

InterOPERA

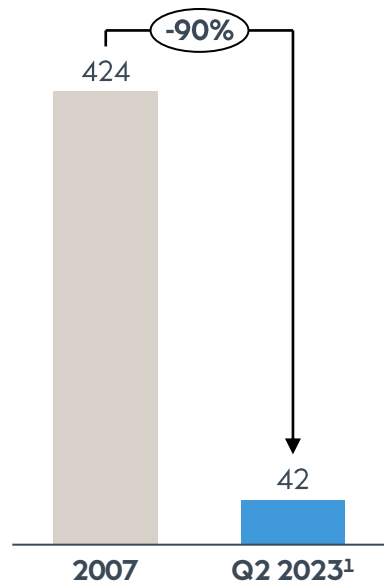
A satellite view of Earth at night, showing the curvature of the planet and numerous city lights glowing across the dark surface. The lights are concentrated in coastal areas and major urban centers, creating a pattern of golden-yellow specks against the deep blue and black of the night sky and oceans.

Enabling HVDC-based Offshore Transmission Systems of **Tomorrow**

Syed Hamza Kazmi
1 Nov 2023

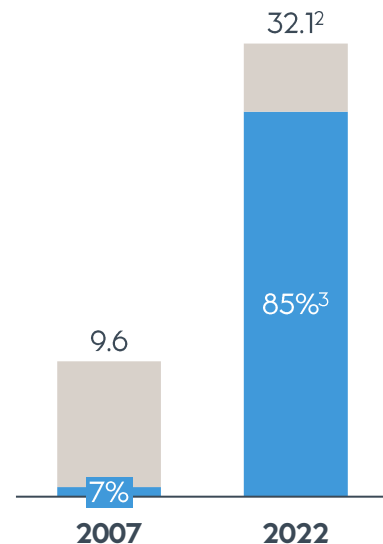
Ørsted has succeeded in profoundly transforming itself from a carbon-heavy producer to a global green energy leader

CO₂ reduction
g CO₂e/kWh

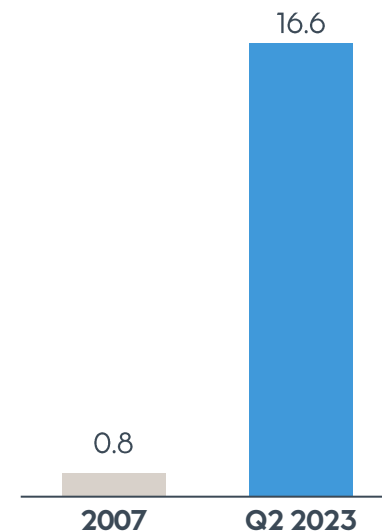


Green transformation
EBITDA, DKKbn, %

■ Share of renewables



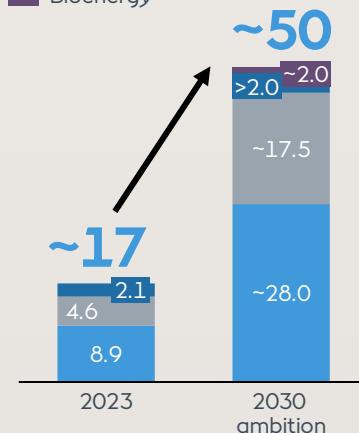
Renewable capacity
Installed capacity, GW



