Americans for a Clean Energy Grid

High temperature, low sag conductor

Growing U.S. electricity demand from 1990 through 2005 increased load on existing transmission lines, many of which were built far before such magnitudes of load were considered. Even after substantial recent additions to the transmission network, about 70% of transmission lines are at least 25 years old and are incapable of handling any further increases in load reliably [3]. Although national electricity demand has grown only marginally in recent years, there are some regions of stronger growth, and even where rates of growth are not high, load will continue to increase with population and as new sectors are electrified. Furthermore, transmission developers experience difficulties in obtaining rights of way required for new transmission lines. This combination of potential increases in load, old age of existing transmission lines, and lack of new transmission lines creates a risk of increased congestion, which can lead to grid failure.

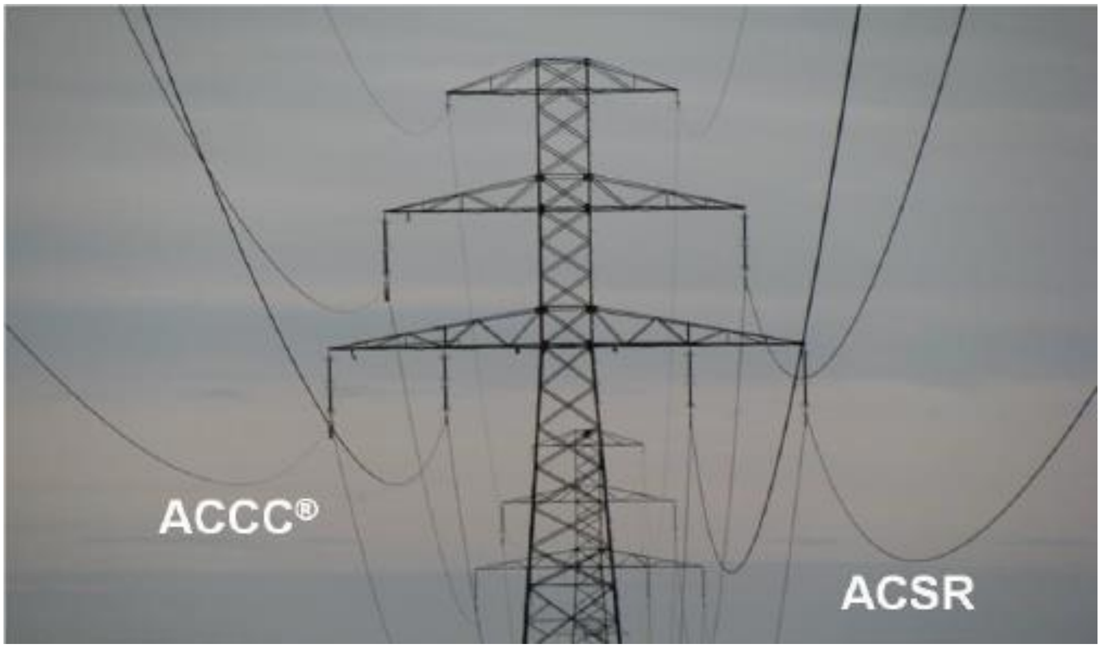
Traditionally, overhead high voltage transmission lines have used the “aluminum conductor steel reinforced” (ACSR) design. ACSR cables are characterized by strands of aluminum wrapped around steel cables. The outer aluminum strands conduct electricity, while the steel core provides tensile strength to the ACSR cable. Aluminum is ductile, meaning that it can deform under tensile stress. The steel core, in turn, prevents aluminum strands from stretching out extensively and sagging lower than the permissible levels.

Although ACSR transmission lines are relatively cheap and have been used over a hundred years for high voltage transmission, they are disadvantaged by their high coefficient of thermal expansion, which causes the cables to expand and sag and generate more resistance with increasing load, causing the lines to overheat [1]. Transmission lines cannot sag beyond a certain limit, after which they pose a threat to public safety. Additionally, greater resistance means greater transmission losses on ACSR lines as grid operators push more power across the system. Because the use of ACSR transmission lines is restricted by these technical inadequacies, they cannot reliably transmit power in excess of their line ratings (under assumed weather conditions) to meet increased demand.

