

Superconductivity Global Alliance (ScGA) for

A Greener, Healthier, Prosperous and Sustainable Future

Special Session

Professor Ziad Melhem
Founder and CEO

Oxford Quantum Solutions Ltd., Oxford, UK

2OrA1

Date: 12th Sep 2023

Time: 16:00-18:00



Agenda

Presentations

2OrA1 - Special Session ScGA

Grand Theatre – Amphitheatre

16:00 **2OrA1-1**

Superconductivity Global Alliance (ScGA) Initiative Overview

Ziad MELHEM, Oxford Quantum Solutions Ltd, UNITED KINGDOM

16:20 **2OrA1-2**

ScGA - Strategic Roadmap of Grand Challenges in Fusion

Neil MITCHELL, ITER Organization, Saint-Paul-lez-Durance, FRANCE

16:28 **2OrA1-3**

ScGA - Strategic Roadmap of Grand Challenges in Power, Industry & Transport

Sastry PAMIDI, FAMU-FSU College of Engineering and the Center for Advanced Power Systems, Tallahassee, USA

16:36 **2OrA1-4**

ScGA - Strategic Roadmap of Grand Challenges in Healthcare

Kathleen AMM, Brookhaven National Laboratory, Upton, USA

16:44 **2OrA1-5**

ScGA - Strategic Roadmap of Grand Challenges in Smart Science

Mark BIRD, NHMFL - FSU, Tallahassee, USA

16:52 **2OrA1-6**

ScGA - Strategic Roadmap of Grand Challenges in Materials for Magnet Applications

Venkat SELVAMANICKAM, University of Houston, AMPeers LLC, Houston, USA

Panel Discussion (1 hour)

Chairs of the Special Session

- Prof. Steve Gourlay (FNAL, USA)
- Dr. Kazuhiko Hayashi (ISIS Chairman and CSSJ Executive Director, Japan)

Challenges & Drivers

Europe 15th July 2021

California 18th July 2021

UAE 17th July 2021



Greenland 2021 - melting
6 X times faster than 1990

Antarctica Icebergs melting fast!



UN Sustainable Development Goals – 17 in total Target completion date 2035!



Key takeaway
Need new innovations!....
Superconducting materials and technologies are
transformational innovations that can *and* will help

Zero Carbon Emission targets

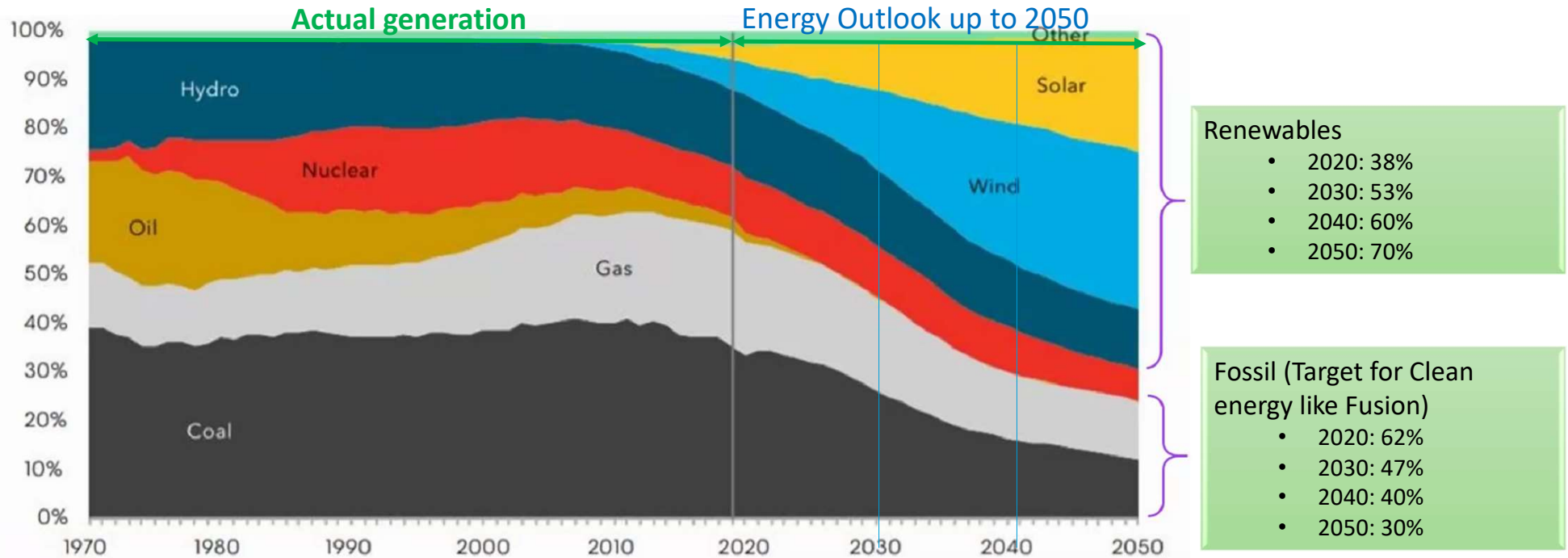
- Achieving net zero requires a significant overhaul of our
 - **Energy systems, transportation, agriculture, and industrial practices.**
- There is an urgent global need to address climate change
 - Unprecedented changes are driven by
 - **Burning fossil fuels, deforestation & industrial processes**
 - Visible impacts of climate change
 - **Rising temperature & Extreme weather events**
 - **Melting ice caps & Sea level rise**
- **The scientific message is clear**
 - **To prevent catastrophic and irreversible consequences of climate change requires serious effort to **reduce greenhouse gas emissions****
 - **Achieving zero carbon emissions by 2050 is an **ambitious but necessary target****
 - Leading us toward a sustainable and resilient future



