Reactor installation sets Olympic speed and payback record

When news was announced that the Olympic torch would be lit in Atlanta for the 1996 Summer Games, among those who sprang into action were the planning engineers at Southern Company Services and the substation design and construction forces at Georgia Power Company, the largest of Southern Company's five operating companies.

Although the increase in demand from the sports venues and the athletes' village would be minimal, it was clear that the influx of visitors would create substantial extra loading in the entire Northern half of the state. Southern Company chose to meet the additional demand and maintain adequate reserves with a mix of new generation and reliance on the capability to import power from neighboring utilities, especially from the Virginia/Carolinas (VACAR) subregion to the east.

However, heavy line loading resulting from unscheduled loop flows reduced the VACAR-to-Southern Available Transfer Capability (ATC) to zero numerous times during the hot 1995 summer. If this situation occurred again in the summer of 1996, Southern Company's ability to import scheduled or emergency replacement power from Duke Power and other utilities to the East would be jeopardized.

Given the uncertainties about the magnitude of additional load, the threat of possible terrorist attack on generation or T&D facilities, the rapidly increasing loop flows and the attention of the world directed at Georgia, Georgia Power and Southern Company Services keenly felt the need to remove restrictions on the VACAR interface.

Normally, power flows from Duke into Georgia primarily via a 500 kV line from Oconee, SC into metropolitan Atlanta (See Figure 1 on reverse side), as well as on several smaller lines including the 230-kV line between Hartwell Dam and the Hartwell Energy plant. Hartwell Dam is a 358-MW, 5-unit hydro plant owned and operated by the U.S. Army Corps of Engineers. Hartwell Energy is a 2-unit, 300 MW IPP which sells energy to Oglethorpe Power Corporation, supplier to 39 of Georgia's electric cooperatives.

Although the Hartwell Dam-Hartwell Energy and Bio-Hartwell Energy lines have two 795 kcmil ACSR conductors per phase, the next line segment downstream, from Bio to Center, consists of 31 miles of single-conductor 795 ACSR. Through load flow analysis, Southern Company Services identified the already heavily-loaded Bio-Center 230-kV line as the most significant limit to the import capability from the VACAR region. The challenge, then, was to drastically reduce loading on this line with less that a year to study the situation, and design, procure and construct any improvements.

The option Georgia Power Corporation eventually selected was purchase and installation of dry-type air core reactors upstream of the critical section of single-conductor line. Six 21-ohm reactors (two per phase, series connected) were manufactured by Toronto-based Haefely Trench and placed near the middle of the 1.2-mile Hartwell Dam—Hartwell Energy 230-kV line, thereby increasing the impedance of this line by a factor of 11 and significantly decreasing flows on the entire transmission corridor between Hartwell Dam and Center. Total installed cost for the six reactors was approximately $2.6 million. With the reactors installed, Southern Company can import up to 1,600 MW more than previously, without the Bio-Center line or any other facility experiencing thermal overloading.

Situated within the right-of-way as a bolt-on installation, six 21-ohm reactors manufactured by Haefely Trench have saved Georgia Power up to $14 million in avoided line installation and station upgrading costs.

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location of the reactors was complicated by the fact that various parties had conflicting goals. For example, if the reactor installation had been placed electrically downstream of Hartwell Energy at the Bio substation, where ample space was available, one reactor per phase would have increased the Duke-to-Southern ATC as much as the chosen option, but at half the cost.

This would have benefited Georgia Power Corporation, Oglethorpe Power Corporation, and the other owners of the jointly-owned transmission system in Georgia. However, the Southern-to-Duke ATC would have been reduced, and power intended for Oglethorpe Power Corporation's consumption would flow through Duke's system, both to Duke's detriment.

The site chosen—between the Hartwell Dam and Hartwell Energy—is on land owned by the U.S. Government, near the middle of the Oglethorpe Power Corporation-owned transmission line. The site required extensive grading; however, alternative sites were not available, as neither the Corps of Engineers' Hartwell Dam substation nor the Oglethorpe Power Corporation's Hartwell Energy switching station had available space, and there were no available flat sites along the right-of-way.

