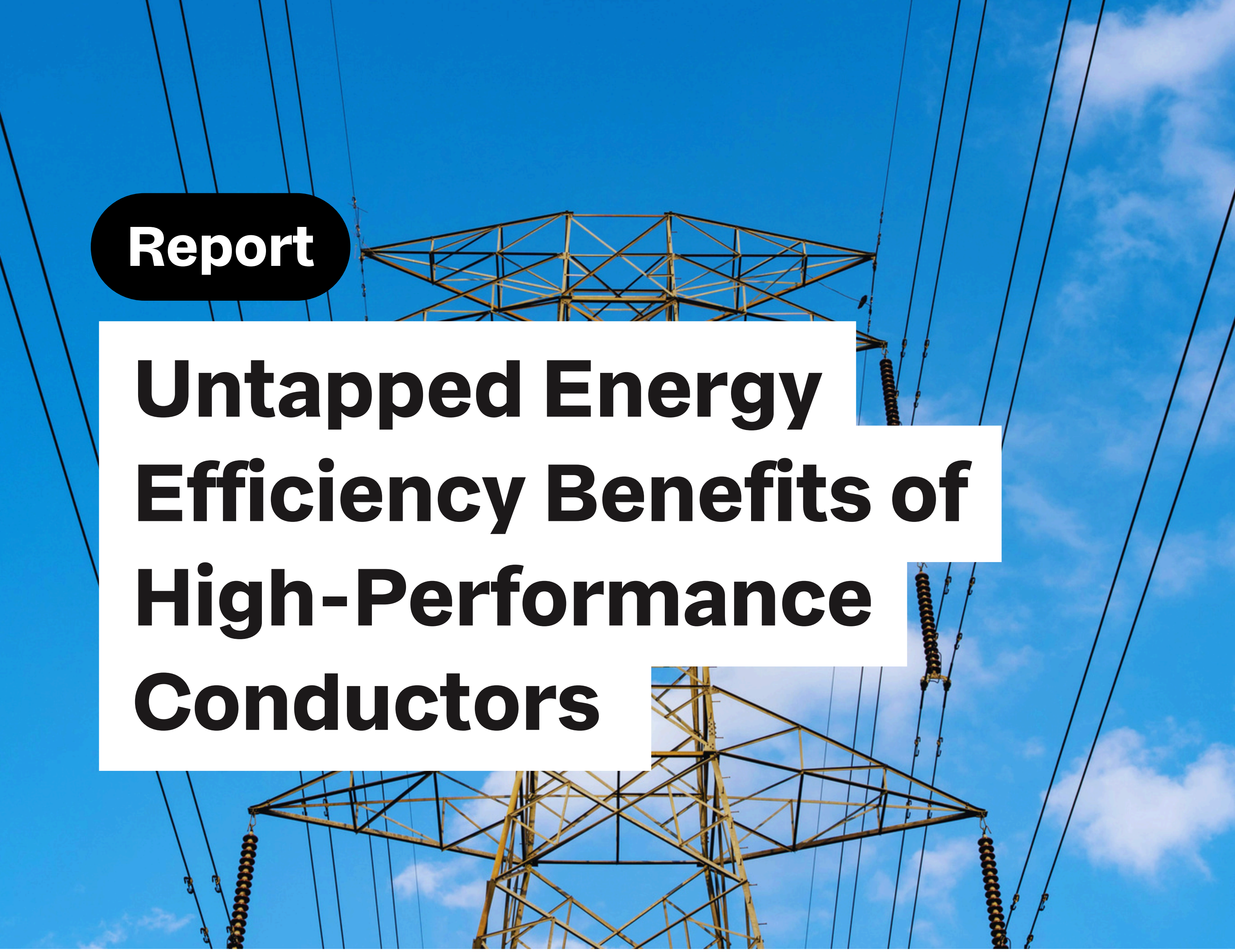

Report

Untapped Energy Efficiency Benefits of High-Performance Conductors

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ACORE

Macro Grid Initiative

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Contents

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Introduction

Since their first commercial installation in 2003, high-performance conductors (HPCs) have demonstrated excellent reliability, efficiency, and value in thousands of transmission projects, ranging from 11 kV to 1000 kV, in various configurations across 69 countries spanning six continents.[1] Despite their well-demonstrated benefits and the HPC industry's steady global growth, HPCs have achieved limited market penetration in North America.[2]

This white paper recommends the evaluation of HPCs for all transmission projects to unlock significant and lasting economic benefits for ratepayers while simultaneously improving the reliability and resilience of the grid. This includes state utility commissions evaluating HPCs in the context of proposed local reliability upgrades, as well as regional planners taking steps for similar evaluations as part of long-term regional planning processes.