Superconductivity will be instrumental in addressing zero carbon emission targets **by 2050**

Estimated Global Electricity Generation Mix

New Energy Outlook 2020 report by Bloomberg (2020)



Key takeaway

- Estimated investment in Electricity generation ~ \$20 Trillion by 2050
- ~ 30% generation by Fossil fuels equivalent to \$ 6.6 Trillion
 - The potential addressable market for Fusion is **VERY LARGE!** (> 35 private companies!)

HTS-based technologies are very climate-positive technologies

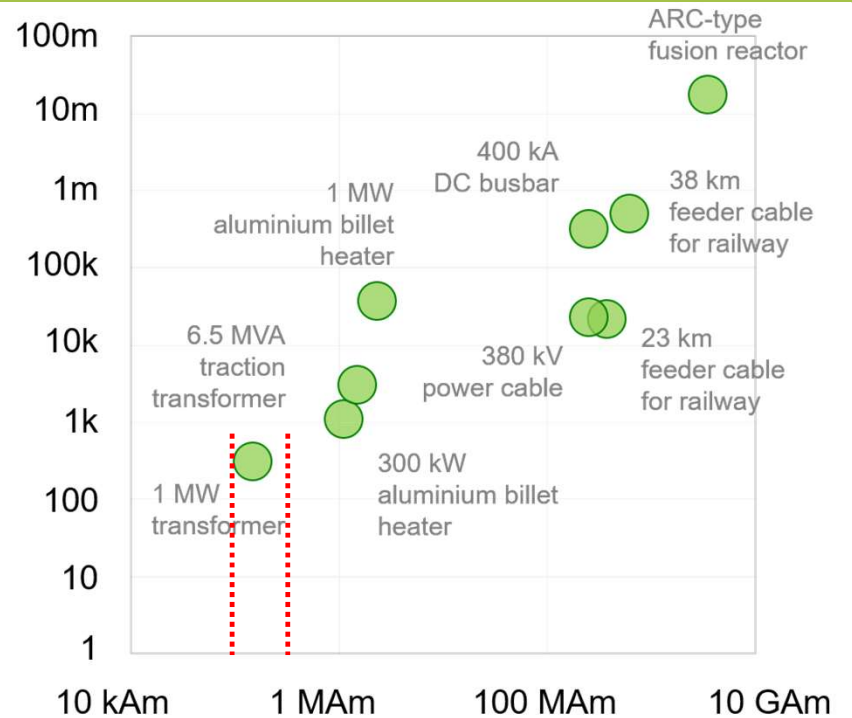
- On average, HTS projects mitigate **5 t CO₂eq / kAm**.
- 5 tons of CO₂ is the mitigation effect of a very large tree.



Example of calculation (for fusion)

- 3.3 kWh is needed to make 1 kAm of HTS, so the production of HTS is the cause of 1.6 kg of CO₂eq emissions per kAm.
- One ARC-like 200 MWe tokamak requires ~3,500,000 kAm of HTS tape to be built and can produce 3.72*10¹⁰ kWh of energy in 25 years, mitigating 17,684,250 tons of CO₂eq.

