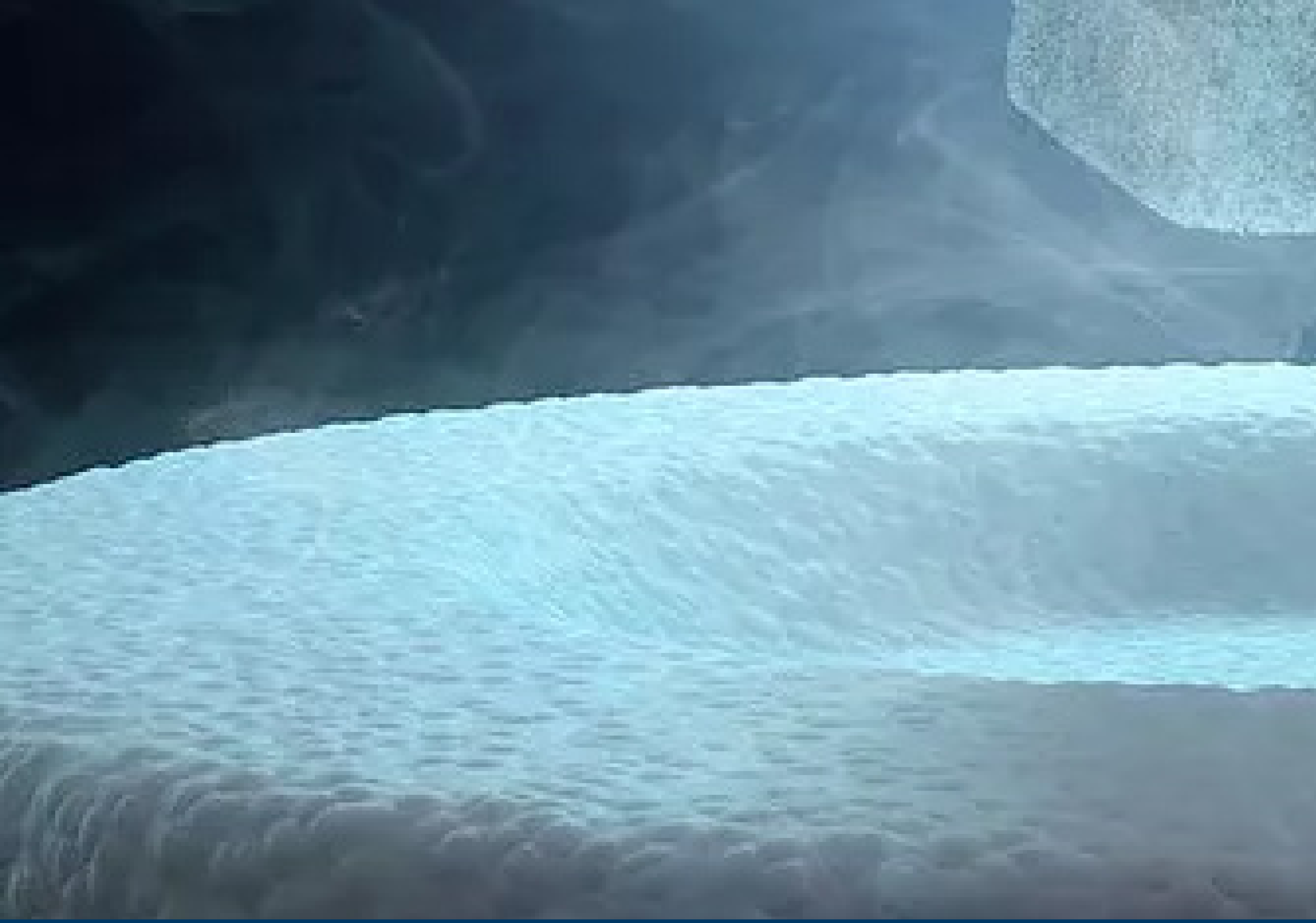
Superconductivity
INTERNATIONAL ENERGY AGENCY

