1. INTRODUCTION: JOHN FITZGERALD / SUPERNODE
2. PROBLEM STATEMENT
3. PROPOSED SOLUTION
4. HOW CERN HELP OVERCOME CHALLENGES
5. WHAT WILL SUCCESS MEAN
OUR VISION AND MISSION

OUR VISION

TO DEVELOP AND MARKET INNOVATIVE TRANSMISSION TECHNOLOGY BASED ON SUPERCONDUCTORS

PEOPLE SHOULD HAVE ACCESS TO SECURE AFFORDABLE AND RENEWABLE ENERGY

OUR MISSION
WHO ARE WE?

EDDIE O’CONNOR
Founder, Chairman and Owner

KJELL INGE RØKKE
Director
(Owner of Aker ASA)

PAT COX
Director
(Former President of EU Parliament)

JOHN FITZGERALD
CEO
(Ex director of Grid Dev and Interconnection EirGrid)

Henrik O. Madsen
Director
(Former President & CEO of DNV)

AKER HORIZONS
(50% ownership)
69% of EU energy is from fossil fuels
25% of energy is electricity
50Hz/60Hz AC synchronous systems - developed over the past 100yrs.

Highly reliable meshed transmission systems with N-1 contingency planning for the loss of any circuit/infeed.

Limited interconnection between countries and very limited connectivity between synchronous systems.

Fossils fuels move globally and there is very limited international trade in electricity.
There are little or no offshore grids.

- Fossil fuel supply lines (ships & pipelines) need to stop.
- DC transmission is better for long distance than AC.

ELECTRIFICATION POWERED BY RENEWABLES IS THE MOST EFFICIENT WAY TO DECARBONISE
EUROPE’S GEOGRAPHY

Wind speed

Solar Irradiance

Population density
WIND AND SOLAR GENERATION IN EUROPE

Source: International Energy Agency
O’Connor (2023) Supergrid – Supersolution
A BIGGER OR PAN EUROPEAN GRID IS NEEDED

Electrical energy demand will **TRIPLE BY 2050** compared to today’s demand.

The best renewable resources are found at the **PERIPHERIES** of Europe.

A **SUPERGRID** can **BALANCE THE VARIABILITY** of renewables over large distances.

2,000GW **RENEWABLES** & at least 450GW **OFFSHORE WIND** needed.
North Sea Vision: evolving the offshore grid to unlock the full green energy potential of the North Sea

450GW Meshed offshore Grid in 2050, National Grid ESO Presentation
April 24th - 9 countries signed the Ostend Declaration: Belgium, Denmark, Germany, The Netherlands, Ireland, France, Luxembourg, Norway and the UK.

Offshore renewable targets set:
- 150GW by 2030
- 300GW by 2050
- Only 15GW offshore wind today

Declaration of energy ministers calls for development and realisation of an ‘Offshore Meshed Grid’.
WE HAVE RENEWABLE TECH TO DO THE JOB

WIND TURBINE ADVANCEMENTS

- 2016 8 MW
- 2021 15 MW
- 2025 20 MW

SOLAR PANEL ADVANCEMENTS

- Current efficiencies of ~20%.
- New materials such as Perovskite have shown efficiencies in excess of 25%.
- Bifacial PV system paired with solar trackers predicted to yield 27% more than a conventional solar system.
EXISTING COPPER-BASED TRANSMISSION IS NOT ENOUGH

- **Current copper-based transmission technology** is not designed or sized for a decarbonised Europe based on weather-dependent renewables.

- Copper-based **underground cables can only carry 1 GW** per cable, suffer from electrical losses, and require large amounts of material and space.

- Copper miners now use **ore grades of 0.5% copper**, a quarter the concentration of a century ago.

- “There is going to be a **very significant shortage in copper**. It’s going to be very difficult to meet the aspirations that have been set,” Richard Adkerson, CEO of US mining group Freeport-McMoRan in FT 31/10 2022.
China has constructed Ultra-HVDC overhead power lines. The largest line has a capacity of 12GW and is 3,324km. Europe faces different geographic and political constraints. New underground and offshore grid technologies will be needed.
HOW DO WE MOVE BEYOND FOSSIL FUELS

KEY ENABLERS

1. Grids
2. Storage
3. Consumer behaviour
WHAT PROBLEM DO WE SOLVE?

- Overhead Lines cannot be delivered.
- Conventional underground cables are current limited to c. 2kA per cable (1GW at 525KV).
- Long term copper supply is an issue and order books are full for marine cables in the near term.
- Transmission products that will be the key enabling technology for the renewable energy transition.
WHAT WE NEED

TRANSMISSION TECHNOLOGY THAT IS:

- Unobstrusive
- High-power
- Scalable
- Long distance
- Marine-enabled

Cable technology based on superconductivity offers a solution
WHAT IS SUPERCONDUCTIVITY?

