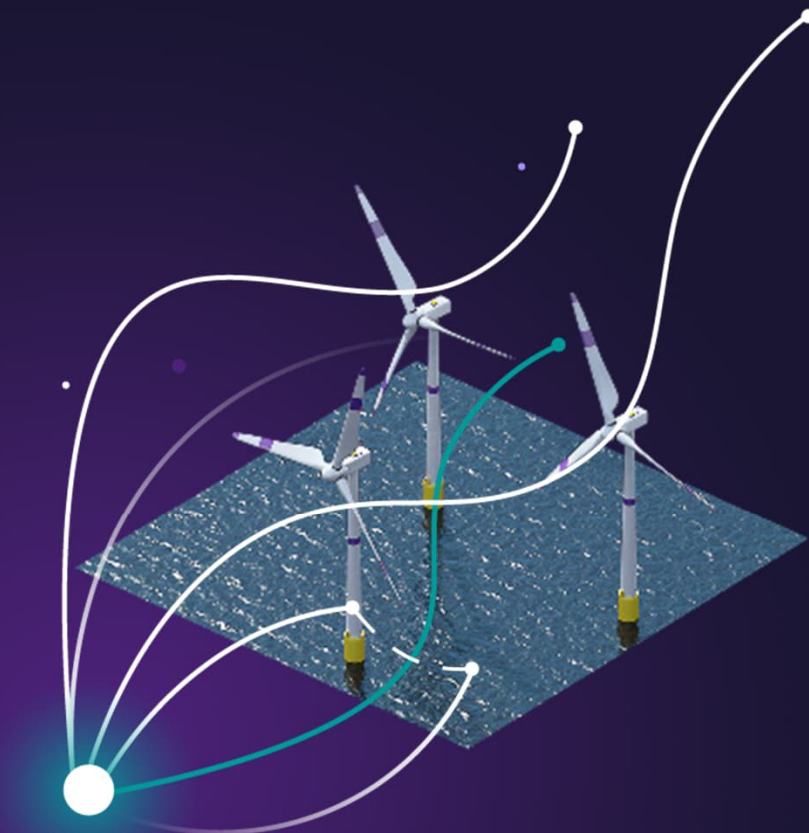


High Voltage Switchgear for Offshore Wind Applications

Alejandro Blázquez
18th January 2023



Agenda

Presentation from Siemens Energy will cover following topics:

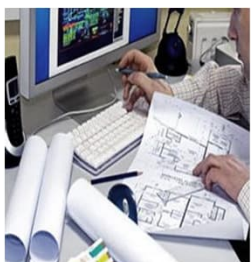
- o Siemens Energy introduction
- o Wind Offshore Connections: General considerations
- o Evolution of offshore substations
- o Floating Windfarms
- o Special requirements for floating



In-house competence & expertise of Siemens Energy

Siemens Energy relies on **more than 100 years experience** in the complete value chain of gas- and air-insulated switchgear technology and is your **one source** supplier for the entire scope of supply and services!

Design & Engineering



Manufacturing



In-House, Independent HV Test Lab (PEHLA)



Supply



Installation, Testing & Commissioning

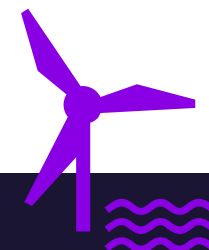


Training & After Sales



Proven expertise offshore wind applications

Safe, reliable and environmentally friendly



Our offer

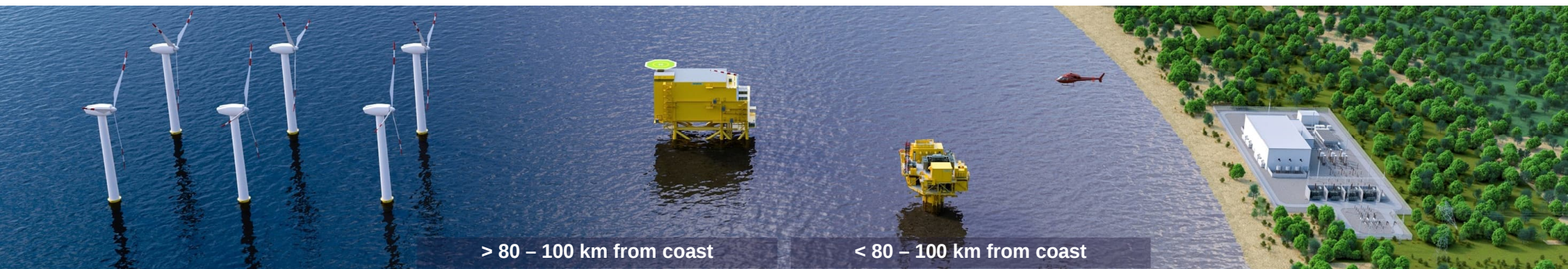
- Siemens Energy is leading in HVAC and HVDC grid access
- Our customers benefit from our comprehensive scope of supply: product supply as well as integrated system comprising primary offshore substation equipment including transformers, HV & MV GIS, LV switchgear and cables, diesel generators and grounding transformers, control and protection, scada system, monitoring, etc.
- Extra consulting service during the sales phase

Our promise

- Reliable and safe solutions for offshore wind farms, tailor made according to our customer expectations
- Smooth coordination and integration of the various stakeholders requirements
- High flexibility in all project phases
- Timely delivery of all products and services
- Excellent on-site service and support

Global references on offshore windfarms including HV-GIS:
more than 700 bays for OSS (up to 420kV)
more than 1150 bays for WTG (up to 145kV)
in 17 countries