ANNUAL REPORT 2021

IEA Technology Collaboration Programme on High-Temperature Superconductivity



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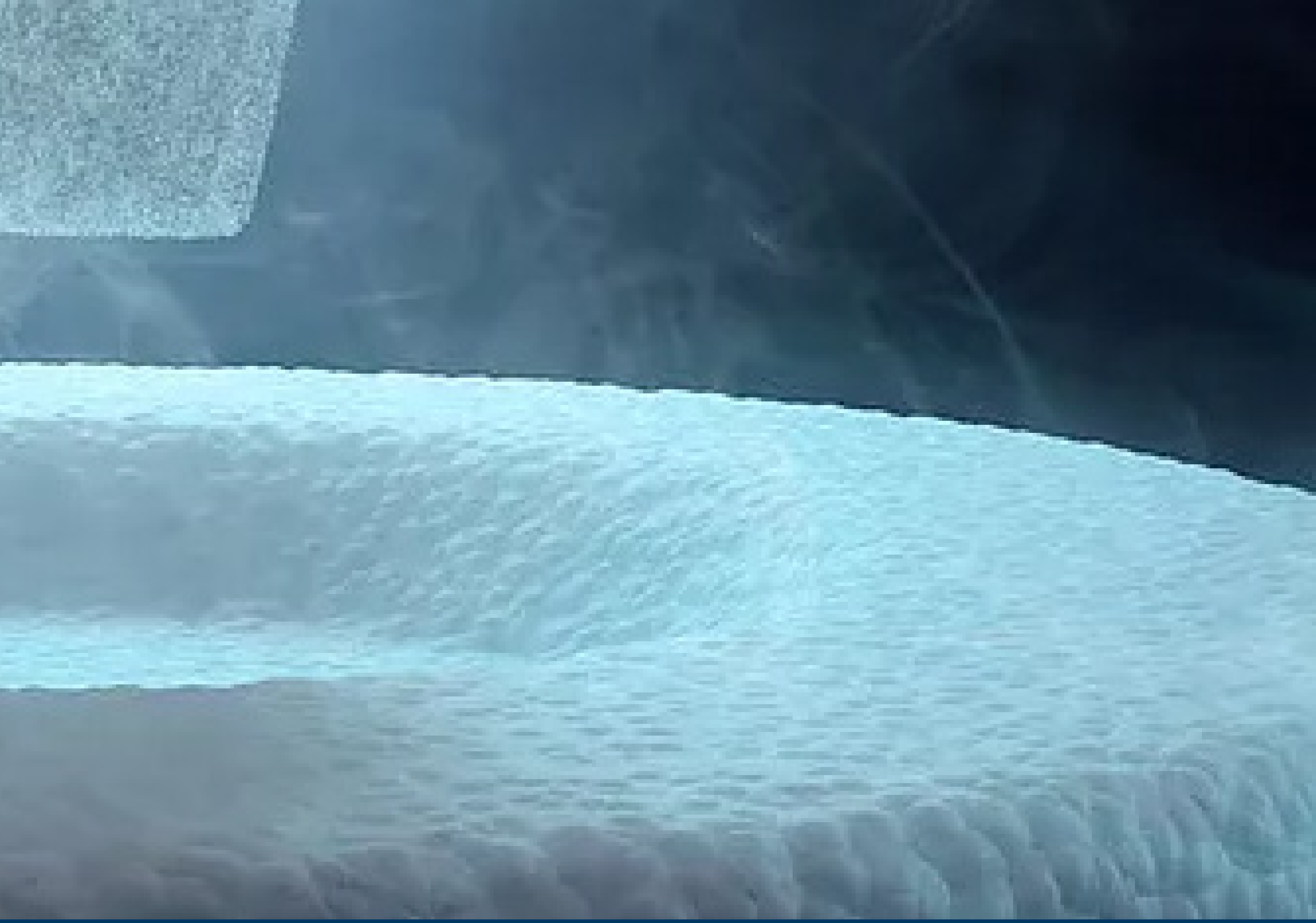


Message from the Chair

This was a pivotal year for high-temperature superconductivity (HTS) and the International Energy Agency's Technology Collaboration Programme (TCP) that promotes it. In Chicago, Illinois, ComEd became the first utility in the United States to install an HTS cable as a permanent asset of their grid. The cable is designed to improve the reliability and resiliency of the power grid while reducing disruption to public infrastructure. Scientists in Europe managed to sustain the longest and most energetic fusion reaction thanks in part to high-temperature superconducting magnets. And our TCP embarked on the first of its new five-year term with new leaders, members, sponsors, and direction.

The achievements of high-temperature superconductivity have begun to mount in not just controlled settings but commercial ones. Now, the disruptive power of HTS brings the vision of a 100% renewable, clean, electrified energy system into focus – one that transmits lossless and nearly limitless power through a global network of invisible, underground conduits to power our trains, planes, cars, devices, homes, workplaces, factories, and more. High-temperature superconductivity unlocks a new world of opportunities that weren't possible without it: more powerful wind turbines, better MRI machines, supercomputers, new physics discoveries, fusion power, the transmission of electricity without losses, electric airplanes, faster trains, and so many more applications we've yet to encounter or imagine.

In 2021, our eight-member TCP sought to describe how much of this vision is already underway and what lies ahead. We published the first of several Application Readiness Maps that illustrate the Technology Readiness Levels (TRL) of various HTS applications across different sectors, including energy supply, transportation, medicine, industrial processes, and the focus of this first report, energy delivery. These reports explore how ready HTS is to "disrupt" the energy landscape – a concept we'll explore in greater depth in the coming year.

As the technology evolved, so did we. Luciano Martini stepped down as Chair of the TCP, and I was elected acting Chairman with Laura Serri from RSE as Vice Chair. Swiss delegate Bertrand Dutoit and Israeli Delegate and former chairman Guy Deutcher retired. We welcomed two new Korean delegates, a new Japanese delegate, and plan to announce a new sponsor in 2022.