The reactors were installed within the right-of-way on 7-foot insulators atop 14-foot steel pedestals to achieve proper magnetic clearance. The reactors themselves are another 12 feet tall. The line is broken with two strings of insulators on each phase; the conductor drop connects from one side of the insulators to the reactors, and then back up to the other side. If bypassing is ever required, the installed jumpers can be cut to disconnect either or both sets of reactors, and spare, pre-made jumpers quickly installed to restore the line to service. A steel fence encloses the entire reactor station.

The reactor support bracing is designed to withstand hurricane force wind-loading of up to 100 mph. Containing no oil, the reactors themselves are environmentally benign, and require no maintenance over their lifetime. The reactor windings are embedded into a matrix of epoxy resin fiberglass and epoxy resin glue. The epoxy matrix provides mechanical integrity to withstand the mechanical stresses produced under short circuit conditions. Each reactor coil weighs 20 tons.

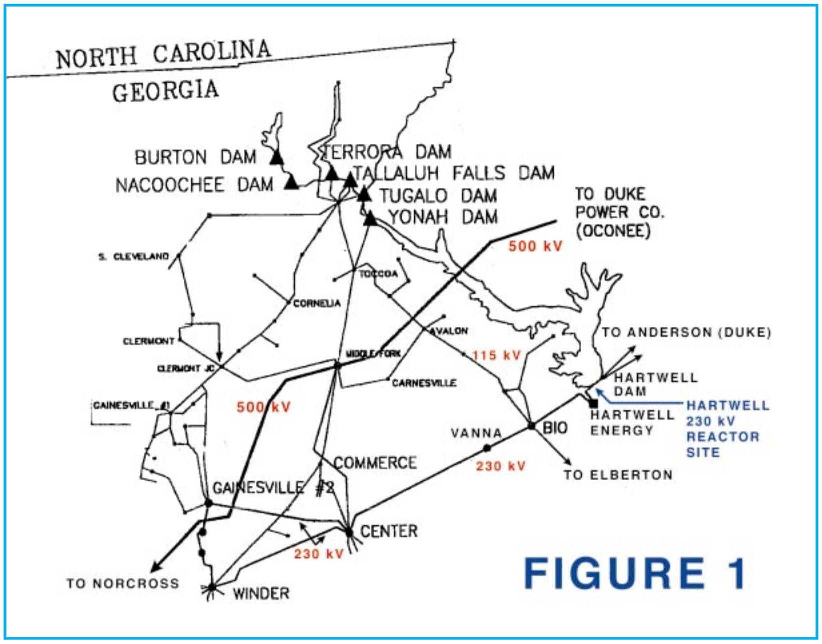

FIGURE 1

Although Haefely Trench could have manufactured three 42-ohm units instead of six 21-ohm units, their size would have made them unwieldy, and a single failure would mean the entire installation would have to be taken out of service to prevent imbalanced operation. Also, the smaller reactors would provide more flexibility if there is ever a need to relocate them in the future due to changing system conditions.

Even though the reactors generate some losses, the total I^2R losses in the transmission line are lower, resulting from the decreased current flow. Real power losses in the reactors are negligible, too, because of the high quality factor (X/R); typical Haefely Trench designs have X/R ratios of greater than 150. Due to the phase relation of the quadrature voltages, the voltage drop across the inserted reactors also remains negligible.

One alternative for reducing the overloading on the Bio-Center line would have been to add a second conductor per phase to this line and to Duke's two Anderson-Hartwell Dam lines, and upgrading the station equipment. The cost for this upgrade would have been approximately $14 million.

To compare this approach with the reactor installation, it is important to note that the alternatives would have brought different benefits.

Although much more expensive, the line upgrading would have provided extra capacity, as opposed to a redistribution of loading away from the Bio-Center line, which the reactors achieve. However, the time available before the Games was too short to complete the line modifications.

In contrast, the speed of the reactor project set something of an Olympic record itself; the contract was given to Haefely Trench in December 1995 with delivery in March 1996.

In addition to cost savings, the major advantage of the reactors to Southern Company has been a large gain in reliability for relatively small expense at a time of critical need, and a quick pay-back. The project could be specified and completed in the short time frame before the Olympics, had virtually no environmental impact and will require no maintenance over its installed life. ■

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