Bringing wind home – with Siemens Energy's broad portfolio



Components for OEM's

- 33/66 kV distribution transformers
 - Dry type (GEAFOL) up to 40.5 kV
 - Fluid immersed (FITformer) up to 66 kV
- 66 kV Gas-insulated switchgear (Blue)

HVDC offshore platform Products and solutions

- Switchgear connection to wind turbine array
- Power transformer
- Platform converter AC / DC
- Onshore converter DC / AC
- Grid feed-in with AIS/ GIS

HVAC offshore platform solutions (OTM and OTP)

- Switchgear connection to wind turbine array
- Auxiliary and earthing Transformer
- Shunt reactor
- Generation step-up transformer
- Switchgear connection for HV cable

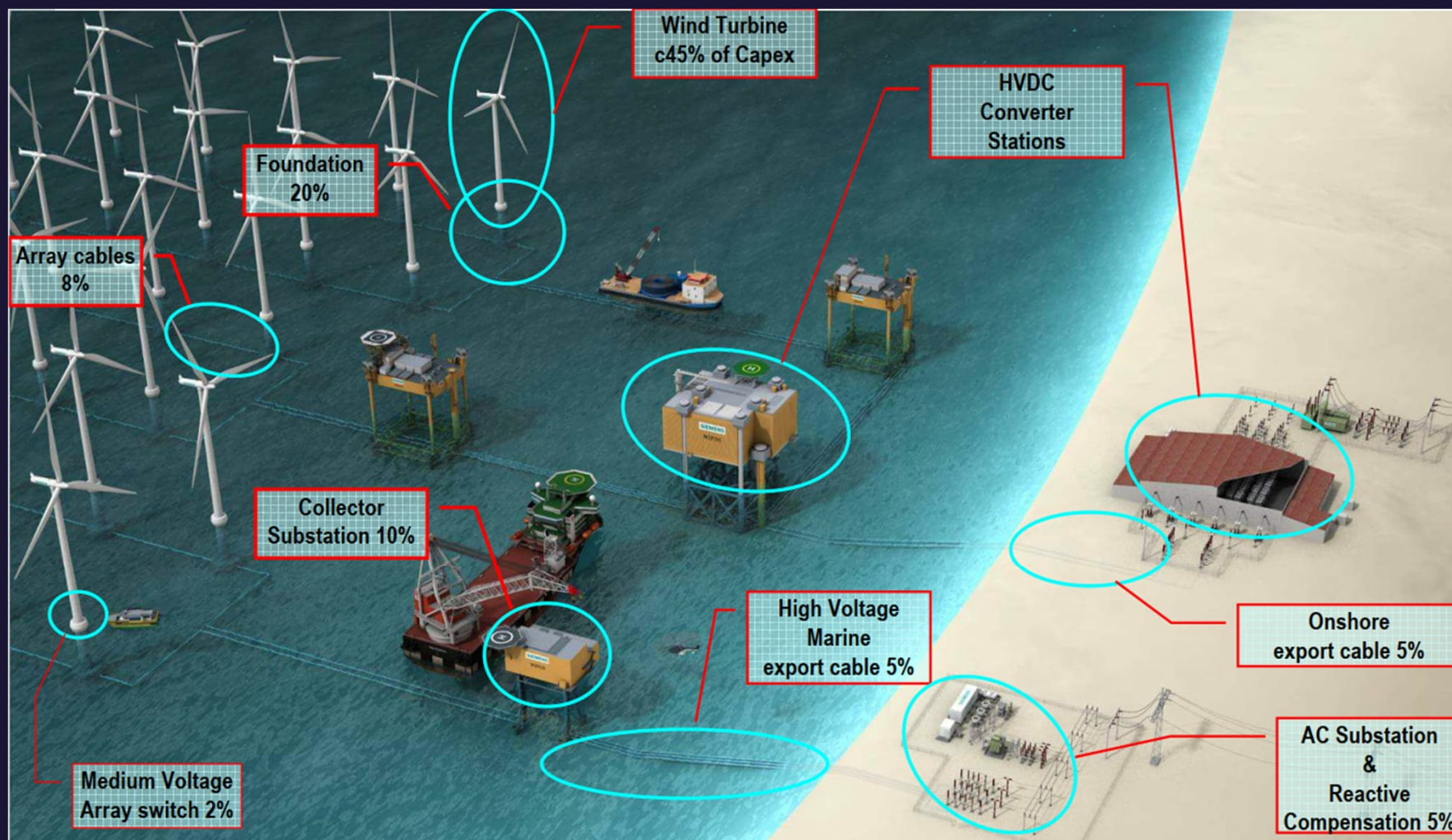
HVDC converter stations and HVAC substation

- HV cable connection with AIS/ GIS
- Power transformer
- Grid feed-in with AIS/ GIS up to 550 kV

Operation & Maintenance Service HVAC / HVDC On- & Offshore Scheduled and unscheduled maintenance activities for:

- On- & offshore substations and OTMs
- Offshore grid access platforms
- Civil on- & offshore structures (foundations)
- Subsea inspections of cables and civil offshore structures