We look forward to additional technical and market advancements in the coming year and integrating the new leadership into the TCP.

HTS TCP Interim Chair

Hiroyuki Ohsaki

Introduction to Applied Research

A great energy transition is underway. The world's energy systems are electrifying, digitizing, and integrating renewable energy more quickly than ever before, placing an unprecedented demand on society to rapidly expand its electrical infrastructure while simultaneously ensuring it is more interoperable and cybersecure. These forces are upending the world's conventional approaches to producing, delivering, and using energy, and new technologies–especially ones offering greater efficiency–are necessary to meet the moment. Superconductivity, and high-temperature superconductivity in particular, is one of those technologies

Superconductivity is a phenomenon that causes certain materials, at low temperatures, to lose essentially all resistance to the flow of electricity. The lack of resistance enables a range of innovative technology applications. The temperature at which resistance ceases is referred to as the "transition temperature", or critical temperature (Tc). Tc is usually measured in Kelvin (K)—0 K being absolute zero. HTS gets its name originally because it has a higher transition temperature (77 K, which can be achieved when using liquid nitrogen) than low temperature superconductivity(LTS) (around 4.2 K, which can be achieved using liquid helium). Several examples of well-recognized types of superconducting wire include:

- BSCCO, known as first generation (1G) HTS wire (Bismuth - Strontium - Calcium - Copper – Oxide)
- REBCO, known as second generation (2G) HTS wire (REBCO stands for "Rare earth - Barium - Copper Oxide" for the superconducting compound; REBCO is also referred to as YBCO since Yttrium (Y) is the element most often used in 2G wire)
- MgB2 (Magnesium diboride)
- Nb3Sn (Niobium-Tin) and Nb-Ti (Niobium-Titanium) alloys

Another critical component of a superconductive device is the cryogenic (refrigeration) system for achieving operating temperatures. Low temperature superconductors operate at the "low" liquid helium temperature of (4 K or -296°C). High temperature superconducting (HTS) materials operate at the "high" temperature of liquid nitrogen (77 K or -196°C). Because liquid nitrogen (LN) is relatively ubiquitous and cheaper than liquid helium, HTS technologies offer greater potential to develop cost-effective solutions for the electric power sector.

Since the discovery of HTS in 1986, research and development have brought new equipment enabled by high-temperature superconductivity to the threshold of electricity transmission and distribution applications. Superconductor-based devices provide improvements over conventional electric grid technologies, but they also offer unique alternatives to system challenges that cannot be addressed otherwise. Laboratory-scale tests have transitioned to large-scale HTS based projects that serve utility customers. HTS projects are now part of permanent infrastructure installations to solve real-world electric grid problems.

Applications of superconductivity have been available in certain niche markets for decades. Superconducting magnets, in particular, are well-established in many applications that require powerful electromagnets like high-energy-physics particle accelerators and magnetic resonance and imaging (MRI) machines. Superconductivity has been employed or proposed for use in a variety of applications and sectors, including the energy, transportation, industrial, medical and defense sectors. High temperature superconducting (HTS) wire is the key enabler that makes devices for the electric power system more efficient and resilient than conventional solutions.

THE BENEFITS OF HIGH-TEMPERATURE SUPERCONDUCTIVITY

The primary focus of the International Energy Agency's Technology Collaborative Program on High Temperature Superconductivity (HTS TCP) is electric power delivery systems, but it monitors advancements made in the areas of wind energy, all electric aircraft and motors, and fusion technology.

Electric Transmission and Distribution

Load growth in urban and suburban regions requires utility companies to make long-range plans for increasing the capacity of the AC circuits that serve that load. It is well known that HTS cables can carry much larger levels of power than conventional cables for the same underground cross-section and right-of-way (ROW). Alternatively, an HTS cable can provide the same level power, but at a much lower voltage. In some cases, both of these features may be realized in a single project. In addition, many of the world's utilities are coping with increasing fault (short-circuit) currents, possibly requiring new substation circuit breakers. An HTS fault current limiter (FCL) can help manage increasing fault currents more cost- effectively and reduce losses by at least 50% in solid-state FCLs and at least 90% in fault-current- limiting reactors.

Energy Storage

Energy storage can increase the penetration of renewable resources and improve power quality. Superconducting Magnetic Energy Storage (SMES) has several advantages over other storage technologies, including rapid response times, nearly infinite charge/discharge cycles without degradation, and very high round trip efficiency.

Wind energy

HTS-based wind turbines have the potential to generate the same amount of power with roughly half the size and weight of conventional designs, needing less rare earth metals and making installation easier.

Motors

Electric motors account for almost two-thirds of all electric energy consumption in the United States and other developed countries. Superconducting motors have the potential to reduce losses by 50% and can be less than half the size and weight of conventional designs, which can improve the propulsion and maneuverability of transportation vehicles.