2030 ambition

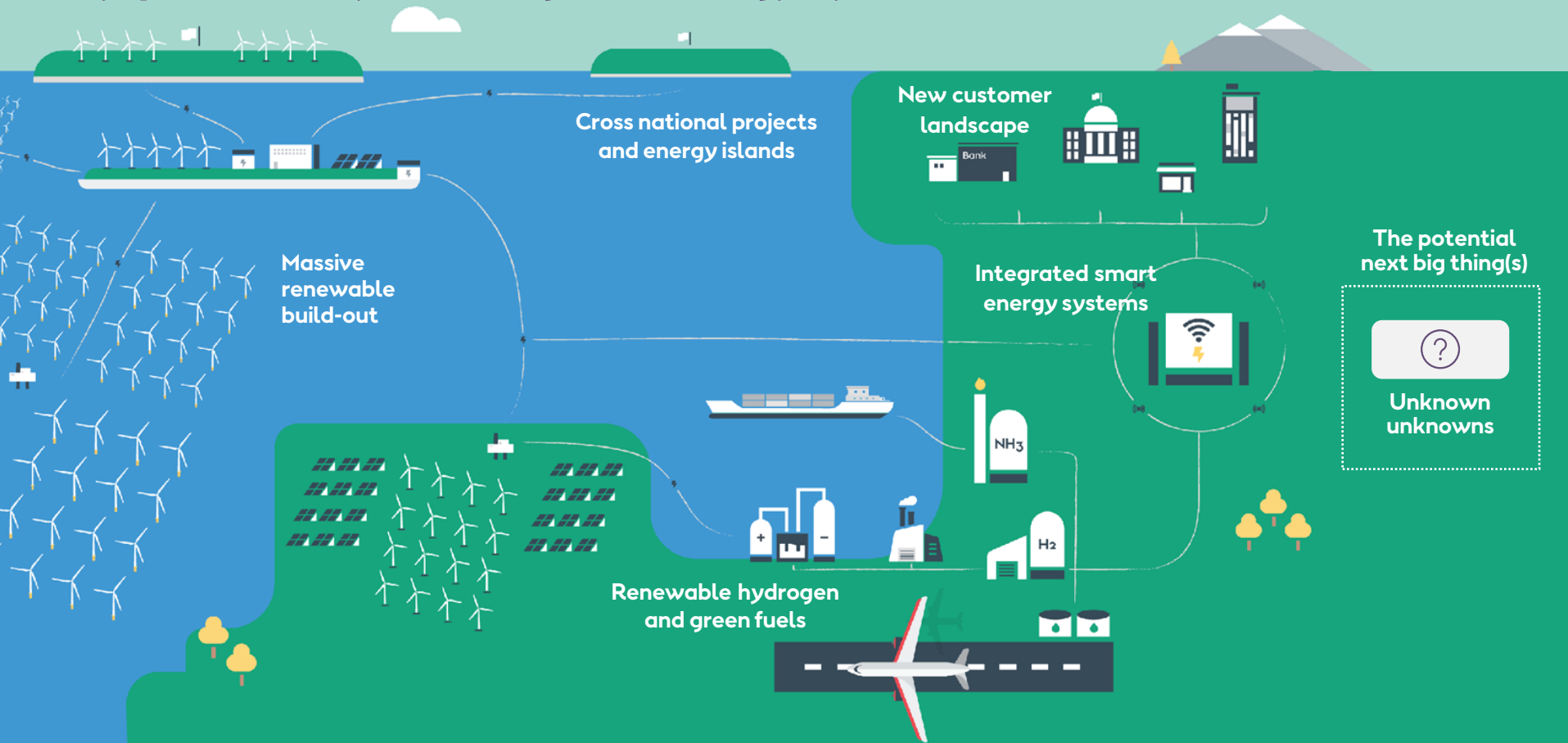
Installed capacity (GW)

■ Offshore
■ Onshore
■ P2X
■ Bioenergy



Notes: 1. Year to date. 2. Including EBITDA from new partnerships 3. Taxonomy-aligned
Source: Ørsted Interim Report Q2 2023

Ørsted aims to create a world that runs entirely on green energy – by proactively building the energy systems of the future



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Why



Context

Need for Multi terminal HVDC systems in Europe

EU objective:
Develop & integrate
**450 GW of offshore
wind** in the **European
electricity system by
2050**

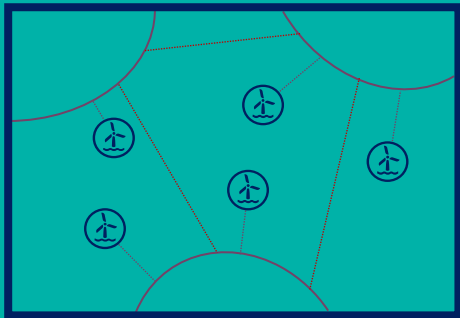
The **transmission
infrastructure** will be
directly impacted.
HVDC systems due to
their power flow
control capability will
be key

