Superconductivity Global Alliance (ScGA)

for

Greener, Healthier, Prosperous and Sustainable Future

Overview

Ziad Melhem

Online

IFAST – HTS Workshop - Trieste

April 18, 2023

The challenge

Global Environmental Challenges

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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!

Key takeaway

Need new innovations!....

Superconducting materials and technologies can and will help

UN Sustainable Development Goals

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Superconducting Technologies and the SDG goals

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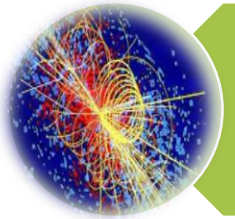
DELWP outcomes	Core SDG	Additional SDG
Net-zero emission, climate-ready economy and community	13 CLIMATE ACTION	7 AFFORDABLE AND CLEAN ENERGY; 11 SUSTAINABLE CITIES AND COMMUNITIES; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION
Healthy, resilient and biodiverse environment	15 LIFE ON LAND	11 SUSTAINABLE CITIES AND COMMUNITIES; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION; 13 CLIMATE ACTION
Safe, sustainable and productive water resources	6 CLEAN WATER AND SANITATION	11 SUSTAINABLE CITIES AND COMMUNITIES; 13 CLIMATE ACTION; 14 LIFE BELOW WATER
Reliable, sustainable and affordable energy services	7 AFFORDABLE AND CLEAN ENERGY	11 SUSTAINABLE CITIES AND COMMUNITIES; 12 RESPONSIBLE CONSUMPTION AND PRODUCTION; 13 CLIMATE ACTION
Productive and effective land management	11 SUSTAINABLE CITIES AND COMMUNITIES	14 LIFE BELOW WATER; 15 LIFE ON LAND; 16 PEACE, JUSTICE AND STRONG INSTITUTIONS
A safe and quality built-environment	11 SUSTAINABLE CITIES AND COMMUNITIES	8 DECENT WORK AND ECONOMIC GROWTH; 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE; 16 PEACE, JUSTICE AND STRONG INSTITUTIONS
Reduced impact of major bushfires and other emergencies on people, property and the environment	11 SUSTAINABLE CITIES AND COMMUNITIES	13 CLIMATE ACTION; 15 LIFE ON LAND

SMART
Electronics & Computing Markets

SMART Industry, Energy Power, & Transport Markets

SMART
Healthcare Markets



SMART
Science Markets

Estimated Global Electricity Generation Mix

New Energy Outlook 2020 report by Bloomberg (2020)

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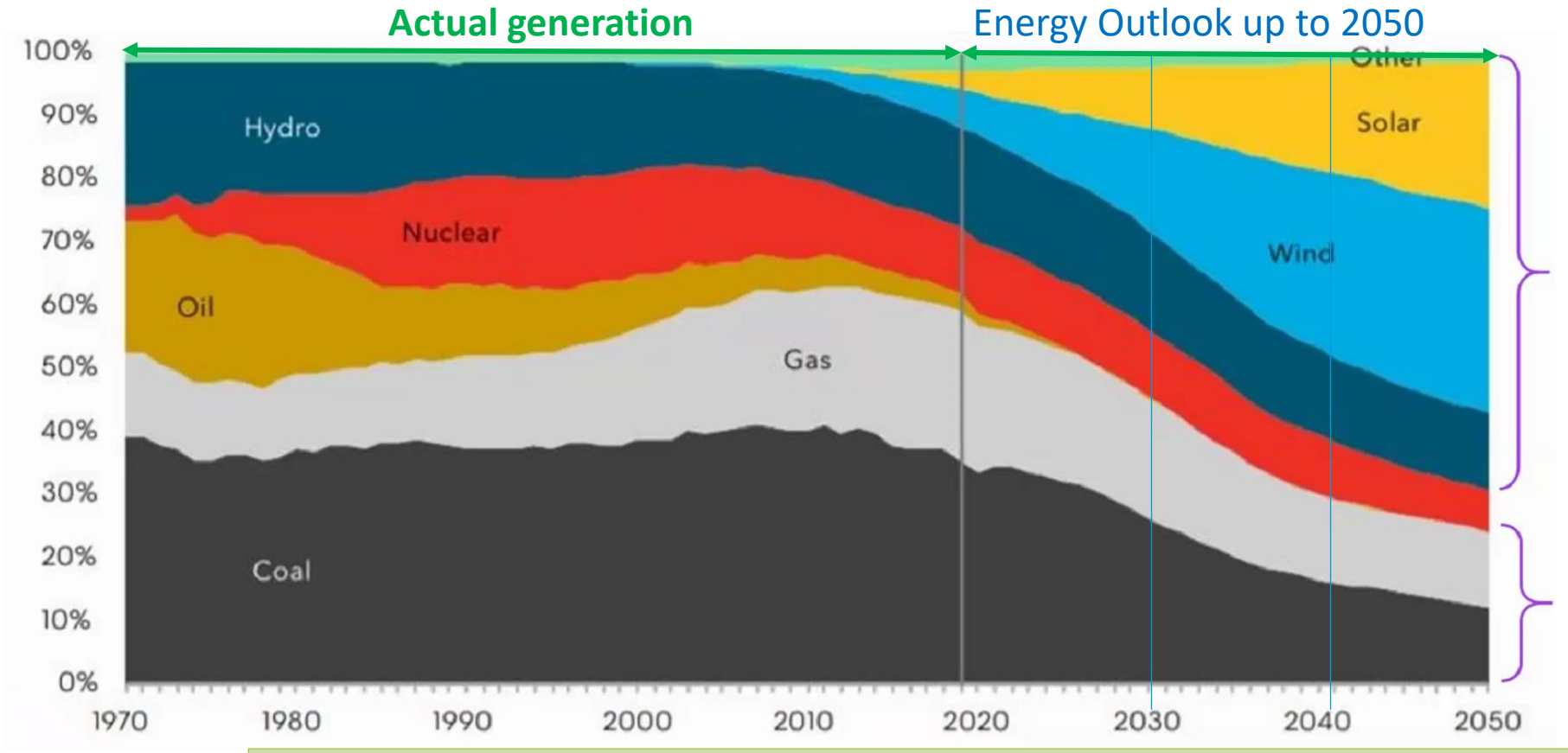

