Superconductivity
INTERNATIONAL ENERGY AGENCY

2023

ANNUAL REPORT

IEA Technology
Collaboration Programme on
High-Temperature Superconductivity

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MESSAGE FROM THE CHAIR

Since September 2023, I have had the honor of chairing the International Energy Agency (IEA) Technology Collaboration Programme (TCP) on High-Temperature Superconductivity (HTS) – with "high-temperature" meaning just a few tens of degrees Kelvin above absolute zero.

But the year 2023 was indeed a "hot" one for superconductivity, with high media interest in the news of the discovery of a room temperature superconductivity material, which was very soon proved to be unfounded. However, this is a good moment to highlight and disseminate the outcomes of the IEA HTS TCP, which, with its publications, aims to reach the stakeholders, the scientific community, and the public with correct and updated information on the state of superconductivity applications in different sectors. Particularly, the HTS TCP is focused on the HTS applications in the power grid.

The work of the TCP in 2023 was in line with the previous years' one and consisted in the organization of both management and technical meetings, as well as in the preparation, publication, and dissemination of two documents. The first document explores how various applications of high-temperature superconducting wire can potentially disrupt markets. The second one is a new roadmap, which identifies the readiness level of high-temperature superconductivity for industrial applications. The progress in base HTS technology, such as materials and cooling systems, can be beneficial for the development and acceleration of all HTS applications – including those for the power grid. It is clear that HTS technology is evolving and entering new sectors, thus making the HTS TCP's systematic approach more and more important. In this view, another document concerning the contribution of HTS applications for Electric Grid Resilience was prepared during 2023 and will be finalized and presented in 2024.

Last but not least, I would like to thank the Vice-Chair Ohsaki-san, the Task Managers, the leadership team, and all the members and sponsors for their constant and fundamental support.

HTS TCP Chair

Laura Serri

WHAT IS HIGH-TEMPERATURE SUPERCONDUCTIVITY?

Superconductivity is a phenomenon that causes certain materials to lose essentially all resistance to the flow of electricity at very low temperatures or under very high pressures. Once those materials pass through their individual critical (and very cold) temperatures, they become superconductors, capable of transmitting electricity at very high currents without losing any of it along the way. In this state, superconducting materials have more than 100 times the current density of copper wire, which allows for more compact cables and other equipment. Superconductors also expel magnetic fields that lock objects into their quantum state, suspending them midair. These capabilities enable a host of applications like contactless weight measurement, touchless biohazard handling, or levitating trains.

Since scientists first discovered superconductivity in 1911 and explained its quantum state in 1957, about a half dozen superconductors have been found. But some materials, like nitrogen, become superconductors at higher temperatures than other materials, like helium, with a critical temperature of 4.2 degrees Kelvin that hovers just above absolute zero. Materials that become superconducting at relatively warmer temperatures would have a significant advantage in most practical applications.

How High-Temperature Superconductivity Can Supercharge the Energy Transition

A room temperature superconductor could fundamentally transform the power, transportation, industrial, and built environment sectors. This promise has led a minority of researchers to falsely claim they discovered it. These claims have made their way through various news media cycles, which has brought positive and negative coverage of the topic. On the positive side, it has slightly increased the knowledge of what superconductivity is and what applications are currently being used in real-world applications. On the other hand, it has attracted negative media attention to superconductivity and revealed a lack of rigor in the peer review process.

In the 37 years since scientists discovered that superconductivity was achievable at much higher temperatures than previously thought, successful R&D efforts have allowed near-resistance-free electricity to power numerous facets of modern life through applications in basic scientific research, medicine, transportation, energy, manufacturing, defense, and quantum computing. Devices based on low-temperature superconductivity have been available in certain specific markets for decades. Superconducting magnets, in particular, are well established in many applications that require very high magnetic fields, such as high-energy physics particle accelerators and magnetic resonance and imaging (MRI) systems – although HTS has since unlocked significant improvements in both applications.

Across the energy landscape, HTS has the potential to supercharge the capacity and resilience of electric grids. Fault current limiters, along with transmission and distribution cables, for instance, have all matured from laboratory-scale projects to fully operational commercial successes in Europe, North America, and Asia. Industrial applications of HTS are beginning to emerge, as well. For instance, superconducting induction heaters can cut extremely energy-intensive, metal-forming industrial processes in half.

The Benefits of High-Temperature Superconductivity

The primary focus of the International Energy Agency's Technology Collaboration Programme on High-Temperature Superconductivity (HTS TCP) is electric transmission and distribution systems, but it also monitors advancements made in wind energy, motors, all electric aircraft, and fusion technology.