All-Electric Aircraft

The use of lightweight HTS could lead to ecofriendly, exceptionally quiet, and highly energy efficient electric planes. Beneficial application of HTS technology is expected in the fields of power generation, power distribution and forming, and propulsion. In addition, auxiliary devices might be replaced by electric HTS-based solutions.

Fusion

Recently, HTS sparked a new vision for achieving practical fusion energy. This approach, known as the high-field pathway to fusion, aims to generate fusion in compact devices on a shorter timescale and lower cost than alternative approaches.

REMAINING CHALLENGES

Over the past few decades, significant efforts have been made worldwide on research, development, and field demonstration of applied HTS devices for the power sector. As a result of these activities, several HTS based devices, specifically HTS cables and FCLs, are being energized in utility grids as permanent solutions to electricity delivery challenges. However, other applications are still lagging in deployment into commercial installations. The transition of HTS applications to widespread market maturity faces several general challenges.

Policy to value CO_2

New policies to value CO2 emissions could help to improve the penetration of HTS.

Synergistic applications

Other HTS applications are a means to reduce costs by increasing manufacturing volume. Some paper studies of wire cost versus production volume suggest that the 20,000 km requirement for a commercial fusion reactor could yield wire costs that would make HTS transmission cable viable. This may be a "chicken and egg" situation, with fusion needing a viable transmission cable market and vice-versa, with neither ultimately happening. Other niche markets like rotating machines, mobility applications, and FCLs could expand HTS.

Improved economics

The cost associated with manufacturing HTS wire due to sophisticated processes, low yields and limited throughput of the manufacturing processes makes it several times more expensive than copper wire. However, it is not reasonable to simply compare the cost of an HTS-based device to a conventional one. Because of the unique attributes of HTS devices, a system cost analysis should be conducted. Furthermore, if raw material cost of conventional materials increase it could provide advantages for HTS based solutions.

Improved process control

There is a general lack of manufacturing knowledge in producing HTS wires with nanometer-sized precipitates or phases uniformly distributed over kilometer lengths.

Proven long term reliability

End users are generally unfamiliar with the materials used in HTS devices and cryogenic systems. Data are not available that proves undiminished product-performance HTS component lifetime over 30 to 40 years.

Reduced business risk

Uncertainty for total cost of ownership and cost and availability of parts from suppliers in a relatively nascent market.

Factory Testing

Underground conventional cable is shipped from the manufacturing plant on large reels. The capacity of a shipping reel is limited to between 0.5 and 1 km, typically, depending on cable design and transportation methods. Factory acceptance testing for voltage integrity of solid electrical insulation is necessary for 100% of all reels shipped to the project site. Otherwise, a reel with potential insulation defects may produce failure in the field when first energized. Location of the failed section, removal, reinstallation, and recommissioning is a costly and time-consuming process.

Projects involving more than a few reels of untested cable have a statistically high probability of encountering a faulty reel due to the inherent variability in any manufacturing process. Acceptance testing is therefore a standardized step in the manufacture of conventional cable. On one hand, at present, there is no means to do the same for an HTS cable because the insulation of present day HTS cables requires wetting paper tapes with a liquid cryogen. Factory testing would require immersing an entire shipping reel in the liquid cryogen – a clear impracticality. On the other hand, the HTS cable electrical insulation is the combination of lapped material, for instance polypropylene laminated paper (PPLP), and liquid nitrogen. Impregnation with liquid nitrogen will be performed on site after cable installation. The likelihood of an insulation defect is lower than in the case of a conventional cable with a solid dielectric insulation.

Cryogenic and Vacuum Systems

There is a need for optimized and field-proven cryogenic systems for HTS cable installations that are essentially "invisible" to the end-user. Cryogenic refrigeration is a well-established industry for many applications, but in medium sized systems, in the range of few dozen kW@70K of cold power, there are not available systems designed specifically for HTS cables. Whereas for larger size systems, in the range of several 100 kW@70 K of cold power, cryocoolers for LNG industry (reliquefication of methane on board) are perfectly suitable. Economic studies suggest that the efficiencies of commercially available refrigerators is inadequate for medium-size utility applications.

Available refrigerator sizes also are not optimal. Space limitations within the substation for refrigeration equipment, particularly in the dense urban locations most attractive for this application, may require innovative approaches, yet to be determined if not compensated by space savings thanks to the compactness of HTS cable systems compared to conventional technologies (less transformers, less terminations). These situations can lead to uncertainties regarding system design and performance below a certain size. Operational characteristics and maintenance procedures are progressing towards unmanned systems with remote controlled systems and maintenance periodicity of 2 to 5 years.

Additionally, there is little or no precedent for mechanical equipment installed inside utility substations besides chilling units for power electronics, nor for the presence of non-utility maintenance personnel that would be required to place the cooling station in areas where no electrical habilitation are required (possible thanks to cryogenic transfer lines). Electric utilities are generally very conservative and risk-averse, preferring equipment that is well-proven for the application and operations that are entirely under their control. Thus, achieving a higher TRL requires cryogenic systems that have been optimized and fully tested, such as cryocoolers for the LNG industry. Operation and maintenance practices that are consistent with current electric utility industry standards are also needed. A significant progress has been made in that direction through the publication in 2019 of IEC standards for AC superconducting cable from 6 to 500kV.