Renewables
- 2020: 38%
- 2030:53%
- 2040:60%
- 2050: 70%

Fossil (Target for Clean energy like Fusion)
- 2020: 62%
- 2030:47%
- 2040:40%
- 2050: 30%

Key takeaway
- Estimated investment in Electricity generation ~ $20 Trillion by 2050
- ~ 30% generation by Fossil fuels equivalent to $ 6.6 Trillion
  - Potential addressable market for Fusion VERY LARGE !

Overview

Innovation in Superconducting applications

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Courtesy of NHMFL

Research & Medical Magnets

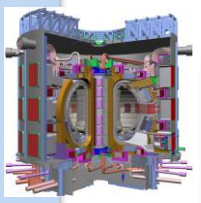
- Medical- MRI, NMR , Proton Bean Therapy
- Basic Research- Physical sciences RM
- HEP- Beamlines/Accelerates/ Detectors
- Fusion – LTS & HTS
  - UHF >25T (LTS+HTS)
  - 5T-20T >20K (HTS)
  - Bench Top Applications (LTS+HTS)
    - 0.5-5T >20K-77K


Courtesy of ISIS


Courtesy of TE


Courtesy of CERN


Courtesy of Varian


Courtesy of ITER

Industrial applications

- Non-destructive Testing
- Inductive Heaters
- Magnetic separation
- Crystal Growth

Power & Energy Applications

- Fault Current Limiters (FCL)
- Transmission Cables
- SC Magnet Energy Storage
- Generators (Wind/Utility)
- Transformers
- Motors
- Synchronous Condensers

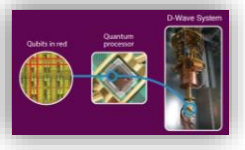

Courtesy of Envison


Courtesy of AMSC


Courtesy of Nexans

Microelectronics

- Quantum Computing
- Faster Computers
- Power Electronics



Courtesy of Dwave

Superconducting (SC) Applications


QMICS Cryolink @ 35 mK for SC cable
Courtesy of Oxford Instruments and WMI

Communications

- Satellite channels
- Wireless devices
- Antennae

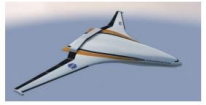
Defence & Security

- Detectors/Sensors
- Rail gun
- Degaussing cables

Transportation

- Electric planes
- Maglev
- Ships
- Rocket propulsion


Chuo Shinkansen Maglev train


NASA N3-X

Opportunities

Expected Emerging SC markets by 2030

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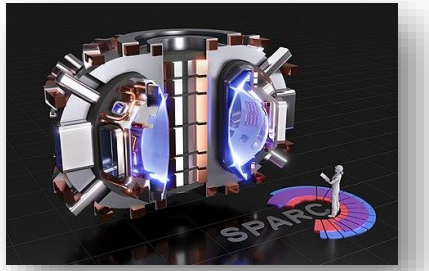
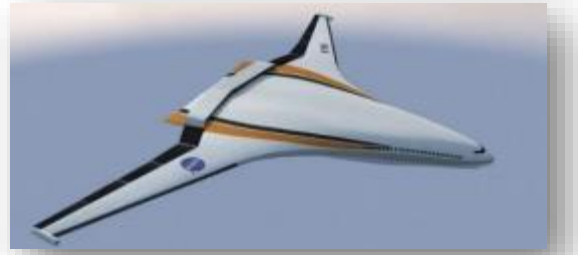
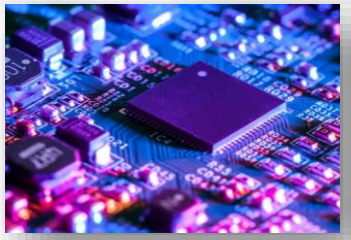
- Fusion
- Electric planes
- SC magnetic storage
- Renewables
- Compact and portable HF magnet systems for Physical and Life Sciences
- SC quantum computing
- Superconducting Electronics
- Medical diagnostics and therapy
- Industrial
- Transport







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

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> 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-HTSPlenarytalk1version9.pdf

