An Objective Assessment of Conductor Technologies for Transmission Design and Planning

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Executive Summary

This paper objectively evaluates advertised claims about overhead transmission conductors. The goal is to support informed decisions for achieving the lowest total owning cost (TOC) for transmission projects. For each year of the conductor's service life, the ratepayers incur a significant return-on-capital charge. Rates 50 years into the future are affected. It is therefore critical to spend the money prudently during the transmission transformation now underway.

Key findings

- Polymer composite core conductors offer benefits in applications involving very long spans and extreme clearance constraints. However, many widely advertised advantages can also be obtained by using more cost-effective alternatives.
- Advertising is misleading when conductors with compact trapezoidal wire (TW) aluminum strands are compared to conductors with round aluminum strands.
- Regulators, planners, and engineers should use like-for-like comparisons and objective criteria. Accepting commercially-driven claims at face value risks poor decisions.

1. Purpose and audience

This paper is written for regulators, commission staff, utility planners, and engineers who must evaluate the prudence and ratepayer impact of conductor technology choices over asset lifetimes of 50 years or more. It is not intended to advocate for or against any specific vendor or technology, but to clarify how different conductor technologies perform when compared on an objective and consistent engineering basis.

Key objectives are to:

- Identify marketing claims, both valid and suspect.
- Evaluate all claims, suspect or not, using transparent and standard engineering methods.
- Translate the technical results into implications for cost, risk, and long-term system performance.

2. Methodology and assumptions

To ensure comparability across technologies, all conductor options are evaluated using the following principles:

- **Like-for-like comparisons**: Where possible, conductors are compared at equal overall diameter or equal aluminum area. Only commercially-available options are considered, but be aware the commercial landscape changes with price changes and new product introductions.

- **Standard calculation methods**: Thermal ratings and ampacity are calculated by software using the IEEE 738 method. Sag is computed using the non-linear conductor model as implemented in commercially-available software.
- **Open and published data**: Conductor properties (strength, modulus, resistance, core type, aluminum grade, strand geometry, model coefficients) are taken from manufacturer data or widely available references and applied consistently across options.
- **Scenario framing**: Results are presented in terms of planning scenarios that regulators and planners routinely encounter, such as climatic regions, reconductoring constraints, and differing assigned values for capacity and line loss.

Where data from existing marketing materials is adjusted or recomputed, the process is to:

- Identify and remove non-comparable alternatives (for example, mixing TW and round wire, or different aluminum grades without stating that fact).
- Introduce appropriately comparable options.
- Recalculate using one consistent method across all conductors.

3. Applications where composite core is advantageous

Before examining individual claims, it is important to recognize where composite core conductors can be the preferred choice:

- **Long spans and river crossings**: Spans where establishing required electrical clearances results in structure costs that exceed the premium for an ultra-low-sag conductor.

- **Specific retrofit situations**: In some reconductor projects, cost, schedule and/or permitting delays for structure upgrades justify the cost premium for an ultra-low-sag conductor.

