White Paper

Reimagining the Grid with High Temperature Superconductor (HTS) Technology

How HTS Can Facilitate the Energy Transition

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Introduction

It's no secret that the energy transition is creating dramatic new stresses on the grid. In many countries, the push to integrate green renewables into traditional power systems and electrify buildings and transportation is being held up by a lack of grid capacity. As the move to electrification accelerates and global populations increasingly migrate to cities, the challenges of expanding urban grid capacity are escalating.

Difficulties in getting new interconnections approved and built will exacerbate these challenges, particularly given the immense need for new transmission capacity. In the US, a recent study by the Department of Energy (DOE) estimates the new transmission need is 47,000 gigawatt-miles of high voltage lines by 2035—a 57% increase over today's system.[1] Globally, the International Energy Agency (IEA) warned in an October 2023 report that in order to meet climate targets and ensure reliable energy supply, some 80 kilometers (roughly 50 million miles) of new or refurbished transmission and distribution (T&D) will be needed by 2040—effectively a doubling of the current global grid size—and that annual investment in T&D infrastructure must double worldwide to more than $600 billion by 2030.[2]

These are lofty targets. To reduce greenhouse gas (GHG) emissions, meet environmental, social, and governance goals set by countries worldwide, and slow climate change, the energy industry must rethink its grid planning and management processes and develop new best practices for sustainable grid capacity expansion.

"Conductor technologies are now available to help accelerate deployment of the new interconnections needed to support growing urban power demand, facilitate renewables integration, and power fleet electrification."

New technology can help deliver the additional grid capacity required. In particular, conductor technologies are now available to help accelerate deployment of the new interconnections needed to support growing urban power demand, facilitate renewables integration, and power fleet electrification. High temperature superconductors (HTS) have the potential to change the way utilities build out new infrastructure and expand capacity in a more cost-effective and socially responsible way.

HTS are a proven technology and have been used in many successful projects worldwide. And while HTS were not previously available at scale for cost-effective use, efficient production of HTS is now underway.

The US government recently demonstrated its belief in the importance of HTS to the energy transition. In October 2023, DOE announced $10 million in grants to three projects developing novel manufacturing technologies for superconducting tapes (a.k.a. conductor), saying that "enabling widely available low-cost high-temperature superconducting (HTS) tapes could have major implications for the United States'

[1] DOE, *National Transmission Needs Study*, October 2023, **https://www.energy.gov/sites/default/files/2023-02/022423-DRAFTNeedsStudyforPublicComment.pdf**.

[2] IEA, *Electricity Grids and Secure Energy Transitions*, October 2023, **https://www.iea.org/reports/electricity-grids-and-secure-energy-transitions**.

transition to a net-zero energy future."[3] Through DOE's Advanced Research Projects Agency-Energy (ARPA-E), the University of Houston, MetOx, and High Temperature Superconductors, Inc. will share the funding to scale up manufacturing of HTS conductor, improve production times and cost, and increase material efficiency and performance.

Major grid infrastructure manufacturers (e.g., Siemens, Mitsubishi) are now building roadmaps around HTS, and the technology is ready for more widespread use, in particular for expanding the capacity of underground urban distribution networks and for interconnecting large-scale renewables and EV fleet charging centers.

This Guidehouse Insights white paper provides an overview of HTS technology, highlights important use cases, and presents several case studies where HTS are being used today.

Why HTS?

HTS have several unique characteristics relative to legacy traditional and more advanced conductor technologies used to distribute power from generation centers to end users. The following sections define HTS technology and outline its advantages compared with more conventional conductor choices.

HTS: It's All About the Physics

In just about any situation in which electricity is being used, whether lighting a bedroom, keeping food cold, or powering a car, some electrical energy is lost as heat—this is called resistance. Materials with lower resistance (e.g., copper and aluminum) are better at conducting electricity, while materials with higher resistance perform worse.

Though nearly all conductors exhibit some electrical resistance, HTS have none. The unique properties of superconductors are used in technologies ranging from magnetic resonance imaging to levitating trains. In the grid, HTS wire can move transmission-level power at distribution-level voltages because of the dramatic increase of current capacity possible when there is no resistance.

