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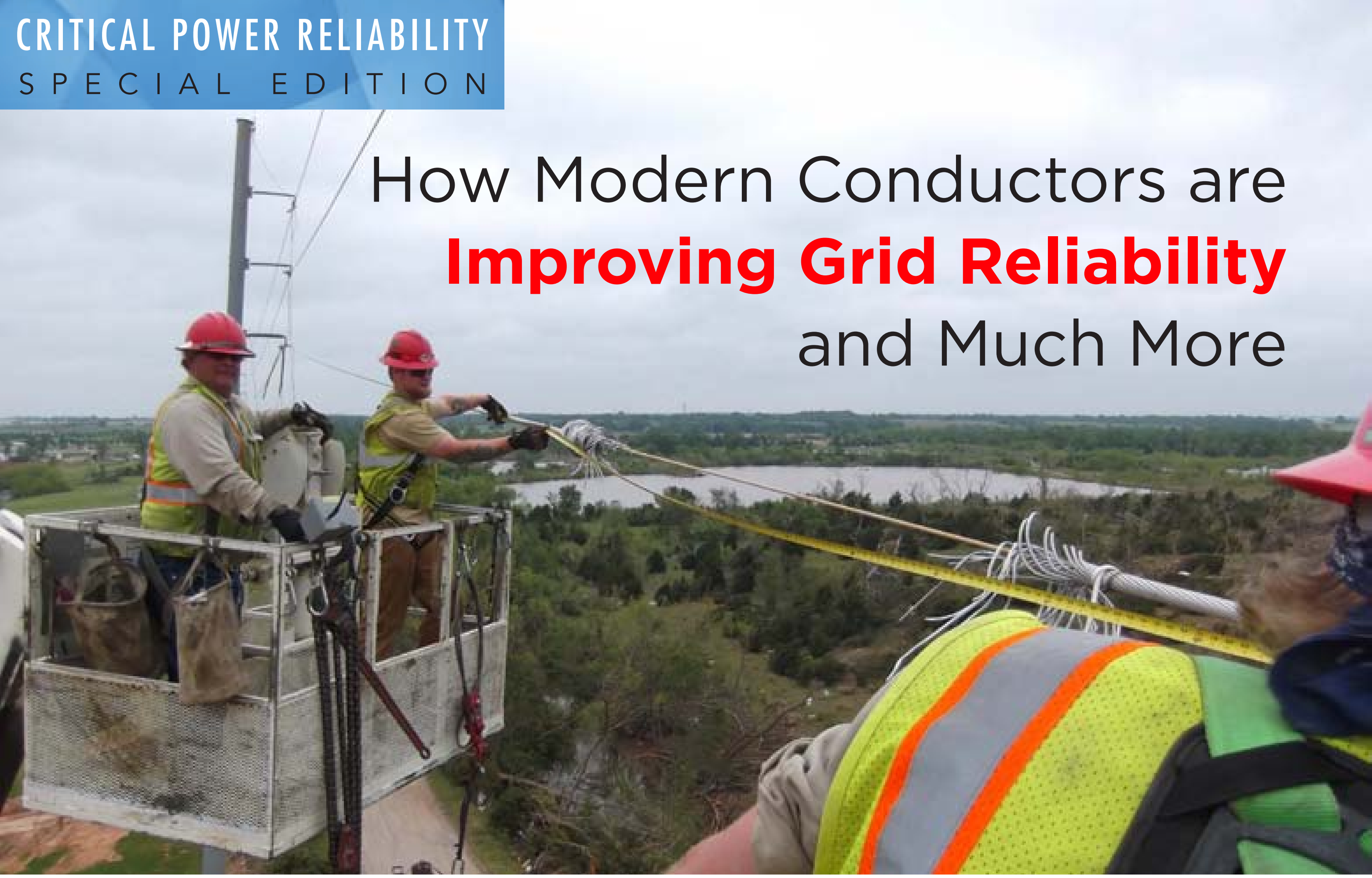


How Modern Conductors are **Improving Grid Reliability** and Much More

By Dave Bryant, Director Technology, CTC Global Corporation

REFLECTIONS:

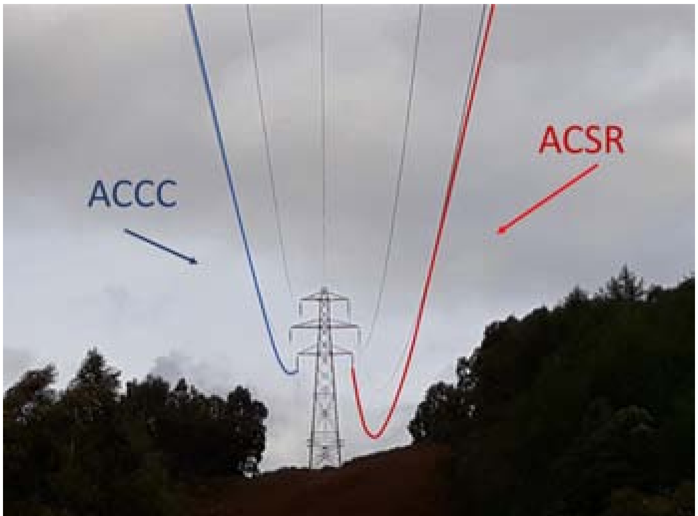
Nearly twenty years ago when I got into the energy business, reliability was a second-tier design objective for most transmission engineers. Safety factors had already been established and the materials we used for structures and powerline wires (conductors) were well known. While demand for electricity wasn't growing at a super rapid pace, many existing transmission lines were congested – meaning they couldn't deliver power from the lowest cost source of generation. While that didn't bother everyone (the money was going somewhere), over time grid operators began putting pressure on utilities to increase line capacity to reduce the cost of power to consumers.

This is when (actually slightly earlier than my arrival), conductor manufacturers began selling high-temperature, low-sag "HTLS" conductors such as ACSS (Aluminum Conductor Steel Supported) which in theory could carry about twice the current of conventional ACSR (Aluminum Conductor Steel Supported) conductor due to the fact that it uses fully annealed aluminum wires that can be operated at higher temperatures without weakening the wire (they came "pre-weakened" / annealed from the factory so the sag characteristics of the wire wouldn't change after installation).

All was pretty good. Utilities, when they needed, could swap out old ACSR wire and install ACSS wire and increase the capacity of existing transmission lines. Sometimes, because the ACSS conductor does sag very much like ACSR conductor, existing structures had to be raised, replaced, or modified. Still, it worked, and was a whole lot less expensive and arduous than waiting on the steps trying to get a new line approved.

BLACKOUT:

On Thursday August 14, 2003, the world's second largest blackout in history occurred in the northeastern United States and Ontario, Canada. The power outage impacted more than 10 million people in Ontario and 45 million people in eight U.S. states. The blackout was caused by a number of factors that included out of calibration telemetry devices, a software bug, computer reboot



failures and poor communications which in turn caused a number of 138 and 345 kV lines to become overloaded, and sag excessively which led to a cascading series of sag-trip outages. Economic losses were estimated at $8 to $10 billion dollars.

POLICY:

As a result of this event (or at least inspired to some degree by the event), the US government enacted the Energy Policy Act of 2005 (signed on August 8th, 2005). This 551-page document was written and put into law to establish various mechanisms to inspire the use of novel technologies and investment in clean energy production, grid enhancements and much more. The Act made a very strong case in favor of energy efficiency and combating climate change, but many decision makers were still not convinced that "global warming" was the result of anthropomorphic (human) activities, until a few weeks later.

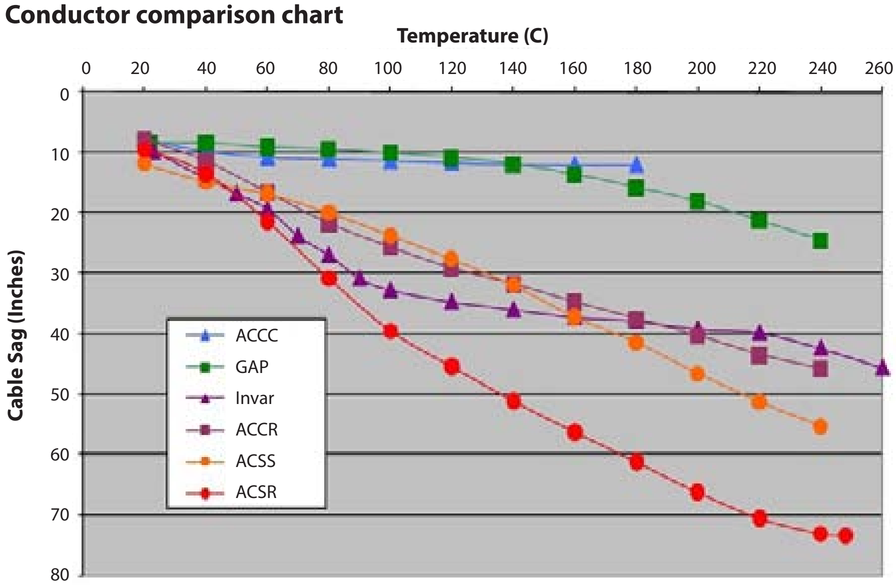
TORNADO:

In late August that same month (2005), Hurricane Katrina (Category 5) slammed into the gulf coast causing over 1,800 deaths and $125 billion dollars in damage. Recall that the major blackout of 2003 caused $8 to $10 billion in economic losses? This was far worse and wasn't just about economic losses. Many more people were killed, lost their homes, businesses and much more. The T&D infrastructure was also hit very hard which undoubtedly captured the attention of our industry leaders. This was expensive. While there may still be a few 'climate change' naysayers, I think we can all agree that the frequency and severity of superstorms and other extreme weather events is causing tremendous havoc.

TODAY:

Things have changed a lot since 2005. We are scrambling to reduce our reliance on fossil fuel generation facilities and build *and connect* renewable sources of generation to reduce GHG emissions; Are anticipating as much as a 50% increase in demand for electricity by mid-century as we transition from gas and oil to electric heaters and automobiles; And are being bombarded by weather events including freezing temperatures in the south, extremely warm temperatures in the north and extreme winds and wildfires in the west (they get all this stuff in the east, but at least *they* are used to it).

Conductor comparison chart



RELIABILITY, CLIMATE CHANGE & WILDFIRES:

On the reliability *and environmental side*, increasing the capacity of the existing grid offers significant advantages. First, it can help move cleaner energy to demand centers. Second, having added capacity can help improve grid reliability and resilience by giving grid operators the ability to re-route power around downed lines or around areas highly susceptible to extreme winds and/or wildfires. In California, the three major utilities are using this strategy when absolutely necessary.

A MODERN SOLUTION:

One of the California utilities is also working quickly to upgrade many of its transmission lines with a carbon fiber composite core conductor developed back in the early 2000's. This modern version of an "HTLS" conductor uses a carbon fiber core to replace the steel cores in legacy ACSR and ACSS conductors. Known as ACCC® ("A triple C"), this conductor offers the higher capacity of ACSS conductors with less than half of the thermal sag. If you are new to the business, when conductors carry higher amounts of energy the electrical resistance of the wires causes them to heat up. Heat causes the aluminum and steel wires to expand - resulting in thermal sag. The coefficient of thermal expansion of the ACCC core is about 10 times less than steel. Reduced sag improves reliability (recall the impact of sagging conductors during the 2003 black out).

While added capacity and sag resistance support grid reliability, the toughness of the composite core also has benefits. On Monday afternoon, May 20, 2013, an EF5 tornado with winds estimated to reach 210 miles per hour struck Moore, Oklahoma killing 24 people, and injuring 377 others. The tornado crossed directly over an ACCC Conductor installation that was used to link a power plant to the city. A large oil drum was picked up by the wind and slammed directly into a 125 foot tall steel monopole which nearly knocked it to the ground. The conductive aluminum strands on the ACCC Conductor snaped due to the shockwave, but the composite core was not damaged. This allowed four lineman in two bucket trucks to quickly splice in a new 15 foot piece of ACCC conductor and put the line quickly back in service. If the core had been severed and the line came down, the linemen would have had to secure a full reel of conductor (and pulling equipment) and the repair would have taken much longer. Reliability and resilience are linked at the hip.

There are a couple of other reliability aspects about the ACCC Conductor worth mentioning that many utilities appreciate. The composite core is impervious to corrosion and cyclic load fatigue. These characteristics make it very useful in highly corrosive agricultural, industrial and salt-air environments and also in areas where wind can cause Aeolian vibration. The smooth surface of the composite core and smooth / wide surfaces of the trapezoidal aluminum strands dissipate vibration much more effectively than conventional round steel and aluminum wire conductors. These attributes improve reliability especially well in harsh environments.

Finally, the ACCC Conductor's lighter weight composite core allows the incorporation of ~28% more aluminum without a weight or diameter penalty. The added aluminum content helps reduce electrical resistance and associated line losses. This can not only reduce fuel consumption and associated emissions, it can also free-up generation capacity otherwise wasted. This conductor technology can not only help you solve your transmission challenges, it can also help your sustainability people and your organization combat climate change.

As many of my friends say: "Another useful tool in your toolbox."