Electric Transmission and Distribution Systems

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. HTS cables can carry about five times more 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 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.

Energized in 2021, this medium-voltage HTS AC cable (pictured above) enhances the resiliency of American utility ComEd's grid by connecting three substations in downtown Chicago, Illinois. This networked configuration allows up to three failures to occur before ComEd would their ability to provide electricity to all consumers served by those substations. *Credit: AMSC, https://www.amsc.com/*

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

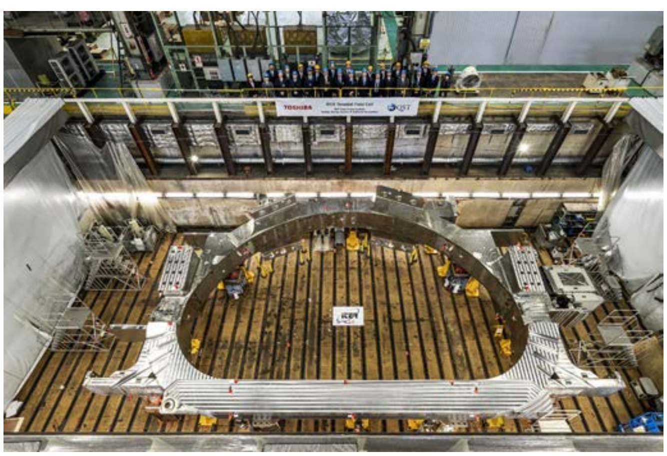
Electric motors account for almost two-thirds of all electric energy consumption in the United States and other developed countries. Superconducting motors have the potential to reduce losses by 50% and can be less than half the size and weight of conventional designs, which can improve the propulsion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

All-Electric Aircraft

The use of lightweight HTS wires could lead to ecofriendly, exceptionally quiet, and highly energy-efficient electric planes. The 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

HTS-based fusion energy significantly improve magnetic fields so they are considerably smaller than conventional, low temperature superconducting magnets. These advancements could lower costs, empower smaller organizations, and create faster schedules compared to larger tokomaks.



The 35-nation collaborative working to build the world's largest fusion demonstrator in southern France received its eighth and final superconducting magnet from manufacturer Toshiba Energy Systems & Solution early in early 2023. With the delivery, ITER now has 10,000 tonnes of magnets with a combined stored magnetic energy of 51 Gigajoules, making it the largest and most integrated superconducting magnet system in the world.
Credit © ITER Organization, http://www.iter.org/

Remaining Challenges

Over the past few decades, significant efforts have been made worldwide on the research, development, and field demonstration of applied HTS devices in 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.

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 increases, it could provide advantages for HTS based solutions.

Other HTS applications are a means to reduce costs by increasing manufacturing volume. Some studies of wire cost versus production volume suggest that the 20,000 km requirement for a commercial fusion reactor could yield wire prices that would make HTS transmission cables economically 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 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.

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 cables. 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 onboard) are perfectly suitable. Economic studies suggest that the efficiency of commercially available refrigerators are inadequate for medium-size utility applications.

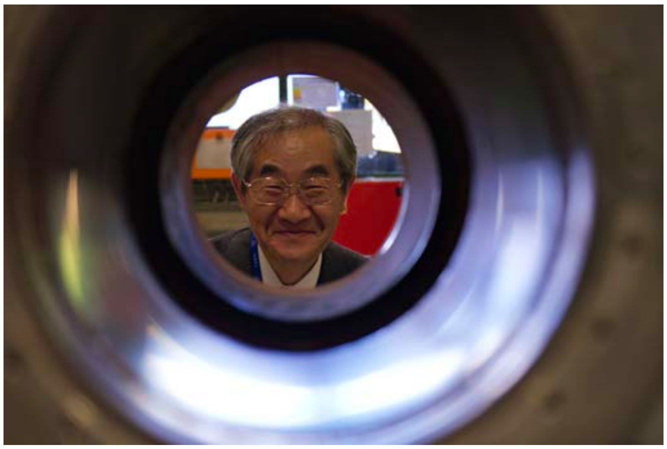
Available refrigerator sizes also are not optimal. Space limitations within the substation for refrigeration equipment, particularly in the dense urban locations most attractive for this application, may require innovative approaches, yet to be determined if not compensated by space savings thanks to 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 two to five years.

Additionally, there is little to 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 is 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. Significant progress has been made in that direction through the publication in 2019 of IEC standards for AC superconducting cables from 6 to 500kV.