"HTS offer more power per area compared with legacy conductors—up to 8 times the power can be moved over the same size cable with virtually no losses."

The superconducting material yttrium barium copper oxide can conduct electricity with essentially zero resistance when cooled below its critical temperature (80-90 K depending on the composition). The wire can then be used in a variety of applications including T&D cables, high field magnets, rotating equipment, and other advanced devices. In each application, the power that can be transmitted over HTS is far greater than what is possible today with conventional copper or aluminum conductors.

In the past, production of HTS in volume was uneconomical, but tremendous advances have been made, and HTS cable for T&D use cases is now being manufactured at scale.

[3] ARPA-E, "U.S. Department of Energy Announces $10 Million for Projects Working to Develop and Domestically Manufacture High Performance Superconductors," October 5, 2023, **https://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-10-million-projects-working-develop**.

Advantages of HTS

As the energy transition advances, HTS technology offers several important advantages over legacy conductor types.

HTS Can Be Run in Smaller Rights of Way

Traditional copper conductors have been used in underground T&D networks for more than a century—but the need for grid capacity expansion as electrification proliferates and energy demands grow can mean that acquiring new or larger rights of way (ROWs) can be a significant hurdle to grid expansion and new interconnection projects. HTS offer more power per area compared with legacy conductors—up to 8 times the power can be moved over the same size cable with virtually no losses. This in turn means smaller ROWs can be commissioned—or power lines in existing ROWs can be reconductored for greater capacity without the need to procure more space.

In the US today, approval and permitting backlogs for new transmission interconnections are substantial—so much so that independent renewables developers (and their financiers) may shy away from new renewables projects in certain states or regions. This is clearly a major impediment to broader green energy and GHG reduction targets.

The Inflation Reduction Act, signed into law by President Biden in August 2022, commits some $370 billion in funding and tax incentives for clean energy investment and emerging technologies—but without a fix for the interconnection queue problem, deploying adequate green generation may not be possible. In order to meet the administration’s stated target of reducing GHG emissions to half of their 2005 levels, radical change may be required. By reducing the need for new or larger ROWs and substations, HTS can be part of the solution.

Designing for Current, Instead of Voltage, Supports Fewer and Smaller Substations

A key differentiator between HTS and legacy conductors is that virtually zero line loss means HTS can be used to transmit the same or even more power at much lower voltages. Engineering for a traditional transmission line must consider how much power will be lost due to resistance as power flows over long distances—and thus voltage must be stepped up at the origin of that line. With HTS, a lower voltage line at a higher current can deliver the same amount of energy using a much smaller conductor.

Substations can be made smaller or, in many cases, will not even be required when using superconducting cables because more power can be moved at lower voltages.

In fact, generation sites like utility-scale wind or solar could potentially be interconnected with the grid further downstream, in the distribution grid rather than at higher transmission portions of the network. This means not only easier access to smaller ROWs but also fewer and smaller substations designed for the interconnection site.

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Smaller substations and ROWs mean more options for siting and faster permits and approvals. Smaller transformers and other equipment can outfit the substation, and construction can be completed more rapidly. In the end, more businesses and residences can have access to more green energy, more rapidly and at lower cost.

Cutting Down on Copper

The mining industry produces around 11% of total global GHG emissions, with copper extraction contributing through emissions from equipment, extraction, and transportation of raw resources for processing and manufacture. Beyond carbon emissions, the extraction of raw copper ore accounts for significant land and water use and can cause environmental damage to surrounding ecosystems, including marine pollution from mining operations and environmental toxins from industrial activities. The continued extraction of virgin resources is also leading to increased scarcity.

To date, the world has mined 700 million metric tons of copper, and some experts have projected that, even without accounting for electrification, another 700 million tons will be required by 2050 for economic growth—a doubling of thousands of years of production in just a few decades.[4] Electrification is expected to raise annual demand for copper to 36.6 million metric tons by 2031, while supply is forecast to be just 30.1 million tons, meaning a 6.5-million-ton shortfall by the start of the next decade.[5] This will surely lead to rising prices for the commodity—and the cable made with it.