Massive deployment
of **offshore wind** in
conjugation with
increased
**distributed
generation**

Consequence:
Development of **Multi-
terminal offshore hubs**
delivered by **multiple
vendors**

HVDC interoperability background: Foreseen Evolution of Offshore Grids

'Following the EU strategy on offshore renewable energy, it is clear that beyond 2030, offshore wind cannot grow without multi-terminal, multi-vendor HVDC...' [1]



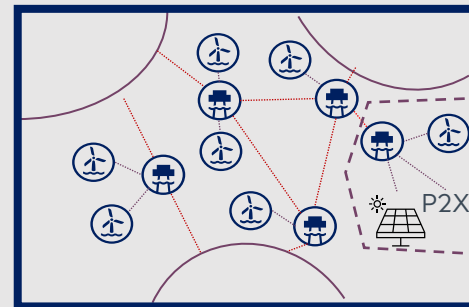
Today's world:

Radial offshore wind connections

- Wind Developer + TSO + Vendor

Embedded links

- TSO (+TSO) + Vendor



The upcoming situation:

Meshed offshore hubs

- TSOs + Vendors + Developers

Meshed onshore/offshore grids

- TSOs + Vendors + Developers

Multiterminal HVDC systems are essential for efficient and resilient energy transport

HVDC features

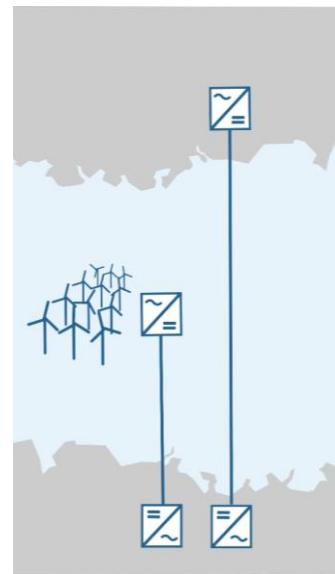
- Fewer losses over long distances
- Power flow control & system stability support capabilities using grid forming

Multi-terminal systems

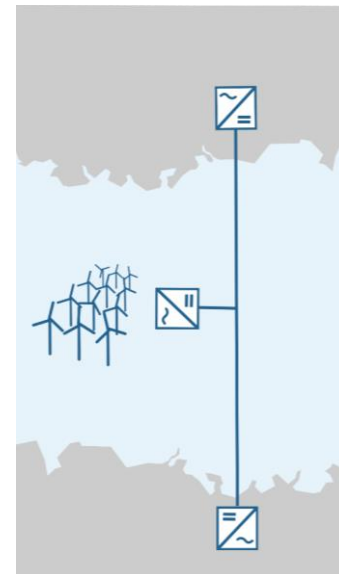
- Higher RES integration capacity
- Increased market coupling, reduced societal costs
- Minimized impact of infrastructure – increased social acceptance

Multi-vendor systems

- Limitation of risks related to one single technology provider
- Increased competition and innovation
- Potential increase in speed of deployment