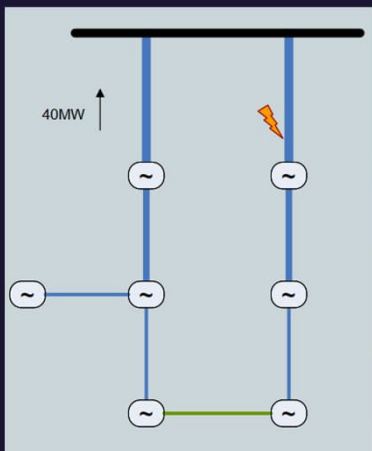
Elements of an offshore windfarm



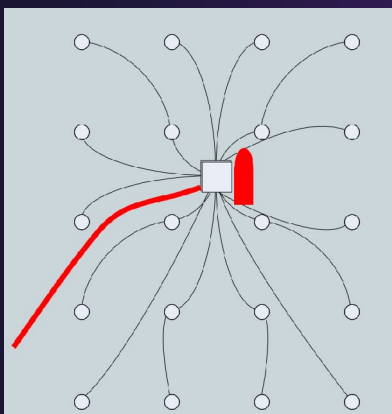
* CAPEX % is typical and for guidance only

General Considerations: Cable arrays

Trends



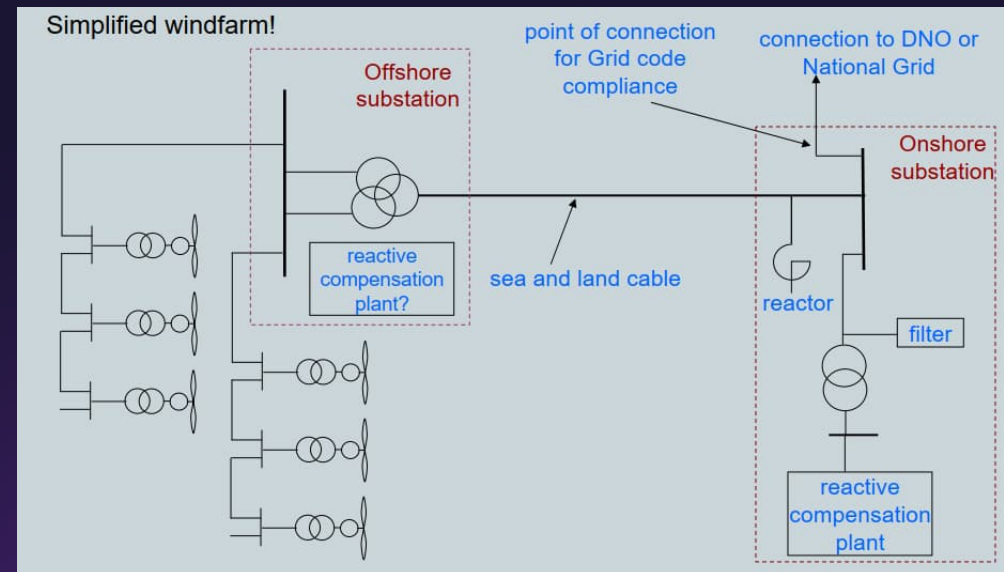
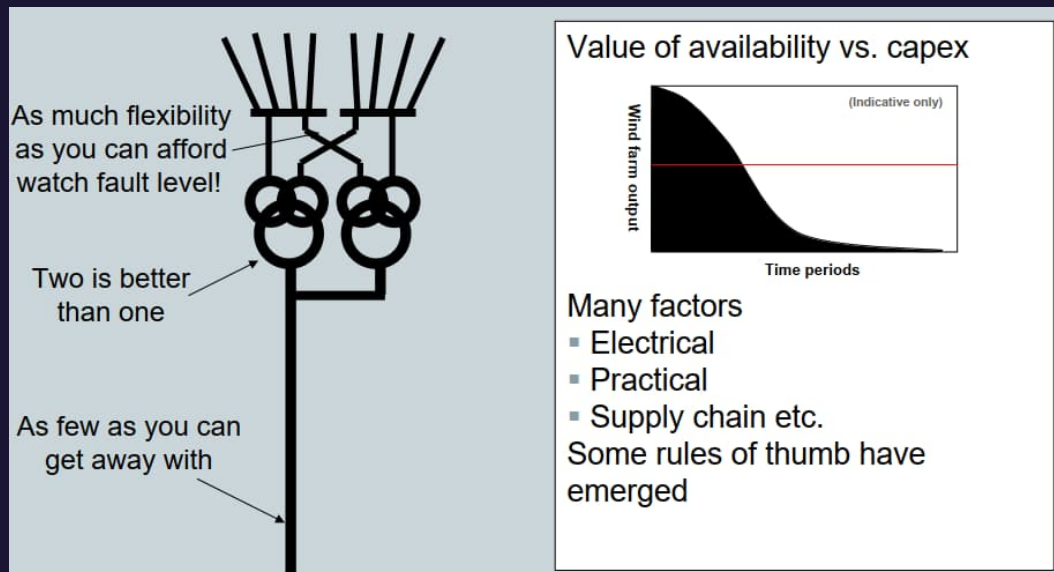
- Wind turbine generators (WTGs) form an array spaced approx. 1km
 - Each WTG needs 1 cable
 - Strings, Tees and tapered cables
 - Closing loops
- Practical installation issues
 - max array cable 400 sqmm?
 - At 33kV this is 40MW per string, 66kV is today the standard
- Real sea-bed issues change the simple layout (Sand waves, wrecks, marine organisms, prior works, installation vessel needs, delivery logistics etc.)