Superconducting technologies will lead to massive Impact

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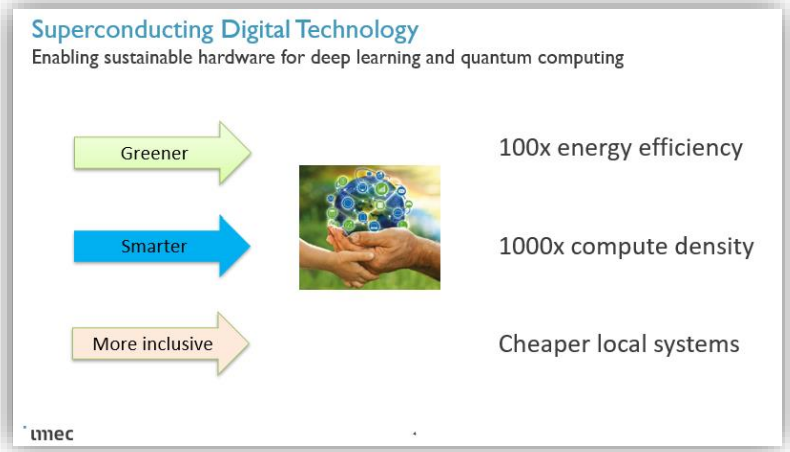
SC Classical and Quantum Computing



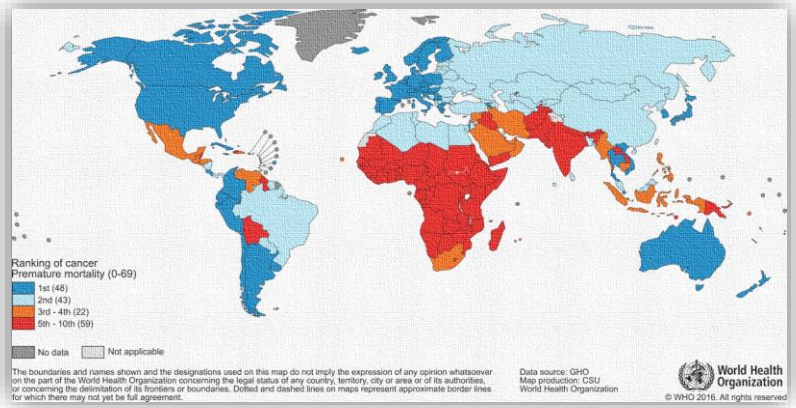
Google 1st to unveil the world's largest quantum computer

IBM demonstrated a 127 Qubit Quantum Computer *Courtesy of IBM*

Key takeaway –

- Superconductivity critical for the digital aged based solutions
- SC qubits leading the way towards Quantum computers and embraced by big industrials

Cancer treatment

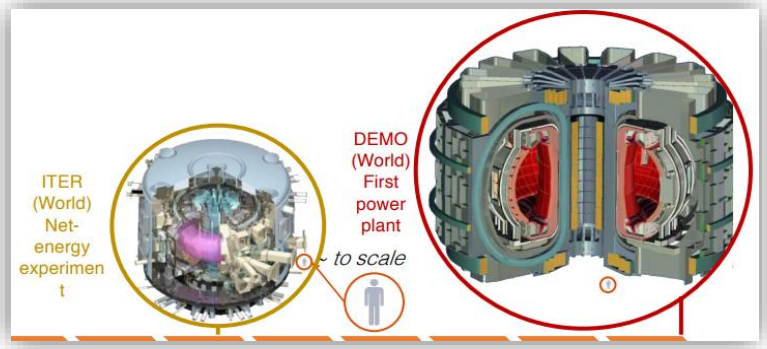


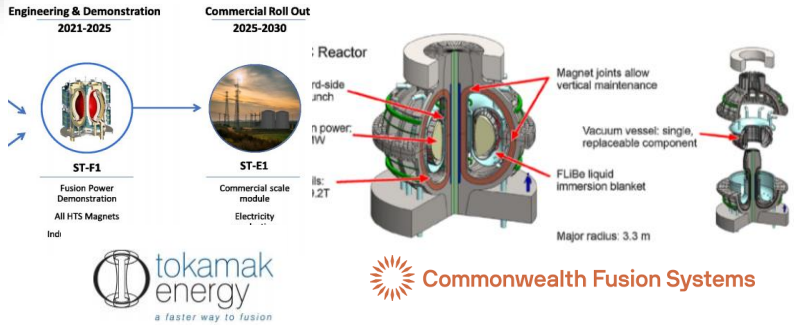
- > 19 million new cancer cases in the world (2020)
  - >4M in Europe
  - The probability to develop (die of) cancer <75 y old in Europe is ~28% (12%)
- By 2040, expected 27.5 M new cases and 16.3 M deaths,
- 1st cause of mortality in higher income countries, 2nd cause of mortality worldwide

Key takeaway

Superconducting based solutions can and will help

Fusion





Key takeaway – HTS impact

Fast tracking development of new power stations

- Clean energy and environmentally friendly
- Safe power generation
- Potential for smaller fusion power devices

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Power applications - Technology Readiness Level (TRL)

