SCARLET

Superconducting CAbles foR sustainabLe Energy Transition

SCARLET - das europäische Netz wird supraleitend

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Partners: SINTEF, IASS Potsdam, WavEC, ELÚ, Absolut System, ESPCI Paris PSL, SuperGrid Institute, RSE, RINA, Supernode, Vision Electric Superconductors, ASG Superconductors, Nexans Electrify the Future

Funded by the European Union

Structure

- Ten-year network development plan (TYNDP 2022)
- Superconducting cables for high-power transmission
- The new EU project SCARLET

TYNDP 2022: Ambitious goals for the EU grid

In 2030

- 64 GW of capacity increases after 2025 on over 50 borders
- 17 TWh of curtailed energy saved each year
- Dependence on gas for power generation decreases by 9 TWh/year
- 14 Mton of CO_2 emissions avoided each year
- Generation costs decrease by 5 billion euro per year
- Existing transmission projects do not cover all system needs, a 15 GW investment gap remains

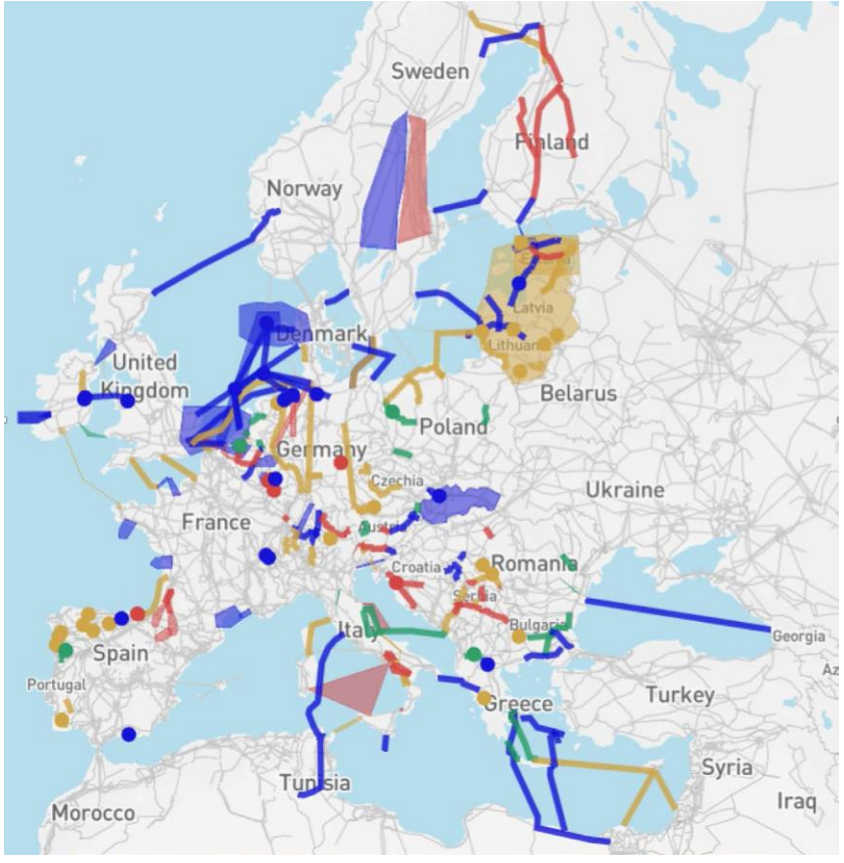
In 2040

- 88 GW of capacity increases after 2025 on over 65 borders, 41 GW of storage in 19 countries and 3 GW of CO_2-free peaking units in 4 countries
- 42 TWh of curtailed energy saved each year
- Dependence on gas for power generation decreases by 75 TWh/year. That's equivalent to 14 % of the EU gas-based electricity generation in 2021.
- 31 Mton of CO_2 emissions avoided each year
- Generation costs decrease by 9 billion euro per year
- Increased security of electricity supply, with 1,6 TWh of avoided energy-not-served
- There are opportunities for new solutions to address the needs throughout Europe