Carbon-negativity over project lifetime
ton CO₂eq



Volume of HTS needed to make a project

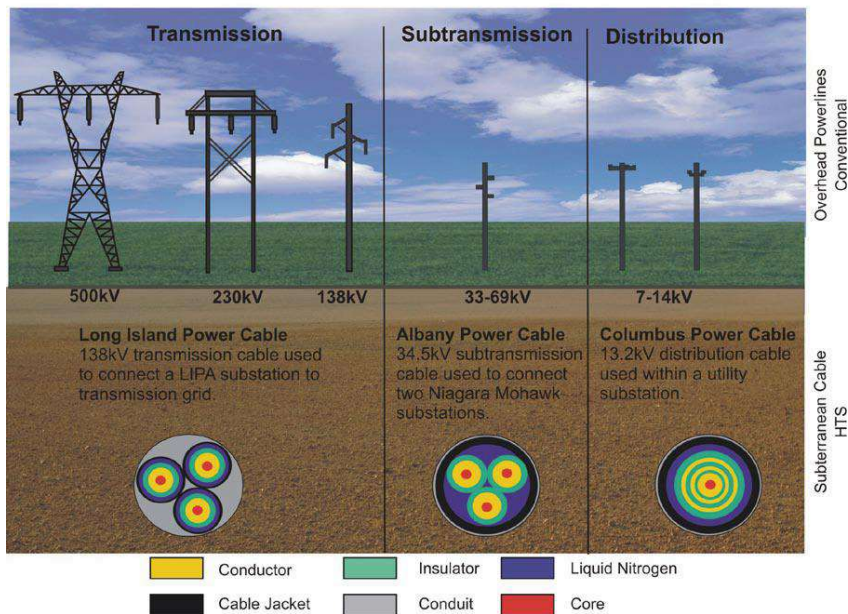
Courtesy of Sergey Samoilenkov



Power Applications- HTS vs Conventional

Power cables

Comparison of Overhead Conventional Powerlines to Underground HTS Cables



HTS technology enables smaller rights-of-way, requires less metals, and reduces carbon emissions

DoE graph, available at: <https://www.intechopen.com/chapters/16185>

Wind generators



| Parameter | Conventional | HTS |
|-----------|--------------|---------|
| Power | 12 MW | 12 MW |
| Weight | 365 ton | 180 ton |

Design and Analysis of a 12 MW superconducting wind power generator, Minwon Park, 2014 Coated Conductors for Applications Workshop, Korea

Superconductivity Global Alliance (ScGA) initiative

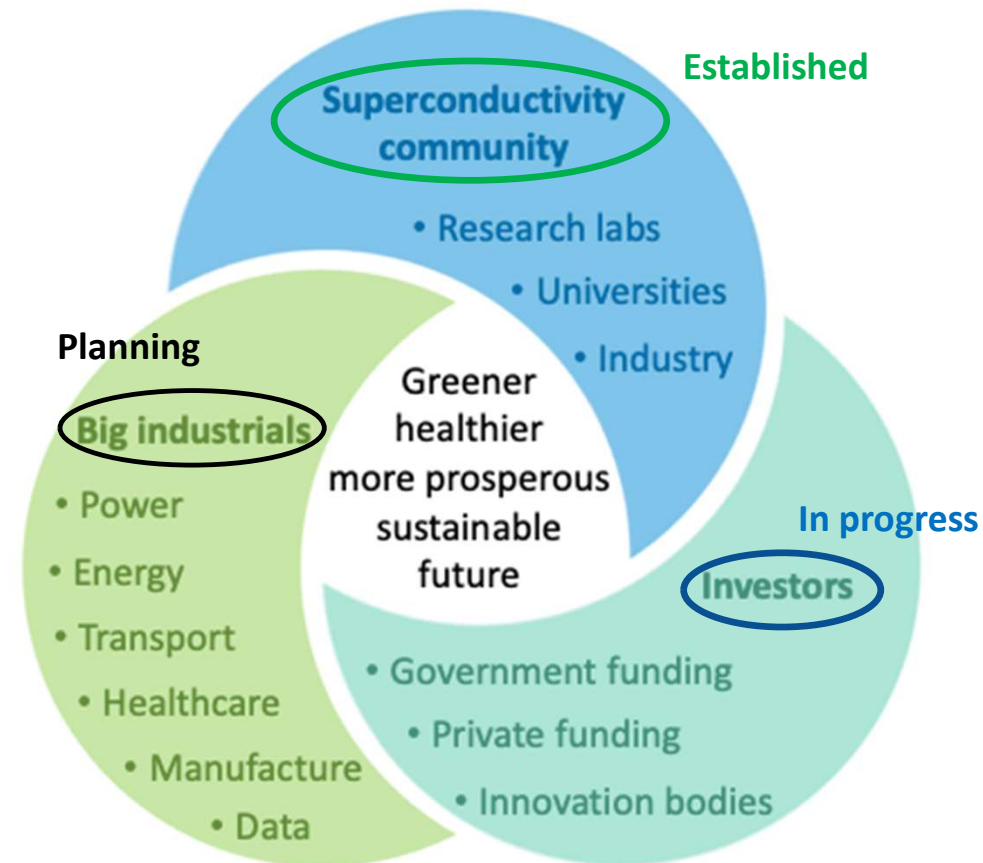
Superconductivity has already enabled major advances and capabilities such as MRI, NMR, high magnetic field research, and high energy physics accelerators which otherwise would not be possible. In the future, superconductivity will provide a means towards zero-emission targets, for example by enabling fusion power, expanding usage of wind power, and facilitating zero-emission transportation, as well as enabling new technologies such as superconducting classical and quantum computing, water purification, new medical diagnosis and therapy tools, and new scientific breakthrough