Today

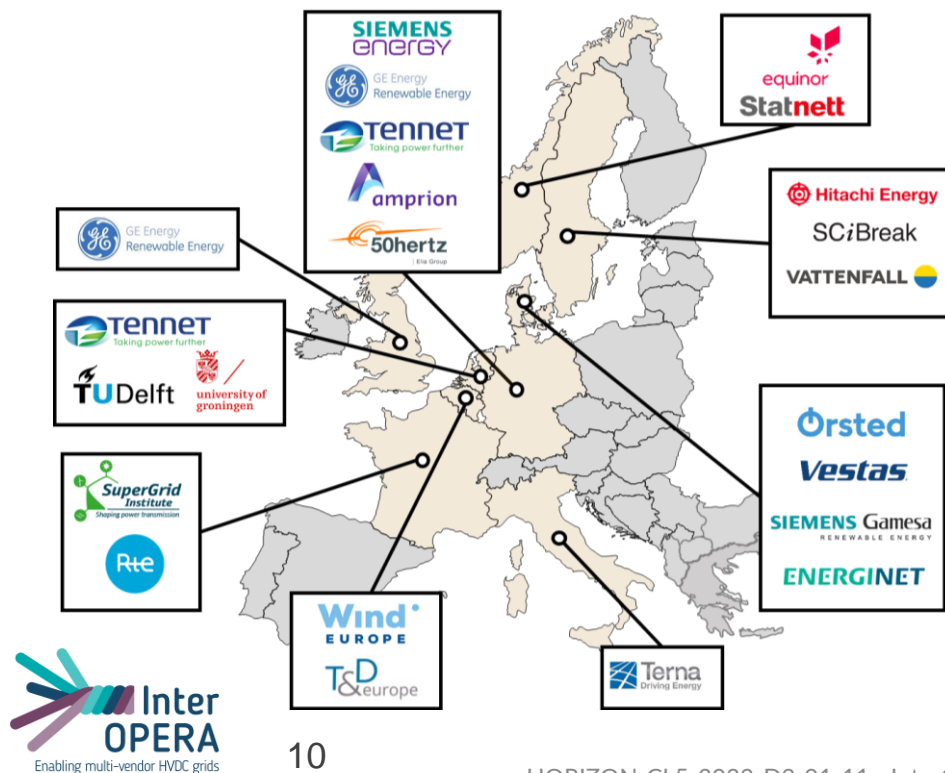


The near future

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What

Project consortium



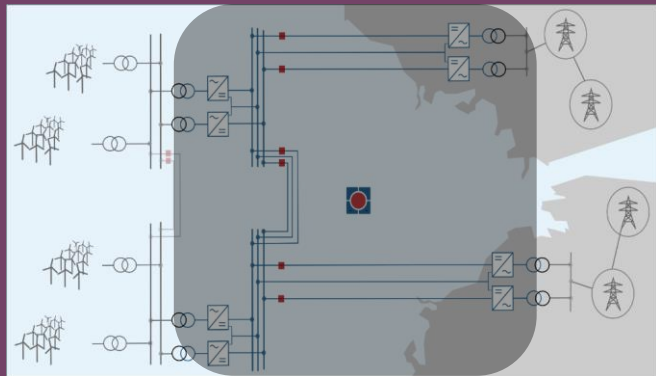
InterOPERA in numbers:

- 11 European countries
- >70 MEur of funding plus in-kind contributions
- 23 Organizations
 - HVDC Vendors
 - WTG Vendors
 - TSOs
 - Windfarm Developers
 - Research Institutes
 - Test Labs
- 7 Work Packages, 2 Project Phases, 1 real-life demonstrator
- >200 Contributors

This project aims to transform the offshore HVDC industry in Europe

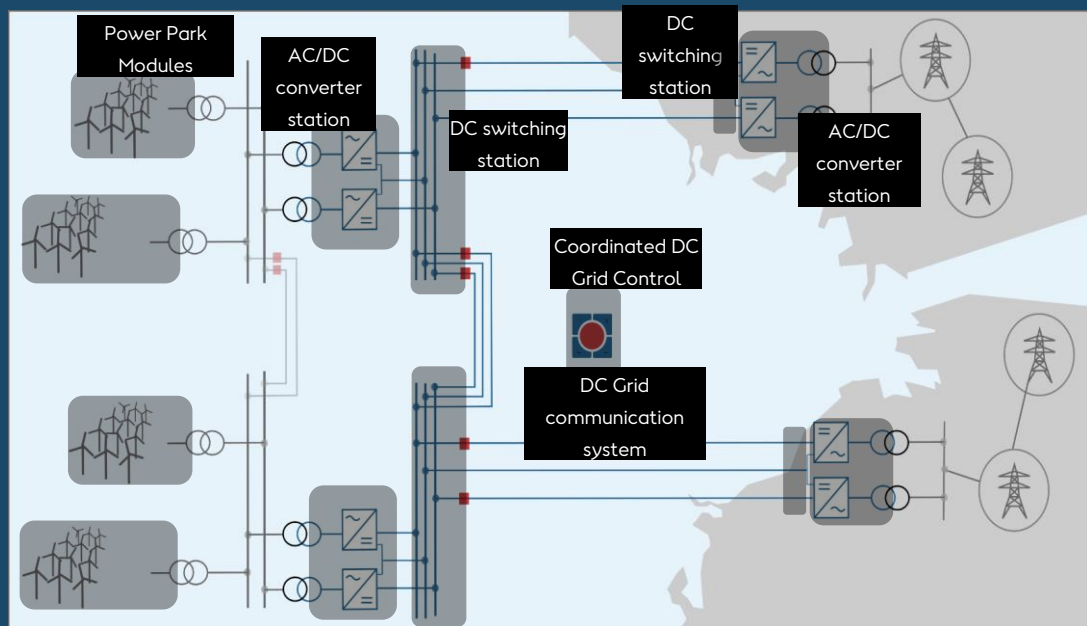
Key Objectives 1/3 : Make HVDC Grids Modular & Interoperable by design