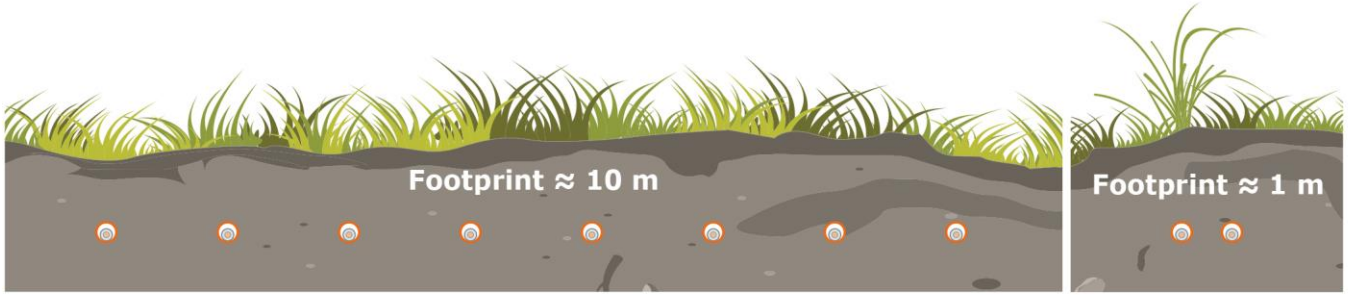
TYNDP 2022: Transmission projects

141 transmission projects in 38 countries

green = under construction (14)
yellow = in permitting (43)
red = planned (29)
blue = under consideration (55)



Superconducting cables for long-distance transmission



Resistive cables (XLPE)
8 cables (320 kV/2500 mm² Cu)

Superconducting cables (MgB_2)
2 cables (320 kV/10000 A)

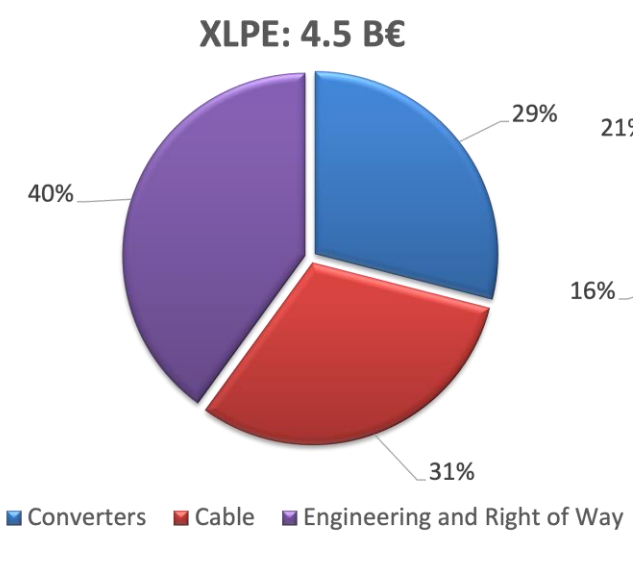
- No resistive losses (10% loss over 1000 km for conventional cables)
- High efficiency and design flexibility
- Compact size (footpath vs. motorway)
- Reduced environmental impact (small RoW, no heat leakage etc.)

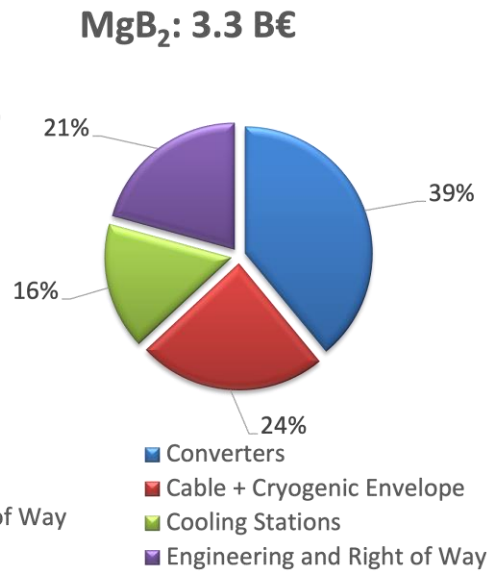
Best Paths results: transmission of very high powers

