VISION STRATEGY REALITY

It's all in the wires

+ TRANSMISSION IS THE BRAWN FOR THE BRAIN

By Kate Rowland

TRANSMISSION WIRES HAVE ALWAYS BEEN THE TRANSPORTATION workhorses of the electric grid. Directing electrical current from generation to substation, these aging electricity highways have traditionally lacked intelligence.

But, faced with the daunting task of increasing power delivery across the grid in a reliable and secure fashion—not one wrought with congestion and inefficiency—today's transmission wire manufacturers are looking at new solutions to transmission issues.

A smart grid solution that focuses only on information and communications infrastructure and smart metering activities, said Jack McCall, director of transmission and distribution systems for American Superconductor Corporation (AMSC), is "looking only at the brain, and not at the brawn." The brawn, in this case, is the superhighway of wires that transport the electricity.

TRANSMISSION NETWORKS

The first five articles in this department cover everything transmission. Kate Rowland looks at the importance of not just information and control technology, but the capabilities of transmission lines themselves. Carolyn Heinze then studies how utilities from across the globe are learning from one another about the smart grid/intelligent utility, which is followed by China and Denmark examples of their efforts in transmission and renewables. William Opalka wraps it up with a look at managing renewables on transmission and distribution networks.

With this in mind, the U.S. Department of Energy (DOE) Office of Electricity Delivery and Energy Reliability began shoring up the maturing brain of the modern grid ideal with some super-powered brawn. With substantial federal investment in play, it has partnered with industry in a national effort to introduce new technology into the power delivery infrastructure by sponsoring projects showcasing the use of high-temperature superconducting (HTS) cables in modernizing electricity transmission and distribution systems.

One of these, by AMSC and the Long Island Power Authority (LIPA), is a 2,000-foot-long, 138-kV HTS cable system capable of transmitting 574 MW of electricity when operating at full capacity. The world's first transmission voltage superconductor cable in operation, the LIPA project was energized on April 22, 2008. The DOE funded $27.5 million of the $58.5 million total project cost.

The cable system, which consists of three individual HTS power cable phases running in parallel, includes six outdoor terminations for connection to LIPA's grid. It was designed, manufactured and installed by Nexans, utilizing second-generation (2G) HTS wire produced by AMSC. The system is cryogenically cooled using an Air Liquide liquid nitrogen refrigeration system. The hair-thin, ribbon-shaped HTS wires produced by AMSC are able to conduct 150 times the electricity of similar-sized copper wires. This power-density advantage means transmission-voltage HTS cables can use far less wire to conduct up to five times more power—in a smaller right of way—than traditional copper-based cables.

"The 2G HTS wire is the underlying smart material," McCall said. A perfect conductor, the wire is able to instantly switch to resistive mode when encountering a surge in current, automatically and instantly suppressing power surges. (Alternating current HTS power cables have inherently low impedance, enabling them to draw power flow away from overtaxed conventional cables or overhead lines to relieve network congestion.)

Another project currently under way using HTS cables is being partially funded by the U.S. Department of Homeland Security Science and Technology Directorate. The $39-million project focuses on the development and deployment of AMSC's Secure Super Grids fault current limiting

technology in the power delivery network of Manhattan operated by Consolidated Edison Company of New York. DHS is providing up to $25 million for the project.

"Project HYDRA, utilizing HTS cables in a downtown urban environment, will enable us to parallel the substations, improve reliability and resiliency, and connect much more substantial power in the urban grid," McCall said. This will better enable the large-scale introduction of plug-in hybrid vehicles without severely straining the downtown grid as commuters drive in to work in the morning and plug in their cars.

The 2G HTS cable also provides the ability to bring electricity into urban areas from more remote generation. The wire is easy to site in a limited right-of-way because it has no electrical or magnetic fields associated with it, and it can also conduct electricity with virtually no electrical losses.

But superconducting alternating current (AC) transmission solutions are also getting some assistance from the direct-current (DC) quarter. ABB's HVDC Light (high-voltage direct current) cable, developed in the 1990s, is gaining some major ground in projects both in the United States and around the world. With overhead, underground and submarine applications, HVDC Light is being used both in environmentally sensitive areas and in applications where the generated electricity has to travel exceptionally long distances.

One example, the Cross Sound Cable, is an HVDC Light underwater cable link between Connecticut and Long Island, N.Y. Running for nearly 25 miles (40 kilometers) underwater, this line is buried under the seabed, with a converter station at New Haven, Conn., and Shoreham on Long Island. The + 150 kV line has a power rating of 330 MW, and was commissioned in 2002.

▲ The Sea Spider, which layed a 24-mile power cable across Long Island Sound, is moored in New Haven, Conn., harbor in this May 15, 2002, file photo. *(AP Photo/Bob Child, File)*

"One of the biggest advantages of direct current in general is that it is controllable, it's dispatchable," said Mike Bahrman, HVDC products marketing manager for ABB. "You can control the voltage." He also noted that DC, unlike AC, does not draw capacitive current, which becomes a limiting factor as distance increases. "This becomes significant over 25 to 30 miles," he said.

In other applications, HVDC Light cables have been type tested to + 320 kV, with power ratings of up to 1,200 MW per circuit, Bahrman said. "If it's overhead, we can double that."

Of course, an uber-marriage of superconducting cable and high-voltage direct current cable might be the perfect combination of capabilities and economics. It's something the Electric Power Research Institute (EPRI) is exploring in its current Superconductivity Program, looking at superconducting DC cable for long transmission.

Kate Rowland is editor-in-chief of Energy Central's intelligent utility topic center newsletters.