Using real project data from eight diverse siting permits, this paper analyzed high performance conductors compared to standard conductors. Key preliminary findings of this white paper include:

- The energy efficiency benefits of HPCs from line-loss savings often yield benefit-cost ratios (when compared with their incrementally higher costs) greater than the 1.25 threshold widely used by transmission planners and regulators for selecting transmission projects for inclusion in regional plans. While all B/C ratios were above 1, six of the eight projects were well above the threshold (ranging from 2.5 to 9.0).
- The incremental cost of substituting HPCs for conventional conductors in rebuild and new line projects is small, ranging from 1% to 11% of total project costs.
- This analysis likely understates the value of replacing conventional conductors with HPCs because it uses conservative assumptions about energy prices, line loading levels, and discount rates. It also excludes significant benefits, including but not limited to avoided generation capacity, demand-reduction-induced price effects, improved reliability, lower tower costs, and other benefits.

Part I: Overview of HPCs

Defining a high-performance conductor

High-performance conductors (sometimes referred to as advanced conductors) use certain technologies that have superior performance characteristics when compared to conventional conductors, including energy efficiency, transfer capacity, thermal sag, and engineering tolerances. They use advanced materials to deliver such comprehensive performance advantages and fall into one of two categories: (1) carbon/composite core conductors[3]; and (2) high-temperature superconductors.[4] This paper focuses on the first category, which is much more widely used in practice.

There is both federal and state policy momentum supporting evaluation of HPCs. The Federal Energy Regulatory Commission (FERC) has issued rules requiring the evaluation of HPCs in transmission planning and in the determination of needed grid upgrades for the interconnection of new resources.[5] The National Association of Regulatory Commissioners Committee on Electricity issued a "Resolution Supporting the Integration of Advanced Transmission Technologies in the Electricity Transmission System" in November 2024, which included support for HPCs.[6] Further, in 2025 alone, 11 state legislatures passed laws that require transmission owners to consider HPCs in transmission project designs.[7]

The definition for HPCs varies across policies. FERC defines "advanced conductors" broadly as "present and future transmission line technologies whose power flow capacities exceed the power flow capacities of conventional aluminum conductor steel reinforced conductors."[8] Some state laws use performance-based metrics with different metrics and thresholds, while others define HPCs based on technology.[9] For clarity, this paper uses a definition of HPCs that *excludes* the following technologies:

- **Aluminum Conductor Steel Reinforced (ACSR)**: Introduced in 1908 as an economical alternative to copper wire ACSR has been the industry standard overhead conductor for over 100 years, comprising the vast majority of all currently operating overhead conductors[10]. ACSR is the electric industry's "default" overhead conductor, and it's not included in any HPC definition.
- **Aluminum Conductor Steel Supported (ACSS)**: Introduced in the 1970s to provide increased transfer capacity at low cost, ACSS uses fully annealed aluminum to allow higher temperature operation. ACSS achieves approximately 2 times the transfer capacity as compared to ACSR, which is similar to HPCs, but it does so by operating at very high temperatures, which dramatically increases line losses. Some versions of ACSS use trapezoidal wires (designated as ACSS/TW) to increase the amount of aluminum on the wire by 15-20% and thus reduce the electrical resistance. These wires do reduce line losses but also exhibit almost identical high thermal sag as conventional round-wire ACSS conductors, which diminishes their value proposition when compared with HPCs.

How do HPCs work?

HPCs replace the steel cores of ACSR and ACSS[11] with carbon composite cores[12] that are lighter, stronger, and more thermally stable than steel. The superior performance properties of carbon fiber composites allow HPCs to incorporate about 28% more aluminum, without a weight penalty, compared with same diameter round wire ACSR and ACSS, and 8-13% more than ACSS/TW. More aluminum means lower electrical resistance and lower line losses, i.e. greater energy efficiency, at all voltages and ampacities. HPCs also reduce thermal sag, which can reduce tower height requirements and wildfire risk. Finally, HPCs improve reliability via superior resistance to cyclic load fatigue, corrosion, and fire damage.

What is the track record of HPCs?

HPCs have been commercially installed for decades in thousands of extremely diverse projects around the world,[13] meet or exceed professional engineering overhead conductor standards,[14] and have a robust supply chain that includes dozens of companies, many of which are global leaders in their respective industries.[15]

Part II: HPCs Reduce Costs Compared to Standard Conductors Through Energy Efficiency

By far the largest overlooked benefit of HPCs is energy efficiency, and the resulting reduced line losses, as shown in the table below. While these benefits are real, they are not commonly evaluated in transmission planning at the state or RTO level. Reduced line losses result in cost savings by avoiding the need for additional energy purchases otherwise necessary to compensate for lost energy. These cost savings pass almost entirely through to customers and can keep electricity costs down for consumers.