- Demonstrated full-scale 3-GW-class HVDC superconducting cable system operating at **320 kV** and **10 kA**
- Validated the MgB_2 superconductor for high-power electricity transfer
- Assessed economic viability, and environmental impact of this innovative technology

Best Paths results: Capital cost comparison for 6.4 GW and 500 km

- the MgB_2-based superconducting link is overall 27% less expensive than the resistive solution
- expenditure on engineering and right-of-way can be reduced by a factor of 2.5 for superconducting links
- cost of cryogenic envelope expected to decrease by at least 30% when upscaling the existing production lines





Courtesy of RTE

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New EU project on superconducting transmission: SCARLET

- **Goal:** develop and industrially manufacture superconducting cable systems at the gigawatt level, bringing them to the last qualification step before commercialization
- **Duration**: September 2022– February 2027
- **EU contribution**: 15 million euro
- **Total budget**: 20 million euro
- **Partners**: 15
- **Countries**: 7
- **Coordinator**: SINTEF, Norway

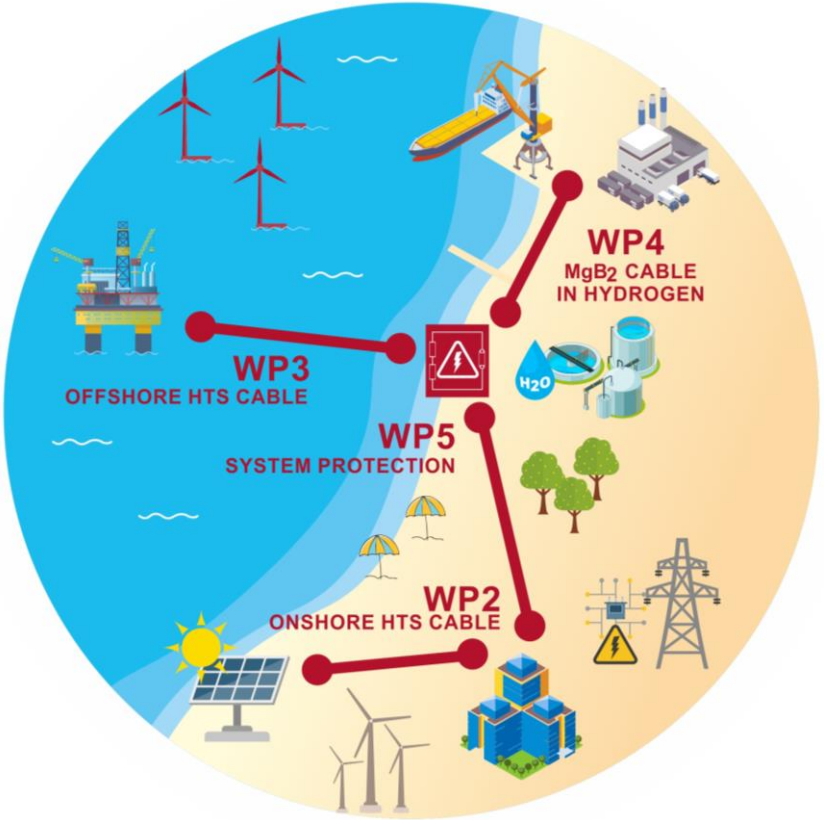
SCARLET partners

- **Goal:** develop and industrially manufacture superconducting cable systems at the gigawatt level, bringing them to the last qualification step before commercialization
- Expertise from **15** industry and research organisations in the fields of material sciences, cryogenics, energy systems and electrical engineering