Cable Splices

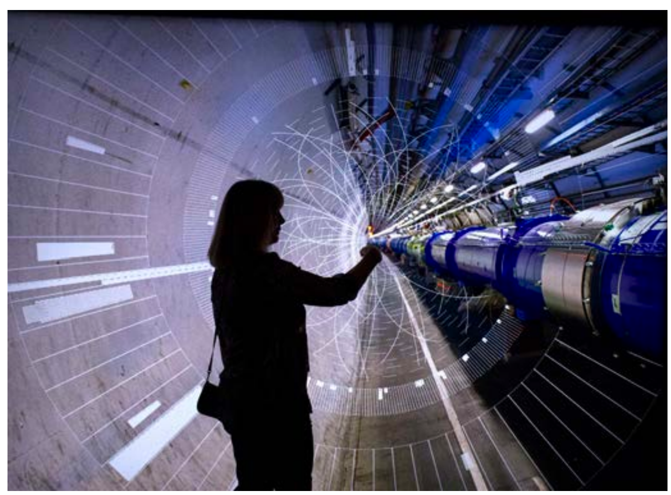
Cable splices between installed sections are a necessary fact for all underground cable systems. Cable splices are by far the weakest link in the cable system and are prone to failure if not properly constructed. Splicing must occur in the field, whether in permanent underground vaults or in temporary 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 IEA HTS TCP works to assess the impact of HTS on the electric power sector. The TCP also monitors the application of HTS in other sectors of the global economy where successful deployments of HTS have created spillover effects that benefit its prospects in electric power sector applications. The TCP's membership consists of government, academic, and industry representatives who collectively plan and pursue activities that identify, assess, and communicate the readiness and benefits of HTS. Some of these activities include:

- Collaborating with electric utilities, governments, professional engineering organizations, and the RD&D community to confirm and communicate the potential benefits of HTS technology
- Sponsoring workshops, co-authoring books and journal articles, exchanging information, introducing Executive Committee (ExCo) members' research facilities to other participants, and guiding the assessments
- Developing position papers and strategic documents, such as roadmaps and technical reports, with input and review from technical experts in TCP member countries, which ensure consistent reporting and progress evaluation across various scientific and engineering fields
- Collaborating with other related IEA TCPs to leverage synergies and opportunities
- Disseminating work at international meetings and workshops, and supporting students, young engineers, and scientists who are learning about HTS applications in the power sector
- Addressing and clarifying real and perceived risks and hurdles to introduce a disruptive technology into the conservative electric power industry



SUMMARY OF THE IEA HTS TCP'S 2023 ACTIVITIES

The 2021-2026 work plan focuses on 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. In the 2021-2026 period, the HTS TCP is focusing 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 has reached a point where HTS operates in numerous electric systems today, but not yet at scale.

The HTS TCP's activities in 2023 demonstrated to key stakeholders that existing HTS technologies are technically and economically viable in several electric power and other related application areas. To achieve this, the HTS TCP worked with its contracting parties to develop technical communications documents that provide information for a range of stakeholders and share critical updates with the wider industry at technical conferences.

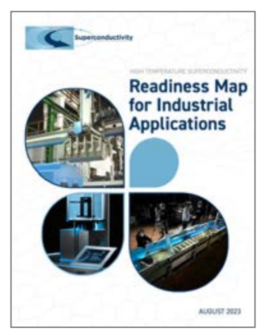
The TCP has maintained a strong policy relevance within each of its member countries. It provided technical expertise to policy makers and contributed to documents in the public domain by gathering data for publication. For instance, the HTS TCP maintains this relevance through various channels such as:

- Government officials from Japan and U.S. who 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

Two Executive Committee meetings were held in 2023, including the first in-person gathering of all HTS TCP members, sponsors, and task managers since the COVID-19 pandemic began in early 2020.

Notable Publications

In April 2023, the TCP published HTS Wire Enabling Market Disruption, a study on the capacity of high-temperature superconducting wire to emerge as a market-disruptive technology that enables entirely new market developments in various economic sectors. The paper discusses how 2G HTS (REBCO) wire has been a gamechanger for magnetic fusion by lowering costs, empowering smaller organizations, and creating faster schedules compared to larger tokomaks like International Thermonuclear Experimental Reactor (ITER).