Turnkey integrated HVDC Grid



Monolithically structured technologies
incompatibility between different vendors

Today



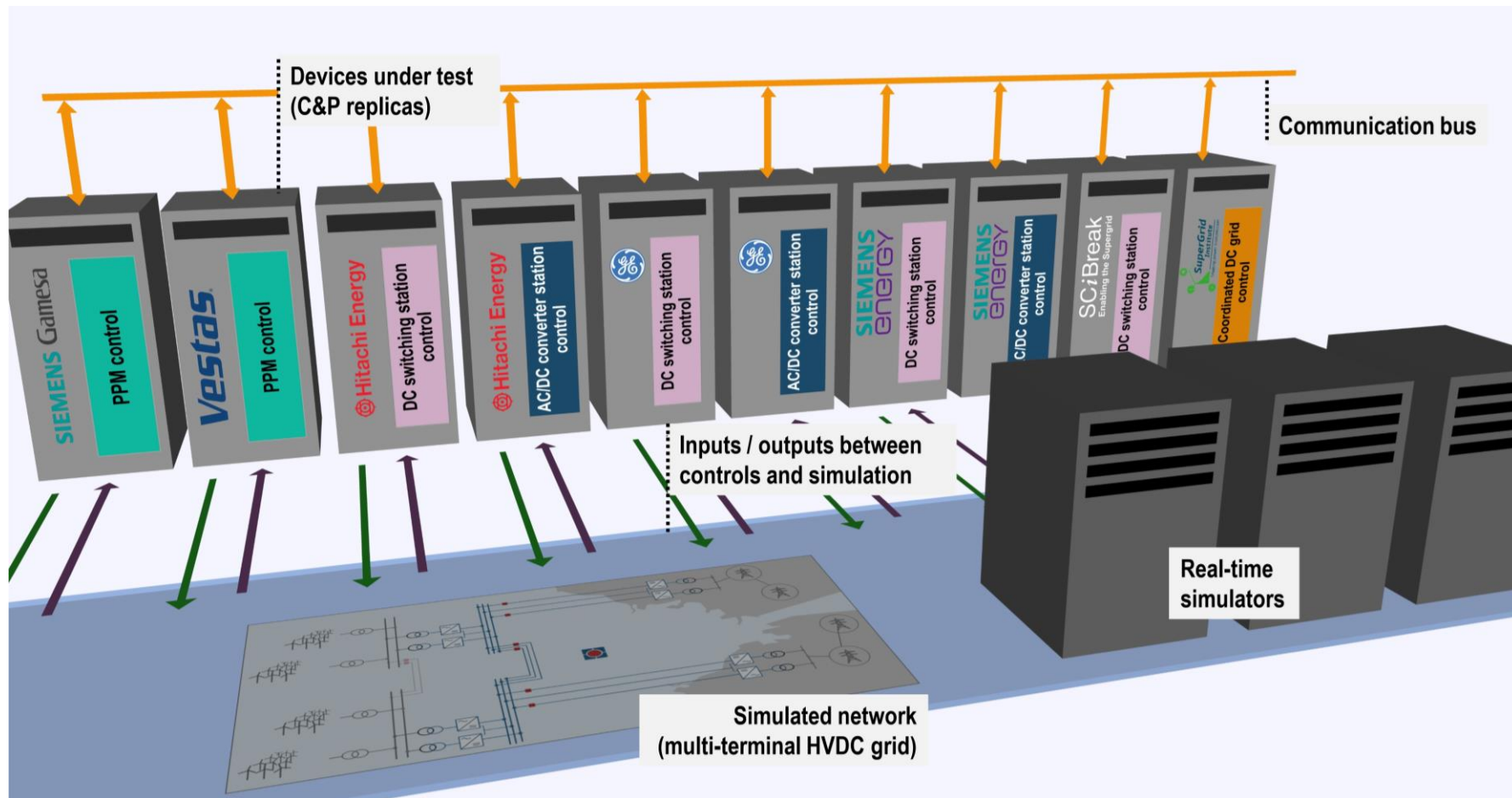
Modular HVDC building blocks with standard interfaces