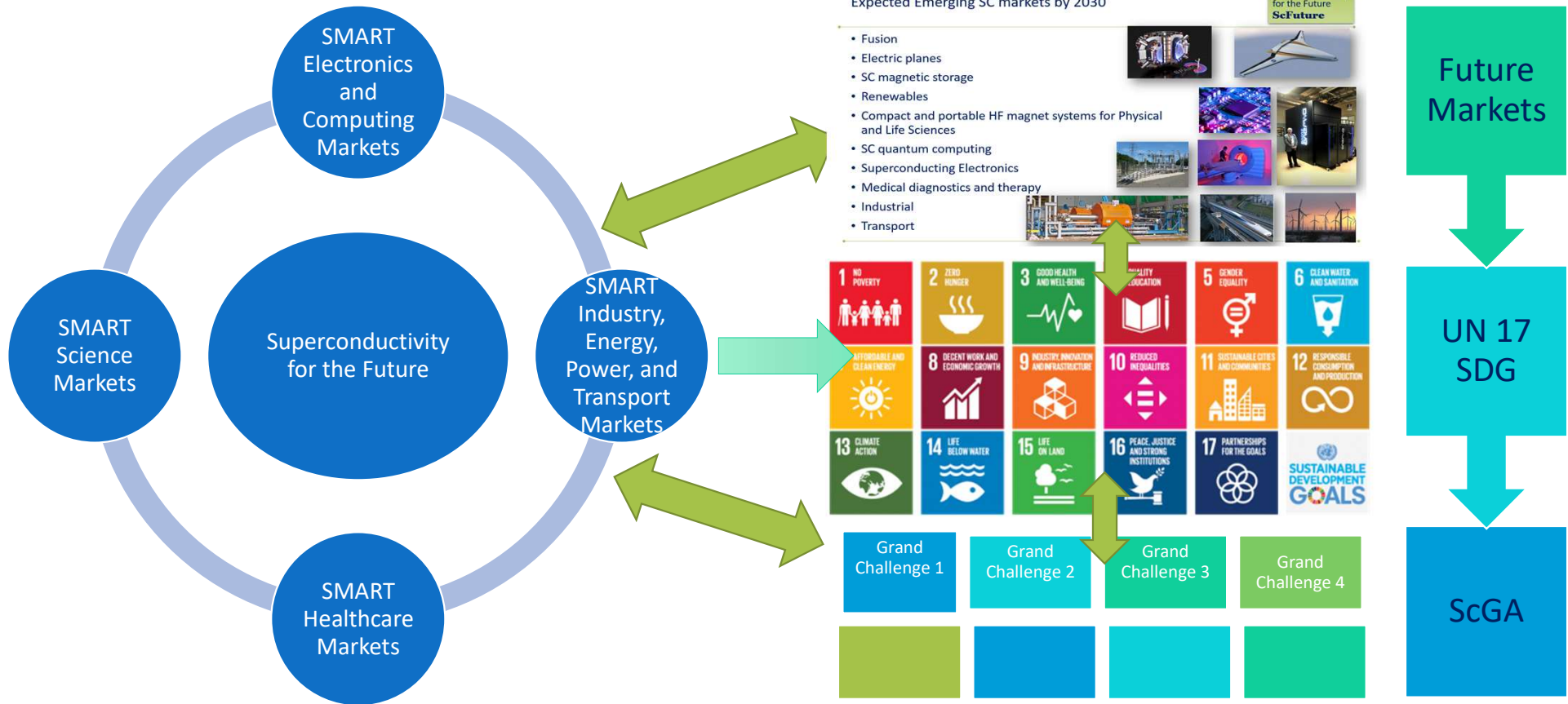
**Superconductivity from the Frontier end to
Mainstream technologies**