- 1st cable section finds the nearest free WTG
- More than 10 or 12 cables means longer runs
- Need to keep 1 side clear for jack-up service vessel
- De-rating factor where cables run close together



Offshore substation and export cable

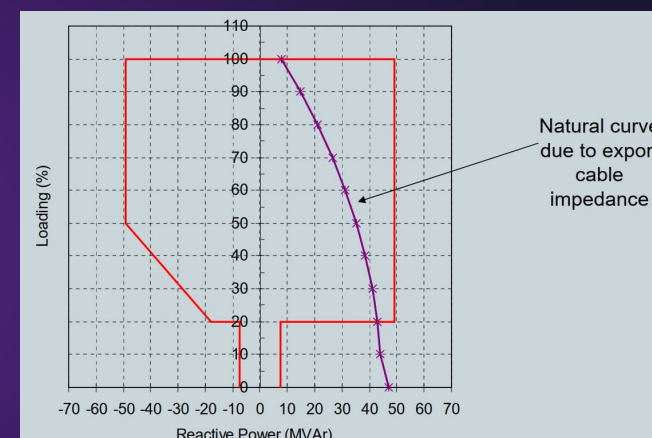


CURRENT STATE OF ART for EXPORT CABLES

- AC connection: 275 kV
- DC connection: 325 kV -> 525 kV



Meeting the Grid Code!



1st Generation of Offshore substations



Rodsand DK



Horns Rev DK



Barrow GB



Princes Amalia (Q7) NL 2007



Lillegrund SW 2007



Robin Rigg W GB 2008



Alpha Ventus D 2008



Horns Rev 2 DK 2008



Gunfleet GB 2008



Rodsand 2 DK 2009



Walney 1 GB 2010

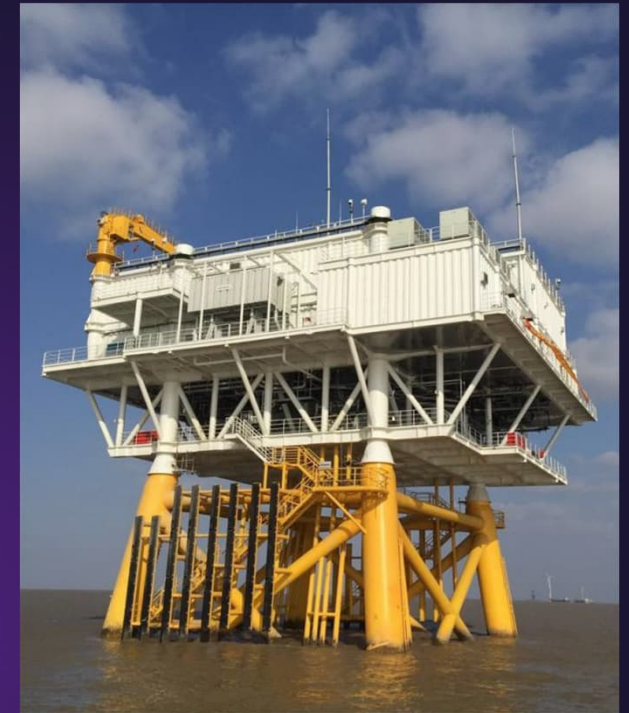


Belwind 1 BE 2010



Ormonde GB 2010

2nd Generation of OSS are higher and more “harmonized”



HVDC platforms makes a new step in the technology



- Control & protection and SCADA
- Redundant step-up transformers
- AC converter high-voltage switchgear
- AC high-voltage switchgear energy income
- Platform converter AC / DC
- Reactors and DC GIS for export cable connection

- Bundling of products including system optimization, engineering and integration in line with platform requirements
- Certified onshore and offshore installation & commissioning

Helwin Project: first self standing topside!

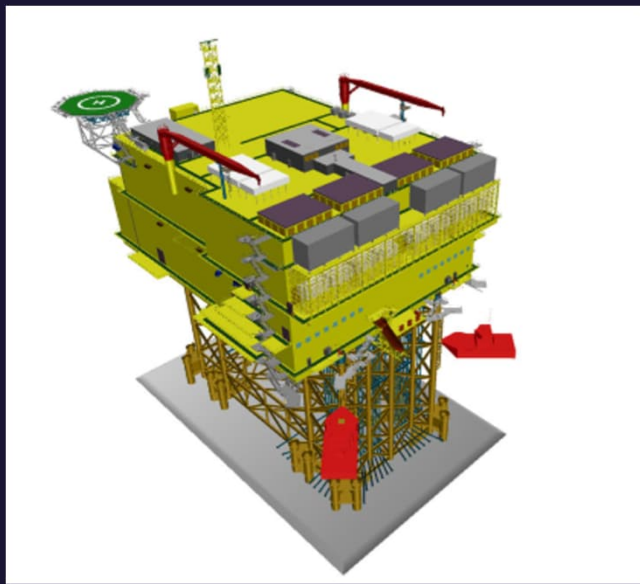


Last projects trends

LanWin1-3

Technical Data:

- Power rating: 2000 MVA
- Voltage: 525 kV
- Frequency: 50Hz
- Insulation: Mineral oil



Beatrice OTM

Technical Data

- Power rating 310 MVA
- Voltage 220 kV
- Frequency 50Hz
- Insulation Synth. Ester



Floating Wind offshore

SE GT S VE

18th January 2023

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Going to deeper water

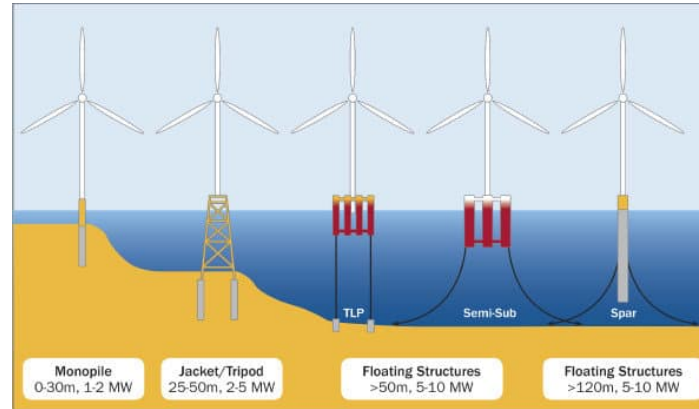
Stage one: Offshore floating wind turbine

