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A transmission line connecting Ninth & Central and Sunset stations crosses a mix of residential and public land.

Designs for Capacity

Avista Utilities uses ACSS to deliver 15% more capacity without any compromise.

By **Bryan Hyde**, Avista Utilities

The need to increase capacity of the U.S. electric power grid — to accommodate load growth and support a more diversified electricity generation mix — combined with an aging infrastructure is driving the construction of tens of thousands of miles of transmission lines across North America. Environmental, landowner, regulatory and financial considerations can complicate the design and engineering process when it comes to constructing or rebuilding lines. With so many hurdles to overcome, it could be tempting for transmission line owners and operators to choose traditional conductors that have worked reliably in the past.

When it came time to rebuild 7 miles (11.3 km) of a transmission line serving portions of Spokane, Washington, U.S., and the adjoining city of Spokane Valley, Avista Utilities took a deeper look. Because the essence of a transmission line is the conductor itself, engineers and planners at Avista understood that doing their due diligence to thoroughly evaluate the latest available conductor options could result in a substantial payoff in terms of low-cost added capacity. This ultimately led them to select a high-capacity aluminum conductor steel supported (ACSS) enhanced with a heat-dissipating E3X Technology coating that added 15% capacity and minimized the environmental footprint without adding operational complexity or cost.

The Growing Northwest

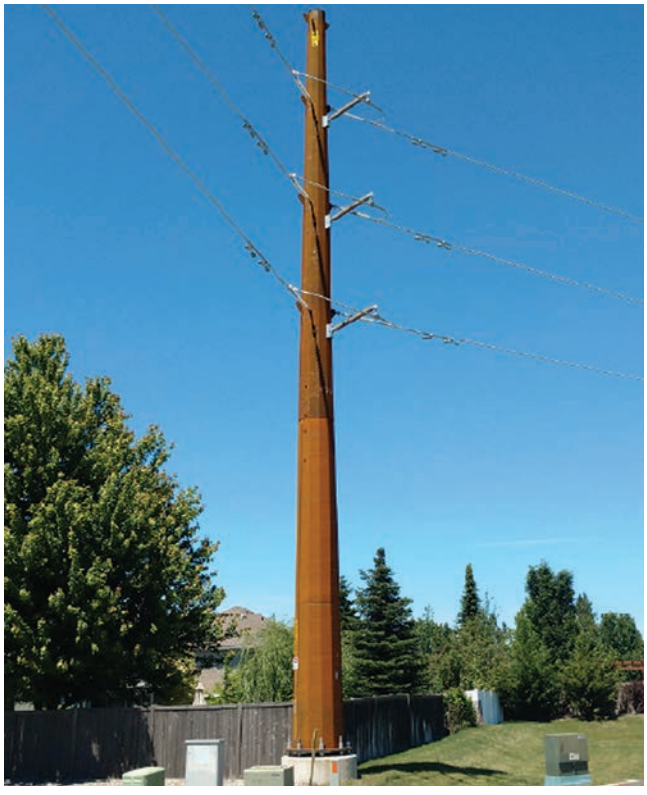
The original Ninth & Central transmission line Avista is rebuilding was constructed in the 1940s. Through the decades that followed, readily available water for generating inexpensive electricity gave way to new industries and subsequent population growth that transformed the Spokane area. Agricultural areas continued to disappear in favor of houses as the area's population grew. And it is still growing. The Washington

Office of Financial Management projects the population of the greater Spokane area will grow by 85,000 over the next 20 years, an increase of about 40% since 2000. As expected, along with the area's population growth has come growth in energy consumption.

Many of the 1940s-era lines are at their end of life and causing reliability concerns. The aging lines combined with the area's population growth and changing power flows have increased the potential for thermal overloads during contingency events. As part of Avista's endeavor to upgrade the lines, one of the replacement projects underway is a 115-kV line connecting the Ninth & Central and Sunset substations located on the south side of Spokane.

As part of this project, Avista also is upgrading portions of the Ninth & Central substation, including replacing outdated equipment within the existing footprint. The overall number of structures and poles on the line will be reduced by replacing the old wood poles with 15-ft to 30-ft (4.5-m to 9-m)-taller self-weathering steel poles. In addition, a fiber-optic shield wire for connectivity and lightning protection will be deployed.

The transmission line connecting the Ninth & Central and Sunset substations passes through residential and public land. Most of the area was rural when the line was originally built in the 1940s, but it now runs through residential backyards and along roadways, and crosses a golf course and public park. The last 2.75-mile (4.43-km) section will be the most challenging, requiring construction to be completed partially by helicopter and partially by hand to minimize the physical impact on the surrounding areas — something that has long been important to Avista, as the utility strives to be a good steward and neighbor.



EX3 Technology enabled the replacement transmission line to have 15% higher line ratings. The new line uses fewer, but taller, self-weathering steel poles.