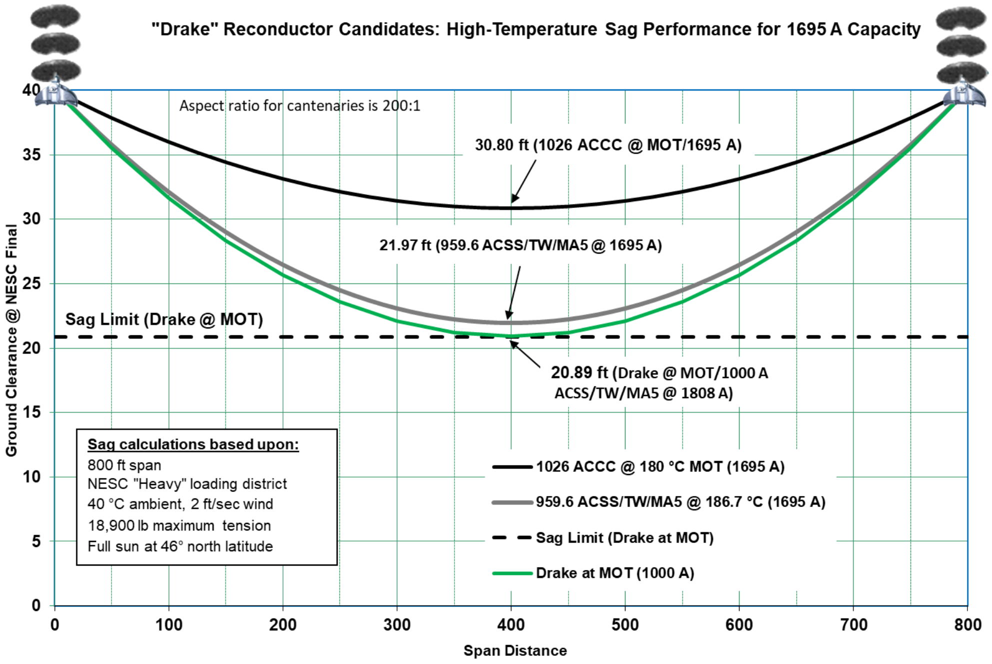
These cases commonly occur, and the composite core conductor has the lowest total owning cost (TOC) despite significantly higher first cost. The remainder of the paper focuses on specific marketing claims that may or may not be false or exaggerated.

4. Analysis of Advertising Claims

4.1 Claim: The sag advantage of composite core conductors justifies a 2x-5x cost difference.

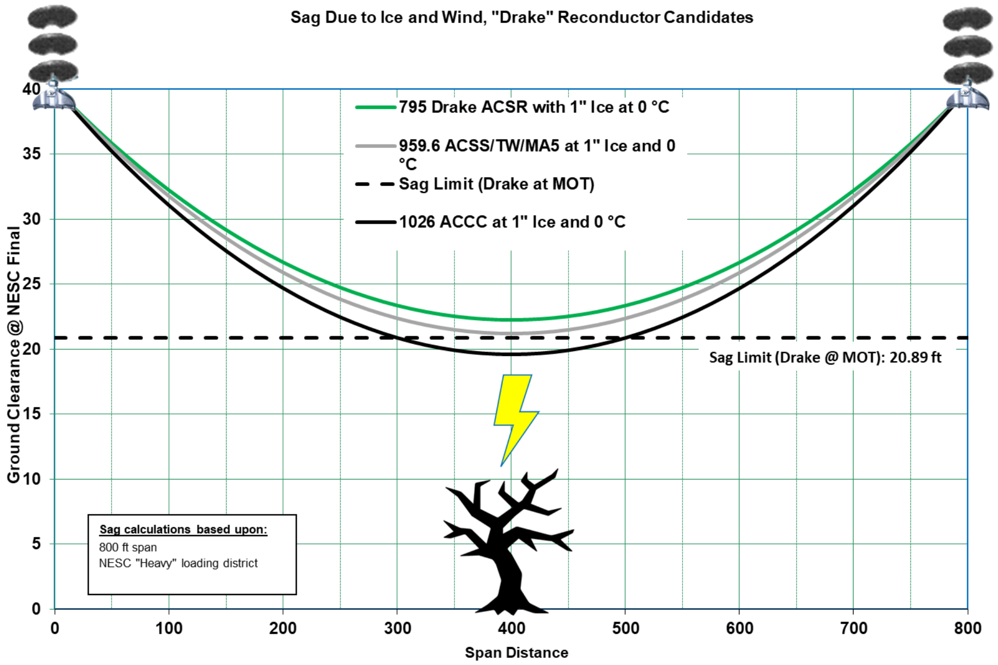
Technical assessment

Composite cores provide greatly reduced high-temperature sag relative to legacy ACSR designs. The value of the sag reduction is a project-specific cost-benefit calculation. In the following example, a lower-cost ACSS/TW/MA5 option provides both higher capacity and significantly lower cost, despite its greater high-temperature sag. The scenario is a Drake ACSR reconductor with NESC “Heavy” tension limits. The required capacity is 1695 A:



ACSS is the original high temperature low sag (HTLS) conductor, so-named because the sag is significantly less than ACSR sag, even at greater capacity. The ACSS/TW/MA5 conductor (gray line) meets the 1695 A capacity goal with ground clearance to spare. If the ACSS/TW/MA5 option uses all of the allowable sag, the capacity is 1808 A, a 7% increase over the maximum capacity of the polymer core conductor. If modest structure modifications allow the ACSS/TW/MA5 conductor to operate at its 250 °C thermal rating, the capacity is 1990 A, a 17% increase over the polymer core conductor.