The wind turbine generator (WTG) is in the stage of pilot projects. Roll out to larger scale projects to come by 2023 and onward

Stage two: Offshore floating substation

The offshore substation (OSS) is in the early stage of development

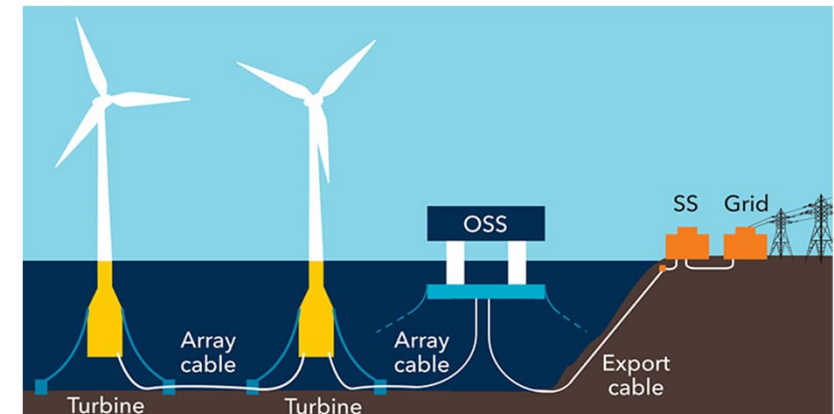
Offshore floating wind turbine project does not automatically mean offshore floating wind substation!



Picture: <https://www.researchgate.net/>

- Up until now the specification for the electrical products, for a floating WTG, has not changed
- Mechanical endurance tests is ongoing for the electrical products for floating vibration for the WTG

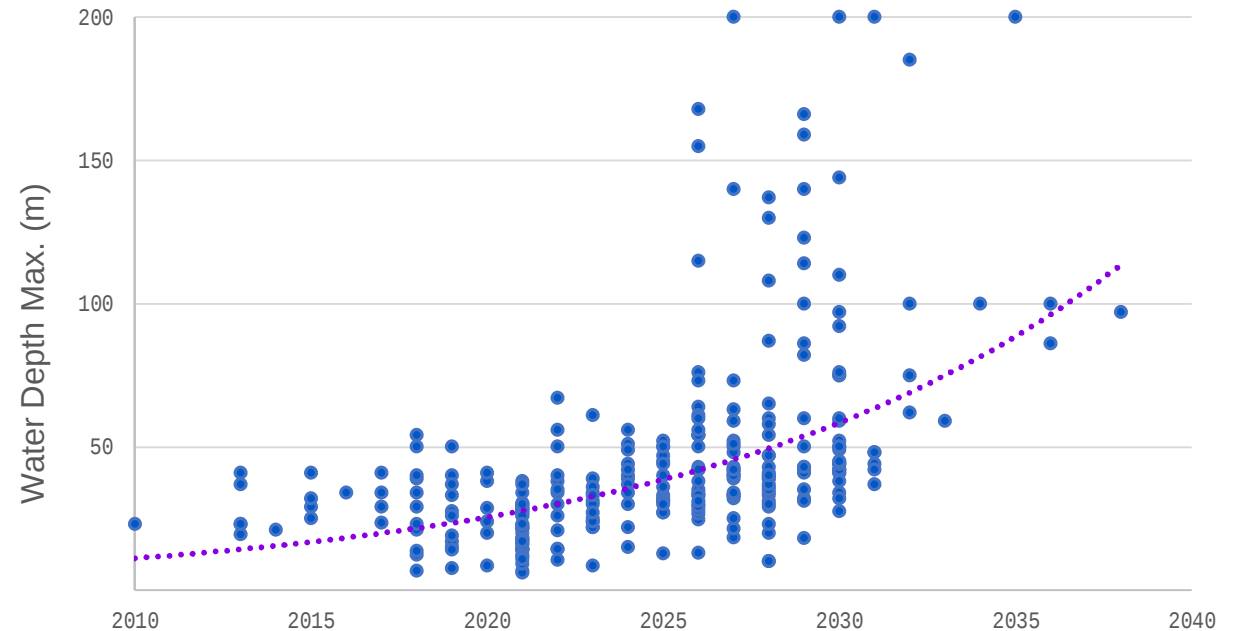
- First floating projects are being executed (for GIS application in oil&gas industry)
- SE is involved in several floating platform studies (e.g. power barge, AC OSS, HVDC OSS)