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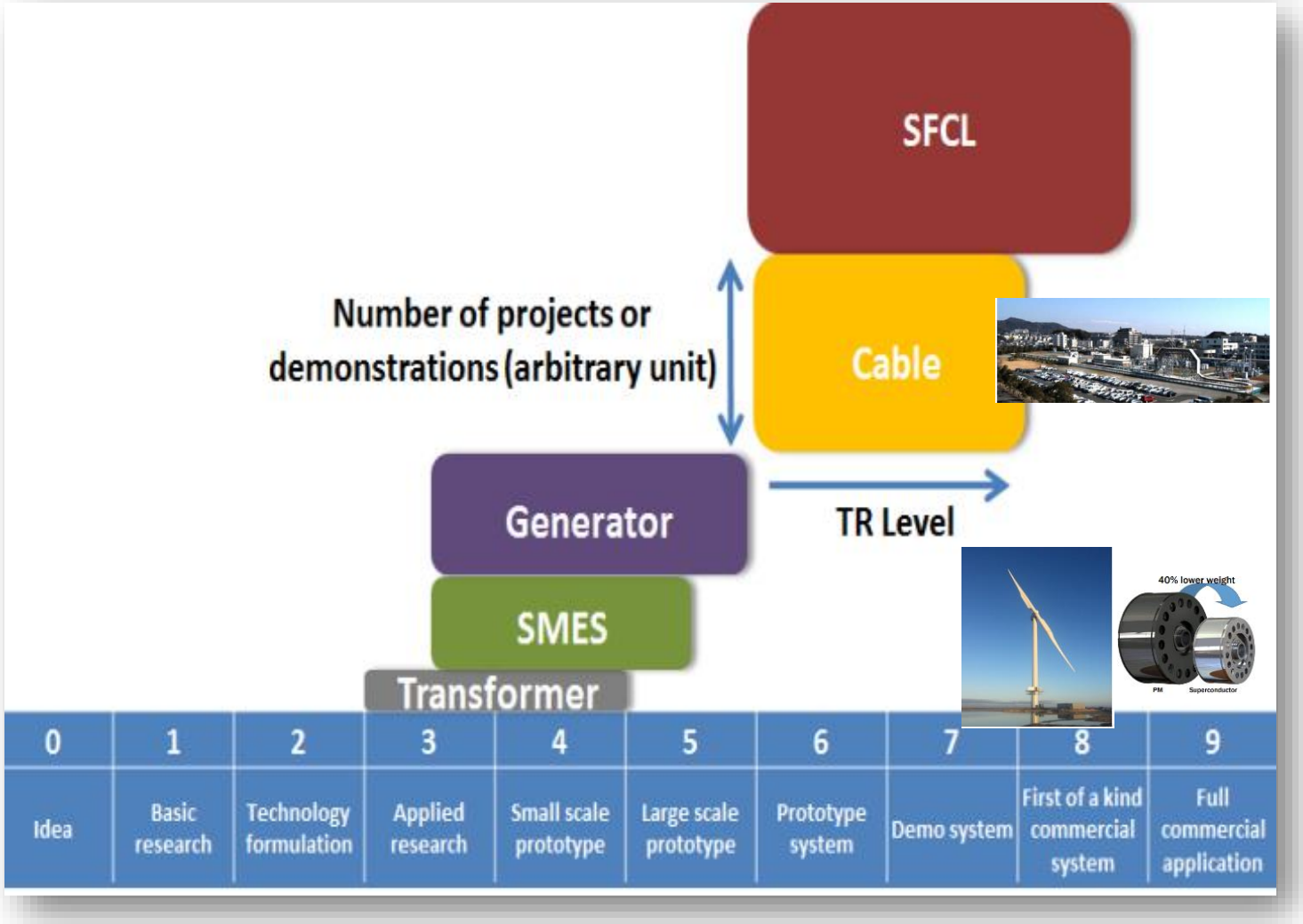
1.	*Transformers*	*-Development*
2.	*Generators*	*-Prototypes*
3.	*Rotator for Wind Farms*	*-Prototypes*
4.	*SMES*	*-Prototypes*
5.	*SFCL*	*-Commercial*
6.	*Transmission lines*	*-Commercial*

Key takeaway

- HTS cables (>70 projects) and SFCL are > TRL 6 and available as a commercial products
- SMES and Generators are next to be commercialised
  - SC wind power generation
    - More MW power per footprint –
      - reduced in volume by 25% and weight by 40%
    - HTS current density > 100 x Cu leading to HF and low energy loss
    - Retrofitting existing infrastructure with enhanced generation



Superconductivity Global Alliance for the Future Initiative

Need new thinking on the role of Superconductivity in our future

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ScGA initiative - The Vision

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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 Frontiers end to Mainstream technologies

