

A superconducting 'SuperStation'

What appeared to be a technically and economically ambitious project when it was announced last year, requiring the very latest in transmission and distribution technology, is gradually taking shape in New Mexico. **Junior Isles**

Just over a year ago, Phil Harris, CEO of Tres Amigas LLC outlined his concept to build the Tres Amigas "SuperStation" to link the three power grids of the US and create the nation's first renewable energy market hub.

Since the project's announcement, there have been a number of developments, including significant interest from transmission companies to connect into the SuperStation. At the time of Tres Amigas' initial FERC filing in October, 2009, five transmission companies – Public Service Co. of New Mexico, ITC, Excel Energy, American Electric Power and Sharyland Utilities – submitted letters of intent, subject to further due diligence, to connect to Tres Amigas. Since then, additional utilities and merchant developers have submitted enquiries, which are now in negotiation.

The vision is for the Tres Amigas SuperStation to tie together America's Eastern Interconnection, the Western Interconnection and the Texas Interconnection (also known as the Electric Reliability Council of Texas, or ERCOT) for the first time to enable faster adoption of renewable energy, and increase the reliability of the grid.

While the project is strategically important, it also has tremendous significance from a technology standpoint, as it will demonstrate one of the many possible applications for superconductors in the power industry.

Jack McCall Director HTS T&D Systems at American Superconductor (AMSC) commented: "The use of superconducting cables in Tres Amigas really does help underscore the maturity and significance of superconductor cables in the industry. It's a pretty spectacular move on Phil's part."

The project requires gigawatt-scale underground cables and power conversion systems that can serve as access points for each of America's interconnections. According to Harris, this made superconductor electricity cables "a natural fit" for the Tres Amigas SuperStation.

AMSC also saw the project as a fit. The company spent \$1.75 million for the purchase of a minority stake in Tres Amigas, LLC and is also expected to provide transmission planning services, superconductor wire and the superconductor cable system for the project.

The project will demonstrate the importance of superconductors in high voltage applications. In the US there are currently about nine HVDC links between the three grids, stretching from Canada almost down to the

Mexican border, with a total power rating of just over 1 GW. This means there is limited power transfer capacity. McCall commented: "Tres Amigas will initially increase this transfer capacity to 5 GW, with an ultimate vision of 30 GW."

The Tres Amigas renewable energy market hub will be constructed in Clovis, New Mexico. This location was chosen for several reasons. It has easy access to all three of the nation's power grids and in particular transmission lines that are designated to moving wind power around Texas.

Locating it outside of Texas also simplified things from a regulatory point of view. Transmission lines that connect to Tres Amigas from ERCOT will not come under the jurisdiction of FERC, making it easier for Tres Amigas to be operated as a merchant transmission entity. "New Mexico has proven to be easy to work with in terms of identifying land and making land available at reasonable prices," added McCall.

Tres Amigas SuperStation essentially consists of three stations located about 3 km apart, with each station comprising multiple DC terminals. Multiple power transmission lines from each of the interconnections will feed power into and out of the SuperStation through multiple AC/DC converters, each connected by DC superconductor cables.

The SuperStation has to act as an active, dynamic trading hub where it must be possible to change the active power flow between regions as necessary. For example during the day when there is abundant solar power in the southwest, there would be a need to move power from west to east. At night when wind generation is higher, power would need to flow

west. Power flows would also alter according to the different peak demands of the different time zones.

Conventional DC technology, which typically only allows power to flow in one direction, was therefore not a real option.

Voltage source converters (VSCs) are the only technology capable of changing the direction of power flow millisecond by millisecond in a multi-terminal application. Compared to conventional HVDC technology, VSCs are more self sufficient from a reactive power standpoint and are



American Superconductor's Amperium wire conducts more than 100 times the electrical current of equivalent sized copper wire. As a result, the few Amperium wires pictured on the right are able to carry as much power as all of the copper on the left. The Tres Amigas SuperStation will incorporate direct current (DC) Superconductor Electricity Pipelines utilising Amperium wire.

Courtesy of American Superconductor Im_9WIRE

therefore more compact – they do not require large filter capacitors and reactor banks to provide reactive power compensation.

There are a handful of manufacturers that can supply this technology to handle DC voltages of 200-345 kV, depending on the manufacturer. In order to allow competitive bidding between all manufacturers, it was decided that the voltage level would be set at 200 kV. However, this would call for a 12500 Amp DC bus between the three stations to transmit 5 GW.

Having a station with a transfer capacity of 5 GW creates another

refrigerators that are needed to keep the cables cold. But these power losses are still small compared to the losses associated with conventional technologies. In addition, the superconductor cable can be placed underground."

The DC terminals within each of the three stations will be connected in parallel to each other and to the superconductor cable through a single connection point.

Notably, as Tres Amigas will act as a load balancing authority, the SuperStation will also make use of storage batteries to assist with load

executed in stages as the different transmission lines connecting into the station are constructed.