Interoperability by design

Validated multi-vendor multi-terminal HVDC functional specs

Target

Key Objectives 2/3 : Perform a real-time physical demonstrator



Key Objectives 3/3 : Pave the way for MVMT HVDC w. Future Expandability

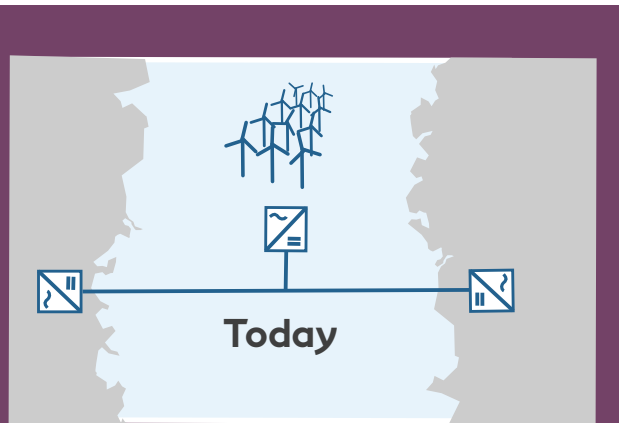
2023

2025

2027

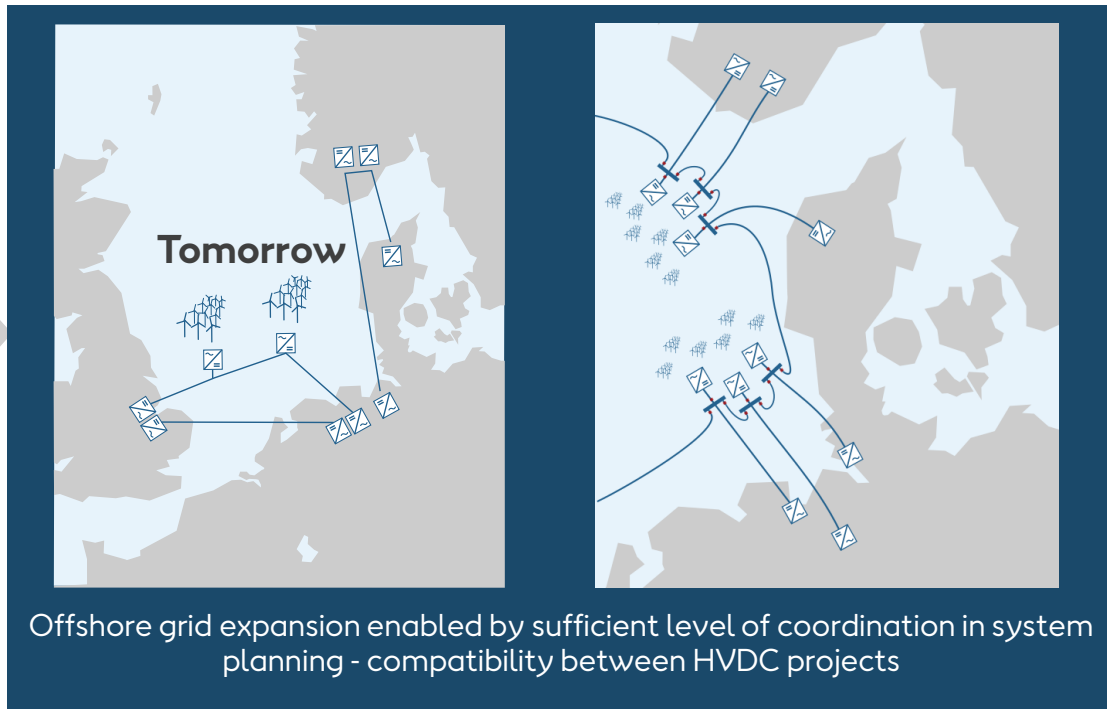
Forward-looking offshore grid design –
Demonstrator definition and
guidance for coordinated HVDC system planning

