Taking the juice for granted: Powering American cities in the new century

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With the new superconducting cable, Manhattan's electrical workers may be able to eventually clear out the aging, subterranean rats' nest beneath Wall Street that amazingly, looks much the same today as it did a century ago. Credit: 1913 image

Barring the occasional thunderstorm, most Americans take the electric current behind their power buttons for granted, and assume the juice will be there when they're ready to fire up an appliance or favorite tech toy. Little do most know, the strain on our electric grid - which has led to rolling brownouts and the massive 2003 blackout that left 40 million people across the Northeast in the dark - will only intensify in coming years.

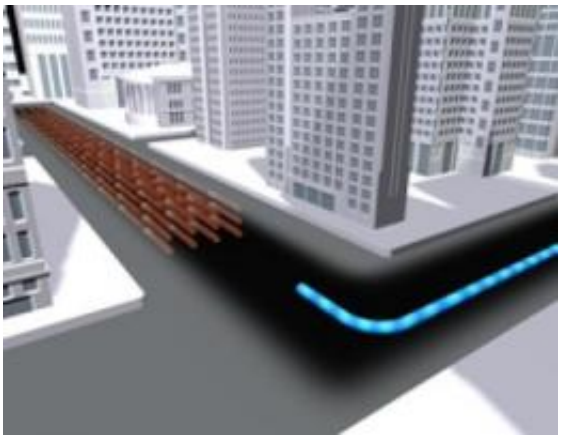
According to the Department of Energy, the annual cost of power

outages is approximately $80 billion. Now add to conventional challenges those risks posed by terrorists intent on crippling our economy. Suddenly, the aim of electrical engineers to develop a technology to keep the country's electrical grid online (and recover faster) *really* begins to resonate.

The Science and Technology Directorate (S&T) of the U.S. Department of Homeland Security is currently funding a promising solution - a superconductor cable that would link electrical substations and allow the sharing of excess capacity during emergencies. This generally is not done now, and so a flexibility like this strengthens the resiliency of the overall grid, reducing the likelihood of major power failures. This is S&T's Resilient Electric Grid project, and the superconducting cable is called an *inherently fault current limiting* (IFCL) superconductor cable.

Engineers are putting decades of existing electrical research (by industry electricity leaders from American Superconductor, Southwire, and Consolidated Edison) into practice. S&T managers and scientists recently participated in a successful test of the new superconducting technology at the Oak Ridge National Laboratory in Tennessee, as they eye the aging rats' nest of power cabling under the crowded streets of New York City.

The benefits are simple but profound: these cables can deliver more power, prevent power failures, and take up less physical space. A single superconductor cable can replace 12 copper cable bundles, freeing up more space underground for other utility needs such as water, natural gas, or phone service. The technology is capable of carrying 10 times as much power as copper wires of the same size, while also being able to adapt automatically to power surges and disruptions from lightning strikes, heat waves, and traffic accidents, even sabotage.



A single superconducting cable (shown in blue) could one day replace a dozen traditional copper cables (shown in red), freeing up much needed space beneath city streets. Credit: DHS S&T

"The IFCL superconducting cable being tested could well revolutionize power distribution to the country's critical infrastructure," said Dr. Roger McGinnis, Director of the Homeland Security Advanced Research Project Agency at S&T. "Eventually, these technologies will help incorporate localized clean, green electricity generation into the power grid."

As for the science, the cables work by transmitting electricity with near zero resistance at higher temperatures than usual. But "high" is a relative term among superconductors. The cables conduct electricity at a chill -320°F instead of an icy -460°F for traditional superconductor cables.

Holding and conducting energy better than traditional copper means these cables take up a fraction of the space. Manhattan's electrical workers may be able to eventually clear out the subterranean congestion beneath Wall Street that amazingly, looks much the same today as it did a century ago.

Since the cables themselves better prevent extremely high currents from cascading through the system, they will help eliminate the power surges that can permanently damage electrical equipment, similar to a breaker switch in a home, explained McGinnis. The cable switches off during a surge or failure, but automatically resets when conditions return to normal.

For some context, electrical substations take electricity delivered over transmission and distribution lines and lower the voltage so it can be used by homes and businesses. Even if power is lost to an individual substation, by creating multiple, redundant paths for the electric current, the cables allow quick power restoration to all the surrounding power loads. Ultimately, these cables may allow substations that had been intentionally isolated from one another in the past, for fear of cascading failures, to be interconnected in order to share power and assets.

Cutting-edge high temperature superconducting cables have been successfully tested in laboratories, and can be found in a handful of demonstration projects around the country, but they remain an emerging technology. S&T is interested in advancing the technology so that it can be used nationwide, and is pursuing an opportunity to connect two Con Edison Manhattan substations with the cable.

The Department of Homeland Security hopes to enable the Department of Energy and various utility companies around the country to replace more than 2,000 circuit miles of power cables in U.S. cities with resilient, safe, and green IFCL cables.

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