4 SMART Markets for the Future linked to Grand challenges

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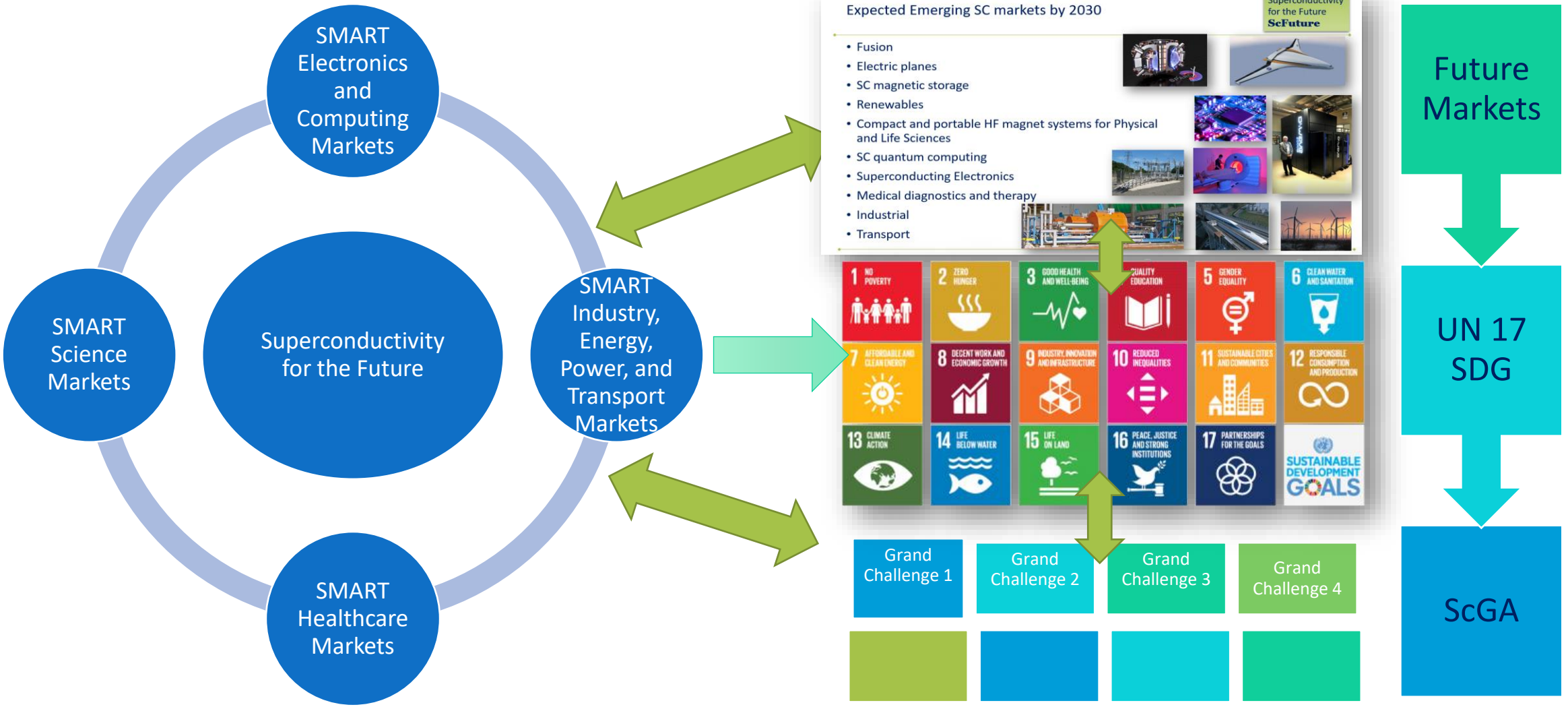

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ScGA initiative - The Proposal