HTS wire conducts 200-600 times more electrical current than an equivalent sized copper wire. T&D cables that use HTS provide an environmentally friendly alternative, enabling copper—a critical raw material for many energy transition technologies—to be saved for use in equipment where there is no obvious economic substitute. The environmental benefits extend beyond the avoidance of high copper consumption. As HTS cables have no ohmic resistance, they have dramatically lower power losses over their lifetime, and the smaller rights-of-way required by HTS reduce the environmental impact of construction. HTS can deliver greener energy to customers, contributing to a faster energy transition and reducing the dependence on GHG-intensive resources.

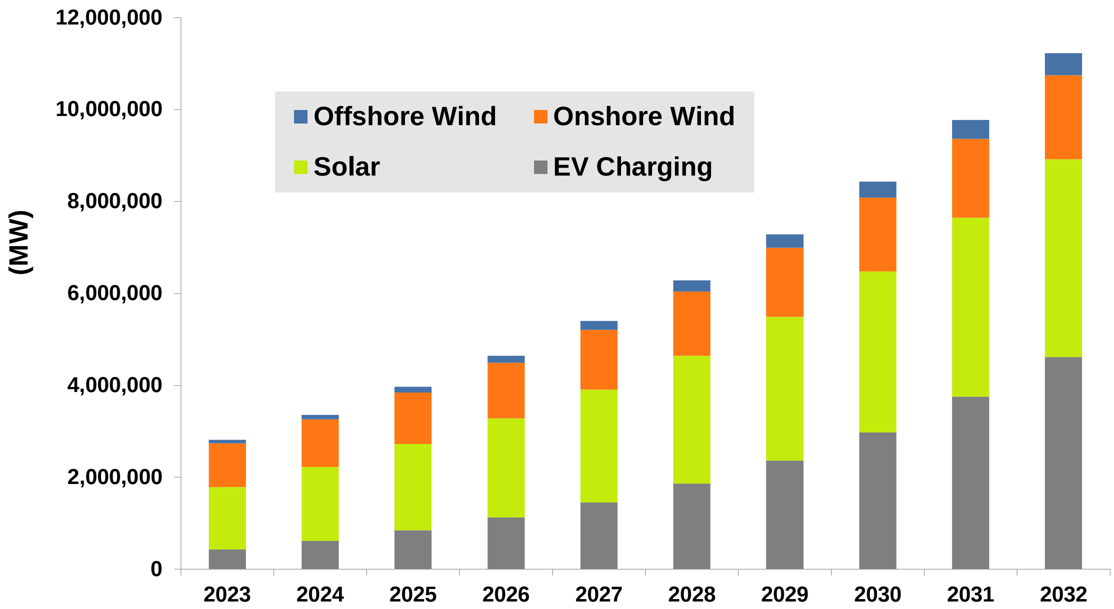
[4] S&P Global, "Massive Copper Supply Required for Electrification of Global Economy: Friedland," May 11, 2022, **https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/051122-massive-copper-supply-required-for-electrification-of-global-economy-friedland**.

[5] Scott Crooks et al., "Bridging the Copper Supply Gap," McKinsey & Company, February 17, 2023, **https://www.mckinsey.com/industries/metals-and-mining/our-insights/bridging-the-copper-supply-gap**.

Boom Time for Renewables and EVs

Considering the outlook for growth in renewables and vehicle electrification over the next decade, integration and management of power flows will not be possible without significant expansion of the existing grid.

Chart 1 ***Cumulative Installed Capacity for Onshore and Offshore Wind, Solar, and EV Charging, World Markets: 2023-2032***



(Source: Guidehouse Insights)

As shown in Chart 1 above, Guidehouse Insights predicts that total installed capacity for solar, wind, and EV charging will nearly quadruple between 2023 and 2032, from 2.8 million MW to 11.2 million MW worldwide. Installed EV charging capacity will grow at the fastest clip, climbing by more than an order of magnitude from 0.4 million MW in 2023 to over 4.6 million MW in 2032.