Cable Splices

Cable splices between installed sections are a necessary fact for all underground cable systems. Cable splices are by far the weakest link in the cable system and are prone to failure if not properly constructed. Splicing must occur in the field, whether in permanent underground vaults or in temporary field facilities for later direct burial. Splicing is as much an art as it is a science. It requires clean conditions and a high degree of training. HTS cable splices have greater complexity which requires a longer repair time in case of failure. Indeed, splicing HTS cables involves integrating the vacuum cryostat in the splice joint. Several HTS cable systems in existence have demonstrated the feasibility of cable splices at both medium and high voltage. The methods for achieving highly reliable splices in the field can take advantage of increasing the part of prefabricated components and reducing the on-site assembly.

Purpose and Scope

The International Energy Agency's Technology Collaborative Program on High Temperature Superconductivity (HTS TCP) brings together key stakeholders to address the challenges of promoting the development and use of HTS technology in view of common interests. Particularly, the HTS TCP:

- Collaborates with electric utilities, governments, professional engineering organization and the RD&D community to confirm and communicate the potential benefits of HTS technology.
- Sponsors workshops, co-authors books and journal articles, exchanges information, introduces Executive Committee (ExCo) members' research facilities to other participants and guides the assessments.
- Develops position papers and strategic documents such as roadmaps and technical reports. Participants also ask experts from their countries to provide for input and to peer review draft reports. These activities help ensure consistency in the reporting and evaluate progress in the different considered fields.

Bending parts of tri-axial superconducting cable, *Courtesy NEDO*

- Provides expertise that can inform the evaluations and assessments performed by ExCo members.
- Interacts with other related IEA TCPs to leverage synergies and opportunities.
- Disseminates work at international meetings and workshops, and supports students, young engineers, and scientists who are learning about HTS applications in the power sector.
- Addresses and clarifies perceived risks and hurdles to introduce a disruptive technology into the conservative electric power industry.

Summary of 2021 Activities

While the pandemic changed the format of the TCPs ExCo meetings, it did not change the frequency. Two Executive Committee meetings were held:

- ExCo meeting (via webinar) was held in May 2021
- ExCo meeting (via webinar) was held in June 2021
- ExCo meeting (via webinar) was held in October 2021

The 2021- 2026 work plan will focus in two main areas: analysis of cross-cutting issues and communications and outreach with increased industry and government collaboration. The HTS Technology Collaborative Program (TCP) works to identify and assess the potential applications and benefits of superconductivity, as well as what technical, economic and regulatory barriers must be overcome to achieve them.

Through its contracting parties, the HTS TCP develops technical communications documents that provide information for a range of stakeholders.

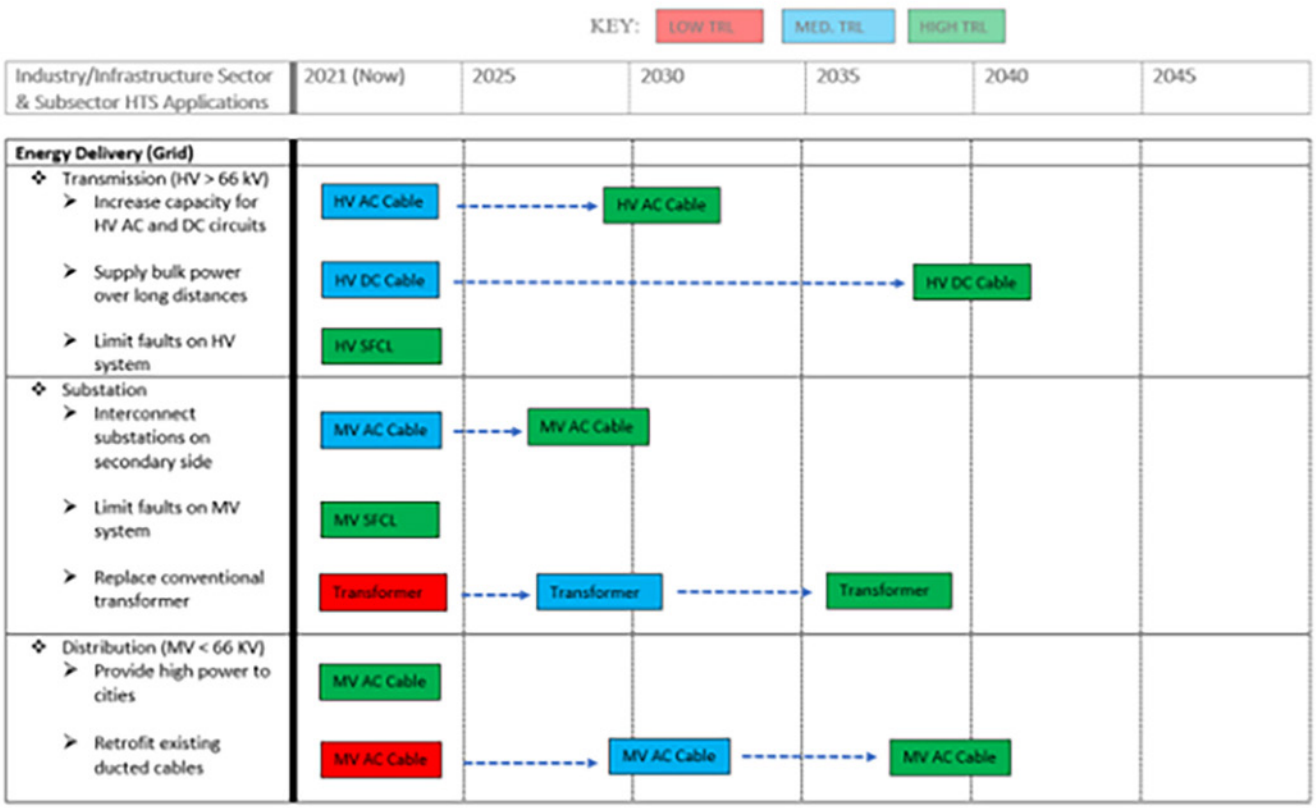
In the 2021-2026 period, the HTS TCP will focus on activities that could accelerate the market adoption of superconducting applications. The rationale for this is that the technology readiness level of several HTS applications is at a point where it is technically capable to be included in electric system operation, for instance. The HTS TCP will demonstrate to key stakeholders that existing HTS technologies are technically and economically viable in a number of electric power and other related application areas.