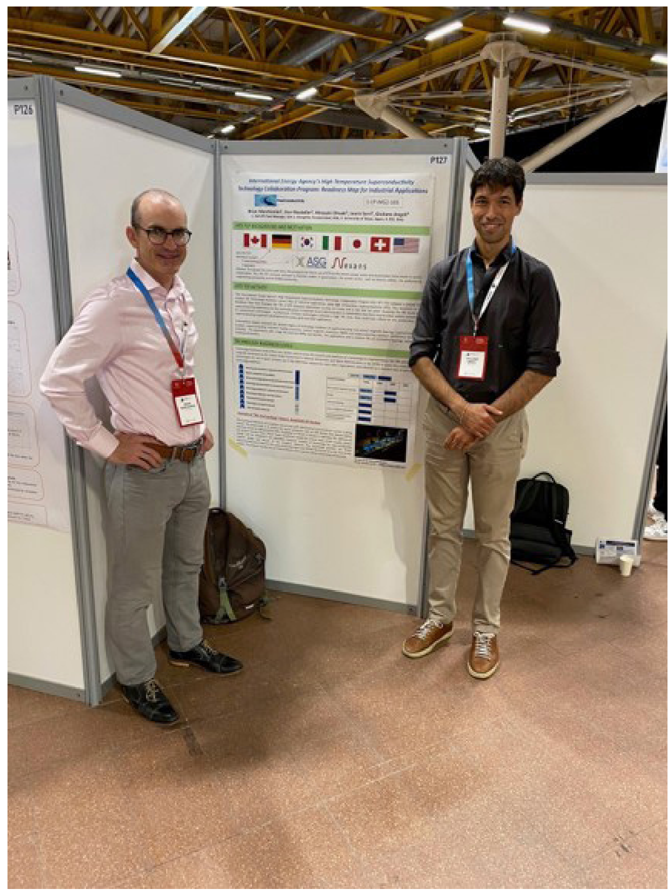
Later in November 2023, the TCP published Readiness Map for Industrial Applications, which analyzes the state of technology readiness levels (TRLs) for industrial applications employing HTS as they are today, and projects their readiness ten years from now. Specifically, this analysis investigated non-contact magnetic bearings, busbars, induction heating processes, nuclear magnetic resonance, and superconducting quantum interference devices. Many of these applications were assessed in the "high-TRL" regime, where technology is most ready to succeed in the commercial marketspace. More than half a dozen experts in each of these fields made contributions to develop this report.

Spring 2023 Executive Committee (ExCo) Meeting – Virtual Meeting, 4 April 2023

All active members of the IEA HTS TCP participated in the Spring 2023 ExCo meeting, which focused on presentations from two guest speakers in addition to an efficient discussion of ExCo business. The TCP first heard from Ziad Melhem of Oxford Quantum Solutions about his newly founded Superconducting Global Alliance, which is striving to connect the capabilities of HTS with various applications, both new and old, that could benefit from HTS-enabled technologies. The TCP and Ziad agreed to identify and coordinate complementary activities across both organizations that could accelerate the investment and deployment of HTS technology, especially in the energy sector. The TCP also learned about an industrial application of HTS from Professor Satoshi Fukui of Niigata University, whose team developed an induction heating approach with HTS.

European Conference on Applied Superconductivity (EUCAS) – 3-7 September 2023

Several TCP members helped organize the 16th European Conference on Applied Superconductivity and delivered talks and even classes on superconductivity research and applications. The HTS TCP Task Manager gave a poster presentation on the industrial applications of HTS and collected additional expertise on the topic from attendees as part of the TCP's market and technology surveillance activities.



Task Manager Brian Marchionini and TCP member Angeli Giuliano standing beside their poster on industrial applications of HTS at EUCAS 2023.

Fall 2023 Executive Committee (ExCo) Meeting – In-Person Meeting, 18-20 September 2023 in Geneva, Switzerland

At the TCP's first in-person, post-pandemic Executive Committee meeting, country representatives, sponsors, and other invited guests gathered in Geneva, Switzerland to exchange updates on the latest HTS industry developments in their countries and plan future TCP activities. New installations of HTS-enabled equipment in Chinese and Korean grids were discussed in addition to the latest developments of America's first commercial deployment of HTS cables in Chicago, Illinois and the SUPERlink project in Munich, Germany that will become the longest HTS cable ever installed once it's energized.

The TCP also elected its new Chair and Vice Chair positions at this meeting and set forth plans to develop white papers on standardization needs in the HTS sector. The group also made its 2024 conference attendance plans, reviewed the proceedings of key HTS industry conferences in 2023, discussed communication and outreach plans, refined its new member and sponsor recruitment strategy, and welcomed guest presentations from the IEA Secretariat, CERN, and Shanghai. The TCP also toured several of CERN's facilities with Senior Staff Scientist and deputy group leader of Magnets, Superconductors and Cryostats (MSC) group Amalia Ballarino, who gave TCP members a tour of facilities where work is underway to upgrade CERN's Large Hadron Collider with the latest HTS technology.