In order to meet global climate goals, simply accelerating existing processes for grid expansion and renewables integration will not suffice. Breakthroughs in new technologies like HTS provide grid operators and regulators the tools they need to expand the grid and meet climate targets.

HTS Use Cases

HTS are not indicated in every grid expansion or interconnection project—but in certain cases the technology brings valuable benefits to the overall cost-benefit equation. The following sections describe HTS-appropriate use cases and provide case studies.

Urban Capacity Expansion

Expanding grid capacity in dense urban environments is exceptionally difficult, particularly when existing distribution networks are underground. Existing infrastructure often poses capacity constraints, and ROW expansion may be all but impossible. New construction is disruptive to local populations as well as expensive. The permitting process may be long and arduous, and local opposition to new substations or high voltage transmission lines can prevent projects from moving forward.

Yet globally, populations are moving to cities in great numbers. According to The World Bank, 4.4 billion people—more than half of the global population—live in urban areas today. This number is expected to grow to 6 billion by 2045, and by 2050 almost 70% of the world's population will live in cities.[6]

Add in the load growth associated with accelerating electrification of buildings and vehicles, and utilities worldwide will have to deliver far more energy to these urban centers—and in order to reduce GHG emissions, that power may need to come from remote renewables plants.

Thanks to its zero resistance properties, HTS technology may fit the bill for delivering significantly more energy over a smaller conductor, allowing for cost-effective grid capacity expansion in urban areas with fewer new substations and within existing ROWs. Strategic use of HTS cables can result in fewer cable replacements, and fewer substations will be needed in more populated areas because more power can be delivered over longer distances at a lower voltage. Building in less populated areas allows construction to take place where land prices and resident opposition are relatively low.

Case Study: KEPCO, South Korea

In the first large-scale commercial use of HTS for capacity expansion, Korea Electric Power Corporation (KEPCO) began using HTS cable made by LS Cable in 2019. The Shingal project served as proof of concept, and the utility has since completed two more HTS projects. Both alternating current and direct current (DC) superconducting cable applications, from 23 kV to 154 kV, have now been implemented by the utility.

The Shingal project expanded capacity by interconnecting the secondary bus bars of KEPCO's 154 kV Shingal and Heungdeok substations with a 23 kV superconducting cable, rather than installing a previously planned 60 MVA transformer at the Heungdeok substation. Connecting the two substations with the HTS cable enabled them to share the additional load on the distribution network while eliminating the need for additional substations or transformers. The project was also chosen because spare conduits already existed between the two substations, eliminating new construction costs. The 23 kV three-phase HTS cable and cryogen liquid nitrogen circulating tube were installed in the available conduit. The main cooling system, a Turbo-Brayton refrigerator with a cooling capacity of 10 kW at -204°C (-335°F), was backed up by a decompression cryocooler.

"Thanks to its zero resistance properties, HTS technology may fit the bill for delivering significantly more energy over a smaller conductor, allowing for cost-effective grid capacity expansion in urban areas with fewer new substations and within existing ROWs."

Based on customer feedback after the 23 kV HTS cable project, KEPCO initiated plans to build additional 154 kV substations in areas more palatable to the local community.

[6] World Bank, "Urban Development," last updated April 3, 2023, **https://www.worldbank.org/en/topic/urbandevelopment/overview**.

Case Study: Munich SuperLink Project

Germany is leading the way in Europe when it comes to installing HTS cables in power grids. With more than 7 years of continuous operation, the AmpaCity project in Essen has the longest service duration of any HTS cable in the world. And now, the SuperLink project in Munich is set to become the world's longest HTS power cable. Covering a distance of 12 km and transferring up to 500 MVA at 110 kV, the project will begin the first phase of installation next year. Transferring 500 MVA typically requires a 220 kV or higher voltage cable; however with HTS this power can be easily transferred at 110 kV and with no ohmic losses.