The TCP published a Readiness Roadmap on HTS in energy delivery. The development of this application map was motivated by the need to clearly communicate the readiness of HTS applications to policy makers and industry executives and will take into account the TCP's current quantitative analysis of various energy-related benefits of HTS technology.

The readiness map as a way to illustrate the technology readiness levels (TRL) over time of HTS applications in various sectors. Examples of sectors that HTS is, or can be, used in include energy delivery, energy supply, transportation, medicine, and industrial processes. The sector this document focuses on is in energy delivery, whose applications can be further broken down into transmission, substation and distribution. The TCP began developing TRL levels of various transmission, substation and distribution applications in the energy delivery sector. For each of the applications, the TRL for today and future were determined by using the input of industry experts. Factors influencing technology readiness include:

- Underlying scientific/engineering maturity (e.g., HTS wire design; cabling technology)
- Potential for ongoing R&D of component technologies (e.g., existing or planned research activities; institutional support; etc.)
- Maturity of component subsystems common to other applications (e.g., cryogenic systems)
- Specific application readiness (e.g., maturity of HTS AC cable design)

The figure on the next page shows the TRL levels of various transmission, substation, and distribution applications in the energy delivery sector.


KEY:
LOW TRL
MED. TRL
HIGH TRL
Industry/Infrastructure Sector & Subsector HTS Applications
2021 (Now)
2025
2030
2035
2040
2045
Energy Delivery (Grid)
Transmission (HV > 66 kV)
Increase capacity for HV AC and DC circuits
HV AC Cable
HV AC Cable
Supply bulk power over long distances
HV DC Cable
HV DC Cable
Limit faults on HV system
HV SFCL
Substation
Interconnect substations on secondary side
MV AC Cable
MV AC Cable
Limit faults on MV system
MV SFCL
Replace conventional transformer
Transformer
Transformer
Transformer
Distribution (MV < 66 KV)
Provide high power to cities
MV AC Cable
Retrofit existing ducted cables
MV AC Cable
MV AC Cable
MV AC Cable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Project Updates

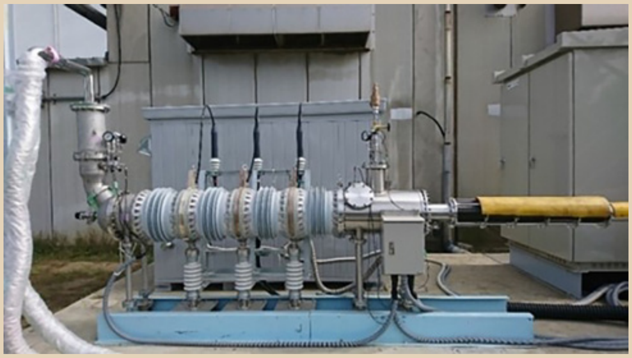
Around the world, projects are demonstrating the technical feasibility of electric power equipment incorporating HTS tapes. The text below highlights several project examples from IEA HTS TCP Member Countries.

GERMANY

The SuperLink project is a superconducting power cable that is planned for installation in the center of Munich, Germany. The 12 km underground power link is expected to be the longest superconducting power cable solution in the world. The SuperLink design has a power rating of 500 MW and a voltage level of 110 kV, which is slated for installation between two substations those are the main Menzing substation in the west of the city and the load center Munich-South using existing ducts to keep the construction work at a minimum.