ScGA initiative - The Proposal

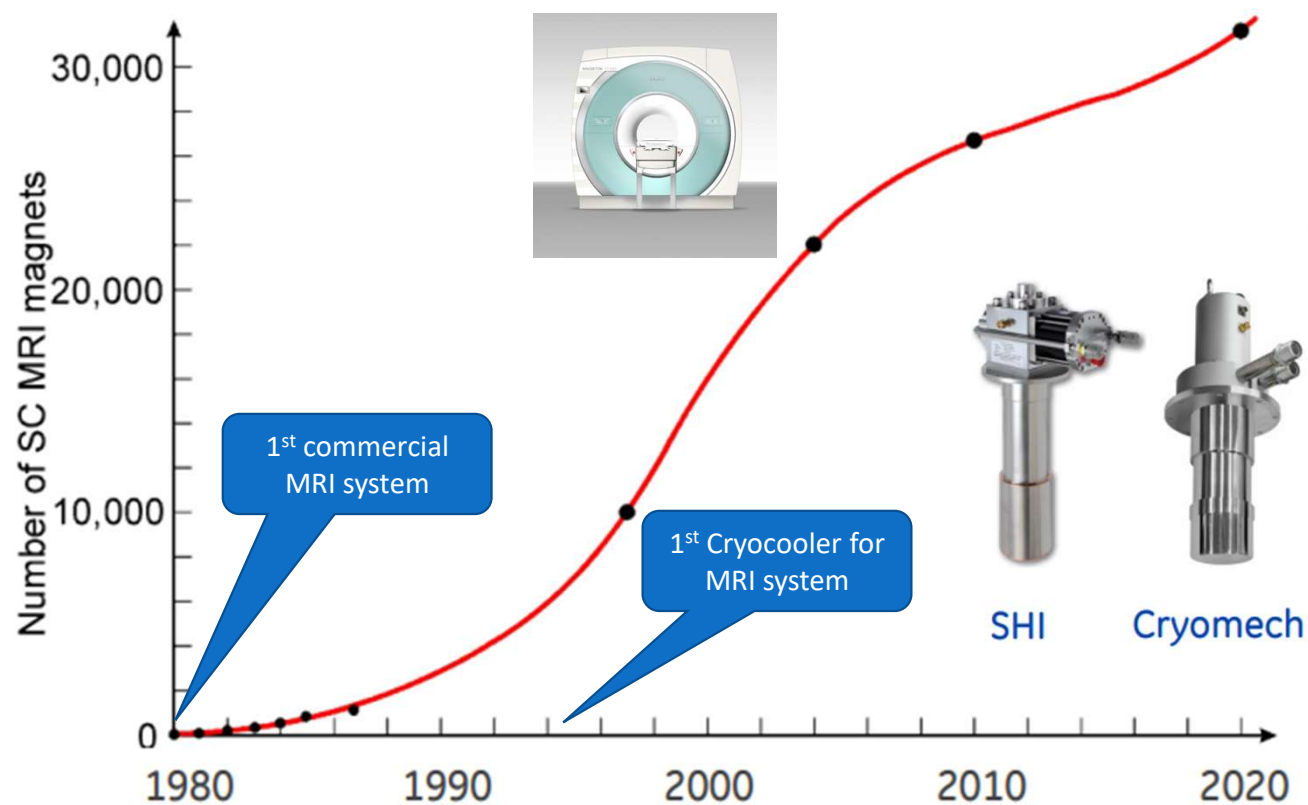
- We wish to catalyse this process and fast-track development through an “Initiative for Superconductivity” towards a greener, healthier, prosperous, and sustainable future.
- We propose to hold a **Superconductivity Summit** at the senior executive and decision-making level to agree on options for **funding superconducting solutions through public and private partnerships.**
- This ambitious initiative will require setting up formally a **Superconductivity Global Alliance (ScGA)** to
 - Facilitate the delivery of the promise of superconductivity.
 - Guide the development of roadmaps and white papers.
 - Facilitate summit meetings.
 - Development of consortia on agreed grand challenges.
 - Commission impact analysis