The analysis presented here utilizes real project data from applications submitted by transmission providers to state utility commissions for certificates of public convenience and necessity (CPCNs, also known as "siting permits"). A diverse sample of recent applications is used to illustrate the consistency of the HPC energy efficiency value proposition across voltage levels, line lengths, and project types. Project names and owners are not included to avoid any implication that utility engineers should have or could have considered selecting higher cost HPCs to reap line-loss saving benefits, since they were not required to do so and because they might have reasonably expected their state regulators and other stakeholders to oppose such investments. Additional details on the analytic methodology, data sources, and assumptions can be found in the Appendix.

Calculations of line loss savings, thermal and mechanical sag, and maximum transfer capacity in Table 1, Table 2, and Table 3 were made using the publicly available Conductor Comparison Program developed and maintained by CTC Global Corporation, an Aluminum Conductor Composite Core (ACCC) developer. As a result, ACCC was selected as the representative HPC for this analysis. Other carbon- and composite-core conductors from different manufacturers are expected to demonstrate similar performance and economic outcomes under comparable conditions (see Endnote 3 for additional information).

Table 1: Replacing ACSR with ACCC

Project type	Voltage (kV)	Length (circuit-miles)	“Base” Wire	Project Cost ($)	HPC Cost Δ ($)	Line loss savings (NPV)	B/C ratio	Simple Payback (years)	Max. Transfer Capacity Δ
1-Rebuild	69	6.5	ACSR	$30M	$0.3M	$1.7M	6.3	0.5	69%
2-Rebuild	230	13.7	ACSR	$51M	$1.0M	$2.4M	2.5	4.3	53%
3-New Line	500	9.4	ACSR	$176M	$2.1M	$5.4M	2.6	4.0	73%
4-Rebuild	230	21.8	ACSR	$63.5M	$1.5M	$3.8M	2.5	4.3	63%

Table 1 summarizes the benefits of substituting similar-sized ACCC for ACSR in four real transmission projects.[16] As a rule, the analysis uses the largest ACCC conductor size capable of meeting the sag and tension limits of the base conductor it was replacing, while simultaneously delivering the same or greater maximum transfer capacity. In several cases, this meant choosing an ACCC conductor slightly larger or smaller in diameter than the base conductor. The ultimate constraint on most transmission projects is the size and cost of structures. The analysis assumes that the structural designs submitted in siting permit applications were fixed. Further, we assessed the maximum sag and tension exhibited by the base conductor under the most extreme conditions representing the performance requirements to be met by the ACCC alternatives. These assumptions were selected to maximize the demonstrated value of line loss savings. A similar analysis could optimize for both line loss savings and structure height reductions; however, to simplify the analysis, this assessment focused only on the line loss benefit and kept structure height inputs set.

The “Project Cost” column comes directly from the CPCN application. The “HPC Cost Δ” column is the difference in cost between the ACCC alternative and the ACSR “base” conductor. Pricing data was obtained from the MISO Transmission Cost Estimation Guide for MTEP 2025. Although not all projects were located in MISO, their guide had the most robust cost data for different types of conductors. In cases where the conductor size for a project was not specified in the MISO Guide, the pricing data was estimated using a linear interpolation between prices for the two closest – larger and smaller – sizes, or a linear extrapolation for sizes outside the range in the MISO Guide.

The "Line Loss Savings" column presents the net present value (NPV) of avoided electricity costs resulting from reduced line losses. The assumptions underlying these calculations—including annual average load factor, wholesale electricity prices, the analysis time horizon, and the discount rate used for the NPV calculation—were tailored to the RTO or planning region in which each project is located. These assumptions, along with supporting references, are provided in detail in the Appendix.

The “B/C Ratio’ column is calculated by dividing “Line Loss Savings (NPV)” by “HPC Cost Δ”. In other words, this is the narrow benefit-cost ratio over the planning region’s standard analysis time horizon with benefits limited to the NPV of monetized line-loss savings. Because the different evaluation time horizons across planning regions can tell a more complicated story around NPV, the table also includes a simple payback period to more easily compare projects.

The “Transfer Capacity Increase” column is the percentage increase over the transfer capacity of the design using the “base” conductor. Greater transfer capacity provides a greater margin for reliable operation and saves money by forestalling the need for future upgrades. If monetized, these benefits would significantly improve the benefit-cost ratio, but they were not included in the NPV calculated in this table to more clearly make the case for line loss saving.