HTS cable was chosen for this project due to the considerable advantages the technology offers when compared to traditional copper cables. Munich is a busy city, and road space is both scarce and expensive, so installing a slim HTS cable in a comparatively narrow trench realizes significant cost savings from reduced civil engineering and surface reconstruction works. And it is not just the costs that are better—the smaller cable has a lower impact on the public and traffic during the construction phase, which is also an important consideration in a highly populated and vibrant city center. Such interference is minimized by the greatly reduced civil engineering work and shortened construction period. Social acceptability is further enhanced by the design of HTS superconducting cable, which prevents any electromagnetic fields from emanating outside the cable and avoids any warming of the surrounding soil. Consequently, there are no strict specifications on spacings, and HTS cables can be laid closely with other infrastructure, which greatly facilitates routing and fast, compact installation.

Transmission Interconnection Backlogs Threaten Renewables Targets

As noted previously, approval delays for new transmission network interconnections represent a bottleneck to large-scale renewables deployment and could impede achievement of GHG reduction goals in the US and elsewhere. While not as onerous as those in the US, such backlogs are beginning to be seen in some parts of Europe as well as Asia Pacific (e.g., Japan, Australia).

In fact, in May 2023 the UK power regulator, Ofgem, issued an open letter setting out its position on electricity connections reform and requesting comment, noting the emergence of severe delays:[7]

> *With the government's recent 'Powering up Britain' publication promising to deliver the new nuclear, offshore wind and solar generation essential to achieve our decarbonisation goals, ensuring these assets can connect when and where they are needed will be crucial in achieving net zero, delivering affordability for consumers and maintaining security of supply.*
>
> *Customers seeking to connect to the network are experiencing significant delays, across all voltage levels, with some customers being offered connection dates in the late 2030s. We are committed to working with industry to take any actions necessary to ensure that the situation improves rapidly and significantly.*
>
> Ofgem Open Letter on Electricity Connections Reform, May 2023

Ofgem is already supporting research into the use of HTS technology for more efficient power transmission—the interconnection delays highlighted in this open letter are surely one reason why.

[7] Ofgem, "Open Letter on Future Reform to the Electricity Connections Process," May 16, 2023, **https://www.ofgem.gov.uk/publications/open-letter-future-reform-electricity-connections-process**.

HTS provide the flexibility for large-scale renewables to interconnect further downstream in the grid, which can mean eliminating the need for new, larger substations—instead, a smaller (and easier and cheaper to site) switching station may be all that is required. With HTS, grid operators can begin to think about designing the network around current rather than voltage, opening up a variety of new opportunities to more rapidly and efficiently integrate green energy into the grid.

One renewable resource in particular—offshore wind—may lend itself well to the use of HTS technology.

New Offshore Wind

Early in 2021, the Biden administration announced plans to invigorate offshore wind energy in the US, citing new jobs and economic opportunity as driving forces in the decision. As part of the announcement, the Department of the Interior's Bureau of Ocean Energy Management announced a new priority Wind Energy Area between New Jersey and Long Island, New York. Additionally, the Interior Department announced that the Vineyard Wind project off the coast of Massachusetts had been granted final federal approval. It will be the first large-scale offshore wind project in the US.

Figure 1 Offshore Wind Farm

(Source: Getty Images)

The US has significantly lagged Europe in offshore wind development. Right now, the US only has two small offshore wind projects, with Vineyard Wind slated to be the third when it begins delivering energy to Massachusetts in late 2023.

That is set to change. In March 2023, DOE released a report, *Advancing Offshore Wind Energy in the United States*, highlighting its goal of reaching 30 GW of offshore wind capacity by 2030 and establishing a pathway to 110 GW by 2050, including 15 GW of floating offshore wind capacity by 2035.[8] Already, the offshore wind project pipeline in the US includes 40 GW of planned projects, with individual state policies aiming to procure at least 39 GW by 2040.

As offshore wind development gains traction in the US (and elsewhere globally), project developers should consider HTS cabling for interconnection. Many of these developments could be very far offshore—California is looking at floating wind turbines that will be sited beyond the continental shelf. The no-loss feature of HTS cabling will allow smaller-size conductors to carry high loads to interconnection points onshore—potentially without the need for large new substations. HTS technology reduces the number of cables required to connect the wind turbine—a single high voltage DC HTS cable can transmit 4 GW at 100 kV—meaning that significantly fewer vessel days are required to complete the connection between the offshore wind farm and the onshore grid. And because smaller cable-laying and installation vessels can be used for the smaller, more lightweight HTS cables, restrictions related to the Jones Act, which requires that US-based ships install offshore turbines, are no longer an obstacle to offshore wind deployments.