Conductor Evaluation

While much is involved in rebuilding a transmission line, a utility's commitment to modernizing the electric grid through innovation is what leads to the implementation of effective and efficient technologies that lay the groundwork for the entire industry to power future progress through greater efficiency. At the same time, the industry is being shaped by new regulations and changing business models that have the potential to disrupt business as usual, posing plenty of uncertainty for whatever the future holds and requiring utilities to make the best and most cost-effective choices in overhead conductor technologies.

While a small portion of the 115-kV transmission line between Avista's Ninth & Central and Sunset substations had been upgraded to a 795-kcmil all-aluminum conductor (AAC), most of the line still consisted of the original 250-kcmil copper conductor, hardware and poles that had been in service for more than 70 years. Avista's original 2013 planning process called for rebuilding the rest of the line with 795-kcmil AAC as the utility had done in the past. To lower costs and reduce the number of poles along the route, longer spans were adopted that required a stronger conductor, such as a 795-kcmil aluminum conductor steel reinforced (ACSR). As Avista's planning department continued to evaluate line demands and growth trends, it determined the need for more capacity.

One of the options to add capacity included the use of a larger conductor, such as a 1272-kcmil Bittern ACSR, which is already providing 28% higher ampacity where deployed by Avista in other areas. Unfortunately, this would have added substantial cost to the project because of the more expensive conductor and structures required to support the additional mechanical loading. This also would have further complicated the already difficult environmental and landowner issues.

High-temperature 795-kcmil Drake ACSS, designed to operate at 200°C (392°F), also had been previously deployed by Avista for reconductoring and rebuilds. By increasing the maximum temperature at which a line can operate, ACSS would enable the line ratings to increase by 60% compared to the same size ACSR. While shifting the design from ACSR to ACSS adds a small amount to the project costs because of the conductor, hardware and taller structures required, Avista determined the extra capacity made ACSS a good value when planning for future load growth on this line.

With the 795-kcmil ACSS line design complete, Avista was approached by General Cable about its E3X Technology. Introduced to the market in 2015, E3X Technology is a thin, durable coating applied in the factory to any aluminum overhead transmission conductor design to improve its performance. Based on NASA technologies, E3X Technology increases conductor emissivity and reduces solar absorptivity, which lowers the conductor operating temperature. In line-rating calculations, it was previously necessary to assume values for the emissivity

Using ACSS with E3X Technology for transmission enables Avista to squeeze out the most capacity from existing rights-of-way.

and absorptivity parameters as they vary with time and environment. E3X Technology fixes the values of these variables, unlocking more capacity in the conductor while reducing line-rating uncertainty.

By improving heat dissipation and minimizing heat absorption, E3X Technology boosts the line rating by 15%. This increase, in addition to the already added capacity afforded by ACSS, made the technology very attractive to Avista, especially because a primary goal of the rebuild was to maximize capacity.

An Easy Decision

Closer examination of the E3X Technology was enlightening. Avista learned that the electrical and mechanical performance remains the same, because E3X Technology only modifies the surface of standard overhead conductor designs, such as ACSS. Therefore, it did not require any modification to the utility's installation, termination and maintenance procedures. For Avista, this meant the structures, splices, dead-ends and support hardware planned for the 115-kV line remained the same with or without E3X Technology.

This gave Avista the opportunity to increase the ampacity rating and reduce the operating temperature of the 795-kcmil ACSS it had already selected for the project — all at a total project cost increase of less than 1% to add the E3X Technology coating. Changing the design to 795-kcmil ACSS with E3X Technology was an easy decision for Avista.

One of the drawbacks of a standard ACSS is higher losses due to the higher conductor operating temperature. By enabling the conductors to run cooler for any given load, E3X Technology helps to lower line losses and increase efficiency, especially as the conductor becomes more heavily loaded during peak demand.

For example, a power flow that pushes a standard ACSS conductor to 200°C can operate at approximately 150°C (302°F) with E3X Technology for the same load. This cooler temperature lowers line losses by approximately 20% when the line is heavily loaded. This is another benefit that, in addition to the 15% higher line ratings, outweighed the less than 1% increase to total project cost added by the E3X Technology coating.

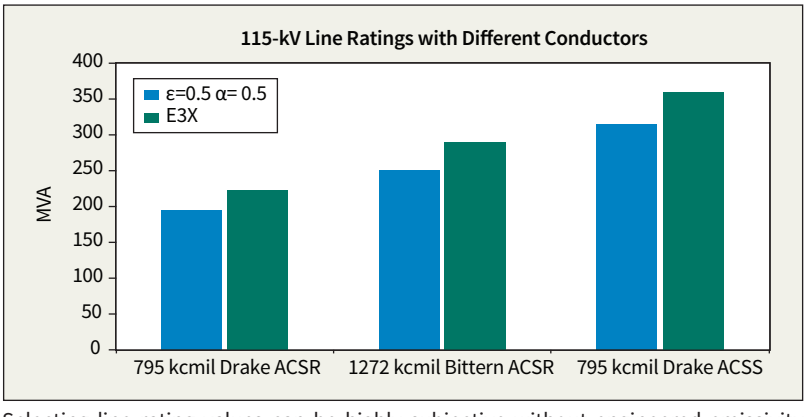
In keeping with Avista's commitment to be a good steward and neighbor, E3X Technology also dulls the surface finish of the conductor, like a non-specular conductor, reducing the visual impact compared to a typical shiny new aluminum.

