The Applied Superconductivity Conference (ASC 2024)

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for

Greener, Healthier, Prosperous and Sustainable Future

Special Session – 3LOr2B

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WG1 Fusion: Conveners: Prof. Chris Grovenor and Dr. Neil Mitchel
WG2 Power, Energy & Industry Conveners: Sastry Pamidi and Michael Parizh
WG3 Transport: Conveners: Marco Breschi, Arno Godeke and Loïc Quéval

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Impact Statement

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- You have heard at the conference about all the excellent superconducting technologies.
- If implemented on a large scale, Superconducting Fusion, Power, Industry, and Transport technologies will enable net-zero emissions targets while creating fulfilling jobs and wealth.
- Beyond their direct impact, Superconducting Power and Transport technologies will catalyze other green technologies, such as the large-scale integration of renewable energies and green hydrogen.
- If fielded widely, Superconducting Power and Transport technologies pave the way for a more sustainable and green energy future. We are at an opportune moment to deliver substantial value.

WP1- Fusion- Grand Challenges and strategic

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WG theme ambition	<4 Years	<7 Years	<10 Years
The 10 – 100 – 1000 challenge Within 10 years to achieve 100 MW for 1000 seconds	• Design nearing, completion, • Contracting for long lead items (buildings, conductors, vessels) is well underway.	• Buildings complete, • first components being delivered to (or manufactured on) site.	• Start of commissioning.

- This is not a Fusion Power Plant…it's a demonstration that magnetic fusion CAN deliver energy
- It STILL needs significant Tritium and Tritium handling capability
- Two contenders so far, both report being well ahead of the schedule
  - Commonwealth Fusion Systems, HTS SC technology, and innovative magnets
  - BEST (ASIPP China), LTS SC technology and 'conventional' magnets (ITER style)

WP1 – Fusion - Mechanisms (Funding, Sharing)

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- Effective deployment of superconducting technology in support of the fusion mission is limited neither by *performance* nor *technical considerations*.
- Focus has shifted to the *materials supply chain*, *magnet technology* (joints, insulation, QD), and the less developed reactor components (*FW, blanket, tritium*)

The incorporation of superconductivity into real fusion machines is being accelerated by private initiatives and public-private partnerships (like those initiated in the USA, Germany and France)

Areas where public-private partnerships have their focus

- HTS supply chain and conductor development
- Sharing data on the performance of superconducting, structural, insulating, and sensing materials under fusion-specific conditions (result sharing can be limited by IP concerns)
- Addressing technical challenges of reliable & critical magnet technology (joints, insulation, QD etc) by designing and testing models & prototypes, to build confidence in the long-term reliability of the technology. Design sharing will be limited but shared/common test facilities may be attractive

WP1 – Fusion Summary of technology limitations

What is holding us back

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Area of concern	Current Status	Recommendations
High Temperature Superconductors, operating at or above 20K		
1. Materials	TRL 8-9 but in limited quantities	Develop incentives for increased production
2. Functional cables	TRL4-5	Accelerated programme of development + Sharing of information
3. Simulation tools	TRL6	Underpinning data needed to validate models
Supporting technologies/capabilities		
1. Structural and functional materials	TRL 8-9 but key data missing If new materials are specified, the supply chain will have to be developed	Shared open database (where no IP conflict) Develop manufacturing capabilities through large trial programmes
2. Shared major test facilities	Some under development/consideration, but serious funding and IP issues	Community needs to decide if it can work together to avoid expensive redundancy
3. Workforce	Scarce at all levels	Urgent emphasis on training and career development at graduate, technical and apprentice levels

WP2 – Power, Energy, and Industry - Grand Challenges

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Overarching Goal	<4 Years	<7 Years	<10 Years
Establish the technical and economic competitiveness, and necessity to achieve Net-Zero Targets of Superconducting Power, Energy, and Industry Applications	• Establish Regional Industry Support Centers to assist businesses to develop SC Power Technologies • Use the Centers to develop trained workforce	• Long-tern demonstration of SC Cables, Wind Generators to retire risks, showcase, and establish confidence	• Operating superconducting substation with integrated multiple SC Devices