Superconductivity is a phenomenon that occurs in some materials that, when cooled below a certain temperature, display unique characteristics:

- Zero electrical resistance
- High power density

How to achieve superconductivity:

- A material must be cooled to below its ‘critical temperature’.
- High temperature superconductors (HTS) are superconductive around -180°C.
### Recent Superconductor Projects

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Ampacity, Essen</td>
<td>1km, 40MVA, 10kV, AC</td>
</tr>
<tr>
<td>2018</td>
<td>EU Horizon’s ‘Best Paths’ Project</td>
<td>30m, 3.2GW, 320kV, DC</td>
</tr>
<tr>
<td>2019</td>
<td>Shingal, Seoul</td>
<td>1km, 50MVA, 23kV, AC</td>
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<tr>
<td>2021</td>
<td>REG, Chicago</td>
<td>62MVA, 12kV, AC</td>
</tr>
<tr>
<td>2023</td>
<td>Superlink, Munich</td>
<td>12km, 500MVA, 110kV, AC</td>
</tr>
</tbody>
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**Shingal Project, Seoul, S. Korea**

![Superconductor Cable System Diagram](image)
THE FOCUS OF OUR SUPERCONDUCTING TECHNOLOGY

- 2GW+ transmission
- Marine and terrestrial deployment
- Materials and Thermal Management
- Efficiency, reliability & robustness

Oil & Gas + Electricity = New Transmission Technology
SUPERNODE’S COMPETITIVE ADVANTAGE

PURPOSE DESIGNED CRYOSTAT WILL INCREASE TRANSFER DISTANCE USING:

- Optimal thermal management
- Novel cryostat materials

SUPERNODE CABLE ADVANTAGES:

- Lower Price
- Significantly less raw materials
- Smaller footprint
- Less local disruption
- Quicker for asset developers
- Supply chain and regulatory regime diversification
- Cheaper, cleaner electricity for the customer
SUPERNODE’S APPLICATIONS

MARINE MVDC, 2GW+, LONG DISTANCE TRANSMISSION
- Reduced size offshore infrastructure
- E.g. Connecting offshore wind farms

TERRESTRIAL MVDC, 2GW+, LONG DISTANCE TRANSMISSION
- Compact high-capacity transmission corridor
- E.g. Interconnections between national grids
Increasing voltage with conventional cables leads to increasing platform size.

Superconductors can operate at much lower voltages, needing smaller and more cost effective platforms.
SUPERNODE CRYOGENIC CENTRE FOR SUPERCONDUCTORS

- State of the art facility which encompasses 15k square feet.
- Contains cutting edge equipment to facilitate SuperNode’s R&D programme.
- Has the capabilities to assemble our first demo project.
OUR PARTNERS

CURRENT
Enabling Network Technology throughout Europe

MAINSTREAM
RENEWABLE
POWER

University of
Strathclyde

AMBER
Advancing Materials for Impact

MaREI
Centre for Marine and Renewable Energy

APT
Applied Polymer Technologies

CATAPULT
Offshore Renewable Energy

AKER HORIZONS

SUPERNODE™
UNIQUE CERN COMPETENCIES AND CAPABILITIES

Materials permeability characterization
Vacuum degradation prediction
Cryostat lifetime simulation

SuperNode Engineer posted in CERN
Develop state-of-the-art test rig to be installed in SuperNode headquarters
TECHNOLOGY DEVELOPMENT TIMELINE

Key patents, proof of concept testing for advanced cryostat & thermal systems

SNL Technology Centre for subsystem prototype testing & high-tech manufacturing

Prototype validation of HTS Cable System Prototype – performance & reliability verified

Design and manufacture of HTS Cable System Prototype

Statement of Feasibility from DNV

Benchmark testing – Gen 01 Cryostat HTS

Market review & HTS Cable Technology concept
TECHNOLOGY DEPLOYMENT TO MARKET

TRL6: Prototype HTS Cable System

Demonstration Project 2
Intermediate cooling with advanced cryostat HTS Cable System

2025

Commercial Project Notice to Proceed

2026

Manufacturing & Commissioning

2027

Commercially Available
Cheapest form of Bulk Power Transfer (GWs)

2028

2029

2030

Demonstration Project 1
Advanced cryostat HTS Cable System

TRL6: Prototype HTS Cable System
ONSHORE SUPERCONDUCTING CABLE SYSTEM

125 m
800kV HVDC Overhead line
4 GW Capacity

5 m
Superconducting cable
4 GW Capacity
(1 bipole = 2 cables)

25 m
525kV XLPE Copper Cable
4 GW Capacity
(2 bipole = 4 cables)
SUCCESSFUL ENERGY TRANSITION IN EUROPE

An interconnected pan-European grid enabled by superconducting cables can provide people with access to energy that is:

- Secure
- Affordable
- Renewable
THANK YOU