SINTEF
RIFS POTSDAM
WavEC Offshore Renewables
ELÚ
ALMA MATER STUDIORUM A.D. 1088
ASG SUPERCONDUCTORS
Nexans
SUPERNODE™
RINA
ESPCI PARIS | PSL
SuperGrid Institute Shaping power transmission
ABSOLUT SYSTEM INNOVATIVE CRYOGENIC SOLUTIONS
VISION® ELECTRIC Super Conductors
RSE Ricerca Sistema Energetico

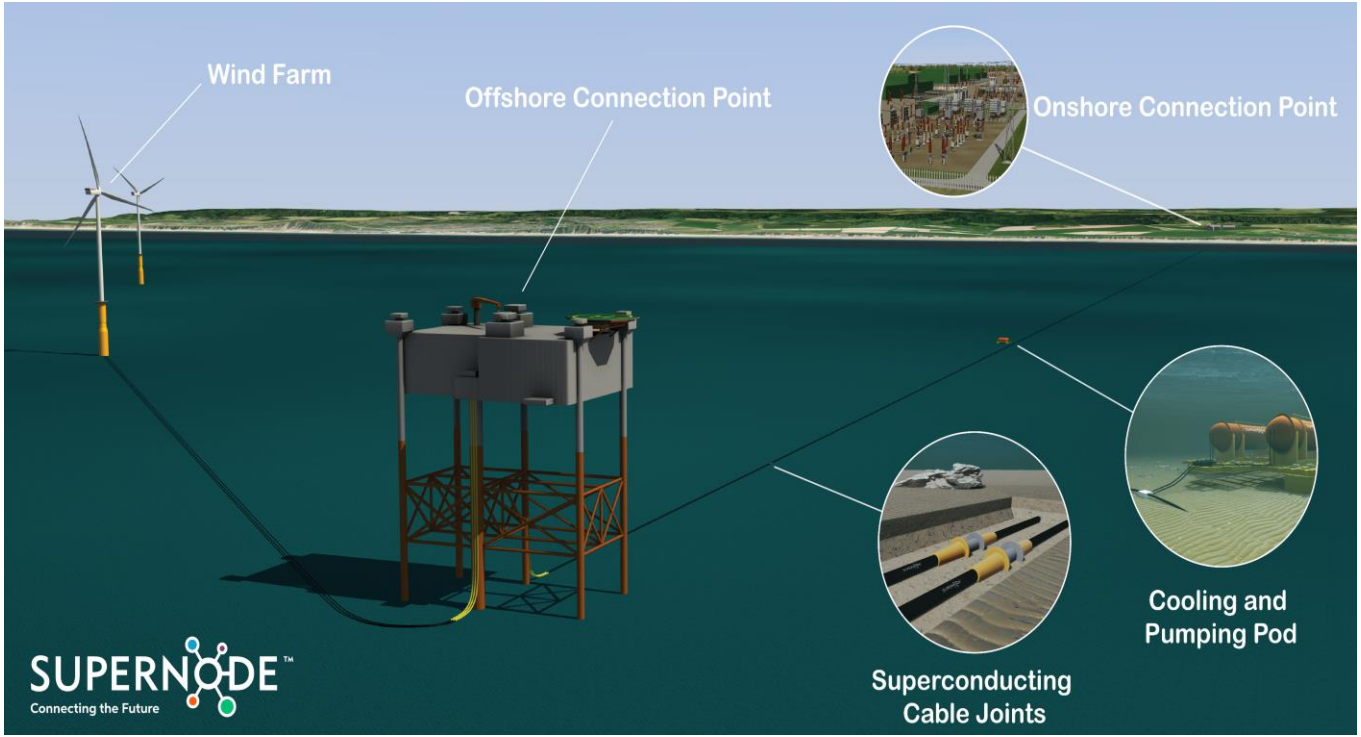
Project structure

- 3 demonstration work packages
  - long-length onshore superconducting cable systems (HTS, 70 K)
  - superconducting cables in liquid hydrogen (MgB_2, 20 K)
  - system protection
- 1 work package on architectures of offshore superconducting cable systems (HTS, 70 K)
- 1 work package for integration studies and economic evaluation
- lastly, work packages for communication and coordination