Weather loads also cause sag increase. In the figure below, a 1-inch ice load causes the polymer core conductor to sag more than the maximum allowable, while the ACSS/TW/MA5 option still meets the sag limit. This is because ice sag is controlled by the elastic modulus (resistance to stretching). In a like-for-like comparison, steel core has a 72% higher elastic modulus than a polymer core.



Planning and regulatory implication

Where reduced high-temperature sag leads directly to fewer or shorter structures, or avoids costly right-of-way or clearance mitigation, the resulting total owning cost savings can justify a premium cost conductor. Regulatory review should focus on whether the proponent has demonstrated that system-level benefits are compared with competitive steel-core alternatives. Comparisons with ACSR baseline values are not valid. Service to the ratepayers requires that the conductor selection is on the basis of least total owning cost for the project.

4.2 Claim: Trapezoidal wire (TW) aluminum strands are a superior technology compared to round strands.

Technical assessment

TW strands were developed to reduce the external diameter for a given aluminum area, thereby reducing ice and wind loads. In climates with light to moderate weather loads, this reduction may not be necessary, and TW strands are counter-productive. In those cases, an equal-area (as opposed to an equal diameter) TW conductor has lower capacity and higher line losses. Capacity is reduced and line loss is increased because the same-area TW conductor is smaller-diameter (the original goal), but with the necessary consequence of a smaller cooling surface. Hotter metal temperature increases the I^2R losses, and lowers the capacity. TW stranding also incurs a higher manufacturing cost.

Planning and regulatory implication

Regulators and planners should ensure that policy does not allow TW stranding unless it delivers tangible system-level benefits under the specific climatic and loading conditions of a project. In light and medium loading regions, a larger-diameter round-wire design with the same aluminum area will provide higher capacity, lower line losses, and lower first cost, compared to a same-area TW conductor. This applies regardless of the core material.

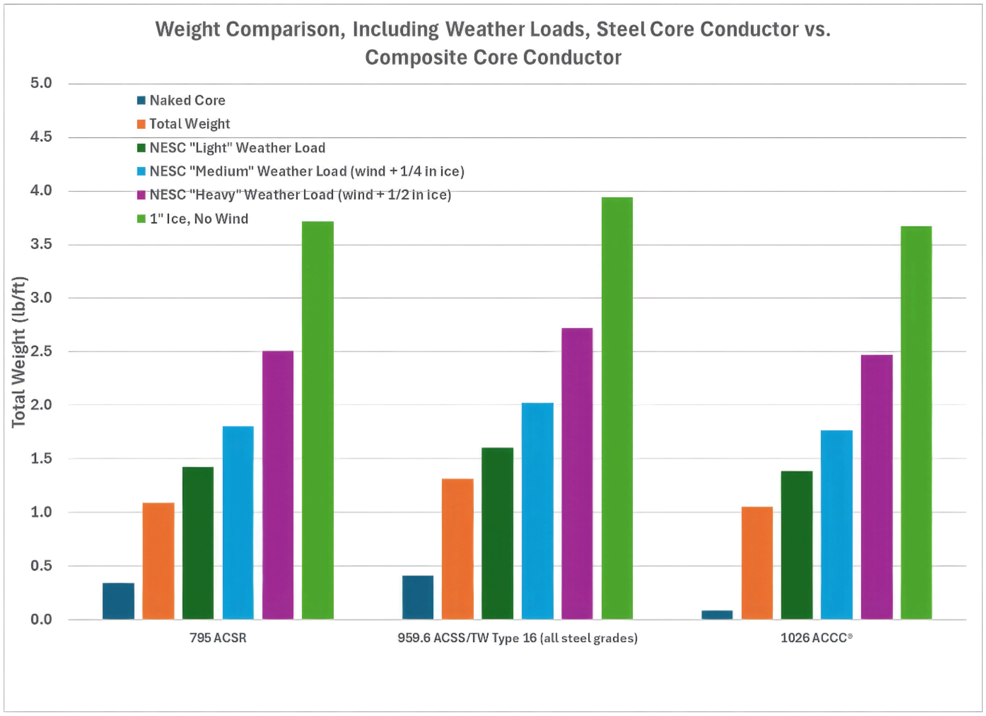
4.3 Claim: The lower weight of polymer composite cores is a game-changing advantage.

