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**Electrical Markets Division
3M High Capacity Conductors**

3M Center, Building 251-2A-39
St. Paul, MN 55144-1000
Phone: 800-245-3523
Fax: 651-736-0431
www.3M.com/ACCR

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Managing Grid Integrity and Affordability in a Changing World

An Executive Overview

Introduction

The United States, like every developed nation, thrives on electrical energy. Electric power drives our economy, provides for our safety and helps ensure our health and well-being. Although actual demand may fall during economic hard times and rise during good times, consumption will inevitably continue to grow. Ours is a power-hungry society.

Feeding that hunger is the function of *the grid*, the largest interconnected machine in the world. Running that machine is the responsibility of the electric utility industry, which manages the system so effectively that the U.S. Department of Energy (DOE) measures grid reliability at 99.97 percent.¹ For nearly 100 years, electric utilities have been the guardians of the grid, ensuring that suppliers and users do not push the existing infrastructure beyond its limits.

Yet today the utility industry finds itself facing a rapidly changing playing field, where rules are being rewritten; where public expectations can conflict with sound planning and engineering; and where efforts to ensure grid reliability are seen as blocking access and constraining the potential of the future.

It's a brand-new game – and as if that were not enough, it's starting in one of the worst global economic environments in history.

This paper will look at one element of the system – the transmission grid – and how an advanced conductor technology from 3M can help utilities manage grid integrity and affordability in a changing world.



A Future of Transformative Change

The uses of and expectations for the grid are changing and becoming much more complex. Nowhere is this more evident than in the regulatory mandates to increase renewable sources in the power generation mix.

Renewables like wind and solar power force a steep learning curve, as utilities determine how to handle variability in output. One such lesson occurred in West Texas in 2008 when power generation dropped with the wind—from about 1700 MW to 300 MW. Although heralded as proving the viability of demand response programs, the event is a reminder of the complexity of dealing with intermittent sources of supply. Nor is loss of power the only concern over variable supply. Surplus energy can be stranded if transmission lines lack the capacity to move power to areas of greater demand.

Balancing load on the fly is one level of complexity. Wholesale transactions represent another. Changing flows for customers who buy power from one supplier one year and from another the next challenge procedures to ensure reliability. Add to that planning and funding of regional transmission and emerging uses such as electric vehicles, and the complexity grows.

Inside a ‘Catch 22’

Ironically, as some argue for less constraint and easier access to the grid for new supply sources, others predict a future of frequent critical events leading up to an “imminent” grid failure – the very problems utilities seek to avoid by managing transactions and access.

The sky isn’t falling yet, but utilities feel the pinch when penalized for being unable to allow wholesale transactions or for delays in bringing renewable generation on-line – all the while opposed by property owners who decry the siting of needed new transmission capacity.

“Approximately 260,000 MW of new renewable capacity (biomass, geothermal, hydro [sic], solar, and wind) is projected over the coming ten years... Though not all of these resources may come to fruition, the integration of this volume of ‘energy-dominant’ resources (or those resources predominately available during off-peak hours) will require significant changes to traditional planning and operating techniques to ensure reliability.”

2009 Long-Term Reliability Assessment 2009-2018, The North American Electric Reliability Corporation (NERC), Version 1.1- December 15, 2009. p. 3

Concerns about grid reliability

- The U.S. Department of Energy suggests an overburdened grid “presents us with substantial risks,” and others warn that a “blackout enveloping half the continent is not out of the question.”^{2,3} In support of these predictions, it is widely reported that of five massive blackouts occurring in the past 40 years, three have occurred in the last nine years.
- The DOE reports to the public that blackouts and brownouts reduce America’s gross national product by \$150 billion annually. It estimates that the August 2003 blackout in northeastern U.S. and Ontario alone affected 50 million people and resulted in a \$6 billion economic loss to the region.⁴
- “This issue of blackouts has far broader implications than simply waiting for the lights to come on. Imagine plant production stopped, perishable food spoiling, traffic lights dark, and credit card transactions rendered inoperable. Such are the effects of even a short regional blackout.”⁵
- The Center for Disease Control (CDC) cites the risks from power outages as “illness from food-borne bacteria, the risk of fire from candle use and the risk of heat stroke or hypothermia in severe temperatures.”⁶



Meeting the Transmission Challenge

3M™ Aluminum Conductor Composite Reinforced (ACCR)...holds great promise for optimizing the capacity of upgrades...