4 SMART Markets for the Future linked to Grand challenges



MRI is a large volume production business- Led to new standard in Wire Supply, Cryogenics and Instrumentation



> 36,000 4 K GM SHI cryocoolers delivered, since 1995



Key takeaway:

MRI scale up led to significant enhancement in:

- NbTi wire supply
- Cost effective NbTi wire
- Cryogenics management
- New cryogen free enabling technologies
- Good example of SC use for commercial products

W Stautner IWC-HTS, 10/14-16/2015, Matsue, Japan
<file:///C:/Users/melhe/Downloads/IWC-HTSPenarytalk1version9.pdf>

The ScGA Strategy

• Stage 1 –

- Consult with senior experts on Superconductivity
 - Industry, National Labs, R&D at Universities
- Establish an International Organising Committee
- Establish conveners for Working groups on
 - WG1 – Fusion
 - WG2 – Industry, Energy, and Power
 - WG3 – Transport
 - WG4 – Healthcare
 - WG5 – Electronics and quantum information processing
 - WG6 – Science Discovery
 - WG7 – Materials for Applications
- Develop whitepapers targeting policymakers, public & and private funders, and big industry.

Zero carbon
emission targets
by 2050

Stage 2 –

- Launch white papers (EUCAS, MT28, and other events)
- Engage with stakeholders – **In progress**
- Hold One-day events – UK, EU, USA, Japan, South Korea – **under planning**

Stage 3

- Develop options for public and private funding
- Establish consortia for grand challenges
- Commission Impact Analysis
- International Summit to Adopt Options

Stage 4

- Funding from public and private partnerships for superconductivity solutions

ScGA Primary Targets

- **Target 1-** Develop Options for public and private partnerships to fund the proposed grand challenges (2024).
- **Target 2-** Facilitate developing consortia/partnerships between the SC Community, National and Private funding, and Big industrials to address grand challenges (2024).
- **Target 3-** Superconducting Global Summit at the senior level to facilitate the proposed partnership (2024).
- **Target 4** – Adoption of identified options with public + private funding at **National Levels for grand challenges ~ > 1 B Euro** over 10 years to deliver on the Strategic Roadmap and the promise from SC for the future.

ScGA Proposed Activities

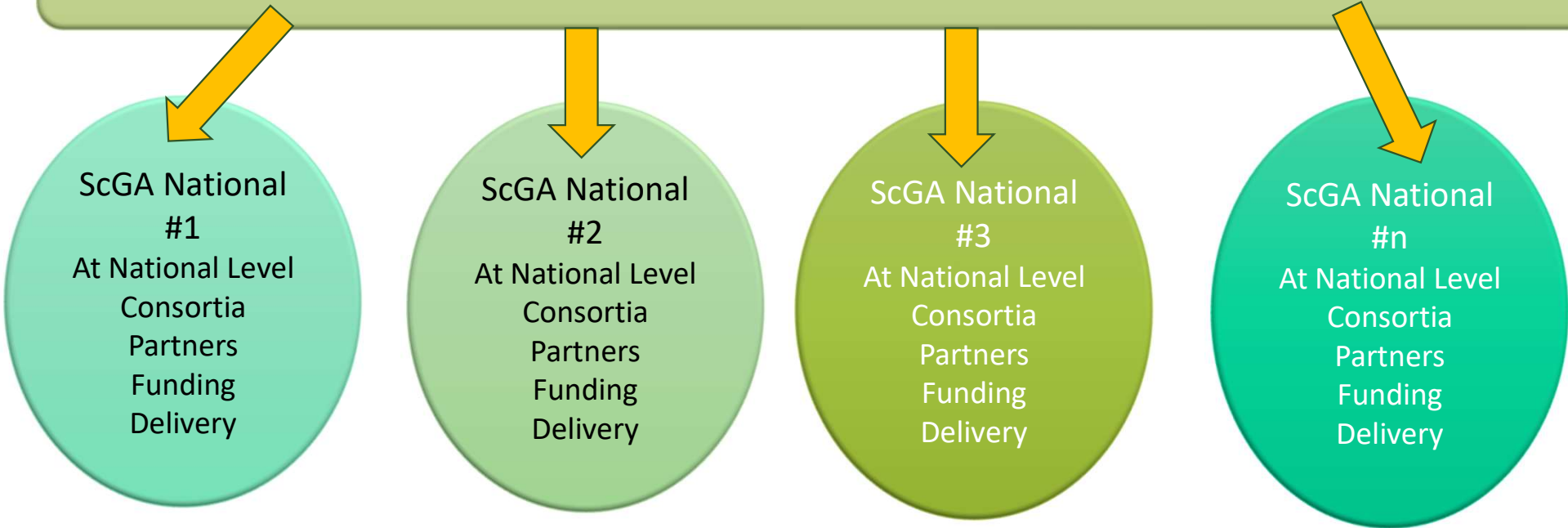
- Develop a Global Superconductivity Strategy to facilitate the development of a National Superconductivity Strategy.
- Develop public and private partnerships with Decision Makers/Funders and Big Industrials
 1. White paper on grand challenges (Delivered by the ScGA)
 2. Strategic roadmap for 10 years directly linked with the SDGs including potential funding required (Delivered by the ScGA)
 - ➔ 3. One-day events (UK, USA, EU, Japan, South Korea, ?)
 4. Global Summit to adopt options.
 5. Mechanisms for Raising Awareness of the Potential of Superconductivity
 1. Aim to present the SC initiative at selected International forums, e.g.
 1. World economic forum – Davos (Jan 2024?)
 2. COP29(Nov 2024 ?)
 3. Doha Forum (Mar 2024 ?)
 4. Others?
 2. Establish regular communication channels
 3. Focused market research on grand challenges
 6. Establish a mechanism for sustaining the initiative