Technical assessment

Polymer cores are significantly lighter than steel cores on a “naked core” basis. However, the core typically represents only a fraction of the total conductor weight. Once the full conductor weight plus ice and wind loads are considered, the relative weight advantage decreases to a few percent in most practical designs. Weight differences in the core do not impact structure or foundation designs except in cases of extremely long spans.

Planning and regulatory implication

Weight advantages should be evaluated at the system level: structures, foundations, and clearances under realistic loading conditions. Regulators should look for line-design studies demonstrating that any claimed structural cost savings are material and can justify a higher cost conductor.



4.4 Claim: Polymer core conductors are suitable for heavy ice regions.

Technical assessment: as noted under heading 4.1, steel core has an intrinsic 72% higher elastic modulus compared to polymer core, meaning far better resistance to elongation due to ice loading. The supplier's comparison table (duplicated as Table 1 below) violates two "equal comparison" criteria: 1) conductors with TW strands versus legacy round-wire conductors, and; 2) omitting the two most competitive options in favor of two designs that are unsuitable for heavy ice scenarios. Compact TW strands reduce the ice accretion area by 22% compared to round aluminum strands. A fair comparison involves only TW variants and includes the leading steel core heavy ice designs. The objective comparison is shown in Table 2. Counter to the commercial narrative, the best steel core option sags 2.3 ft less than the best polymer core option. The steel core elastic modulus advantage cannot be overcome even with a polymer core option using a higher grade of carbon fiber.

Table 1: Supplier’s Advertised Comparison (“Ranking” Column Added)

Conductor Type	RTS (lb)	Sag @ 1800A (ft)	Sag @ 1.5” Ice (ft)	% RTS @ 1.5” Ice	Supplier’s Ranking
ACSR Drake	31,500	31.72	27.52	59.8	N/A
ACSS Drake (MA2)	25,900	31.66	33.45	60.2	3
ACSS Drake (MA5)	32,600	28.75	31.67	50.4	4
ACCC® Drake	41,200	16.91	31.54	39.8	2
ACCC® ULS	47,900	13.59	**28.51 (best per supplier comparison)**	38.7	1

Table 2: Objective Comparison with Realistic Competition

Conductor Type	RTS (lb)	Sag @ 1800A (ft)	Sag @ 1.5” Ice (ft)	% RTS @ 1.5” Ice	Objective Ranking
795 kcmil ACSR “Drake”	31,500	N/A	27.5	59.8%	N/A
959.6 kcmil ACSS/TW/MA5	38,600	29.94	29.4	43.6%	3
959.6 kcmil ZTACSR/TW/MA5	47,300	28.00	**24.3 (best per objective comparison)**	43.1%	1
1026 kcmil ACCC®	41,200	17.05	32.1	35.9%	4
1026 KCMIL ACCC® ULS	47,900	13.59	26.6	38.0%	2

Planning and regulatory implication

In heavy-ice regions, regulators and planners should require that any claimed advantage be demonstrated using conductors with comparable strand geometry and aluminum grade. Steel core options specialized for heavy weather loads should be included, as they have the potential to handle the ice burden and reduce the ratepayer burden.