Picture: <https://www.dnv.com/>

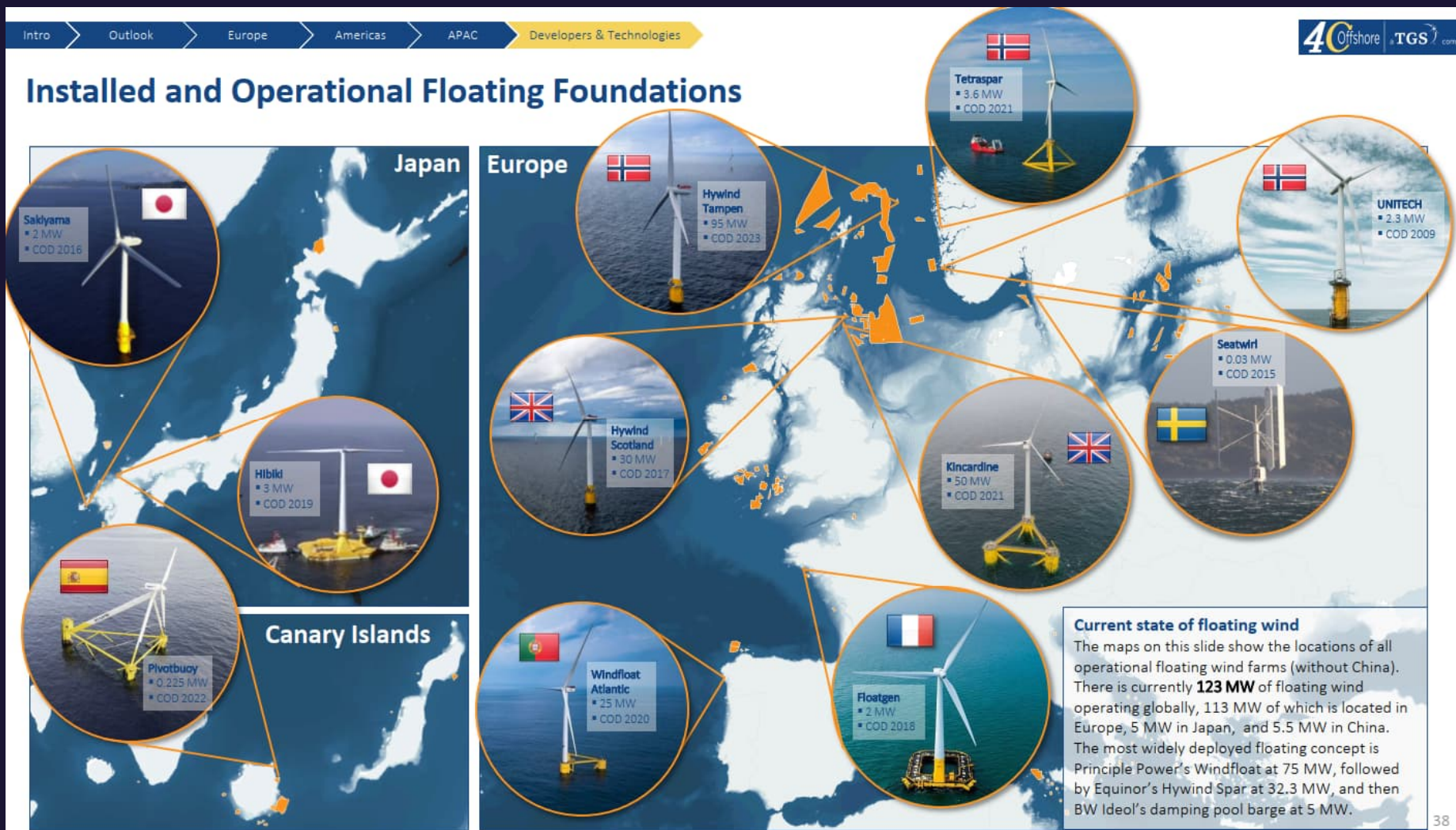
Drivers and challenges for floating offshore substations

Increasing water depth as a driver for FOSS



- Demand for FOSS from 2025 onwards due to increasing water depth
- Main challenge earmarked around FOSS is the viability and high cost of dynamic export cables

WTGs are already in advanced stage, ready for commercial operation



Special Requirements for Offshore Application GIS-Equipment



Offshore Platform

Mechanical Requirements

- Deflection
- Acceleration
- Pitching, Tilding, Rolling, Heaving

Environmnetal Requirements

- Corrosion Protection
- Size, Weight
- Accessability (impact to needed space)

Other Requirements

- High current in busbar and transformer feeder (66kV)
- In case of GIB to THX: Fire resistant wall connection
- Sea-fastening
- HV-Test philosophy (Full HV-test at yard, soak test offshore)

Future Trends

- Voltage level 66kV → 132kV
- Voltage level 220kV → 275kV
- Trend from regulators: environment friendlier products
→ Blue GIS (no SF6) / Transformers with syth. Ester (no mineralic oil)

Floating Offshore Platform

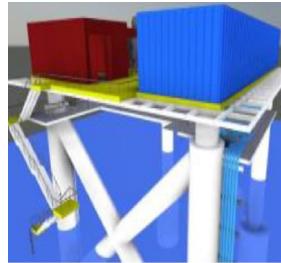
Additional Requirements for Floating Platforms

- Fatigue load
 - acceleration values at GIS-deck
 - Live-time of platform
 - Type of input data for calculation (deterministic, simplified fatigue or sprectral-based)
- Products for floating application (OSS)
 - 66kV GIS
 - SF6: 8DN8 (up to 145kV)
 - Blue: 8VN1 (up to 145kV)
 - 220kV up to 300kV and 420kV (HVDC):
 - SF6: 8DQ1 (up to 420kV)
 - Blue: GIB connection
 - DC:
 - SF6: DC-GIS (up to 550kV)

Different substation designs under development



- HVDC or HVAC
- Light and simple cubic
- Hull space can be used for hydrogen or ammonia storage



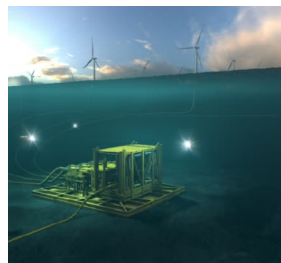
- Partners bring together expertise in substations, floating applications and transformers
- For capacities up to 300 MW