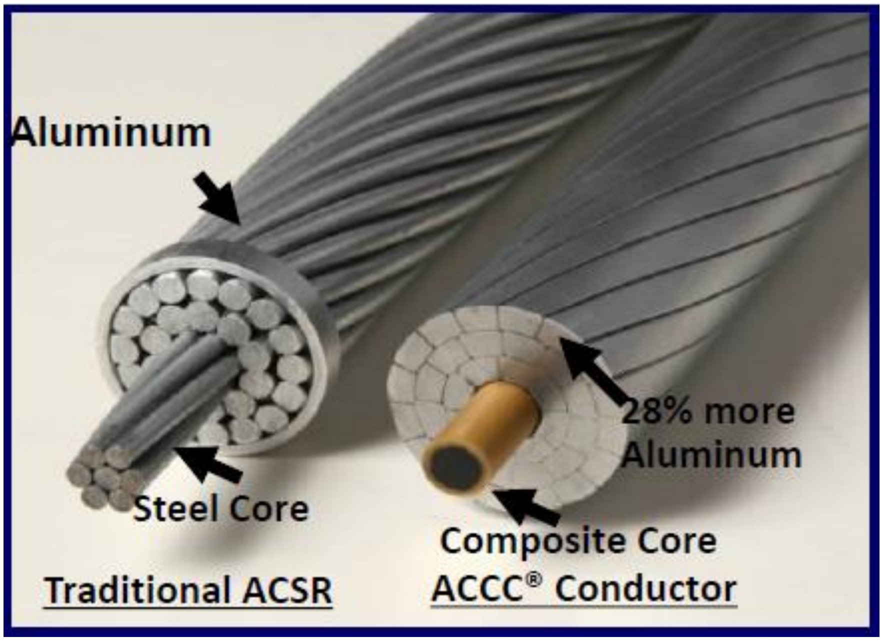
Line losses (the loss of power during transmission) can range from zero to more than 20% of the electricity being transmitted as a function of line and weather conditions [3]. The current national average is that roughly 8% of power generated at central stations is lost in transmission, which is converted into waste heat by the resistance of the transmission lines. This loss is greatest when power is most valuable and needed: under peak demand conditions, in hot and wind-free weather [3]. Technologies that can increase the capacity of the transmission network by making lines more capable of carrying higher volumes of power without overheating or sagging can significantly reduce this loss and increase the efficiency of the installed transmission infrastructure.

So how can the transmission capacity of the power grid network be increased without acquiring new rights of way? One option is to replace ACSR with “aluminum conductor composite core” (ACCC) transmission lines through “reconductoring,” the process of exchanging new cables for original cables using the existing towers and rights of way. Reconductoring requires that the transmission line be taken out of service during the work, which imposes a burden on the rest of the grid and creates costs to transmission operators. The reconductoring process may be undertaken in several portions of the transmission line simultaneously to reduce down time, but the overall downtime depends on the length of the transmission line and the size of the crew working on the project. Reconductoring with ACCC cables can increase the transmission capacity of the power grid without having to acquire new rights of way. In ACCC lines, aluminum strands conduct electricity, while the carbon fiber composite core provides tensile strength to the cable. Carbon fiber composite core is up to 25% stronger than steel core, which significantly reduces the sag of ACCC transmission lines at high temperatures [1]. This means that ACCC cables can carry more current while sagging less than ACSR cables. Additionally, ACCC cables are up to 60% lighter than ACSR cables, which allows ACCC cables to have longer spans and require fewer and shorter supporting structures [1]. The smaller number of supporting structures required reduces the capital costs of transmission line installation projects. Because they sag less, electricity flowing through the conductor experiences less resistance, meaning that ACCC can also reduce transmission losses of power from 25% to 40% [1]. If transmission losses are reduced, less electricity generation is required to meet the same amount of load, and emissions of greenhouse gases from fossil fuel-based power plants decrease. Finally, ACCC cables resist degradation from vibrations, corrosion, ultraviolet radiation, corona, chemical and thermal oxidation, and cyclic load fatigue [1].

The picture below demonstrates the reduced sag of ACCC versus ACSR [2]:



CTC Global, for example, developed an ACCC cable that has 28% more aluminum compared to an ACSR cable of the same size, which allows the cable to carry more current while suffering lower power losses [4]. The image below shows a CTC ACCC cable compared to a traditional ACSR cable of same size.