Tres Amigas has made a number of announcements this year that bring the project closer to reality. Last month, Alstom Grid was awarded the contract for the supply of the VSCs.

The engineering firm has been selected, as has the battery supplier and the company that will design, build and operate the power trading platform. As yet, there has been no announcement on the DC terminal suppliers and AMSC has not yet selected who will supply the superconductor cables.

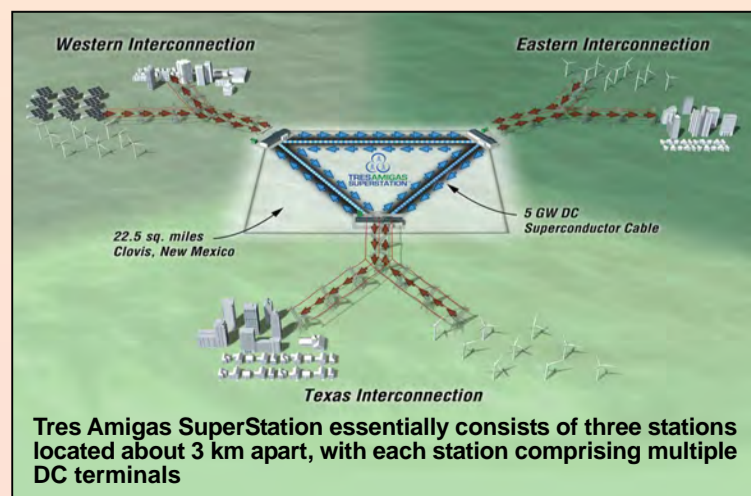
In late August, Tres Amigas initiated the study and regulatory processes necessary for the first key interconnections. In particular, Tres Amigas requested that the Southwest Power Pool (SPP) execute an interconnection agreement to enable Tres Amigas to interconnect to SPP. Tres Amigas is seeking a similar interconnection agreement with Public Service Co. of New Mexico (PNM) and the broader Western Electricity Coordinating Council (WECC). These interconnection agreements are expected to be finalised early in 2011.

Once there are firm commitments from transmission companies to build lines into the SuperStation, the next step will be to sell-off the capacities of the station. This will allow Tres Amigas to obtain financing to start building the SuperStation.

Some would argue that such a project presents a high financial risk, but McCall disagrees. "In a merchant transmission project, you are auctioning off a number of things. You are auctioning the transmission capacity of the line and you can also charge for the individual transaction of shipping the MWh across the line. In addition, there are a range ancillary services that can be packaged and sold. So there are plenty of financial vehicles if you look at it as a series of merchant lines. The calculations show it is definitely a financially viable project."

Hopefully, the belief in the financial viability of the project will allow this visionary project to become a reality.

The use of superconducting cables in Tres Amigas helps underscore the maturity and significance of superconductor cables in the industry



dilemma in terms of the number of AC transmission lines that would have to come into the station. The highest voltage in Texas is 345 kV, which means typically a transmission capacity of about 600-800 MW per line. This would require as many as a dozen lines for 5 GW. The Western Interconnection is limited to 345 kV and 500 kV lines. Only the Eastern Interconnection has lines of 765 kV, which can transfer 1.5-2 GW of power.

McCall commented: "This meant Tres Amigas was looking at a scenario where there would potentially be dozens of lines coming into the superstation. With the likelihood of tornadoes and snow and ice storms in the region, it wasn't desirable to have all of these lines in one location where a storm could have a very significant impact."

The challenge of possibly needing such a high current DC bus and so many transmission lines converging in a single location led Tres Amigas to consider superconductors. McCall explained: "For the high currents that are necessary, superconductors are the ideal conductor. They have zero resistance and zero power losses when transmitting DC. In this case, you can move 12500 Amps around this 9-10 km loop in a single cable with virtually no power losses, other than the losses that are due to the

balancing. "Tres Amigas will be legally obligated to ensure there is a balance of power. Since power flow will come largely from renewable sources, Tres Amigas decided to put some battery storage on each of the three DC terminals. The storage will act as a bit of a shock absorber for momentary power imbalances. It will also offer the opportunity to store some power for resale via ancillary service contracts."

AMSC has designed the superconductor cable system and is currently evaluating designs from cable manufacturers around the world.

McCall said: "We will be looking at the technical merits of each design, e.g. how the cable and terminations will be built, what will be the refrigeration requirements etc. The refrigeration is a significant portion of the system costs, perhaps 15-20 per cent of the cost of the superconducting system."

But the cost of the superconductor system will be a "drop in the bucket" compared to the overall cost of the SuperStation. With HVDC terminals typically costing \$160 000-180 000 per MW, estimates for the entire project have been put at \$1-2 billion. However, because of the modular nature of the VSCs, the entire 5 GW of all three stations does not have to be built straight away; it can be