Members of the IEA HTS TCP Executive Committee (ExCo) stand on the steps of Foundation Hardt in Geneva, Switzerland at the Fall 2023 ExCo meeting.

HTS PROJECTS AROUND THE WORLD

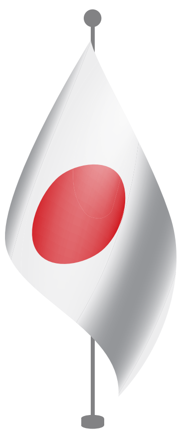
Around the world, projects are demonstrating the technical feasibility of electric power equipment incorporating HTS tapes. Here are some of the latest developments in HTS TCP member countries.

Germany

The latest HTS research, development, demonstration, and deployment (RDD&D) activities in Germany are currently advancing applications of HTS in its energy, industrial, and transportation sectors. As part of Germany's efforts to expand its transmission grid and support the energy transition, Germany commissioned the SuperLink project in 2020 to design, build, and test all the components of a 110 kilovolt, 500 megavolt-ampere HTS cable in an active grid substation. In 2023, the SuperLink consortium concluded the type tests of this 150-meter-long cable, which they will install, energize, and operate as a complete system for six months in 2024. Lessons learned from this field demonstration will inform the construction and operation of the world's longest HTS cable: a 12-kilometer-long HTS distribution cable that will run underground through the center of Munich to connect a load center in the city's south to the transmission grid north of Munich.

Italy

At the beginning of 2022, a new three-year project started on the evolution, planning, programming, and operation of electricity networks. The goal of its first task is the investigation of insulated and non-insulated superconducting windings based on 2G tapes in AC and DC. In the superconductivity lab of Ricerca sul Sistema Energetico – RSE S.p.A. (Milano), a new support for layer-wound HTS coils was designed, realized, and tested in collaboration with the University of Bologna. In the second task, a dedicated software called OSCaR (Optimization tool for Superconducting Cable Research) was developed. OSCaR targets multiple cost indexes and cable design parameters, and an application of this code is concerned with DC MgB2 cables.



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 termination of a tri-axial superconducting cable, courtesy of NEDO's existing facilities. The cable was installed on an existing rack, which is located about 5 meters above the ground, which required a cable bend of 90 degrees (bending radius 1.5 meters) at four locations. The cable's flexibility 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 it can be used for complex plant layouts.

Korea

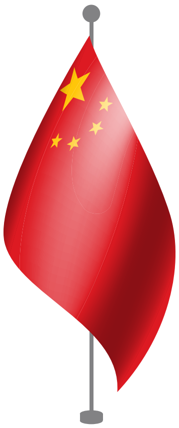
The KEPCO-sponsored Shingal Heungdeok triple-core HTS power cable project was energized in July 2019 and has been operating as expected. The success of this project has spawned an additional project. The MunSan Project is planned to have two HTS cables that are each 1km long and operational at 23kV, 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 2025.

United States of America

Since August 2021, the Resilient Electric Grid (REG) system has been a permanent asset of the Chicago Illinois's electric grid designed to improve reliability and resiliency while reducing disruption to public infrastructure. The REG system enables 200 times more power than 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. The partners are AMSC and the Commonwealth Edison Company (ComEd).

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.

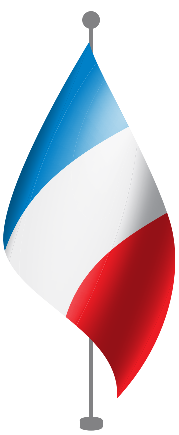
OTHER HTS ACTIVITY AROUND THE WORLD



China

China has integrated HTS-enabled applications such as electric power transmission, maglev trains, induction heaters, and magnets. In 2020, China added the world's first transmission voltage superconducting fault current limiter to its power grid on Nan'ao Island to enhance its reliability and resilience. In 2021, China energized two, tri axial HTS distribution cables in Shenzhen and Shanghai, and their operational success helped initiate conversations in 2023 for a 5-kilometer-long cable, which if commissioned, would become the second-longest HTS cable in the world. Last year, CRCC Changchun Railway Vehicles Co. Ltd. completed China's first test run of a superconducting maglev train that could someday reach speeds of 1,000 kilometers per hour (in a low vacuum tunnel).

Today, China has several manufacturers of rare-earth barium copper oxide (REBCO) tapes are producing in large volumes. The fusion energy race is propelling the production of HTS tape in China, as well, while second generation HTS tapes with lower prices are also highly anticipated.