Jan
2023 ?



ScGA structure

ScGA - Global role
Vision, Strategy, Coordination, Reaching out, Global partnerships, Options



Current status














ScGA initiative Members (> 100) (Research and Industry)




















Industry (35) - Univ (27) - RI (39)

International Organising Committee (IOC)









Superconductivity
Global Alliance
ScGA

| Member | Affiliation | Logo |
|----------------------------|--|---|
| Prof. Ziad Melhem | Oxford Quantum Solutions Ltd/UK |  |
| Dr. Joe Minervini | Novum-Industria, MIT, IEEE-CSC/USA |   |
| Dr. Luca Bottura | CERN, ESAS/France/Switzerland |  |
| Prof. Susannah Speller | University of Oxford/UK |  |
| Prof. Lance Cooley | Florida State University, IEEE-CSC/USA |    |
| Prof. Venkat Selvamanickam | University of Houston/USA |  |
| Prof. Stephen Gourlay | Fermi National Accelerator Laboratory, USA |  |
| Dr. Anna Herr | Interuniversity Microelectronics Centre (IMEC) |  |
| Dr. Kathleen Amm | Brookhaven National laboratory, IEEE-CSC, USA |  |
| Dr Kazuhiko Hayashi | ISIS Chairman and CSSJ Executive Director | ISIS,  |

ScGA Working Groups and Convenors

| I. Applications | | | | |
|--|--|--|---|---|
| 1. SMART & Sustainable Industry, Energy, Power, and Transport | | | | |
| 1a. Fusion (WG1) | Prof. Chris Grovenor University of Oxford/UK  | Dr. Mitchell Neil ITER/EU  | | |
| 1b. Industry, Energy, Power (WG2) | Dr. Parizh, Michael GE Research/ US  | Prof. Sastry Pamidi Florida State Univ./US  | | |
| 1c. Transport (WG3) | Prof. Marco Breschi University of Bologna/Eu  | Dr. Loïc Quéval University of Paris/Eu  | Dr. Arno Godeke Independent Consultant | Dr. Mohammad Yazdani Asrami University of Glasgow/UK  |
| 2. SMART Healthcare (WG4) | | | | |
| | Dr. Amm, Kathleen Brookhaven National Lab/US  | Dr. Joe Minervini Novum/MIT/US  | | |
| 3. SMART Electronics and quantum information processing (WG5) | | | | |
| | Dr. D. Scott Holmes IEEE/US  | Prof. Giampiero Pepe ESAS/Eu  | Dr Anna Lees de Escobar Founder/CEO of Technology Vector Inc | |
| 4. SMART Science discovery (WG6) | | | | |
| a. HEP/Nuclear science | Dr. Mark Bird NHMFL/US  | Dr. Luca Bottura CERN/Eu  | Prof. Amalia Coldea University of Oxford/UK  | |
| b. HF research & Astrophysics (Dark Matter) | | | | |
| II. Materials for the identified applications (WG7) | | | | |
| | Prof. Susannah Speller University of Oxford/UK  | Prof. Selvamanickam, Venkat University of Houston/US  | | |
| III. Communications & Funding (WG8) | | | | |
| | Prof. Ziad Melhem Oxford Quantum Solutions  | | | |