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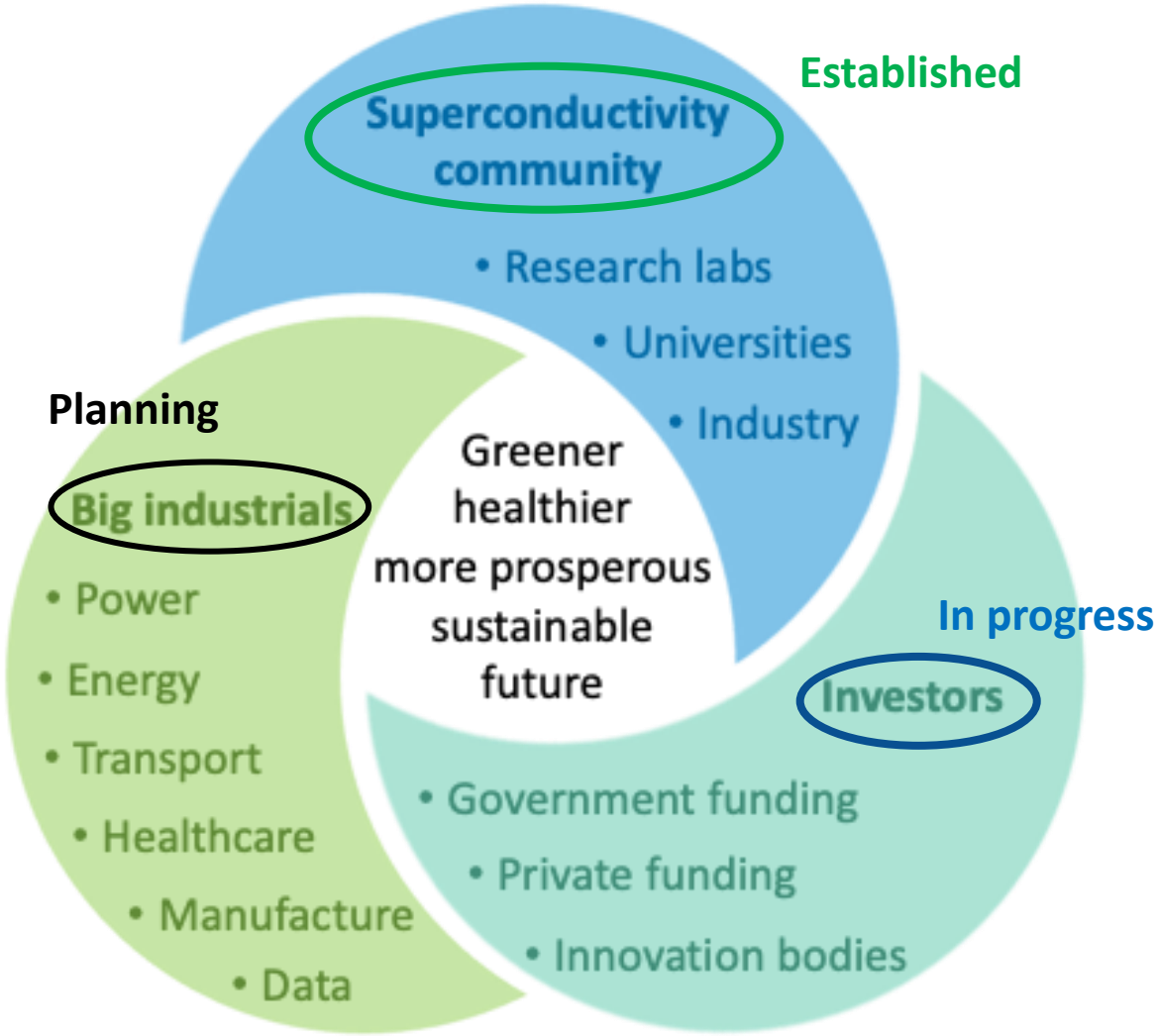
- We wish to catalyse this process and fast-track development through an "Initiative for Superconductivity" towards a greener, healthier, prosperous, and sustainable future.
- We propose to hold a Superconductivity Summit at senior executive and decision-making level with the following objectives:
  - Develop and agree on a strategic roadmap for superconducting solutions and commercial products, including a concise list of grand challenges where SC can make a step change and significant impact on commercial products . This will include:
    1. Define and found a collaboration partnership between the SC Science and industrial community, Government, Private Funding, and Big Industries.
    2. Develop an "Initiative" including funding on Superconductivity for the Future.
    3. Establish a mechanism for sustaining the development of commercial SC solutions and products linked to the 17 SDGs.
- This ambitious initiative will require setting up formally a Superconductivity Global Alliance (ScGA) to facilitate the delivery on the promise from superconductivity and guide the development of roadmaps and white paper and facilitate summit meetings and development of consortia on agreed grand challenges.



ScGA proposed 2-year program – In progress

ScGA proposed 2-year program – In progress

Need a program for 2 years to reach primary objectives from the initiative

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1. Final version for the summit White paper and Strategic Roadmap (April 2023?)
2. Develop a high-level document for Business leaders (Jun 2023)
3. Hold 1-day events with attendees from the SC community, Funders, Decision Makers, and Big Industrials (first wave 2023)
4. Develop a plan to reach out to decision makers/stakeholders (Dec 2023)
5. Summit (6 MTh from holding the workshop to finalize plans for the summit
    1. Summit duration 1.5 days (2024)
    2. Proposals on the Strategic Roadmaps and Grand Challenges
    3. Mechanism to endorse the options by the attendees (circulate before the summit)
6. Develop an initial plan for delivery of the strategic roadmap for identified grand challenges with actions on support and funding

7. Establish nucleus consortia for each Grand Challenge (SC Community, Funders, Stakeholders, Big Industrials)
8. Develop a mechanism to sustain the initiative
    1. Establish an organization to represent the proposed Superconductivity for the Future Alliance
    2. Establish funding for the short term (Jun 2023)
    3. Establish a budget for the 2 years and mechanism for funding (Jun 2023)

Proposed Deliverables of the ScGA

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- **We need to develop partnerships with Decision Makers/Funders and Big Industrials**
  1. White paper on grand challenges
  2. Strategic roadmap for 10 years directly linked with the SDGs including potential funding required
  3. ScGA current targets:
     1. **Target 1-** Superconducting summit at senior level to facilitate the proposed partnership (2023)
     2. **Target 2-** Options for national and private funding of the proposed grand challenges (2024)
     3. **Target 3-** Develop consortia/partnerships between the SC Community, National and Private funding and Big industrials to address grand challenges (2024)
  4. Mechanisms for raising awareness of the potential from Superconductivity
     1. Aim to present the SC initiative at selected International forums, e.g.
        1. World economic forum – Davos (Jan 2024?)
        2. COP28 (Nov 2023?) , COP29(Nov 2024)
        3. Doha Forum (Mar 2024 ?)
     2. Establish regular communications channels
     3. Focused market research on grand challenges
  5. **Establish mechanism for sustaining the initiative**