France

The Super Rail project will install two superconducting DC cables near Montparnasse station in Paris. This is the first time that cables of this type will be integrated into a rail network and is set to be the first permanent installation in France on any network. These power cables will help secure the network at a time when rail traffic is constantly growing in mega-cities. Nexans and its partners won the project from Bpifrance (French Public Investment Bank) under the "Investissements d'Avenir" (Investments for the Future) initiative coordinated by SNCF Réseau. Partners of the project include SWM, NKT, Linde, THEVA, University of Applied Sciences South Westphalia, and KIT.

WORKING ARRANGEMENT

The Task Manager is based in the United States and works closely with the Presidium and ExCo to execute on the duties in their annual work plan. The HTS TCP operation is supported by a combination of cost-, task-, and knowledge-sharing. ExCo members have historically covered their own travel expenses to attend ExCo meetings and industry workshops.

The ExCo Chair, Vice Chair, 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 with a Common Fund to which all HTS TCP members contribute. No changes to either the working arrangement or current structure fee are anticipated. The fee structure is 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.

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.

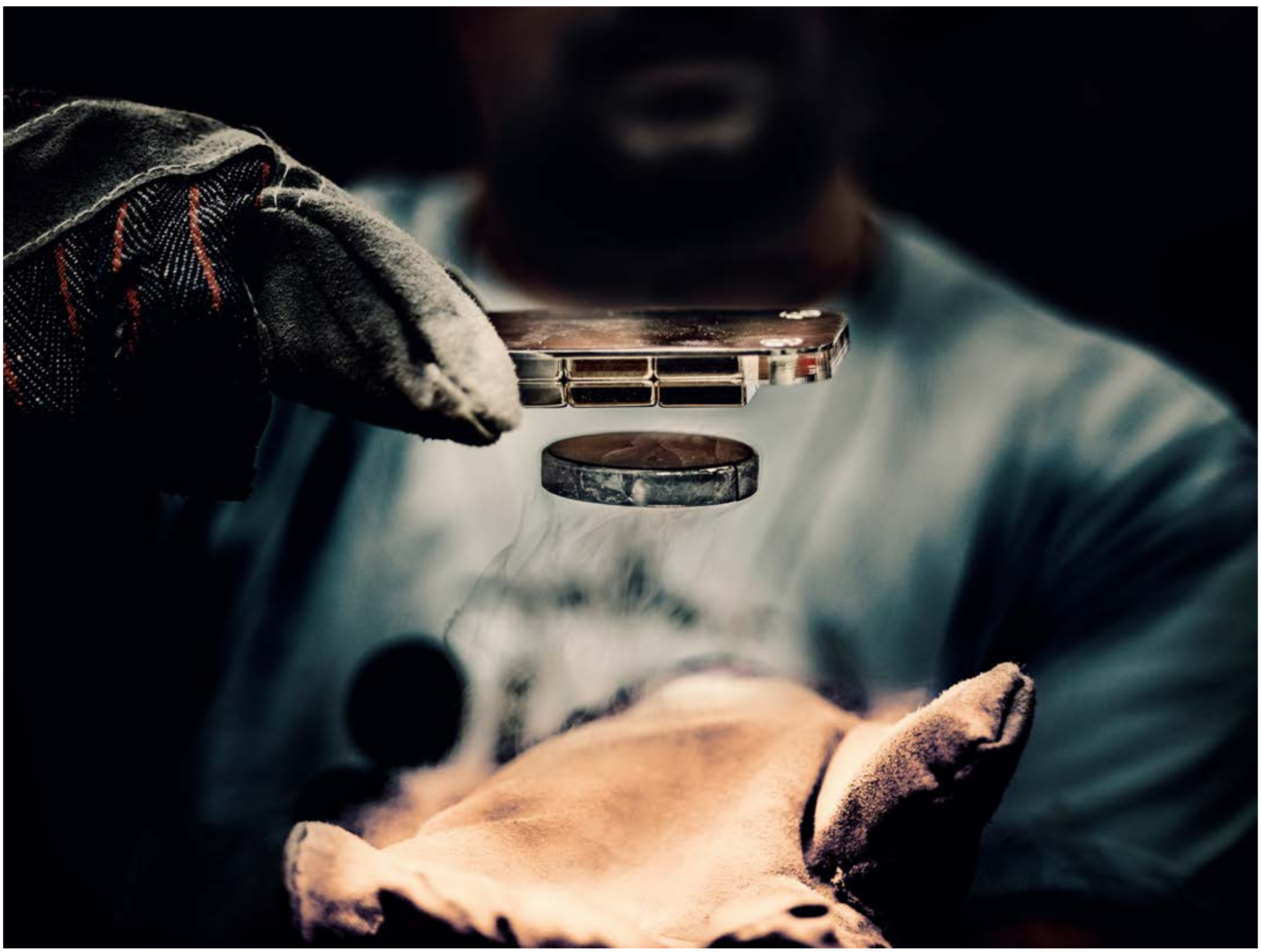
- **Energy Efficiency:** Contributes to several applications with improved efficiency over conventional systems in electricity grids, industry, and transportation. Examples include components for AC and DC grids such as cables, transformers, energy storage systems, busbars, but also induction heaters 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. The TCP connects with other IEA TCPs such as the International Smart Grid Action Network and Wind TCP.