In each case, the ACCC alternatives selected delivered efficiency benefits while meeting or exceeding the base conductor’s electrical (both peak load requirements and maximum transfer capacity), engineering, and reliability performance with equal or potentially reduced structural costs.[17] Table 3 below discusses the engineering performance criteria in more detail.

These limited examples strongly suggest that substituting ACCC (or similar HPCs) for ACSR would consistently yield superior value to ratepayers across all project types, voltages, and environmental conditions, even when *benefits considered are strictly limited to line-loss savings.* There are three primary findings to highlight:

- B/C ratio’s range from 2.5 to 6.3, counting only line losses.[18]
- Payback periods range from 0.5 to 4.3 years, for investments expected to operate for 30-plus years.
- Incremental conductor costs are equivalent to 1-3% of total transmission project costs.

Table 2: Replacing ACSS with ACCC

Project type and ID number	Voltage (kV)	Length (circuit -miles)	"Base" Wire	Project Cost ($)	HPC Cost Δ ($)	Line loss savings (NPV)	B/C ratio	Payback (years)	Transfer Cap. Δ
5-Rebuild	115	53.5	ACSS	$375M	$6.2M	$7.0M	1.1	8.5	1%
6-Rebuild[19]	138	5.5	ACSS/TW	$15.5M	$0.7M	$0.8M	1.1	5.4	11%
7-New Line	230	9.4	ACSS/TW	$60.4M	$1.4M	$12.3M	9.0	1.0	5%
8-Partial Rebuild	345	105	ACSS/TW	$123M	$13.5M	$73.1M	5.6	2.0	<1%

Table 2[20] shows that substituting ACCC for ACSS consistently yields positive value across all project types, voltages, and environmental conditions, showing that:

- B/C ratios range from 1.1 to 9.0, counting only line losses.
- Payback periods range from 1.0 to 8.5 years, for investments expected to operate for 30-plus years.
- Incremental conductor costs are about 2 to 11% of project costs.

The benefit-cost analysis presented here understates the BCRs, since the analysis excludes large benefits, notably avoided generation capacity and reduced power outages from greater resilience during extreme weather. This analysis therefore *excludes* six of the seven categories of benefits transmission providers are required to consider in accordance with FERC Order No. 1920 (*italicized text below excluded)*:

1. *Avoided/deferred transmission & aging infrastructure investments*
2. *Loss of load probability and reduced planning reserve margins*
3. *Production cost savings*
4. Reduced transmission losses (included)
5. *Reduced congestion due to transmission outages*
6. *Mitigation of extreme weather*
7. *Capacity cost benefits from reduced peak energy losses*

Moreover, transmission owners today generally limit consideration of HPCs to two situations that comprise a very small percentage of all projects:

1. Reconductoring an existing line to increase transfer capacity in lieu of wrecking and rebuilding the line to accommodate a larger sized ACSR or ACSS.
2. Extreme engineering challenges, e.g. long spans, tight clearance requirements, and unusually large transfer capacity needs.

As the analysis above shows, the energy efficiency benefits of HPCs demonstrates their applicability for multiple types of projects – including wreck-and-rebuild and new lines. A 2022 report by Grid Strategies estimated that reconductoring represented just 3 to 5% of total investments approved through regional transmission expansion plans and expected to be placed in service by 2030, in both the Midcontinent Independent System Operator (MISO) and PJM Interconnection.[21] This data implies that limiting consideration of HPCs to reconductoring projects is likely excluding the overwhelming majority of total transmission investments.

Part III: HPCs Do Not Compromise Engineering Performance

Table 3 demonstrates that the HPCs selected would not incur additional structural or construction costs in wreck-and-rebuild projects and new lines. HPCs in all cases significantly reduce thermal sag under the highest loads, which is critical for maintaining required ground clearances over vegetation under transmission lines. Transmission owners that fail to maintain required clearances are heavily and repeatedly fined for sag clearance violations until they are addressed. Maintaining required clearances is taken very seriously by regulators because it minimizes safety, reliability and wildfire risks.

HPC alternatives also closely match or beat the maximum mechanical sag performance of ACSR and ACSS. Maximum mechanical sag occurs under the most extreme ice loading condition each project is required to meet, which depends on where the project is located (colder regions generally have higher ice loading requirements, while warmer regions have lower ones). Sag under ice raise two concerns: clearance and tension that must be safely supported by transmission structures.[22] Heavier ice loads produce more tension, which means that stronger – and more expensive – structures are needed.