4.5 Claim: Composite core conductors have superior fatigue performance

Technical assessment

Fatigue performance is largely governed by the tension, hardware, strand geometry, aluminum temper, and application of vibration dampers. When conductors share the same aluminum grade, and strand configuration, the intrinsic fatigue characteristics are similar regardless of core material. Some marketing comparisons conflate differences in strand geometry (e.g., round vs TW) and aluminum grade with core material, resulting in misleading conclusions. Here is a marketing example of round-wire conductors being compared with a TW conductor, where the core material is not a factor in what is being claimed:

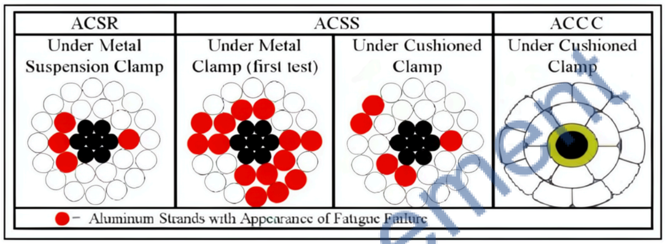


Figure 41 - Fatigue Failure Comparison ACSR, ACSS, ACCC

Planning and regulatory implication

Project-specific vibration control measures (conductor type, dampers, span lengths, tension, hardware) have far more impact on fatigue life than core material alone. Regulators should ensure that claims are supported by applicable data.

4.6 Claim: A composite core allows approximately 30% greater aluminum area within the same overall conductor diameter, resulting in 30% higher capacity.

Technical assessment

Increasing aluminum area within a given diameter is primarily a function of using trapezoidal aluminum strands and reducing the core diameter. This can be done with both polymer and steel core. The core material itself contributes nothing to ampacity unless it is conductive. Consequently, a similar increase in aluminum area, and therefore current-carrying capacity, can be achieved with advanced steel-core conductors using the same geometric strategies.

Planning and regulatory implication

When higher ampacity is the primary objective, proposals should demonstrate that the observed capacity gain could not be matched by a steel-core design with similar aluminum area, strand geometry, and operating temperature.

Regulators may reasonably request comparative designs that hold aluminum area and diameter constant while varying only the core material and cost. The ratepayers are best served if the lower total owning cost option is implemented.

4.7 Claim: Composite core conductor delivers 2-3 times the capacity of traditional ACSR conductor**.**

Technical assessment

Very high percentage capacity increases rely on significantly higher operating temperatures (resulting in higher losses), and higher aluminum area than the round-wire legacy conductor. When polymer-core and advanced steel-core options are compared at the same diameter and conductor-specific maximum temperature (for example, up to 180 °C for polymer cores and up to 250 °C for ACSS/TW steel-core designs), capacity gains over legacy ACSR are substantial in both cases. Published data for commercially-available polymer composite conductors demonstrates only a 69.5% capacity increase for a same-diameter polymer core conductor. Table 3 is an objective comparison that is typical of comparisons with a “same diameter” ACSR conductor.

Table 3: Maximum Ampacity of “Drake” Diameter Conductors

Comparison assumes 40°C ambient, 2 ft/s wind, and full sun at 46° N Latitude.

Conductor Type	Aluminum Strand Shape	Max Operating Temp	Max Capacity (A)	Capacity Increase vs ACSR
795.0 kcmil ACSR “Drake”	Round	100°C	1,000	0% (Reference)
795.0 kcmil ACSS/GA2	Round	200°C	1,602	+60.0%
1025.6 kcmil “Drake/ACCC”	TW	180°C	1,695	+69.5%
795.0 kcmil ACSS/MA3	Round	250°C	1,809	+80.0%
959.6 kcmil ACSS/TW/MA5	TW	250°C	1,990	**+99.0%**

Planning and regulatory implication

Capacity claims should always be tied to explicit assumptions about diameter, aluminum area, and allowable operating temperature. Regulators and planners should scrutinize whether capacity claims are driven by temperature assumptions that could also be applied to lower cost designs, and whether structure, clearance, and hardware ratings have been fully considered.

4.8 Claim: “Reduces electrical power line losses by up to 40% or more”

Technical assessment

Line losses are governed primarily by conductor resistance and loading, not by the core material. Because polymer cores are non-conductive, they offer no inherent advantage in reducing I^2R losses. For a given budget, a larger conventional conductor with lower resistance will achieve greater loss reductions at lower cost than a more expensive polymer-core alternative.

Planning and regulatory implication

When loss reduction is a key benefit cited to justify a higher conductor cost, filings should demonstrate that the same loss reduction could not be obtained more cost-effectively using a larger, but lower-cost, conventional or advanced conductor. Regulators should ask for quantified loss-reduction benefit-cost analyses that compare the competitive conductor types under the same assumptions.