"A single high voltage DC HTS cable can transmit 4 GW at 100 kV—meaning that significantly fewer vessel days are required to complete the connection between the offshore wind farm and the onshore grid."

Transport and EV Fleet Charging

Electrification of transportation—in particular medium and heavy duty vehicles (MHDVs; e.g., trucks, buses, delivery vans)—represents a major opportunity to reduce GHG emissions. MHDVs can emit up to 30 times the amount of CO_2 of a typical passenger vehicle, and while they only account for a small percentage of vehicles on the road, they cause upwards of one-fourth of vehicle emissions in the US.

Fleet electrification is a growing area of focus for policymakers at local, state, and national levels and is seen as an important tool for meeting climate goals. For utilities, fleet electrification represents a real opportunity to sell more power and generate more revenue—but also a real challenge to grid management.

In 2021, National Grid and Hitachi Energy conducted an analysis to determine the grid impacts of electrifying fleet vehicles.[9] The study sought to provide an understanding of how differences in fleet locations and sizes, usage patterns, vehicle types, and charging patterns would affect specific portions of T&D systems. The study identified more than 50 fleets currently operating in a metro area in the northeastern US, analyzed their potential charging behaviors and power needs if the fleets were fully electrified, and mapped those fleets to a specific portion of National Grid's distribution system.

[8] DOE, *Advancing Offshore Wind Energy in the United States*, March 2023, **https://www.energy.gov/sites/default/files/2023-03/advancing-offshore-wind-energy-full-report.pdf**.

[9] National Grid and Hitachi Energy, *The Road to Transportation Decarbonization: Understanding Grid Impacts of Electric Fleets*, September 2021, **https://www.nationalgridus.com/media/pdfs/microsites/ev-fleet-program/understandinggridimpactsofelectricfleets.pdf**.

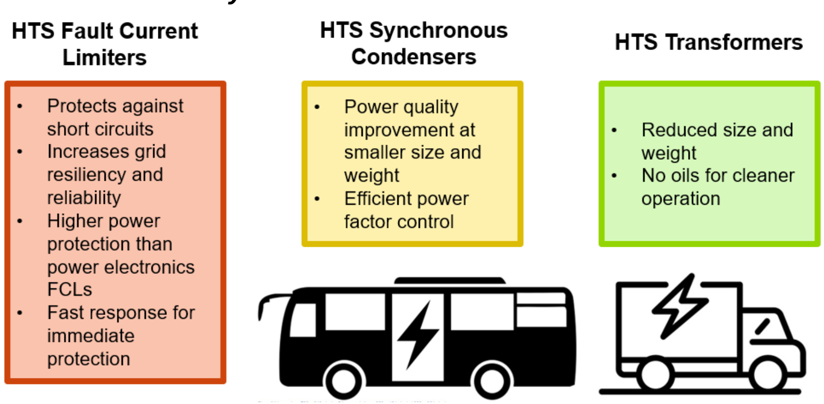
Figure 2 EV Fleet Charging

(Source: Supamotionstock.com/Shutterstock)

The study found that grid impacts will vary substantially at different parts of the grid and that fleet electrification will require strong collaboration and proactive planning. Because fleets are often clustered in specific geographic areas, certain feeders could be disproportionately affected. For instance, the analysis identified two distribution feeders that might eventually need to support more than 400 fleet vehicles—and could require more power than that portion of the grid's current capacity.

Utility and fleet managers will need to collaborate in the proactive planning recommended by the study—and HTS technology should be considered one of the tools in the toolbox for managing high capacity fleet charging centers. In addition to using lower voltage HTS wire to bring ample energy capacity to these locations, HTS technology can also be used in substation equipment such as fault current limiters (FCLs), synchronous condensers, and transformers, reducing the cost, size, and weight of these items—meaning the need for larger substations can potentially be avoided.