Table 3 shows that even for lines designed to manage the most extreme ice conditions applied to US projects,[23] HPCs closely match the mechanical sag of their ACSR and ACSS alternatives at the same maximum structural tension. Projects 7 and 8 exceed the maximum sag by slightly more and slightly less than one foot, respectively, at the same structural tension, differences that are extremely unlikely to affect ground clearance or structural requirements. The mechanical sag of Project 6 is about one foot greater than its ACSS/TW alternative (13.1 ft vs. 12.0 ft) at the same tension, but the thermal sag of the ACSS/TW (22.4 ft) is more than nine feet greater, making that value the governing sag limit for clearance purposes.

Table 3: HPCs consistently match or exceed the engineering performance of ACSR and ACSS while simultaneously delivering energy efficiency

Project type	Voltage (kV)	Length (circuit-miles)	Wire type, size (in kcmil), name, and conductors per phase (if >1)[24]	Thermal sag at max. temp. (ft)	Max sag under ice (ft)	Max structure tension (lbf)
Project 1 comparison: ACSR vs ACCC						
Rebuild	69	6.5	ACSR 556 Parakeet	30.8	22.2	8,869
Rebuild	69	6.5	ACCC 725 Amsterdam	17.7	22.5	8,858
Project 2 comparison: ACSR vs ACCC						
Rebuild	230	13.7	ACSR 1590 Lapwing	24.0	15.8	15,882
Rebuild	230	13.7	ACCC 1865 Antwerp	17.2	15.8	15,880
Project 3 comparison: ACSR vs ACCC						
Rebuild	500	9.4	3-ACSR 1352 Martin	19.4	18.8	67,470
Rebuild	500	9.4	3-ACCC-ULS 1738 Bordeaux	10.6	18.8	67,312
Project 4 comparison: ACSR vs ACCC						
Rebuild	230	21.8	ACSR 1590 Lapwing	44.8	40.2	24,282
Rebuild	230	21.8	ACCC 1865 Antwerp	25.7	40.0	24,273
Project 5 comparison: ACSS vs ACCC						
Rebuild	115	53.5	ACSS 795 Drake	21.1	20.9	13,629
Rebuild	115	53.5	ACCC 1026 Drake	12.0	20.8	13,608
Project 6 comparison: ACSS/TW vs ACCC						
Rebuild	138	5.5	ACSS/TW 1927 Cumberland	22.4	12.0	15,584
Rebuild	138	5.5	ACCC 2741 Bluebird	18.0	13.1	15,551
Project 7 comparison: ACSS/TW vs ACCC						
Rebuild	230	9.4	2-ACSS/TW 768 Maumee	25.6	26.8	25,122
Rebuild	230	9.4	2-ACCC-ULS 1011 Galveston	17.7	27.9	25,119
Project 8 comparison: ACSS/TW vs ACCC						
Rebuild	345	105	2-ACSS/TW 954 Cardinal	32.8	33.4	30,861
Rebuild	345	105	2-ACCC-ULS-1169 Rome	24.8	34.2	30,849

Limits of this Analysis

This exploratory analysis is unable to analyze every factor that must be considered by transmission design engineers, some of which may change the B/C ratios of substituting HPCs for traditional conductors in specific projects.

For example, using lower or higher resistance conductors changes the electrical impedance of transmission lines, which is basically how much a power line “pushes back” against electricity flowing through it. Transmission engineers must always ensure that impedance levels are managed to maximize power transfer and minimize the risk of increased losses, voltage drops, and other potential sources of inefficiency and instability. A full analysis should consider the relative costs of diligent impedance management for each alternative, including any equipment that may be required, e.g. voltage compensation devices, insulators, bundling configurations, and/or alternative structural designs.

Another consideration not analyzed here is the effect of higher transfer capacity and lower resistance on adjacent lines and substations. Rebuilds and new lines that are built at least in part to increase transfer capacity are usually “packaged” with such upgrades if planners determine that they’re necessary. Thus, engineers would need to consider whether substituting HPCs for conventional conductors would incur any incremental cost over the upgrades already planned. In upgrades that are not driven by the need to increase transfer capacity (i.e. upgrades to address deteriorated asset conditions or reliability violations) and thus do not incorporate other system upgrades, investments needed to mitigate downstream effects may impact the value proposition of HPCs.