While the decision to deploy E3X Technology was made easy by the culmination of several benefits, Avista also did its due diligence in making sure the technology was proven.

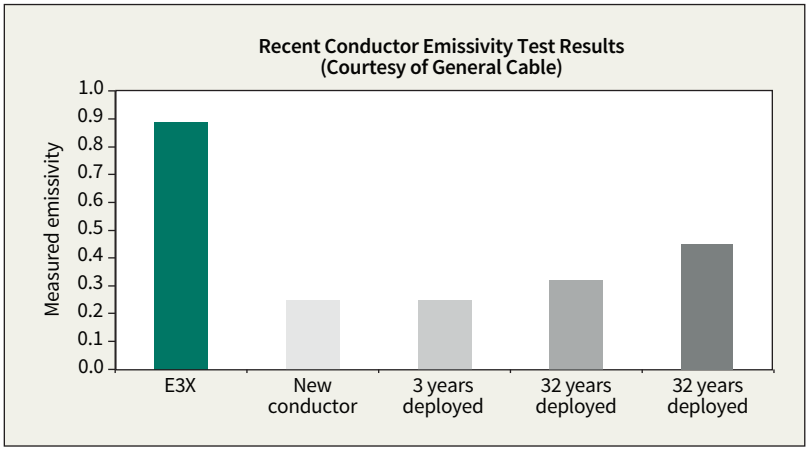
First installed and energized on utility lines in late 2013, conductors with E3X Technology have been tested to stringent protocols and evaluated by extensive validation in field trials and customer deployments. The technology has been installed and tested by independent test laboratories such as Kinectrics and the Oak Ridge National Laboratory, and it continues to be validated through installations in climates around the world. Avista is pleased to join the ranks of more than a dozen forward-thinking stakeholders that have deployed E3X Technology across North America.

Innovation for the Future

Since its founding in 1889 on the banks of the Spokane River, Avista Utilities has embraced innovation as part of its



Selecting line-rating values can be highly subjective without engineered emissivity from E3X Technology.



E3X Technology can be applied to increase capacity of any aluminum conductor deployed by Avista.

culture and identified ways to create value for all stakeholders, resulting in significant achievements. In 1902, the utility began construction on a 100-mile (161-km), 45-kV electric transmission line, the longest high-voltage transmission line in the world at that time. The utility also built the tallest spillway in the world in 1915 and later built the first biomass plant in the United States solely to generate electricity.

Avista continues its tradition of innovation today as a founding partner of Urbanova, a living laboratory in Spokane to design cities of the future. As one of the nation's 100 largest electric power producers, Avista also has maintained its commitment to environmental stewardship and is ranked among the lowest for rates of carbon-dioxide emissions in the country. The decision to deploy E3X Technology goes hand in hand with this culture.

When complete, E3X Technology will enable the new 115-kV Ninth & Central–Sunset transmission line to increase capacity by 15% more than traditional non-E3X Technology ACSS. And, because General Cable developed the E3X Technology coating to be as durable as the conductor itself, this increased capacity is built to last throughout the ACSS conductor life cycle.

Avista's previous line lasted more than 70 years, and the choice the utility made today to maximize capacity for tomorrow will enable it, once again, to meet the growing needs of the Spokane area for decades to come.

As utilities plan to upgrade the aging grid amid a dynamic business environment, many industry experts believe the best path to improve the sustainability of transmission lines is one that leverages the existing infrastructure and routes. Forward-thinking innovators like Avista are leading the way by engaging in projects that will shape how the new energy future looks.

By increasing capacity on new, rebuild or reconductoring projects, E3X Technology can provide the means to improve sustainability of the more than 90,000 miles (144,841 km) of U.S. transmission lines expected to be upgraded over the next decade, helping utilities to hedge against the uncertainties of the future. That is why Avista plans to deploy General Cable's E3X Technology moving forward to increase the capacity of its transmission lines and lower losses on additional future upgrades. TDW

Bryan Hyde (bryan.hyde@avistacorp.com) is a transmission engineer who has been with Avista Utilities for six years. He is responsible for the design as well as project and construction management of multiple 115-kV and 230-kV transmission lines every year. These projects mainly consist of upgrading the existing conductor to provide adequate capacity and, in turn, upgrading existing structures to accommodate the new larger conductors. He also is responsible for certain transmission line maintenance items and standards. A native of Spokane, Washington, U.S., Hyde is a graduate of the University of Idaho and holds BSEE and MEEE degrees.

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