According to many industry professionals, if utilities are to come close to meeting the goals being established by federal and state regulatory bodies, the system could become severely stressed. Advocates for a smart grid argue for an overhaul akin to the national effort to build the interstate highway system some 60 years ago. Unfortunately, without a 1950's style post-war economic boom, there are few options for funding a project of such scale. Operators seem to be on their own in finding ways to bring not only added capacity on-line but also a new robustness and flexibility to the grid. That's why a number of utilities are looking closely at advanced grid technologies – especially in the area of transmission.

The North American Energy Reliability Corporation (NERC) warns that to ensure reliability at least 11,000 miles of 200 kV and above transmission must be installed over the next five years.⁷ Yet public opposition and permitting requirements make traditional procedures for adding capacity more and more difficult and lengthy – sometimes taking as long as a decade.

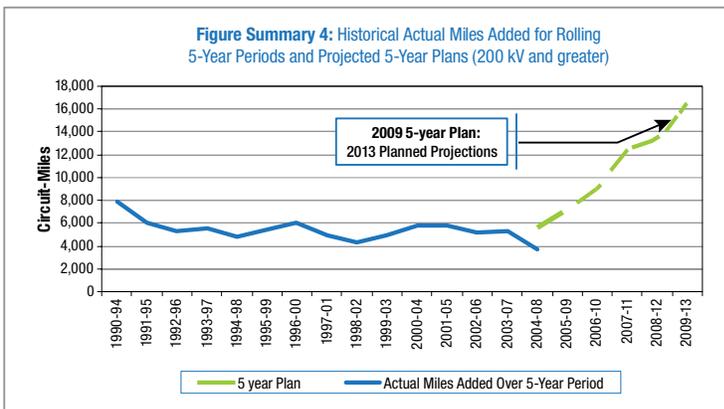


Figure 1. (2009 Long-Term Reliability Assessment 2009-2018, The North American Electric Reliability Corporation (NERC), Version 1.1- December 15, 2009. p. 29)

One tool to address this capacity gap – and one perhaps more compatible with the economics of the times – is upgrades. Advanced transmission technology such as 3M™ Aluminum Conductor Composite Reinforced (ACCR), a high-temperature, low-sag (HTLS) conductor holds great promise for optimizing the capacity of upgrades, allowing utilities to accommodate renewables, enable transactions, and manage new uses at reasonable costs compared to many other options.

Building grid robustness and flexibility through transmission upgrades

- Grid scale renewables often are located far from demand centers. While the utility may need to build a new tap line with traditional materials, the main line might be reconducted with 3M™ ACCR. Installing ACCR in an upgrade helps ensure capacity will be available to meet new requirements and added transactions.
- Utilities also use ACCR as an upgrade for lines serving traditional generation that must ramp up and down quickly.
- Upgrading contingency lines with 3M ACCR can enable higher ratings for EHV lines and provide a robust system to support Smart Grid investments.



Aluminum Conductor Composite Reinforced (ACCR)

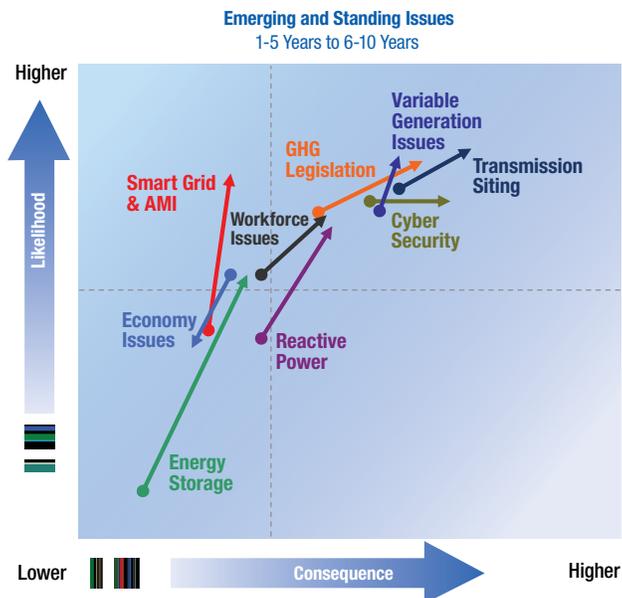


Re-conductoring with 3M™ ACCR often minimizes or eliminates extensive review processes compared to rebuilds, especially when lines cross environmentally sensitive areas, public lands, areas of dense population.