Finally, in Order 1920-A, FERC clarified that “transmission providers have flexibility to apply good engineering judgment to identify the specific transmission elements that are likely candidates for specific enumerated alternative transmission technologies.”[25] Transmission providers and their engineers will likely have important information to add to this analysis that might affect its findings for specific lines. Nonetheless, as FERC reiterated in Order 1920-A, “nothing in this clarification obviates the requirement for transmission providers to support their determinations, the Commission’s transparency requirements, or the potential to challenge a transmission provider’s consideration of the enumerated alternative transmission technologies.”[26]

Conclusion

Considering HPCs is necessary to ensure that every transmission project is the best investment for ratepayers. The value of energy efficiency has been recognized and monetized in electricity end-uses and generation for decades, but not in transmission and distribution. HPCs deliver energy efficiency benefits that are easy to quantify and largely independent of wider conditions on the grid. Simply put, reducing the electrical resistance of transmission lines saves money.

Consideration of HPCs by transmission providers is today severely limited. Most commonly, HPCs are considered for extreme engineering challenges, e.g. long spans, tight vertical clearances, and more, where a smaller, lighter weight, and more thermally stable conductor can deliver the required transfer capacity and simultaneously meet clearances. Transmission providers also consider HPCs when their cost premium is offset by structural savings, making the overall project cost cheaper, regardless of energy efficiency or other benefits. The overwhelming majority of transmission projects do not fall into either of these categories, and the most valuable benefit of HPCs – energy efficiency via reduced line losses – is almost uniformly ignored. Thus, HPCs are ignored for use in many projects where they could provide significant benefits.

The analysis presented here strongly suggests that this failure to broadly, consistently, and transparently consider HPCs in all transmission projects is imposing avoidable long-term costs on ratepayers. The incremental costs of HPCs is small and the B/C ratios of these incremental investments are often higher than the 1.25:1 threshold used by most regional transmission planners for selection of transmission projects in regional transmission plans. Given the immense pressure on the grid to meet rapid demand growth, transmission providers, state utility commissioners, and consumers can no longer afford to ignore transmission energy efficiency and technologies like HPCs that can consistently deliver it.

Appendix

Key assumptions and references:

- *Only CTC Global ACCC® conductors were analyzed.* CTC Global's Conductor Comparison Program (CCP) the only currently publicly accessible tool designed for this purpose. Carbon-fiber-composite core conductors from other manufacturers (TS Conductor, Epsilon, Southwire, et. al.) are likely to produce similar results.
- *The analysis assumes that no structural changes would be required to change from the "base" conductor to the HPC.* Only conductors capable of matching/beating maximum thermal and mechanical sag at lower/equal total structural tension were considered. Accordingly, no structural savings were considered.
- *Extreme weather conditions* used to compare mechanical sag/blowout performance included ice loading, extreme wind, and extreme ice with wind, according to information in the project filing. If no such information was provided, NESC Heavy was used. (See Endnote 22.)
- Only conductors able to achieve an *equivalent or higher maximum transfer capacity* than the "base" wire were considered.
- Conductor pricing data was obtained from the MISO Transmission Cost Estimation Guide for MTEP 2025 (June 6, 2025).
- Load factor was assumed to be 30% for all lines analyzed. We used the definition of "transmission utilization" and data for 23 control areas comprising most of North America's Western Interconnection (including control areas in Canada and Mexico) from *U.S. Transmission System Utilization Study Phase 1: WECC,* by Rajanie Prabha and Liang Min, Stanford University, December 12, 2025. We believe our assumption is conservative because the average utilization was 35% and 18 of the 23 control areas analyzed had utilization rates above 30%. The paper defined "transmission utilization" as: Utilization = (Line Flow + Reliability Reserve Margin) / Thermal Rating * 100%
- Wholesale prices of electricity and discount rates and time horizons for NPV calculations were specific to the RTO/planning region where each project is located. Below are the values used in the analysis and references for each.
    - PJM (Projects 1,2,3,4, and 7)
      NPV Calculation Discount Rate for Benefits (real or nominal not specified): 7.2%
      Reference: https://www.pjm.com/-/media/DotCom/planning/rtep-dev/market-efficiency/informational-market-efficiency-analysis-assumptions-july-2026.pdf
      Time Horizon for NPV Calculation: 15 years
      Reference: informational-market-efficiency-analysis-assumptions-june-2024.pdf
      Wholesale price of electricity: $59.94/MWh (24-month average ending April 2026)
      Reference: US - Wholesale Electricity Prices by Region | Electricity | Collection | MacroMicro
    - MISO (Project 8)

NPV Calculation Discount Rate for Benefits (real or nominal not specified): 7%
Time Horizon for NPV calculation: 20 years
Reference (for both above): Alma-Blair-345-kV-LRTP-Tranche-1-Benefits-Analysis.pdf
Wholesale price of power: $43.17/MWh (24-month average ending April 2026)
Reference: US - Wholesale Electricity Prices by Region | Electricity | Collection | MacroMicro