4.9 Claim: Polymer cores avoid corrosion issues

Technical assessment

Contact among carbon fibers, aluminum, and water results in catastrophic aluminum corrosion. This is prevented by a protection layer to ensure isolation of the carbon fibers from the aluminum strands. Similar to the case with polymer composite cores, steel strands require a protective coating to avoid corrosion issues. Steel coatings are highly developed with grades of Misch Metal alloy that at least double the already long corrosion life of steel core. Advanced protection supports the long-term reliability of steel designs. Even with the original hot-dip zinc coatings, there are examples of ACSR lines remaining in service for more than 100 years.

Planning and regulatory implication

From a regulatory perspective, neither technology should be assumed to provide unlimited service life. Asset-management plans and depreciation schedules should be based on realistic, evidence-based lifetime expectations and maintenance practices. Filings that claim dramatically longer service life for polymer cores should provide long-term field data or robust accelerated-aging evidence.

4.10 Claim: Polymer composite core conductors offer longer service life.

Technical assessment

All polymer materials undergo aging over time, even at room temperature. Aging is accelerated by exposure to heat, moisture, UV, and environmental chemicals. Changes include surface degradation, embrittlement, and increased moisture retention. Carbon-fiber composite (CFC) cores, which rely on polymer matrices such as type F epoxy, are subject to these same aging mechanisms and therefore cannot be assumed to have unlimited life. By contrast, aside from corrosion, steel cores do not experience comparable aging in typical overhead line environments. Steel core corrosion mechanisms are well understood. Rust damage is visible in the form of red stains on the conductor's lower surface long before catastrophic failure.

Planning and regulatory implication

For regulatory and planning purposes, neither polymer-core nor steel-core conductors should be treated as having longer service life; instead, asset lives should be based on evidence from material science, field experience, and inspection practices. Claims that polymer cores will significantly exceed the demonstrated long-term reliability of steel-core conductors should be supported by robust long-duration field data or well-validated aging studies, rather than by generalized assertions of longer service life.

4.11 Claim: ACSS/TW suffers from corrosion due to water trapped at the sag belly

Technical assessment

Historical issues with water entrapment arose with ACSR self-damping (ACSR/SD) conductor designs that used keystone-shaped strands to create a void space around the core. Modern TW designs used in ACSS/TW and ACSR/TW do not entrap water because they do not employ keystone geometry. Extrapolating historical ACSR/SD experience to modern ACSS/TW conductors is not valid.

Planning and regulatory implication

When corrosion concerns are raised in support of a more expensive technology, regulators, planners, and line designers should require evidence that the concern applies to current designs and not to older, mostly-discontinued geometries. Field data and failure statistics by conductor family are more informative than anecdotal references to outdated products.

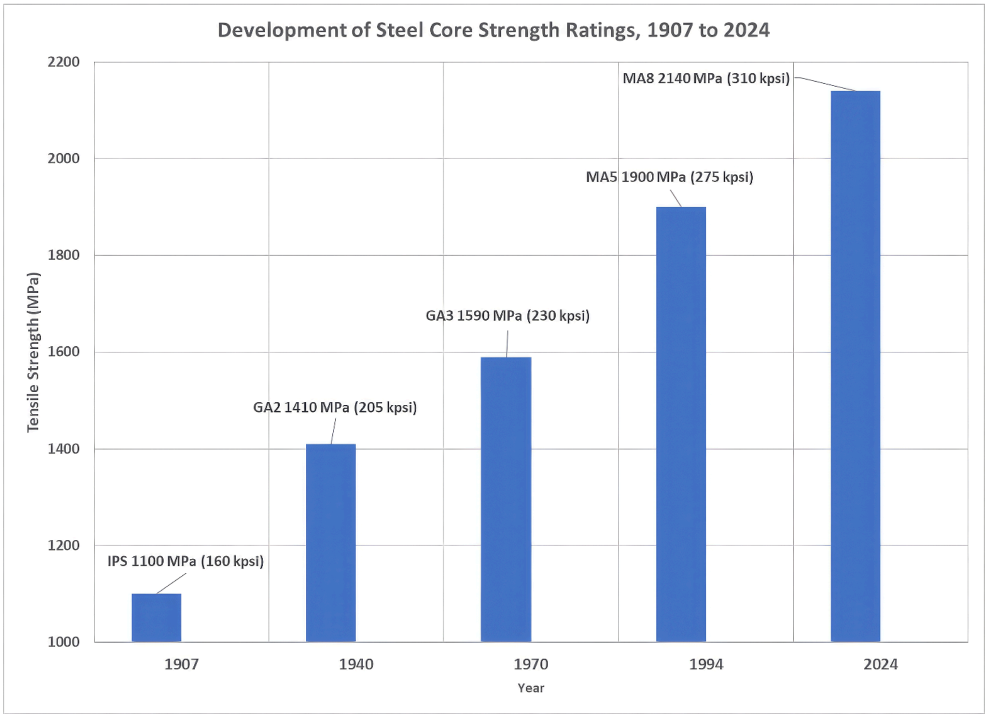
4.12 Claim: Steel core technology is obsolete and superseded by polymer composite cores.