Case in point: An installation in Minnesota allowed a crossing over a protected wetland using existing rights of ways and towers, without the impact of heavy construction equipment.

3M™ ACCR is the result of extensive technical development and years of testing in laboratories and in the field. ACCR was developed by 3M, located in St. Paul, Minnesota, under a joint program with the U.S. Department of Energy and in collaboration with several North American electric utilities.

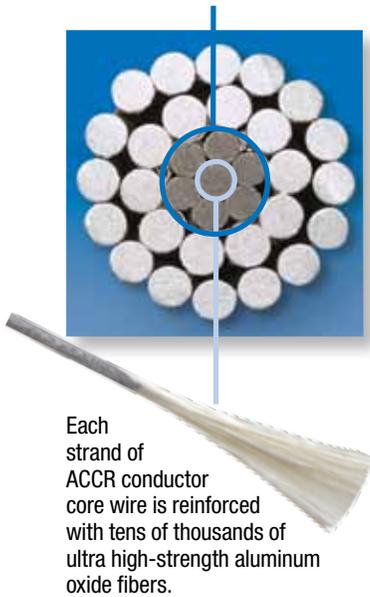
ACCR offers up to a 2X capacity upgrade using existing corridors and towers while maintaining or improving tensions and clearances – and typically at a much lower cost than rebuilds. ACCR does not increase transmission line footprints or change structure height or line appearance, so it can help minimize the impact on property owners and the environment. ACCR provides utilities a fast, sustainable way to reduce transmission constraint and accommodate the integration of renewables and other new uses of the grid. And, as an all-metal conductor, it is as durable and reliable as standard conductors.



Note: The colors of the arrows in this graph were randomly chosen to differentiate overlapping arrows – the colors do not represent additional data or special meaning. Arrows point from the “1-5 Years” ranking to the “6-10 Years” ranking.

“The ability to site and build transmission is emerging as one of the highest risks facing the electric industry over the next ten years. A 15 percent increase in the miles of transmission is projected by 2018 in North America. With the increase in wind and solar resource projections, transmission will be needed to ‘unlock’ renewable resources in remote areas, increase diversity of supply, and provide access to ancillary services required to manage their variability.”

Figure 2. (2009 Long-Term Reliability Assessment 2009-2018, The North American Electric Reliability Corporation (NERC), Version 1.1- December 15, 2009. p. 29)



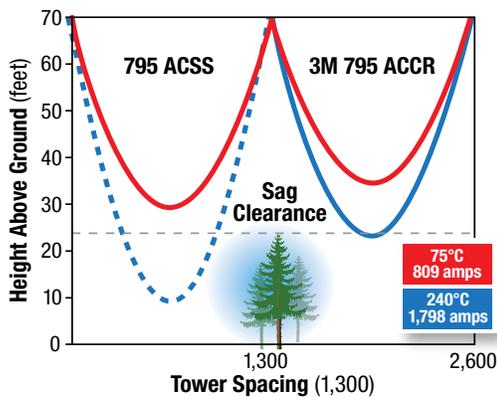
Advanced materials technology from 3M

The 3M™ ACCR core is stranded from wires composed of alumina fibers embedded with high purity aluminum. The outer, current-carrying wires are hardened aluminum zirconium alloy.

Table 1

Core Property Comparison: ACCR vs. ACSR/ACSS

Conductor Core Material	ACCR Aluminum Matrix	ACSR/ACSS Steel
Strength (ksi)	200	185
Density (lbs/in ³)	0.122	0.282
Strength/Density	1,681	656
Coefficient of Thermal Expansion (10 ⁻⁶ /°F)	3.5	6.7



Compared to ACCR, the same diameter ACSR and ACSS may limit the potential of an upgrade. For example, 3M ACCR can offer:

- Half the thermal expansion for less sag at high energy levels
- Twice the strength-to-weight ratio

These attributes can result in two or more times the ampacity while maintaining or improving clearances, tensions and mechanical loads on structures, thus optimizing the potential of the upgrade.