Usable procurement documents,
tender processes & governance
frameworks



First single-vendor hybrid multi-terminal
HVDC links

Expandability hindered by lack of
coordination in power system planning

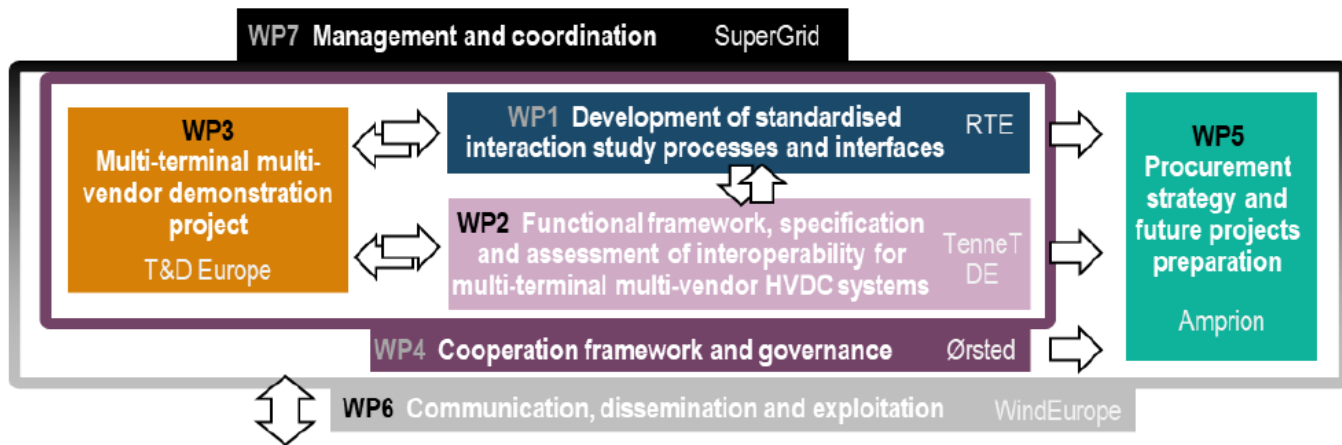


Offshore grid expansion enabled by sufficient level of coordination in system
planning - compatibility between HVDC projects

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How

Work Packages & Breakdown of Key roles



Power system planning, design and operation

Tennet
ENERGINET
SuperGrid Institute
Shaping power transmission

Modelling and simulation, system integration

TU Delft
Rte
equinor

Real-time communication, control & protection development

Hitachi Energy
SIEMENS energy
Vestas
SCiBreak
SIEMENS Gamesa
SuperGrid Institute
Enabling power transmission