Technical assessment

Steel has some compelling and relevant properties unmatched by polymer composites. Steel has a 71% advantage in elastic modulus which means better resistance to weather loads. The high temperature resistance of steel is another durable advantage, and allows for significantly higher capacity. Bending tolerance is a steel core significant advantage. Toughness (energy at break) for steel core is a multiple (~4x) of the toughness of polymer composite. The cost advantage of steel is unlikely to be overcome by advanced composites.

Innovation in the steel industry and the conductor industry continues. Figure 3 illustrates the strength increases for steel core over the 120+ year history of steel-core conductors.

Figure 3



Innovation includes the evolution from stranded aluminum to ACSR, and from ACSR to ACSS. Next came the invention of TW stranding, improved aluminum annealing processes, ever higher-strength steel, and advanced corrosion-resistant coatings that support operating temperatures up to 250 °C. The introduction of composite core circa 2000 is another innovation, but there are no indications that steel core is obsolete. These innovations have significantly raised conductor performance, but steel-core maintains compelling performance at relatively low material and manufacturing costs. Very recent developments in super-ultra-high strength steel core further reduce any performance gap with polymer composite cores.

Planning and regulatory implication

Given the ongoing innovation and long track record of steel-core technologies, it is not accurate to treat them as obsolete in regulatory or planning processes. Instead, steel-core and polymer-core options should be evaluated objectively on a total owning cost and performance basis, including capital cost, losses, sag, and long-term durability.

4.13 Claim: A solid polymer core is more reliable than a stranded polymer core.

Technical assessment

This engineering tradeoff is similar to the tradeoff between single-strand steel core and stranded steel core. Both have advantages and disadvantages. Stranded polymer core has roots in other demanding civil engineering applications, where it established a reputation for reliability and long service life long before its introduction in the conductor industry circa 1998. Field experience and laboratory testing have raised no concerns over its use in overhead transmission conductors.

Planning and regulatory implication

Unfounded negative claims about a competitor's product should be dismissed as non-credible.

5. Guidelines for regulators, planners, and engineers

To make effective, evidence-based decisions about conductor technologies, regulators utility planners and design engineers are encouraged to apply the following guidelines:

- Require like-for-like technical comparisons that hold diameter, aluminum area, operating temperature, and loading conditions constant across alternatives.
- Ask proponents to present multiple options, including at least one advanced steel-core design, in any filing that uses polymer core marketing claims.
- Focus on total owning cost (TOC) over the expected service life, including capital, losses, maintenance, and realistic replacement or refurbishment timelines.
- Evaluate whether claimed advantages (sag, capacity, losses, corrosion resistance) could be achieved through less costly design changes (e.g., larger conventional conductor, advanced steel-core options, or improved hardware) before approving more expensive technologies for inclusion in the rate base.
- For any TW conductor proposal, confirm that weather loads exclude the use of a same area round-wire conductor. The same-aluminum area, same-core round wire option has intrinsically lower losses, higher capacity, and lower first cost.
- Encourage transparent documentation of methods, assumptions, and data sources so that independent technical staff or intervenors can reproduce key comparisons.