- ISO-NE (Project 5)
  NPV Calculation Discount Rate for Benefits (real): 4.37%
  ISO-NE doesn't specify a discount rate for benefits NPVs in economic analyses. In its *Avoided Energy Supply Components in New England: 2024 Report*, Synapse Economics calculated a 1.74% real discount rate (p 365). We averaged this value with 7%, the higher of the two values recommended for use in benefit-cost analysis by the federal Office of Management and Budget. (from: Discounting for Public Benefit-Cost Analysis.)
  Time Horizon for NPV Calculation: 10 years
  ISO-NE has historically conducted system planning analyses over a 10-year time horizon, although the New England States Committee on Electricity recently asked FERC to allow longer term analyses. ISO-NE proposes transmission planning changes to boost states' ability to reach environmental goals | Utility Dive
  Wholesale price of power: $71.40/MWh (24-month average ending April 2026)
  Reference: US - Wholesale Electricity Prices by Region | Electricity | Collection | MacroMicro
- ERCOT (Project 6)
  NPV Calculation discount (real): 5.5%
  Reference: SPP_ERCOT_Rayburn_Study_Scope_Public_1_29_2018.pdf
  Time Horizon for NPV Calculation: 6 years
  Reference: 1247NPRR-09 ERCOT Comments 101124.docx
  Wholesale price of power: $35.88/MWh (24-month average ending April 2026)
  Reference: US - Wholesale Electricity Prices by Region | Electricity | Collection | MacroMicro

- *For NPV of benefits calculations, only line loss savings (a.k.a. "avoided electric energy") were monetized.* Some Regional Transmission Organizations (RTOs) and planning regions monetize line loss savings in large-scale regional planning analyses as "system losses" or "energy savings", but approaches are varied.
- B/C ratios and payback periods were calculated using line-loss only NPV calculations of benefits and conductor pricing references as described above.

Endnotes

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[1] "How Advanced Conductors Are Helping Utilities Deliver More Power Quickly", T&D World (sponsored article), (November 1, 2025), https://www.tdworld.com/sponsored/article/55325257/how-advanced-conductors-are-helping-utilities-deliver-more-power-quickly; Chojkiewicz, et. al., Goldman School of Public Policy, University of California Berkeley and GridLab, 2035 Report: Reconductoring, Appendix II: Examples of Successful Advanced Conductor Deployment at Scale, From Around the World (April 2024), available at: https://gridlab.org/portfolio-item/2035-report-reconductoring/
[2] For more details on the demonstrated benefits of HPCs, see Unlocking the Grid: A Playbook on High Performance Conductors for State and Regional Regulators and Policymakers, AMP Coalition, Grid Strategies, and the American Council on Renewable Energy, and the Macro Grid Initiative (October 2024), available at: https://acore.org/resources/unlocking-the-grid-a-playbook-on-high-performance-conductors-for-state-and-regional-regulators-and-policymakers/
[3] Several carbon-fiber composite core overhead conductor designs and brands are now available for purchase, encompassing several names and acronyms, including: Aluminum Conductor Composite Core (ACCC®), Aluminum Encapsulated Composite Core (AECC), Epsilon Cabon Reinforced Conductor (ECRC®), Aluminum Conductor Composite Supported (ACCS, also branded as C7-TS®), Aluminum Conductor Composite Single (ACCS), and Aluminum Conductor Composite Multistrand (ACCM), Carbon Fiber Composite Conductor (CFCC). For the sake of clarity and simplicity, this paper uses "ACCC" in the analysis to represent all these products, which deliver similar electrical, economic, and engineering performance.
[4] See "VEIR Successfully Demonstrates 3-Megawatt Superconducting Power Delivery for AI Data Centers, Eliminating Critical Growth Bottleneck," (Nov. 12, 2025), available at https://veir.com/veir-successfully-demonstrates-3-megawatt-superconducting-power-delivery-for-ai-data-centers-eleminating-critical-growth-bottleneck/
[5] Order No. 1920-A, 189 FERC ¶ 61,126 at P 598-600; Order No. 2023, 184 FERC ¶ 61,054, at P 1578 – 1581.
[6] Resolutions Passed by the NARUC Board of Directors at the November 10-13, 2024 NARUC Annual Meeting and Education Conference, available at https://pubs.naruc.org/pub/812873F4-E348-B77F-4D75-E513FF13A86D.
[7] 11 States Pass Laws on High Performance Conductors in 2025, AMP Coalition (August 27, 2025), available at: https://www.ampcoalition.org/news-and-events/state-legislation-in-2025; "Enabling ATTs and GETs", State Climate Policy Dashboard, updated July 21, 2025 and Order No. 1920-A, 189 FERC ¶ 61,126 at P 598-600.
[8] Order No. 2023–A, 186 FERC ¶ 61,199 at P 631.
[9] For example, Virginia's law requiring the State Corporation Commission to consider the use of advanced conductors defines advanced conductors as including "aluminum conductor composite core, *aluminum conductor steel supported*, aluminum conductor composite reinforced, thermal-resistant aluminum alloy conductor, and any similar technologies." Emphasis added. See VA Chapter 551, https://lis.blob.core.windows.net/files/1077362.PDF.
[10] ISO-NE Pool Transmission Facilities (2026) Final shows that ACSR is currently installed in 77% of the six-state region's overhead transmission circuit miles. ACSS is in use in 12%, and all other conductors – including but not exclusively HPCs – are used in the remaining 11%.
[11] In almost all overhead conductor designs, the core material provides mechanical strength and the external aluminum strands conduct the electricity. Only in all-aluminum conductors and copper wires, both approaching obsolescence today for cost and performance reasons, does one material provide both mechanical strength and electrical conductance.
[12] Carbon fiber composites were developed in the 1950s and 1960s and adopted first by the aerospace industry in the 1970s through the 1990s. They now comprise about 50% by weight of new commercial aircraft, and are increasingly being used in the structural engineering, automotive, wind energy, medical device, sporting equipment, marine, firearms, military equipment, aerial drone, robotics, and micro-electronics industries.
[13] "How Advanced Conductors Are Helping Utilities Deliver More Power Quickly", op. cit.
[14] Carbon fiber composite core conductors meet or exceed numerous engineering and industry standards and have passed the most rigorous testing requirements, including, but not limited to: ANSI (American