Five Grand Challenges of WG2: Superconducting Power and Energy Technologies

1. Regional power and energy centers for supporting the superconducting industry
2. Long-duration tests for superconducting power cables to retire risks
3. Establishing the baseline designs of a 25 MW superconducting wind generator
4. Establishment of standards for superconducting power and energy technologies
5. Showcase integration of power technologies in a superconducting substation

WG2: Strategic roadmap

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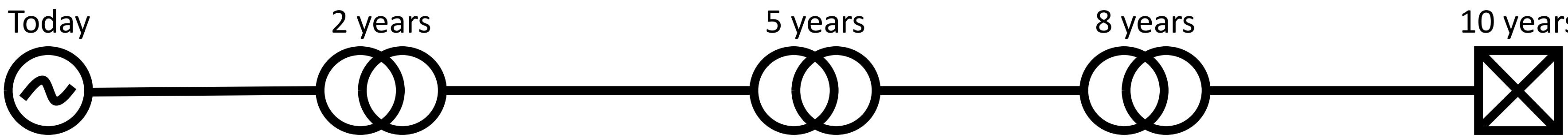

- Build collaborations
- Secure funding

#1 – Develop conductors & cables supply chains

#2 – Create 4 regional superconducting centers

#3 – Develop open environmental and techno-economic life-cycle assessment codes & databases

#4a – Superconducting power cable systems

#4b – Multi-MW superconducting conversion chain from basic blocks ………… to integrated prototype

#4c – Superconducting substation

#5 – Join working groups/develop industry standards

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Current Status of HTS Power and Energy Applications

- Governments have set ambitious targets for reducing greenhouse gas emissions.
- Superconductivity can play an important role in achieving net-zero emissions targets in the Power, Industry, and Transport sectors.
- Startups and Large Projects are underway – examples: VEIR, SuperLink, and more
- We need to organize globally to move the superconducting technologies to the marketplace
- It is impossible to meet the emissions targets without superconducting technologies

REG, Chicago

EcoSwing, Denmark

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Grand challenge # 1: Regional power and energy centers for supporting the superconducting industry

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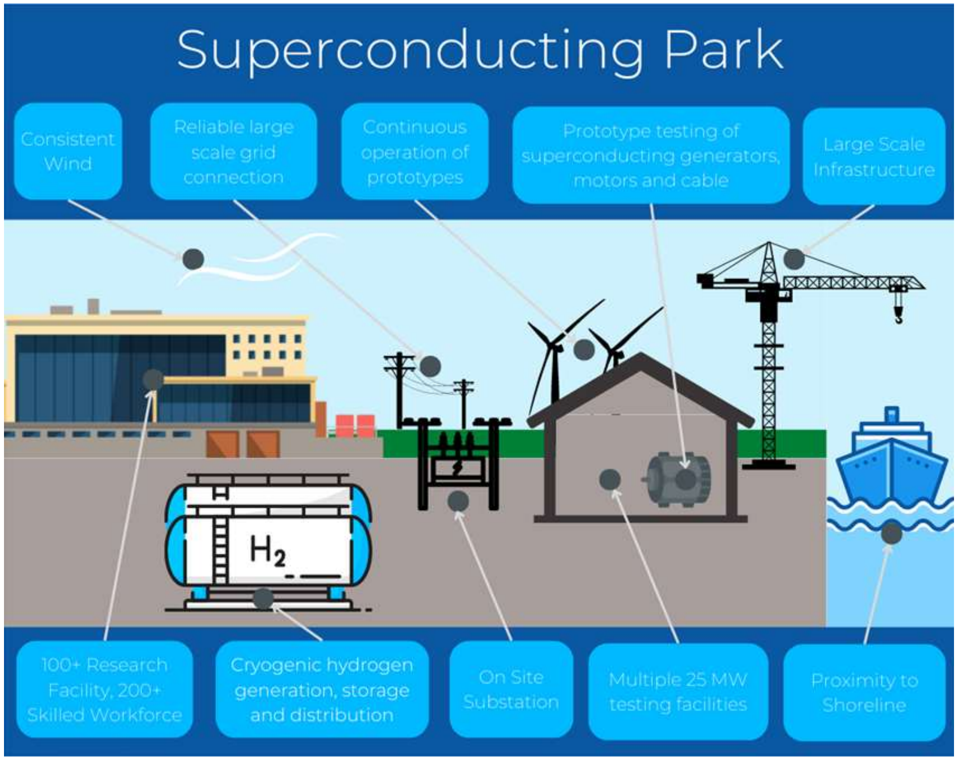
Challenge #1: Entry barriers

- "Large initial investments required are hindering companies to venture into this new technology."
- "There is a shortage of skilled workers with the required multidisciplinary expertise in high-voltage and high-current electrical system operations, cryogenics and material science."