Proposed contents of the Whitepaper (In progress)

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- Detailed white paper for the ScGA SC pillar
- Executive white paper for stakeholders, investors and decision makers

Typical contents of the detailed white paper

- Capturing the state-of-the-art,
- Shortlist of grand challenges,
- 10-year roadmap with 4, 7, and 10 strategic deliverables,
- Top-level timeline together with first-order approximation of the investment required
- Potential ScGA partners for consortia,
  - SC community
  - National innovation bodies and funding agencies and private funding
  - Big industrials
- Potential players to be invited to the ScGA
- List of stakeholders outside the community we need to reach out as part of the (ScGA)

WG Theme Ambition			
	4 years	7 Years	10 Years
Ambition #1			
Ambition #2 …			

Current status

Members (> 95) (Research and Industry) of the ScGA initiative

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Current members of the GSA

Industry (30) - Univ (23) - RI (39)

International Organising Committee (IOC)

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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 Convenors

Superconductivity Global Alliance **ScGA**

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**	**Dr. Mohammad Yazdani Asrami, University of Glasgow/UK**	
1c. Transport (WG3)	**Prof. Marco Breschi** **University of Bologna/Eu**	**Dr. Loïc Quéval** **University of Paris/Eu**	**Dr. Arno Godeke** **Independent Consultant**	
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**		
4. SMART Science discovery (WG6) **a.** HEP/Nuclear science b. HF research & Astrophysics (Dark Matter)	**Dr. Luca Bottura** **CERN/Eu**	**Dr Pierre Vedrine** **CEA/Eu**	**Prof. Amalia Coldea** **University of Oxford/UK**	**Dr. Mark Bird** **NHMFL/US**
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/UK		-	

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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	

Updated timeline for GSA

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Pre March 2022
- Consultation with SC experts

17 May 2022 V-Mtg 1
- Launch the SCSI
- Setup of actions and framework for activities

17 Jun 2022 V-Mtg 2
- WGs setup
- Agree on next steps

Jun 2022 to 11 Jul 2022
- WGs prepare for SC Workshop in Oxford

11-12 July 2022
- SC Workshop in Person at Oxford University

30 Sep 2022
- Report and Notes from SC Workshop

31 Dec 2022
- First draft of strategic RMap from each WG
- Draft outline of the White paper/WG
- Shortlist list of stake holders

30 Jan 2023
- Review status of the first draft of the Strategic Rmap
- Draft outline of the White paper/WG
- Reach out to stakeholders

30 Feb 2023
- Review Potential dates for the Summit
- Review timeline for the Strategic RMap and white papers

31Mar 2023
- First draft of the WP
- Reach out to stakeholders
- Informal contact with COP organizers

30 Jun 2023
- Complete white paper for selected grand challenges

Nov-Dec 2023 ?
- Target date for the Workshop
- Informal contact with DAVOS WEF organisers

ScGA outreach activities Status

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- ScGA special session at MT28 – France (Confirmed)
  - Keynote ScGA overview
  - Update on Healthcare, Fusion, Big Science, Industry
  - Panel
    - IOC+Conveners to nominate representation for the updates and the panel attending the MT28 conf.
- ScGA Plenary event EUCAS 2023 - Italy (Confirmed)
  - Keynote ScGA overview
  - Update on 4 SMART markets strategic roadmap and Shortlist ambitions/partnerships
  - Panel
    - IOC+Conveners to nominate representation for the updates and the panel attending the MT28 conf.
- Invited Plenary at ICSM 2023 (06-05-2023) – (Confirmed)
- **IOP+InnovateUK One day event (SC Community+Funders+Industrials) – London UK (19th Jun 2023)**
  - IOC+Conveners to nominate representation
- One-day event in EU in (SC Community+Funders+Industrials) – Brussels or Geneva organized (TBC)
  - Potential for IFAST to host such a meeting
  - IOC+Conveners to nominate representation
- One-day event in the USA in (SC Community+Funders+Industrials) – (TBC)
  - IOC+Conveners to nominate representation

IOP + InnovateUK One-day event
(SC Community + Funders + Industrials)

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- IOP (Superconductivity Group) + InnovateUK One day event (SC Community + Funders + Industrials) –
  - Location – London UK - IOP Headquarters
  - Date - 19th June 2023
  - Agenda (TBC)
    - AM
      - ScGA Overview
      - WG - Grand challenges and Strategic Roadmaps
      - Morning Break and Network
      - Invited talks from End users
    - Lunch and Network
    - PM
      - Round tables (SC Community + Funders + End-users/big industrials)
      - Closing remarks
- Sponsored by IOP + InnovateUK