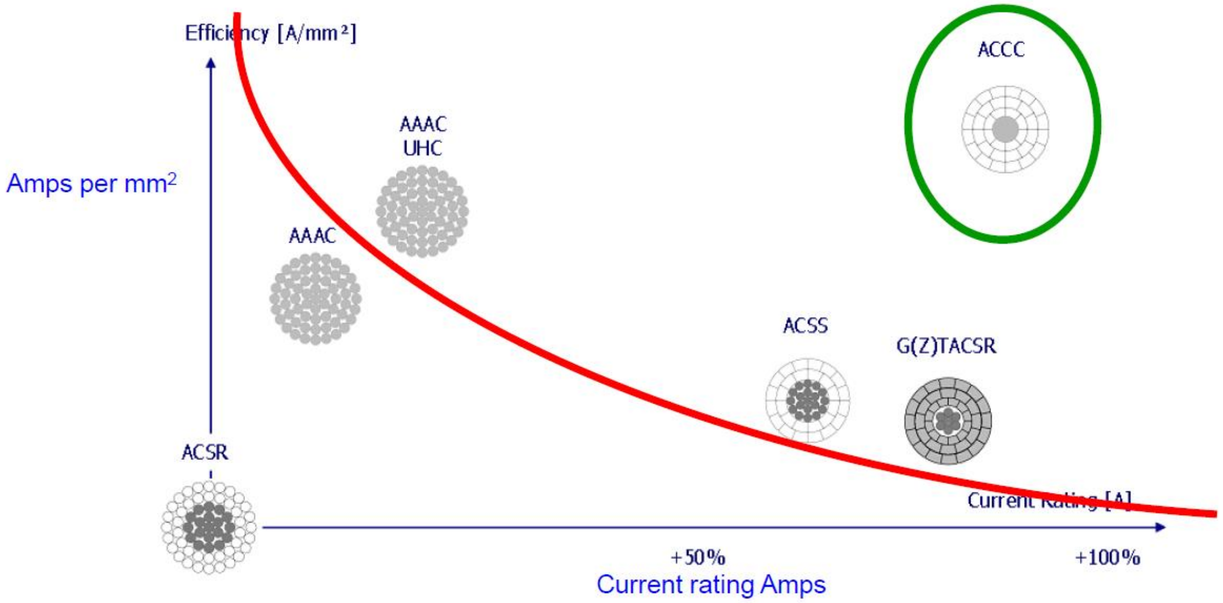


[1]

Because ACCC cables experience lower transmission power losses, they save money for utility companies. A study done by the CTC Cable Corporation highlights the economic benefits of reduced power losses for a 100-kilometer ACCC three-phase transmission line operating with a 53% load factor [1]:

	Peak Amps	**Temp. at Peak Amps (C)**	**MVA**	**Annual Line Losses (MWh)**	**Line Loss Reduction**	**Value of Reduction (at $50/MWh)**	**Value of Reduction per linear conductor**	
							(meter)	**(foot)**
ACSR	1000	95	398	76,917	---	---	---	---
ACCC	1000	82	398	56,588	20,329	$1,016,450	$3.39	$1.03

The graph below shows how various cable designs line up in terms of efficiency and current carrying capacity [1]:



As can be seen, ACCC cables combine efficiency with increased power carrying capacity to create a clear financial advantage over other lines, and especially ACSR lines. Additionally, after a certain current threshold, ACCC cables are less expensive than the traditional ACSR cables. The table below provides the cost analysis of ACCC versus ACSR for various current requirements and conductor sizes (note, conductor sizes are represented by given names rather than precise measurements) [2]:

	ACCC		**ACSR**	
Current Requirement	**Conductor Size**	**Cost/Foot**	**Conductor Size**	**Cost/Foot**
1000	Linnet	$3.80	Gannet	$ 3.06
1260	Hawk	$3.36	Rail	$2.84
1400	Dove	$3.69	Bunting	$3.50
1520	Grosbeak	$4.01	Martin	$4.63
1760	Drake	$4.78	Lapwing	$4.90
1960	Cardinal	$5.17	2032	$7.20

In summary, ACCC cables offer the following benefits:

- Increased current carrying capacity and reduction in transmission congestion;
- Reduced power losses during transmission reduces the electricity generation needed;
    - Reduced levels of electricity generation reduce greenhouse gas emissions;
- Reconductoring of existing ACSR cables with ACCC cables can increase the capacity of the grid without having to acquire more rights of way;
- Fewer and shorter structures are required to support ACCC cables, and this can reduce the cost and environmental impact of transmission projects.

The lower cost and power losses of ACCC cables make them the preferred conductor for reconductoring and new installation projects. CTC alone has installed over 22,000 km of ACCC cable at various projects worldwide as of 2013 [1]. As the demand for power increases, more ACCC cables will likely be installed to increase the current carrying capacity of the grid without acquiring new rights of way.

References

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