Future Activities

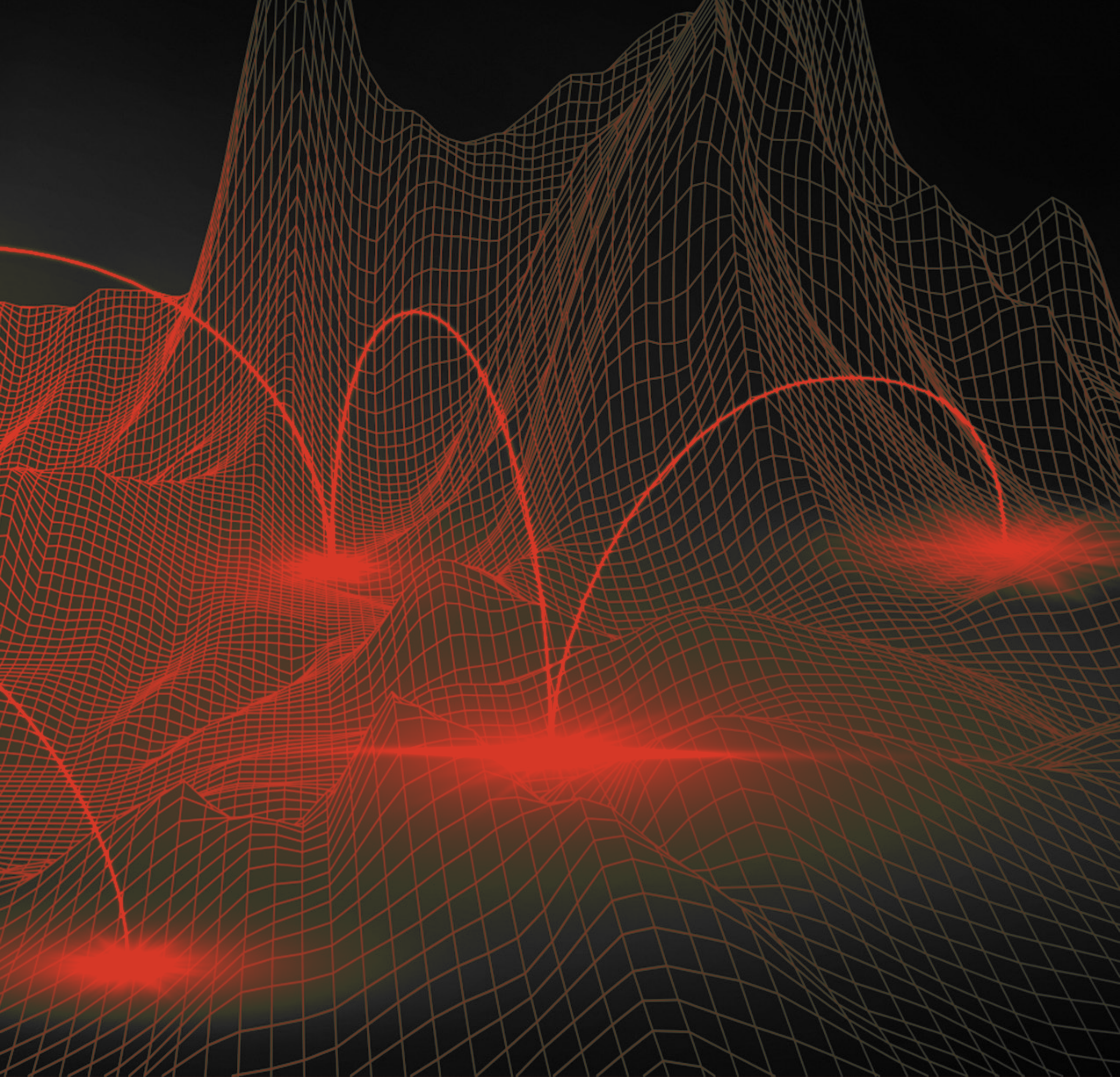
Several activities planned for 2024 include:

- The TCP is planning to hold a joint meeting with the IEA Wind TCP to explore the viability of applying HTS technologies in wind turbines in 2024, such as superconducting motors that could boost performance. Both TCPs plan to explore ways to partner and learn from one another in this meeting.