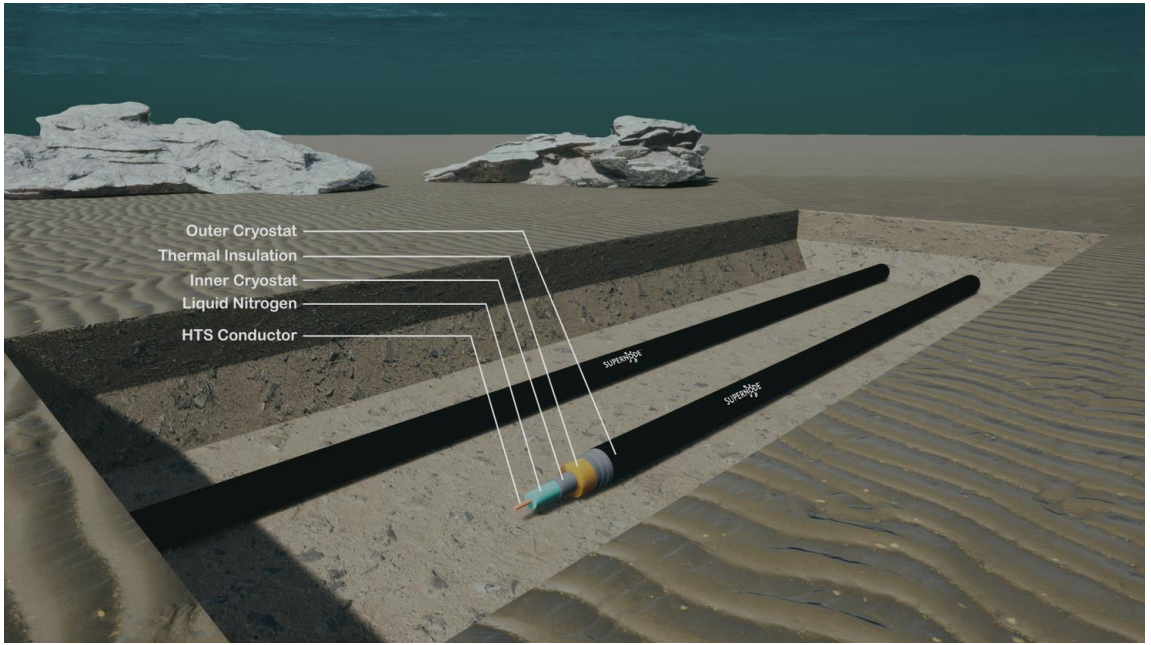
Scarlet highlight: Offshore superconducting cables

- Offshore development is one of the basic pillars of the European Green Deal
- 131 GW of offshore wind expected by 2040 (TYNDP 2020)
- SCARLET is the first publicly funded offshore superconducting project



Offshore superconducting cables at MVDC

Main idea: MVDC operation eliminates costly high-voltage converter stations and allows for smaller and much less expensive equipment at offshore wind power farms

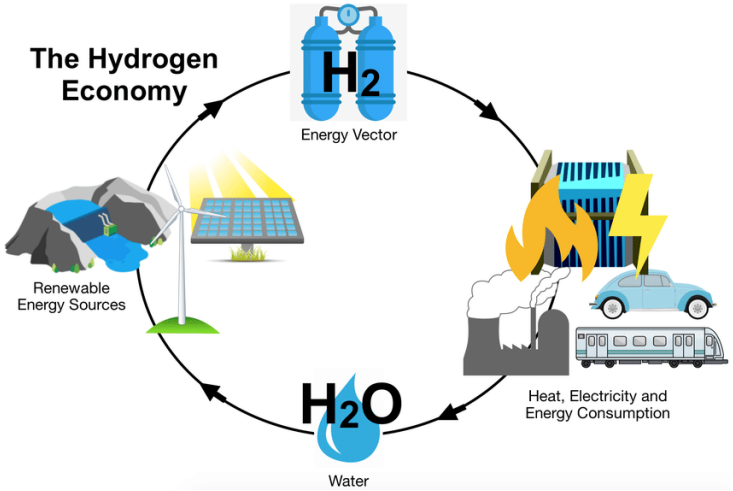


Scarlet highlight: Dual transport

- **Main idea**: combination of MgB_2-based cables and liquid hydrogen in the same pipeline to simultaneously transmit two independent energy vectors: electricity and hydrogen