JAPAN

The New Energy and Industrial Technology Development Organization (NEDO), SWCC Showa Cable Systems Co., Ltd. (SWCC), and BASF Japan Ltd. (BASF) have completed the world's first demonstration test of a tri-axial superconducting cable system installed in a commercial chemical plant. The project was completed at BASF Japan's Totsuka site (Totsuka Ward, Yokohama City) from November 2020 to September 2021. The testing proved the system is capable of supplying power reliably for about one year. A condition of this test was that it was necessary to use the plant's existing facilities, so the cable was installed on an existing rack, which is located about 5 meters above the ground. Therefore, it was necessary to bend the cable 90 degrees (bending radius 1.5 meters) at four locations; the flexibility of the cable allowed it to be installed without any problems. Although the flow path of liquid nitrogen becomes narrower at bends with a compact cable, it can flow over long distances (approximately 400 meters round trip) in the system without any problems, confirming that it can be used for complex plant layouts.



Terminal of tri-axial superconducting cable, *Courtesy NEDO*

KOREA

The KEPCO sponsored Shingal Heungdeok triple-core HTS power cable project was energized in July 2019 and has been operating as expected. The success of this project has spawned two additional projects. The MunSan Project is planned to have two HTS cables that are each 1km long and operational at 23kV, 60MVA. This triaxial power cable will connect the Munsan and Seonyu substations. One of the benefits of using the HTS cable is that it uses a small 23kV switching station instead of a larger 154kV substation, which is important for the urban area where the project is planned. The cable is planned to be energized in 2022. The Onsu project is planned to have a 154kV 400MVA cable that is 1.6km. This project will connect two 154 kV substations using one HTS cable instead of two XLPE lines. There is also reduced civil works costs because the project will use an existing tunnel. The construction period is expected to end in 2023.

UNITED STATES

On August 31, AMSC and the Commonwealth Edison Company (ComEd) announced the fully operational introduction of the Resilient Electric Grid (REG) system, a permanent asset of Chicago's grid designed to improve the reliability and resiliency of the power grid while reducing disruption to public infrastructure. The AMSC REG system is based on HTS, that allows enormous amounts of power – 200 times that of normal copper wire – to be transferred from one point to another without electrical resistance loss. At the same time, the wire is uniquely able to self-heal and protect the system against dramatic changes in current flow, a protection not possible with conventional technologies. ComEd has contemplated a project to extend the Chicago REG project to connect additional, existing substations in Chicago's central business district. If pursued, the second project would be larger in scope than the first and provide greater reliability, resiliency and load-serving capabilities during outages or other grid disruptions. The larger scope of the second project would create an even more resilient and reliable electric grid for Chicago and ComEd, which delivers electricity to more than 4 million customers in northern Illinois.

These project updates are examples from other countries and regions.

CHINA

Shanghai Electric Cable Research Institute is developing a 35kV 2.2kA HTS cable project in Shanghai. It is a 3 in 1 type cable that is about 1.2km long. The route construction started on April 30th, 2020. The project will be energized in 2021. The Chinese Academy of Sciences and Electric Power Research Institute is working on integrating an HTS cable and liquefied natural gas transportation into a single pipeline. HTS DC cables are a promising solution for large-scale power transmission over long-distances. However, the refrigeration system for the HTS cable is challenging. Considering that liquified natural gas is used more widely, the Chinese organization is designing, fabricating and testing a new energy transportation system that is a 10 kV/1 kA energy pipeline. Guangdong Grid Company of China's Southern Power Grid is leading a project to develop a 160 kV/1 kA resistive type direct current superconducting fault current limiter. The project is starting as a laboratory prototype and when scaled up it will help to improve the safety of the HVDC network by reducing the fault current levels in the grid.

EUROPE

The FastGrid project is developing a cost-effective fault current limiter using advanced superconducting tapes for future high voltage direct current grids. There is strong interest for HVDC SFCL, but today's tape is not suitable in terms of cost. In addition, the enhancement of reliability under high voltage is required. The project is working on significant advances of the attractiveness of SFCLs by improving REBCO tapes, especially in their current limitation mode.

Working Arrangement

In 2021, one operating agent (OA) based in the United States supported the HTS TCP. The position was renamed in 2021 to Task Manager. Task managers are managed by the ExCo, whose duties are specified in a contract with the OAs and include provision of technical and support services. The HTS TCP operation is supported by a combination of cost-, task-, and knowledge sharing. ExCo members have historically covered their travel expenses to attend ExCo meetings and bear all the costs incurred in conducting task activities, such as report writing and travel to meetings and workshops. This will continue when the ExCo starts holding in person meetings again.