IP - Legal

Ørsted
Statnett
university of groningen

Procurement, Regulation

amprion
Terna
50hertz
E.ON Group

International energy policy, industry alignment

Wind* EUROPE
T&D europe

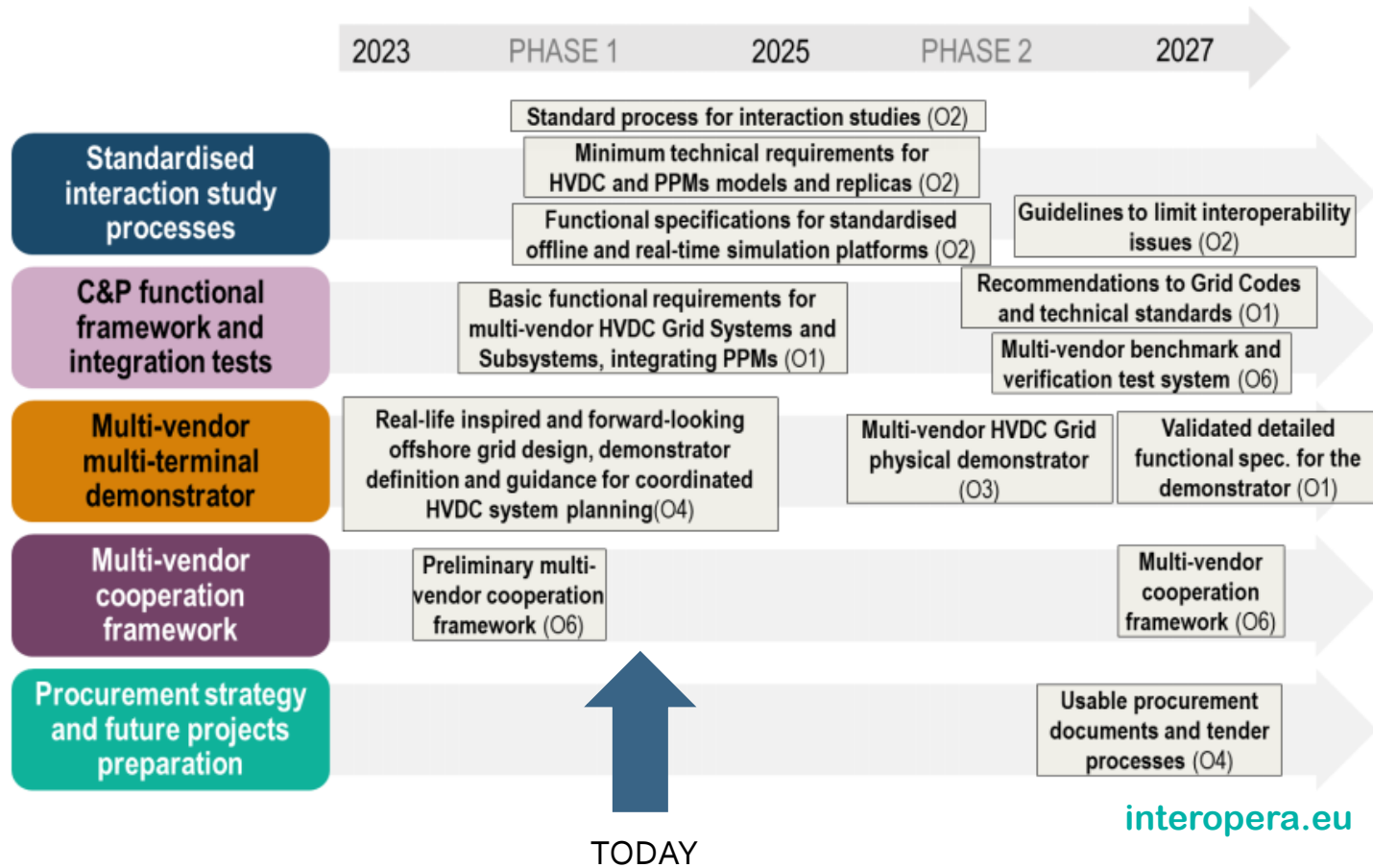
Project concept and objectives

Workstream for the development of multi-vendor HVDC systems*



Planning of Activities

Core activities allow InterOPERA to achieve its ambition



Thank you and please reach out!



Syed Hamza Kazmi

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Let's create a world
that runs entirely on
green energy



A stylized globe of the Earth with blue oceans and light green continents, centered behind the main text.

Love your home