Action #1: Create 4 regional superconducting centers

- Test centers with the necessary electrical power (MW scale) and cryogenic infrastructure.
- Expertise center to assist industries in design, development, prototyping and long-term operational tests.
- Education center to train and develop the next generation of professionals in this field
- All under one single roof.



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Grand challenge # 2: Long-duration tests for superconducting power cables and wind generators components to retire risks

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Challenge #2: Lack of data and public information on long-duration operation of power cable and other devices, including cryogenic systems

- Lack of precompetitive technology demonstration with open access to the challenges and the mitigations devised – electric utilities know the benefits, but worried about cryogenics and unknown risks

Action #2: Long-duration tests for superconducting power cables and wind generators components to retire risks

- To showcase the technologies broadly
- To openly discuss operational challenges encountered and solutions devised
- Open access to operational and maintenance costs
- Showcase competing technologies – termination designs, cryogenic systems, superconducting material
- Trusted data on the relative merits of conductor choice/cryogenic system choice/cable design choice

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Grand challenge # 3: Establishing the baseline designs of a 25 MW superconducting wind generator

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Challenge #3: Lack bold vision for large Superconducting Wind Generator Design Concepts

- Conventional technologies are moving past 10 MW. Superconducting technologies must target ~25 MW systems

Action #2: Feasibility studies and baseline design options for 25 MW generators – on-shore and off-shore

- To show the possibilities
- Engage potential producers with the possibilities
- Demonstrate a module/coil and cryogenic cooling effectiveness
- Challenge # 1 will support component testing and design validation

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1. Grand challenge # 4 & 5: Establishment of standards & Showcase a superconducting substation with power technologies

Action #4: Engage with industry and standards organizations to develop standards for superconducting power devices, design validations, cryogenic interfaces

Action #4: Grand Grand Challenge - Showcase a superconducting substation with multiple power technologies and cryogenic systems, including integration of liquid hydrogen

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WP3 - Transport – Grand challenges and Strategic roadmap

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Ambition	4 years	7 years	10 years
1. Fully-superconducting motor	Basic technology elements available and demonstrated	Prototype demonstrated in a lab	Ready for commercial use in aviation
2. Fully-superconducting generator	Basic technology elements available and demonstrated	Prototype demonstrated in a lab	Ready for commercial use in aviation
3. DC HTS cable	Demonstrated in lab	Ready for commercial use in aviation	
4. AC HTS cable	Demonstrated in lab	Ready for commercial use in aviation	
5. Cryogenic power electronics	Optimized for cryogenic usage	Required components demonstrated in a lab	Ready for commercial use in aviation
6. Liquid hydrogen storage and distribution	Safety criteria established	The prototype demonstrated in a lab	Ready for commercial use in aviation
7. System level integration	Design refinements based on component performances	Selection of optimal configuration and design	Ready for commercial use in aviation

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Call for action

- Let us come together to advocate for superconducting technologies.
- Promote the benefits of superconducting technologies to businesses, investors, and the general public.
- Train students in superconducting technologies if you have opportunities.
- Please support the international effort to establish Government-Industry-Academia-Trade Organizations-NGO partnerships to commercialize superconducting power, energy, and transport technologies.

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Concluding remarks

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- Superconducting Fusion, Power, Industry, and Transport technologies will enable net-zero emissions targets, while creating fulfilling jobs and wealth.

- Superconducting technologies, in addition to their direct impact, will serve as a catalyst for other green technologies, enabling the large-scale integration of renewable energies such as green hydrogen and paving the way for a more sustainable future.

- With the new policies for green energy technologies, the synergies between hydrogen and superconducting technologies, and the high TRLs, we are at an opportune moment to deliver substantial value.




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