How you can support and get engaged

ScGA is an INCLUSIVE Initiative and COMPLIMENT current SC activities -

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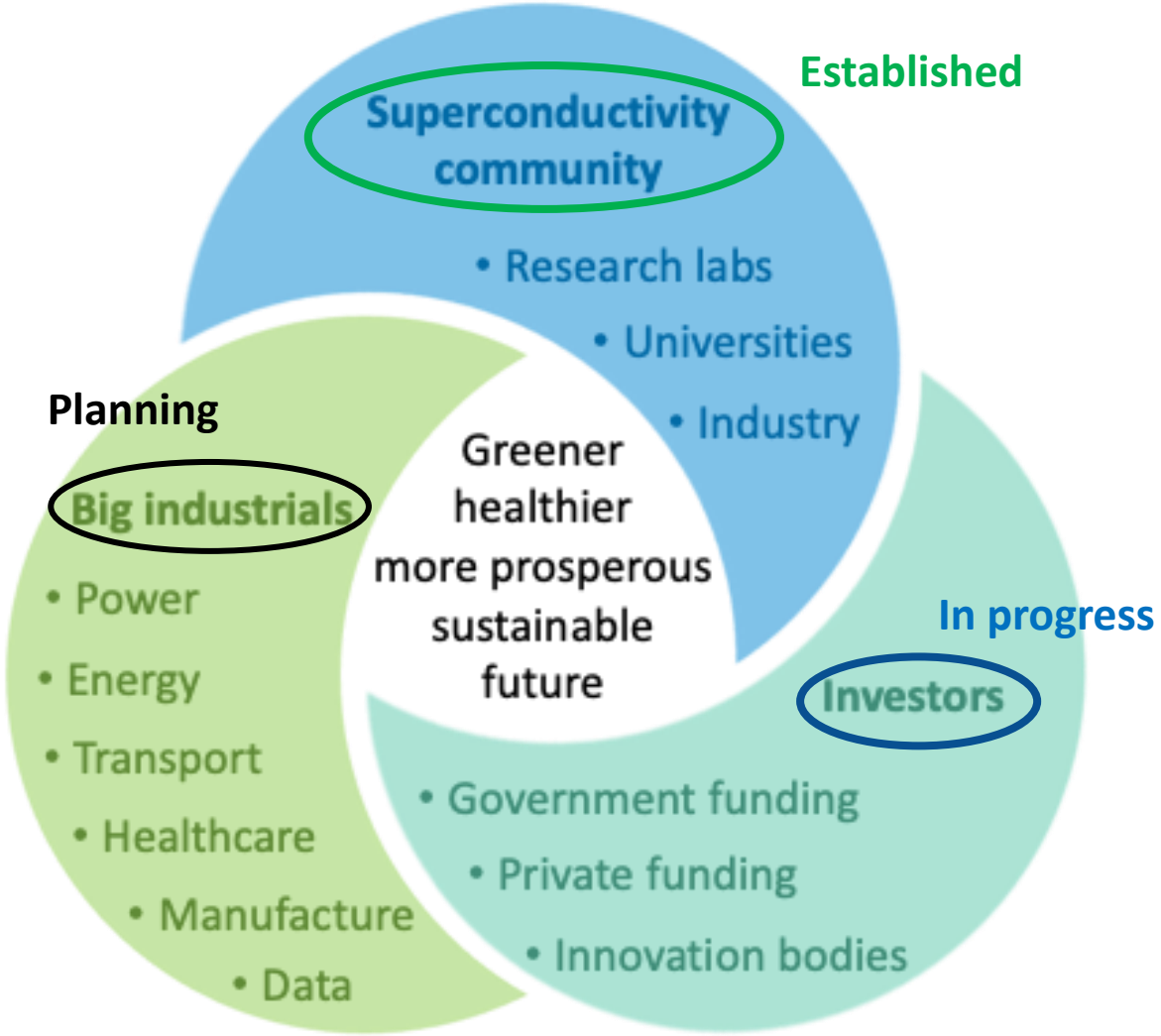
- Join WG - Inclusive initiative
  - In progress
- Workshop
  - Under planning
- One-day events with stakeholders
  - Under planning
- Summit
  - Under planning
- Reach out to stakeholders
  - Public/Private funders, Decision makers
- Impact Analysis on the SMART markets
  - To plan
- Support Consortia development/activities



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Acknowledgments

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- Thanks to ScGA IOC, WG Conveners and Members > 90
- Thanks to IEEE-CSC for sponsoring ASC 2022 Mtg and Lunch
  - Thanks to Bruce Strauss and Kathleen Amm for securing the sponsorship and to Paula for the setup
- Thanks to Sponsors of the Oxford Workshop on 11-12 July 2022
  - IOP Superconductivity Group members
    - Thank you Tim Coombs
  - CfAS at Oxford University, the Host
    - Thank you Amalia Coldea, Stephen Blundell, Susannah Speller and Chris Grosvenor
  - IEEE-CSC
    - Thank you Elie Track, Bruce Strauss and John Przybysz
  - ESAS
    - Thank you Luca Bottura (Secretary), Giampiero Pepe (President) and David Cardwell (Treasurer)
  - British Cryogenic Council
    - Thank you Beth Evans

Sponsors of Workshop held at Oxford University 11-12th Jul 2022

QS Oxford Quantum Solutions
British Cryogenics Council
IEEE CSC Council on Superconductivity
esas European Society for Applied Superconductivity
IOP Institute of Physics Superconductivity Group
Oxford Centre for Applied Superconductivity