  H_2: Storage and distribution with a LH_2 pipeline grid

  Electricity: up to 1 GW with a compact DC cable inserted in the LH_2 pipeline grid



	H_2	Electricity
	10t/h steel smelter for reduction	50 to 200 MW
	200-300 m^3 LH_2 on board 2-3 t/h	50-100 MW
	80 kg/truck - 100 truck: 0,3 t/h - 1000 truck: 3t/h	150 kW per fast charge point -100 vehicles: 15 MW

Dual transport: Possible solution

Design example for a bipolar cable:

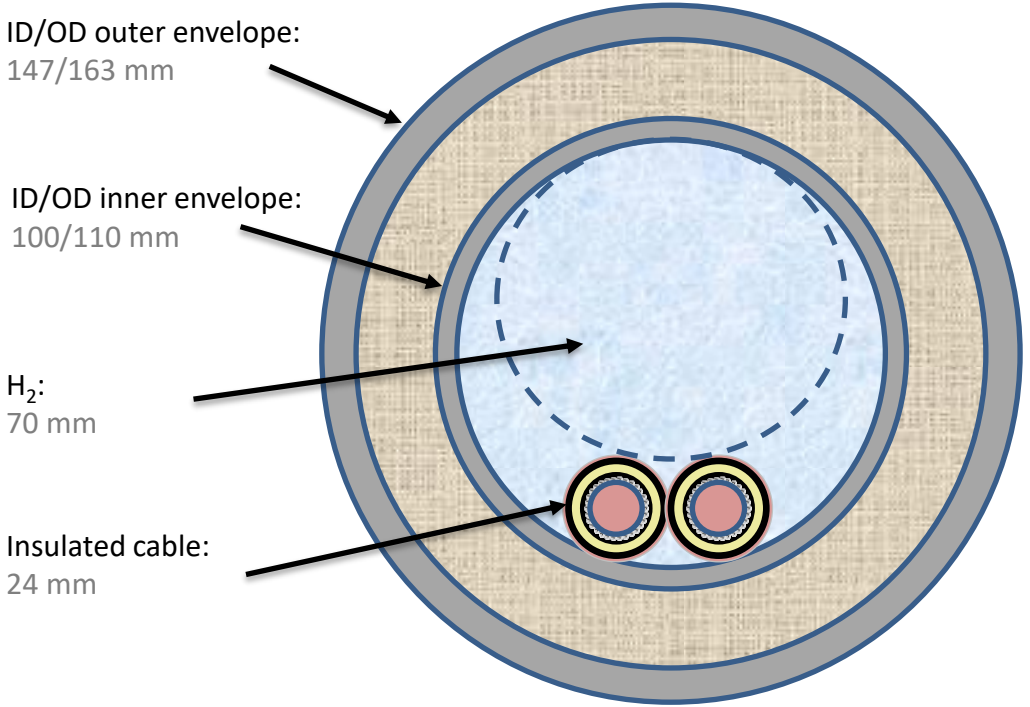
1 GW power: 2 x 20 kA and 25 kV

H_2 mass flow: 2.8 t/hour

System length: 5 km

Important: Safety issues will be addressed in detail within Scarlet

Long-term test: last 6 months of the project



Conclusions

- MVDC superconducting cables allow for high-power transmission with improved system efficiency and environmental impact
- Growing interest of Transmission System Operators recently, thanks to the high ampacity, compactness and grid simplification, especially for offshore applications (suppression of high-voltage transformers)
- Improvement of Technology Readiness Level toward commercial availability expected in the next 4 years within the framework of SCARLET

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https://scarlet-project.eu

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