- Hitachi ABB will provide substation packages
- Based on BW Ideol's shallow-draft Damping Pool concept



- HVDC or HVAC
- For capacities up to 1200 MW
- Minimal topside structure



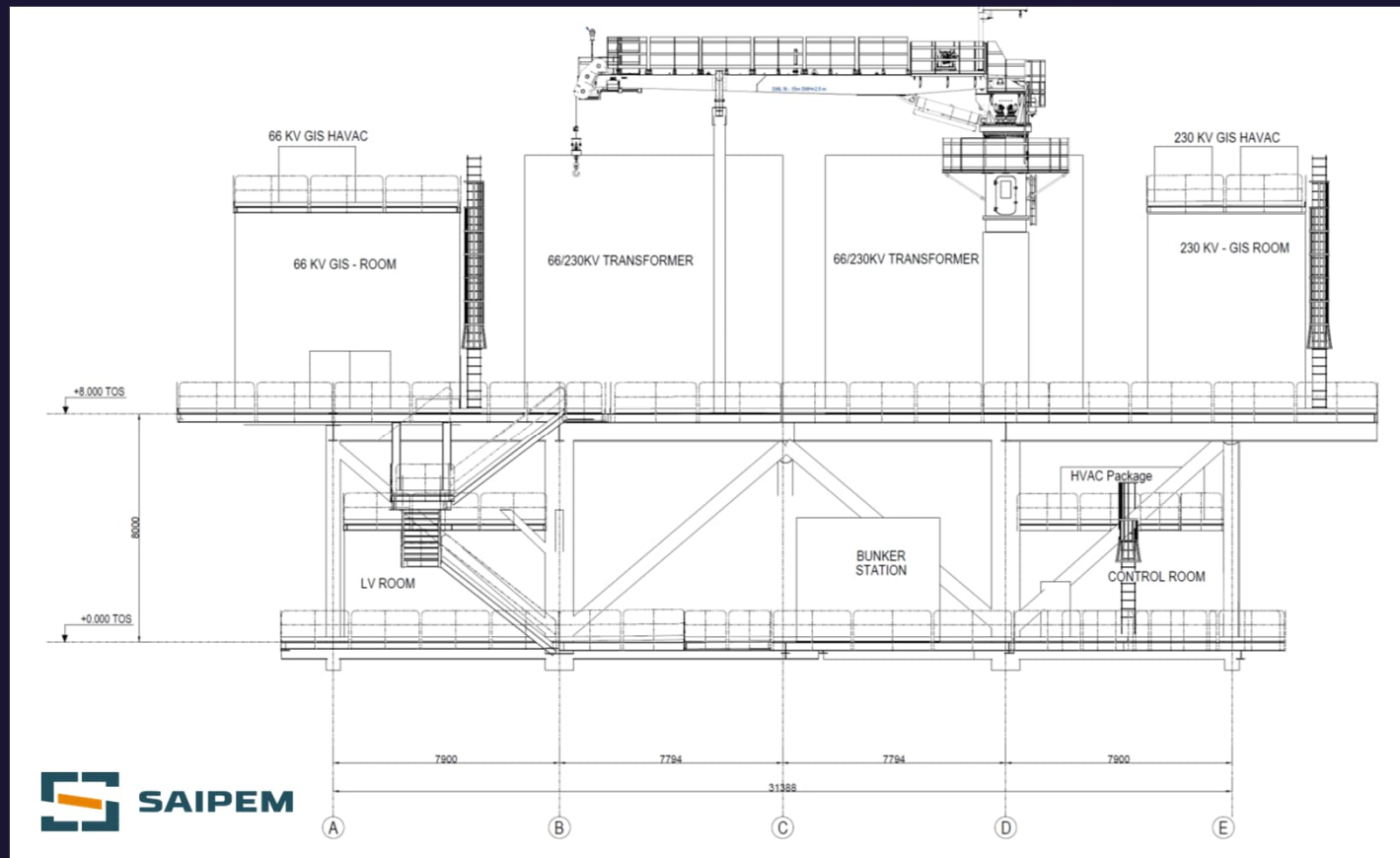
- Underwater substation
- Sea water as natural cooling system
- Reduces LCOE by 20% compared to traditional substations



- Hydrogen storage solution
- Excess wind power is converted to green hydrogen and stored at the seabed

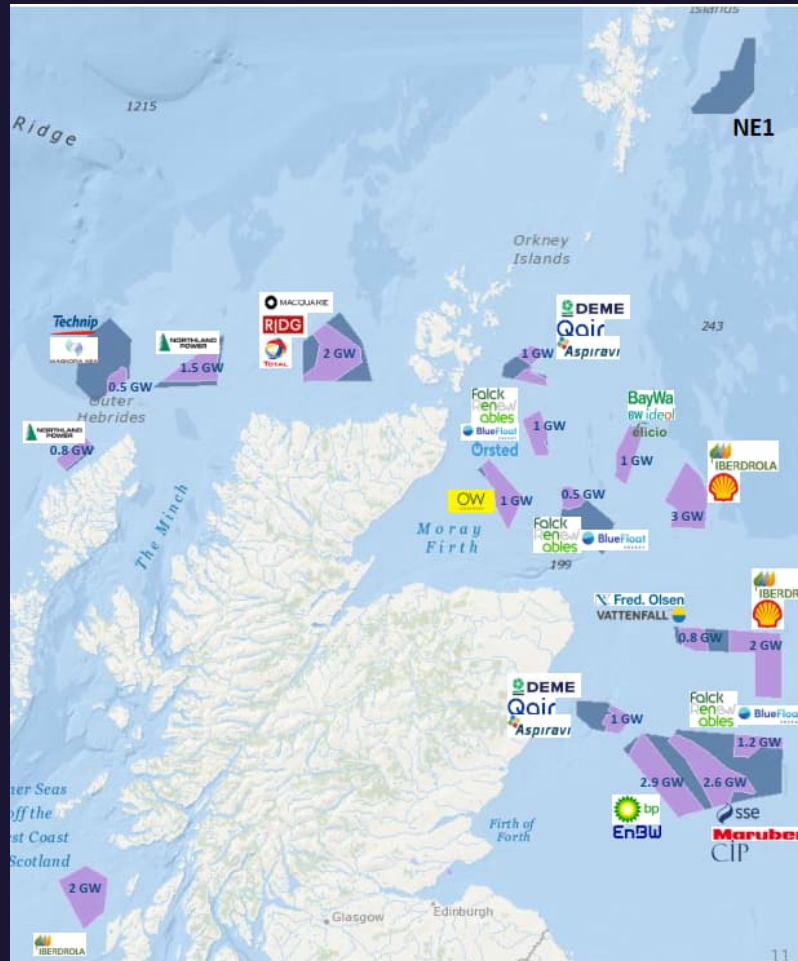
Floating OSS Conceptual Study – SAIPEM topside layout (draft 02/2022)

