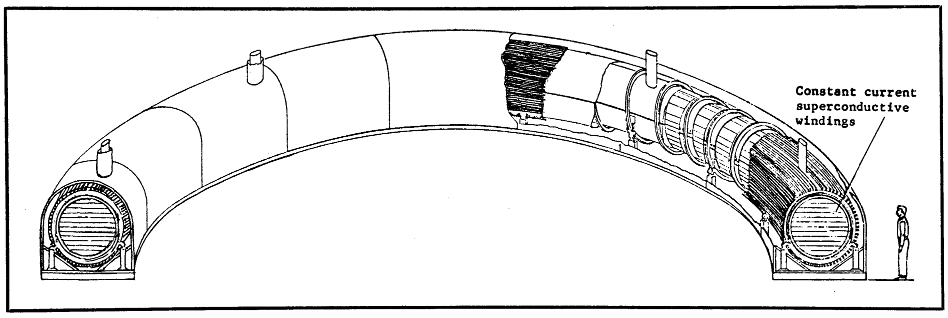
# Superconducting Swirls of Stored Energy




**by Dietrick E. Thomsen**

The world's electric-power enterprises have considerable capital invested in generating capacity that is used only part of the time. The reason is that demand for power varies according to a 24-hour cycle that peaks in the afternoon, and generating capacity must be able to handle the peak load. This is an unhappy practice from an engineering as well as a financial point of view. The system becomes inefficient when the load falls off, and engineers would prefer to operate at full load levels during the whole 24-hour day. And in the future there are likely to be power sources, such as solar energy, that generate only at certain hours. Some way is needed to even their output.

To achieve those ends requires energy-storage devices, banks into which energy can be deposited during off-peak hours and withdrawn during peak times so that the load on the generators is evened and their capacity can be made something less than the peak demand. One way to do this is called pumped hydro storage: The excess energy is used to pump water from a low reservoir to a high one. When energy is wanted, the water is allowed to flow back down, turning a turbine on the way. Systems of this kind are in operation in several places, and efficiencies up to 70 percent are claimed for them, but they can be used only where there are hills, a condition that rules out large areas.

Another possible method is batteries. But if 50 percent of a bank of batteries are discharged every day, replacement is necessary in two years, a costly process.

How about a system that is 95 percent efficient, depreciates very slowly, has no moving parts and is suitable for flat locations? Such a device is the Cryogenic Energy Storage System projected by a collaboration between the Fermi National Accelerator Laboratory (FermiLab) in Illinois and the University of Wisconsin. If funding is forthcoming, it could be built at FermiLab in three years. The estimated cost is $20 million including seven percent a year for inflation.

The idea is to use the magnetic field generated by a superconducting magnet to store the energy, putting it in during the night and taking it out during the day. A superconducting magnet is necessary to avoid resistance losses. Once you get a superconductor charged, the current just goes round and round and the energy stays neatly stored in the magnetic field and the stresses that the field applies to the magnet's structure and supports.

The reason for choosing FermiLab as the site for what is from the public point of view a pilot project is that it suffers in miniature from the same problem as power grids—uneven demand. FermiLab's synchrotron takes power in surges. Evening out the draw would be desirable for several reasons, one of which is relations with the power company. The accelerator's surges could make trouble for a power grid. As it happens, FermiLab's supplier, Commonwealth Edison, has a large interconnection and is able to handle the jolts it gets from the accelerator at present. But when the accelerator goes to higher operating energies, that favorable condition may not continue.

Conceptually the energy storer is quite simple: FermiLab's P. V. Livdahl describes it as a large solenoid tied to a power line. But it would be the granddaddy of all superconducting solenoids. It would be a doughnut-shaped coil with the major radius of the doughnut 8.8 meters, the minor radius (half thickness of the coil itself) 1.8 meters. It would take 25,000 pounds of niobium-tin superconductor (estimated cost $1 million) supported by 800,000 pounds of copper ($1.6 million). It would generate a 5-tesla magnetic field that will store one megawatt-hour of power.

Because the accelerator's pulses come fast—a 10-second cycle—FermiLab's version of the energy storer needs a protective device that will probably not be necessary in power-grid applications of the idea. The swiftness with which the magnetic field changes during charging and discharging in the 10-second cycle could induce eddy currents that might foul up the operations. To neutralize them an aluminum shielding coil (40,000 pounds, $80,000) is planned. With the 24-hour cycle of general public power use, the field changes would be slow enough that eddy currents would not be likely to be a problem.

But scaling up from the one-megawatt-hour FermiLab device to the 10,000-megawatt-hour installation that would be economical from a power-company point of view presents other problems, chief among them the enormous stresses involved. The FermiLab version would sustain a tension in the hoop of 8,500 pounds per square inch and a compressive stress of about 2,260 pounds per square inch. According to the scaling law derived by the designers, the hoop tension should rise in proportion to the two-thirds power of the energy times the two-thirds power of the maximum field, so the stresses at 10,000-megawatt hours would be thousands of times those at one megawatt-hour.

Structures to contain such forces are a bit of a problem. FermiLab's version would be housed in a relatively ordinary building, but a 10,000-megawatt-hour version might have to be housed in a natural or artificial cave, Livdahl figures, and tied to bedrock to hold the stresses. So, someday in the 21st century energy we get from the sun may be stored in the tension of the solid earth itself beneath the planet of the electrical engineers. □

*This is the last of a series of four articles on the Fermi National Accelerator Laboratory by Physical Sciences Editor Dietrick E. Thomsen. The previous articles and issue dates:*

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| *'On Location at FermiLab'* | *Nov. 9* |
| *'Physics at FermiLab'* | *Dec. 7* |
| *'Son of FermiLab'* | *Jan. 4* |