- The TCP will hold a virtual Spring Executive Committee meeting in April. The current plans are to invite a guest speaker from an emerging HTS application area (e.g. industrial sectors, fusion) from the industry or one of the TCPs with which the IEA HTS TCP is coordinating.
- The group is developing a report on HTS Applications for Electric Grid Resilience, which details how HTS applications can help improve the resilience of electric delivery systems worldwide. The importance of improving the resilience of energy systems worldwide was evident in a recent IEA End Use Working Group (EUWG) meeting, which inspired the TCP to develop a new publication that will identify existing threats to energy reliability and describe where HTS is a well-suited to mitigate those risks and thereby enhance resilience.
- The TCP will hold its next in-person ExCo meeting in Karlsruhe, Germany and tour the SuperLink demonstration cable at the Karlsruhe Institute for Technology (KIT).



CONTACT INFORMATION FOR EXCO DELEGATES / ALTERNATES, SPONSORS, AND TASK MANAGERS



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ABOUT THE INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA)

At the heart of the global dialogue on energy security and clean energy transitions, the International Energy Agency (IEA) is the world's leading energy authority. IEA works with governments and industry to shape a secure and sustainable energy future for all. It provides reliable and comprehensive data, analysis, and policy recommendations with the goal of shaping a secure, sustainable, and affordable energy future for all while meeting the climate change objectives of the 2015 Paris Agreement.

The IEA was founded in 1974 to ensure the security of oil supplies. Energy security remains a central part of its mission, but today's IEA has a wider mandate. In 2015, the IEA's Ministerial Meeting approved the modernization strategy presented by the Agency's newly appointed Executive Director, Dr. Fatih Birol, to strengthen and broaden the Agency's commitment to energy security beyond oil, to engage with major emerging economies, and to provide a greater focus on clean energy technology, including energy efficiency.

Today's IEA focuses on a full range of energy issues, including climate change and decarbonization, energy access and efficiency, investment and innovation, and ensuring reliable, affordable and sustainable energy systems. It examines the full spectrum issues including renewables, oil, gas and coal supply and demand, energy efficiency, clean energy technologies, electricity systems and markets, access to energy, demand-side management, and much more.

Since 2015, the IEA has opened its doors to major emerging countries to expand its global impact, and deepen cooperation in energy security, data and statistics, energy policy analysis, energy efficiency, and the growing use of clean energy technologies. This "open door" policy has since allowed the IEA to deepen its collaboration with 13 new countries through the Association programme: Argentina, Brazil, China, Egypt, India, Indonesia, Morocco, Thailand, Singapore, South Africa, and most recently, Ukraine, which joined in 2022, and Kenya and Senegal, which joined in 2023. This IEA family of members and association countries now represents over 80% of global energy consumption, up from 40% in 2015.

IEA member governments agreed to further expand the Agency's mandate at the Ministerial Meeting of March 2022, to guide countries as they build net-zero emission energy systems to comply with internationally agreed climate goals, and to broaden the Agency's scope to include the critical minerals and metals needed to develop clear energy technologies.

The Technology Collaboration Programme

The Technology Collaboration Programme is a multilateral mechanism established by the International Energy Agency that was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of thousands of experts across government, academia and industry in 55 countries dedicated to advancing common research and the application of specific energy technologies.

The Technology Collaboration Programme supports the work of independent, international groups of experts that enable governments and industries from around the world to lead programs and projects on a wide range of energy technologies and related issues. The experts in these collaborations work to advance the research, development, and commercialization of energy technologies. The scope and strategy of each collaboration is in keeping with the IEA Shared Goals of energy security, environmental protection, and economic growth, as well as engagement worldwide.

The breadth of the analytical expertise in the Technology Collaboration Programme is a unique asset to the global transition to a cleaner energy future. These collaborations involve over 6,000 experts worldwide who represent nearly 300 public and private organizations located in 55 countries, including many from IEA Association countries such as China, India, and Brazil.

Currently there are 38 individual technology collaborations working across several technology or sector categories: energy efficiency end-use technologies (buildings, transport, industry and electricity), renewable energy and hydrogen, fossil energies, fusion power, and cross-cutting issues.

Disclaimer

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