Editorial Board (EB)

| Member | Affiliation | Logo |
|------------------------|--|---|
| Dr. Joe Minervini | Novum-Industria, MIT, IEEE-CSC/USA |   |
| Prof. Susannah Speller | University of Oxford/UK |  |
| Prof. Lance Cooley | Florida State University, IEEE-CSC/USA |    |
| Prof. Stephen Gourlay | Fermi National Accelerator Laboratory, USA |  |
| Dr. Cathy Foley | Australia's Chief Scientist, Australia | |
| Prof. Ziad Melhem | Oxford Quantum Solutions Ltd/UK |  |

WP Status

7 WPs have been completed (*...and a shortlist of 26 Grand challenges have been identified*)

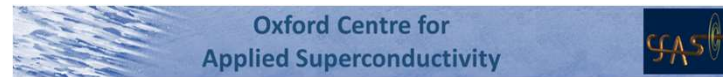
- SMART & Sustainable Industry, Energy, Power, and Transport (*Shortlist of 9 Grant Challenges*)
 - Fusion (WG1) (Prof. Chris Grovenor, Dr Neil Mitchell)
 - Industry, Energy, Power (WG2) (Dr. Parizh, Michael, Prof. Sastry Pamidi)
 - Transport (WG3) (Prof. Marco Breschi, Dr. Loïc Quéval, Dr. Arno Godeke)
- SMART Healthcare (WG4) (Dr. Amm, Kathleen, Dr. Joe Minervini) (*Shortlist of 4 Grant Challenges*)
- SMART Electronics and quantum information processing (WG5) (Dr. D. Scott Holmes, Anna Leese de Escobar, Prof. Giampiero Pepe) (*Shortlist of 4 Grant Challenges*)
- SMART Science discovery (WG6) (Dr Mark Bird , Dr. Luca Bottura, Prof. Amalia Coldea,) (*Shortlist of 9 Grant Challenges*)
 - HEP/Nuclear science
 - HF research & Astrophysics (Dark Matter)
- Materials for the identified applications (WG7) (Prof. Susannah Speller, Prof. Selvamanickam, Venkat)

ScGA Focus meetings – Planned activities

- Invited Plenary at ICSM 2023 – Turkey
- Update at LTSW by Joe Minervini – Florida, USA
- ScGA Plenary event EUCAS 2023 - Italy
- **ScGA special session at MT28 - France**
- IOP+InnovateUK One day event (SC Community+Funders+Industrials) – London UK (**16th Oct 2023**)
 - 1st Meeting is on ScGA for Net Zero Emission Targets by 2050 (Oct 2023)
- One-day event in EU in (SC Community+Funders+Industrials) –Brussels/ Geneva/?TBC
- One-day events in the USA in (SC Community+Funders+Industrials) –
 - FermiLab Mar 2024 TBC (In discussion) (Steve Gourlay)
 - Washington DC Spring 2024 TBC (In discussion) (Joe Minervini and Steve Gourlay)
- Special event in South Korea (Confirmed and Coordinated by Kazuhiko Hayashi)
 - ISIS meeting in **South Korea (Nov.7 - 9)**
- Special event in Japan (Confirmed and Coordinated by Kazuhiko Hayashi)
 - Special symposium at CSSJ domestic meeting (**Dec.4 - 6, Shimonoseki near Fukuoka, Japan**)

Acknowledgments

- Thanks to ScGA IOC, Editorial Board, WG Conveners, and Members > 100
- Thanks to IOP, BCC, IEEE-CSC, and ESAS, University of Oxford for sponsoring various activities



Agenda

Moderators of the Panel Discussion

- Prof. Lance Cooley (Florida State University (FSU)/USA)
- Dr. Luca Bottura (CERN/EU)

Members of the Panel Discussion

- Invited panel members
 - Dr. Cesar Luongo (EuroFusion/EU)
 - Dr. Klaus Schlenga (Bruker, Gauss Fusion /EU)
 - Prof. Tim Coombs (University of Cambridge/UK)
- Conveners Panel Members:
 - Dr. Neil Mitchell (ITER, EU/France))
 - Prof. Sastry Pamidi (FSU/USA))
 - Dr. Kathleen Amm (BNL/USA)
 - Dr. Mark Bird (FSU/USA)
 - Prof. Venkat Selvamanickam (UoH/USA)
 - Prof. Ziad Melhem (OQS/UK)