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energy

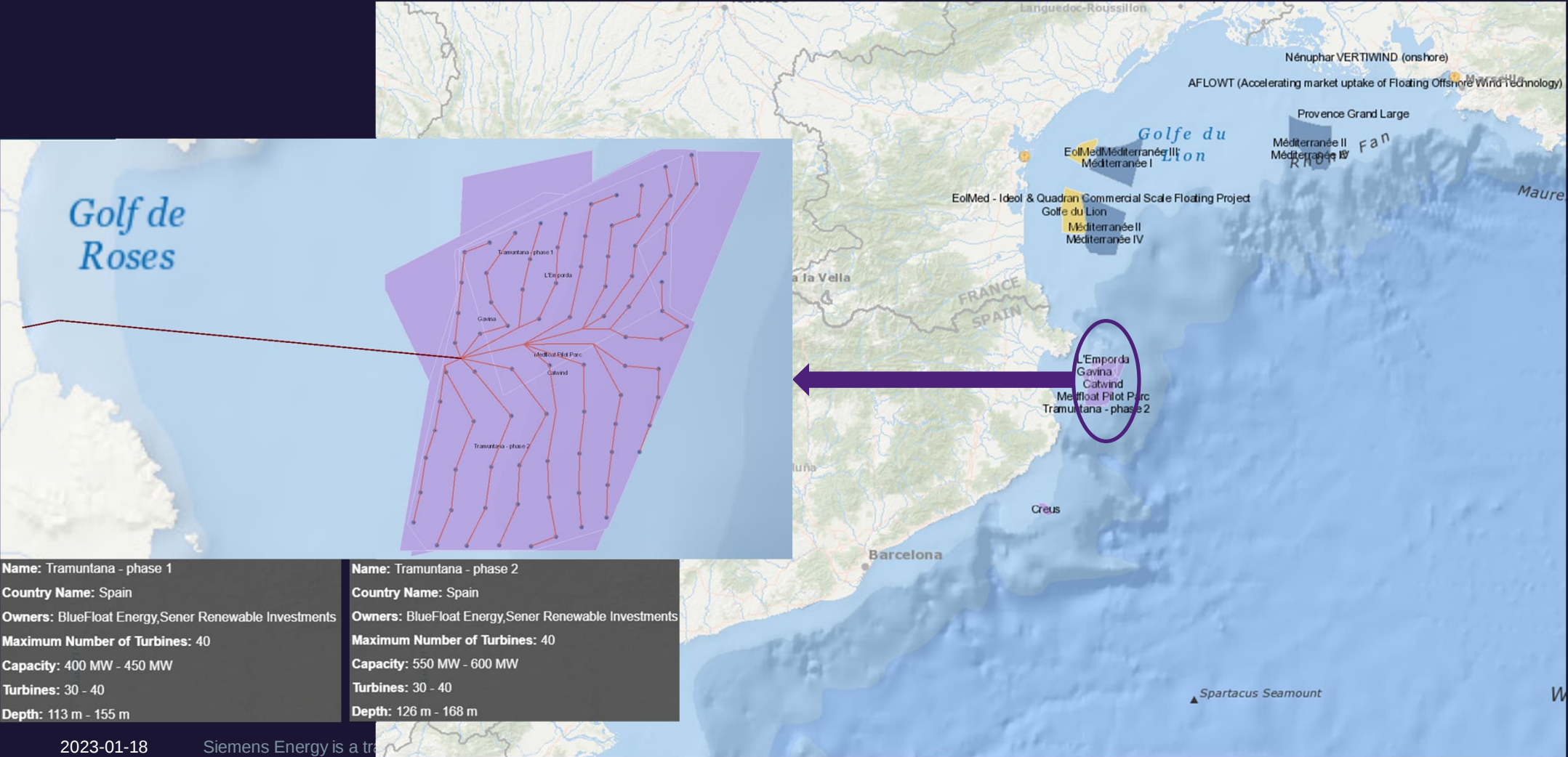


Timeline for HVDC: urgent development

Scotwind 1



Catalunya status



Contact page



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Further reading:

- [Siemens Energy Blue Products](#)
- [Siemens Energy Gas-insulated substations](#)
- [Siemens Energy Transmission Products](#)

[siemens-energy.com](https://www.siemens-energy.com)