Figure 3 HTS Use Cases Go Beyond Conductors



(Source: MetOx & Guidehouse Insights)

HTS will become an important element of transportation electrification. Beyond large fleet charging plazas, HTS may be used in port and rail use cases, where similarly critical and high volume power needs are anticipated.

Case Study: Paris Montparnasse Train Station

Built in 1840, Paris Montparnasse is the fourth-largest railway station in Paris, with more than 50 million passengers using it annually and more than 90 million expected in 2030. France's state-owned railway company, SNCF, commissioned Nexans to manufacture and install two HTS cables to secure power supplies for the station now and into the future.[10]

SNCF faced many challenges when it embarked on a project to strengthen the power supply to Montparnasse, due in large part to difficulties navigating existing infrastructure on the site. In the end, only a superconducting cable could provide a practical solution due to the need for both reduced cable diameter and exceptional high capacity to deliver the performance required by SNCF Réseau: 3,500 amps at 1,500 VDC. Using HTS enabled SNCF to save on implementation costs related to infrastructure modification, avoid potential disruptions to rail and road traffic, and limit risks in terms of execution time and commissioning date. The superconducting cable is the result of Nexans' innovation capabilities in the fields of electricity and global sustainable electrification—an approach that has been part of the company's history for more than 120 years. Nexans also supplied HTS cable to the hugely successful AmpaCity project in Essen, which was in continuous service for its 7-year trial period.

[10] Nexans, "A World-First in France at Montparnasse Train Station: Nexans Installs Superconducting Cables to Strengthen and Secure the Power Supply," June 9, 2022, **https://www.nexans.com/en/newsroom/news/details/2022/06/a-world-first-in-France-at-montparnasse-train-station-nexans-installs-superconducting-cables.html**.

HTS Technology Is Here and Ready to Support the Energy Transition

The continued electrification of transportation and buildings, the shift from fossil fuels to zero carbon energy sources, pressure from corporations to continue to develop and use renewable energy, increasing mandates and incentives from federal and state governments to transition the US energy system, funding for the development of fusion energy, and the overall urgency of the climate crisis all create strong tailwinds for expanding grid capacity using more efficient energy technology.

HTS technology is not new—numerous projects over the past 15 years have demonstrated the advantages of superconductors in the power industry—but until recently, availability of HTS-based products was limited. That is now changing, with HTS cable being manufactured at scale and new use cases being proven globally.

The timing is fortuitous: as the world accelerates efforts to mitigate the impacts of climate change—through deployment of large-scale renewables and building and transportation electrification—the demands on the grid are set to climb rapidly. Grid capacity needs to be expanded quickly, often in densely populated urban areas.

"Utilities looking to enhance grid capacity to meet burgeoning loads and integrate large-scale renewables and EV charging may now consider HTS an option poised to solve certain critical problems, particularly where interconnections or dense urban environments make traditional methods a challenge."

HTS cabling and substation equipment can support critical grid power capacity expansion and new transmission interconnections within the constraints many utilities face today—such as unavailable or very expensive real estate for wider ROWs or new substations. It can deliver much higher power capacity than traditional conductors over smaller cabling and allow new substations to be strategically located further from city centers—making procuring and receiving permits faster and less costly, and building substations less disruptive to local populations.

In short, utilities looking to enhance grid capacity to meet burgeoning loads and integrate large-scale renewables and EV charging may now consider HTS an option poised to solve certain critical problems, particularly where interconnections or dense urban environments make traditional methods a challenge.

Scope of Study

Guidehouse Insights has prepared this white paper, commissioned by MetOx International, Inc., to provide an overview of high temperature superconductor (HTS) technology for use in grid capacity expansion. It includes an overview of the key benefits of HTS technology versus traditional conductors and offers a description of key use cases where the advantages of HTS technology offer valuable benefits. Several case studies are included in support of the suggested use cases.

Sources and Methodology

Guidehouse Insights' industry analysts use a variety of research sources in preparing research reports and white papers. The key component of Guidehouse Insights' analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Guidehouse Insights' analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within the report.

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