In addition, 3M ACCR conductor's lightweight, conductive aluminum-based core generally means more overall conductivity than steel core conductors, and more aluminum with less weight. In fact, an ACCR trap wire design can reduce resistance by approximately 20% over ACSR of equivalent diameter. Yet, it is just as durable, even if operated at high temperatures over long periods in extreme environments.

Keeping Transmission Affordable and Flexible

By eliminating the need for new towers, land acquisition and other factors, upgrades using ACCR conductor can offer substantial savings, as shown in the example in Table 2.

Due to its advanced material properties (see Table 1), ACCR can help reduce future costs compared to limiting technologies like ACSS. In one case, a customer serving a major U.S. city upgraded with ACCR just 4 years after installing an ACSS line that could no longer provide the needed capacity. In another case, an ACSS line was replaced with ACCR in just 24 months.

Keeping Transmission Affordable and Flexible
(continued)

ACCR conductor also helps reduce installation time, a factor of growing importance considering the rapidly evolving public expectations and resulting regulatory mandates. In the southwestern U.S., for example, a project was completed in four months rather than the estimated 20 months when a line was upgraded with ACCR conductor instead of building a new, parallel line with ACSR. And, a water crossing in Brazil was installed in just 6 days, compared to the time that would have been required to replace towers and set new foundations in the river.

Table 2
ACCR Conductor Upgrade Cost Comparison Example
(from an actual customer installation)

In the example below, a customer originally planned to build a new line parallel to an existing line. Instead, they met their capacity requirements by re-conductoring the existing line with 3M™ ACCR Conductor.

Project Costs (\$/circuit mile)

	Parallel Line ACSR	ACCR Upgrade
Environmental	\$15,000	\$2,000
Surveying and Geology	\$12,600	
Land	\$15,000	
Design and Contract Administration	\$54,360	\$22,649
Construction and Inspection	\$386,000	\$21,000
Conductor	\$60,826*	\$269,280*
Furnished Equipment		\$3,750
Substation Additions	\$160,980	
Contingencies –15%	\$100,341	\$7,410
Total	\$805,107	\$326,089
	Savings:	\$479,018/circuit mile

*2004 project; conductors listed at 2007 prices.

A Technology Partner You Can Trust

There are scores of 3M™ ACCR Conductor installations throughout the world – each 100 percent successful.

3M’s advanced materials expertise, extensive lab and field testing, and close collaboration with utility and industry experts have all combined to make ACCR conductor one of the most trusted new grid technologies.

For more than 100 years, customers have counted on 3M to help them succeed. In ACCR conductors, utility professionals are finding a proven, reliable, versatile and cost-efficient tool for delivering electric power with minimal environmental and community disturbances.



A Tool to Help Manage a Complex Future

The existing grid was never designed to handle the intermittent loads from renewables or provide the flexibility demanded by complex transactions and future loads like electric vehicles. Yet expectations for both reliability and access continue to grow as new uses for electric power evolve.

The challenge to electric power utilities will be to find new ways and new tools to meet an increasingly complex future. Advanced technology grid components like 3M™ ACCR Conductor can help build the robustness and flexibility that will be demanded of a future grid and help the electric utility industry keep the nation's lights on for years to come.

¹ *The Smart Grid: An Introduction*, A report prepared for the U.S. Department of Energy (DOE); Publication date not given. p. 5

² IBID

³ Mazza, Patrick, "Powering Up the Smart Grid: A Northwest Initiative for Job Creation, Energy Security, and Clean, Affordable Electricity," *Poised for Profit in Clean Energy Report*, July 2005. p. 6

⁴ *The Smart Grid: An Introduction*, A report prepared for the U.S. Department of Energy (DOE); Publication date not given. p. 5, 8

⁵ IBID, p. 7

⁶ "Meanwhile, in Texas, a Brief Lull in the Wind," *Knowledge Problem: Commentary on Economics, Information and Human Action*, Knowledgeproblem.com/2008/02/09.

⁷ 2009 Long-Term Reliability Assessment 2009-2018, The North American Electric Reliability Corporation (NERC), Version 1.1—December 15, 2009. p. 29

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