The ExCo Chairman, vice-chairman and task managers prepare an annual work plan and associated annual budget for the calendar year, which are submitted for approval by the ExCo. The expenses associated with the operation of the HTS ExCo and the annual work plan, including the task manager's time and travel and other joint costs of the ExCo, are met from a Common Fund to which all HTS TCP members contribute. No changes to either the working arrangement or current structure fee are anticipated. In FY 2017 the fee structure had been modified based on the GDP of the member countries. The HTS TCP Common Fund is financially secure and has had a surplus for the past several years.

Membership in the ExCo changed in 2021. Israel withdrew from the TCP, and the TCP's leadership changed. Chairman Luciano Martini stepped down from as Chair; Vice Chairman Hiroyuki Ohsaki became the Acting Chairman. Laura Serri was elected Vice Chairwoman of the TCP.

The ExCo is making a concerted effort to increase membership. The TCP has a strong policy relevance within each of its member countries. It provides unbiased technical expertise to policy makers and contributes to documents in the public domain by gathering data for publication. For instance, the HTS TCP maintains this relevance through various channels such as:

- Government officials from Japan and U.S. participate in the ExCo
- One of the German delegates advises the responsible persons in its government
- The Italian representative is supporting the Ministry of Economic Development
- Korea is represented by its electric power company which has a vigorous HTS RD&D program that is among the world's leaders

ALIGNMENT WITH IEA MISSION

The HTS TCP's strategy is aligned with key components of the IEA mission. These include energy efficiency, energy security, system integration of renewables and engaging stakeholders around the world.

- Energy Efficiency: Contributes to several applications with improved efficiency over conventional systems in electricity grids, industry and transportation. Examples include, components for AC and DC grids such as cables, transformers, energy storage systems, busbars, but also induction heaters and in future transportation applications for all-electric aircraft, high-speed train, and electric ships.
- Energy Security: Supports energy security focusing on HTS-based technologies - primarily fault current limiters and superconducting magnetic energy storage systems (SMES), that can help to enhance grid reliability and resilience.

- System Integration of Renewables: Provides research, analysis and information related to the use of HTS components - such as high-capacity power cables, fault current limiters, high-efficiency generators for offshore wind turbines, energy storage, and innovative transformers–able to facilitate increased renewable generation integration in electric grids.
- Engagement Worldwide
  - Actively engages groups of stakeholders, such as electric utilities, governments, the professional engineering community and the RD&D community, worldwide.
  - Connects with other IEA TCPs such as the International Smart Grid Action Network and Wind TCP.

FUTURE ACTIVITIES

Several activities that could be undertaken in the next year include:

- Expanding on the HTS Application Readiness roadmap that describes the market readiness level for where the HTS industry is now and in the future in the electric sector.
- Continue building relationships with other TCPs to explore collaborations, share experiences, and find synergies to use HTS technologies.
- Bridging the gap between technology developers and electric utility system planners by developing technical materials to explain how the systems work and provide best practices and lessons learned from other projects.
- Increase communication and active engagement with relevant industry sectors where appropriate, extending the distribution of policy recommendations to a wider industry audience.
- Continue to document environmental benefits from the future deployment of HTS power equipment.
- Collectively work to build new HTS application projects to help realize environmental benefits.
- Organizing at least two executive committee meetings and co-locating other industry meetings to leverage expertise from other experts.

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About the International Energy Agency

International Energy Agency

The IEA is an autonomous organization which works to ensure reliable, affordable, and clean energy for its 29 member countries and beyond. The IEA has four main areas of focus: energy security, economic development, environmental awareness, and engagement worldwide. Founded in 1974, the IEA was initially designed to help countries coordinate a collective response to major disruptions in the supply of oil such as the crisis of 1973–1974. While this remains a key aspect of its work, the IEA has evolved and expanded. It is at the heart of global dialogue on energy, providing authoritative statistics and analysis.

As an autonomous organization, the IEA examines the full spectrum of energy issues and advocates policies that will enhance the reliability, affordability, and sustainability of energy in its 29 member countries and beyond. The four main areas of IEA focus are:

- Energy security: Promoting diversity, efficiency and flexibility within all energy sectors;
- Economic development: Ensuring the stable supply of energy to IEA member countries and promoting free markets to foster economic growth and eliminate energy poverty;
- Environmental awareness: Enhancing international knowledge of options for tackling climate change; and
- Engagement worldwide: Working closely with non-member countries, especially major producers and consumers, to find solutions to shared energy and environmental concerns.

ENERGY TECHNOLOGY INITIATIVES

The IEA energy technology network is an ever-expanding, co-operative group of more than 6,000 experts that support and encourage global technology collaboration. At the core of the IEA energy technology network are a number of independent, multilateral energy technology initiatives – the IEA Technology Collaboration Programmes (TCPs).

Through these TCPs, of which there are currently more than forty including 4E, experts from governments, industries, businesses, and international and non-governmental organizations from both IEA member and nonmember countries unite to address common technology challenges and share the results of their work. Each TCP has a unique scope and range of activities.

Further information is available at: ***http://www.iea.org/tcp***

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