National Standard Institute) and EPRI (Electric Power Research Institute) 1500 Cycle Thermal Aging Test, ASTM International Standard B-987-20, and numerous hardware and other tests.

[15] The production and delivery of carbon fiber core conductors involves at least two kinds of companies: (1) designers and manufacturers of carbon fiber composite cores, e.g. CTC Global, TS Conductor, Epsilon Composites, Tokyo Rope, DeAngeli, ZFCC, Indore, and Exel Composites; and (2) Aluminum stranding companies that produce the finished conductor and deliver it to transmission providers, e.g. Prysmian, Southwire, Lamifil, Sterlite, APAR, Taihan, Midal, et. al.)

[16] Detailed information on each line was taken from transmission owner siting permit filings with state utility commissions.

[17] A detailed description of the engineering assumptions and methodology are included in the Appendix.

[18] B/C ratio calculated assuming a 30-year Net Present Value (NPV), $30/MWh avoided electricity cost, 40%-line-load -factor, and 5% annual discount rate (ADR). Additional details on the analytic methodology, assumptions, and references can be found in the Appendix.

[19] This project is in ERCOT, which, as noted in the Appendix uses a very short 6-year time horizon ("the planning horizon") for its benefits NPV calculation. ERCOT explains that "it is not feasible to perform this simulation for the entire 30 to 40 year expected life of the project," but does "[make a qualitative assessment] of whether the factors driving the economic benefits due to the project can reasonably be expected to continue." Comments of ERCOT on the Incorporation of Congestion Cost Savings Test in Economic Evaluation of Transmission Projects, May 11,2024.

[20] Table 2 uses the same calculation methods and definitions as table 1. The only difference is that the "base" conductors specified in the utility filings were ACSS. The MISO Cost Estimation Guide provides separate pricing estimates for ACSS conductors, and the same methods were applied here as in Table 1.

[21] "Advanced Conductors on Existing Transmission Corridors to Accelerate Low Cost Decarbonization," by Jay Caspary and Jesse Schneider, Grid Strategies, March, 2022.

[22] Conductors operating at high temperatures reduce structural tension, so the only concern for them is clearance.

[23] NESC (National Electrical Safety Code) provides detailed guidance to transmission engineers regarding extreme weather conditions (e.g. ice, wind, and concurrent ice and wind) to be applied to transmission conductors and structures in specific US geographic regions. Transmission providers use this information and their local knowledge and experience to develop their own ice loading and wind loading standards. The maximum extreme ice loading condition in the US is1.5 inches of radial ice, used by several transmission providers in several regions. "NESC Heavy" is 0.5 inches of radial ice.

[24] Wire sizes are given in kcmils, "thousand circular mils", a measure of the cross-sectional area of aluminum on the conductor.

[25] Order No. 1920-A, 189 FERC ¶ 61,126 at P 598

[26] Order No. 1920-A, 189 FERC ¶ 61,126 at P 599