R&D Webinar - AFOSS-DC Project Outcomes

Designing the electrical substations of the future

With the financial support of:

Topside general arrangement and outcomes of the semi-submersible floater design analysis

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Chantiers de l'Atlantique

Agenda

1. Presentation of Chantiers de l’Atlantique
2. Topside General Arrangement
3. Semi-submersible floater design
4. Conclusions

Chantiers de l'Atlantique

3 Business Units

Ships



Services



ATLANTIQUE OFFSHORE ENERGY



Atlantique Offshore Energy: an EPCICM contractor for Electrical Offshore Substations

- Chantiers de l'Atlantique’s BU dedicated to Offshore Wind managing its own resources (2 fabrication & assembly workshops / 1 painting hall / ~360 FTE),
- One single site for all the processes, delivering 200,000 mT+ of complex maritime projects every year,
- In-house Engineering Department & Product Development (Floating / H2 / HVDC).

Topside General Arrangement

General Arrangement

Objectives/Constraints

- The topside shall be designed to host the High Voltage and auxiliary equipment for the 2GW HVDC application
- Its design shall be compliant with the functional analysis and electrical architecture
- Direct Current technology and 2GW power lead to significant increase of volume and weight compared to the current HVAC substations
- Topside structure shall sustain lifting, towing and extreme in-place loads and motions

Construction Philosophy

- Dimensions limited to make the Topside buildable in Europe

- A modular approach is adopted

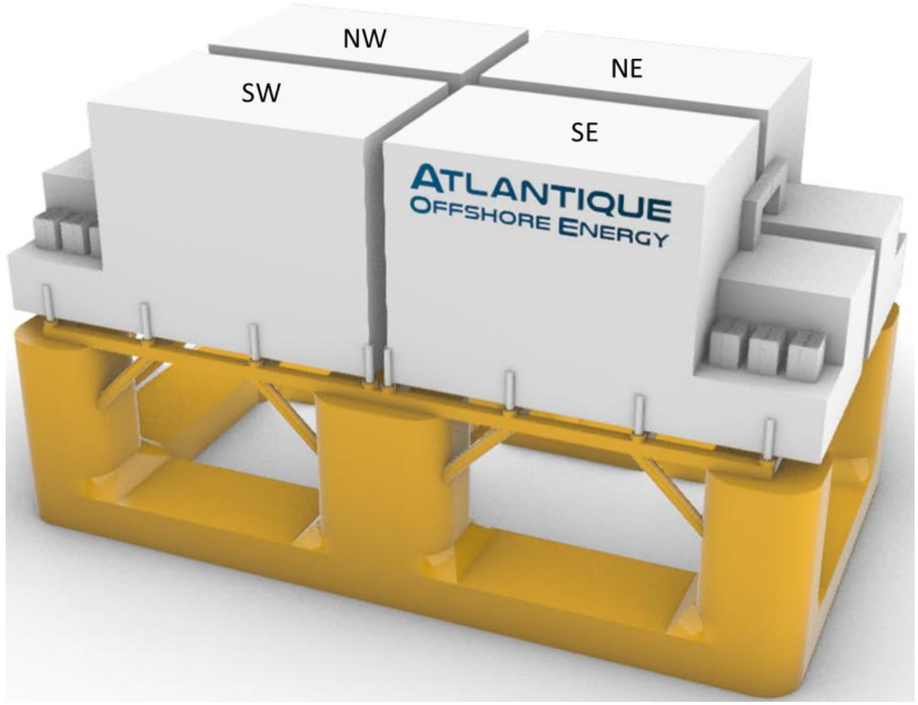
  Many of the HV equipments are repeated 4 times

  - Advantages:

  – Adapted to the European supply chain
  – Easier to build
  – Easier to install
  – Repeat effect

  - Implications:

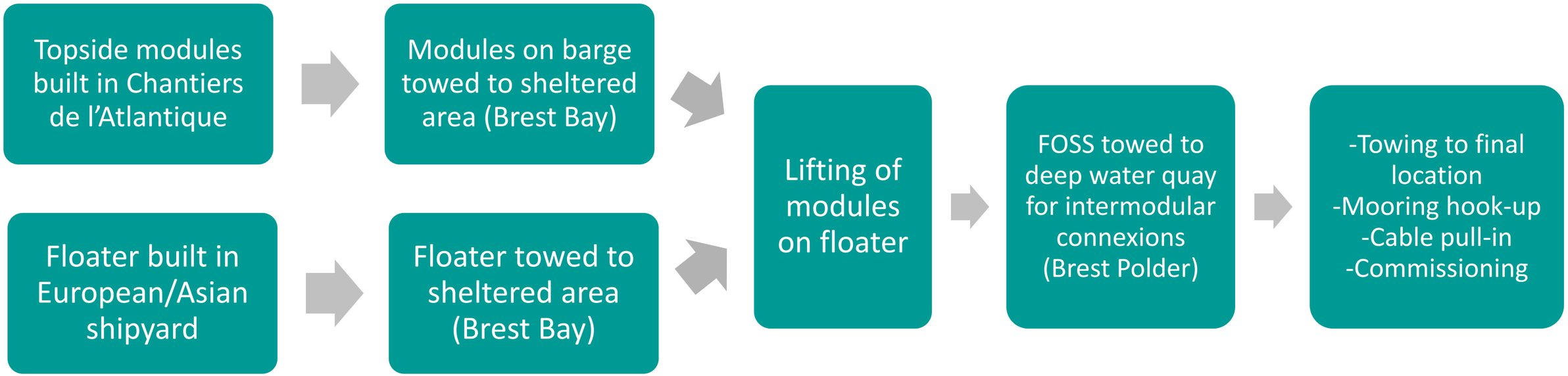
  – Nearshore works after lifting for module interconnexions (electrical, pipes, ducts, access, …)
  – Overall weight larger than integrated topside



T&I Philosophy

- A module weight not exceeding 6000t facilitates the lifting operation using a Heavy Lift Vessel

- Installation scenario



General Arrangement

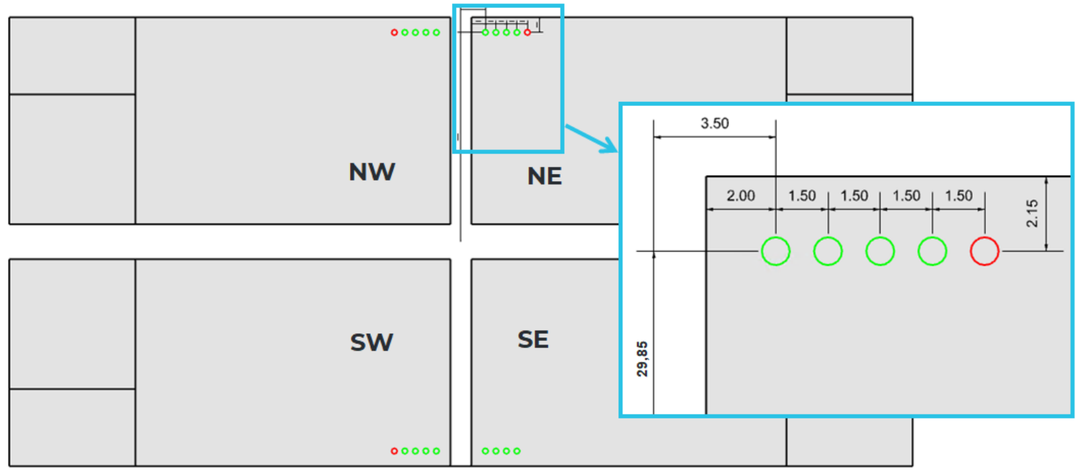
Topside description

- HV equipment distributed in the 4 modules
- Attention paid to module symmetry
- Auxiliary systems integrated in the topside
  - HVAC system
  - Cable routing
  - Safety
  - Main crane and secondary cranes
  - Access and communication
  - Floater Ballasting system control (if any)
  - Living quarter

- 4 Inter-Array Cables per module
- 1 export cable in 3 modules

	Module name			
Designation	NE	SE	NW	SW
GIS 132 kV	1	1	1	1
EAT 1	1	1	1	1
EAT 2	1	1	1	1
Main Transformer	1	1	1	1
GIS 400 kV	1			1
DC converter hall (valves)	1	1	1	1
Reactor DC inductances	1	1	1	1
GIS DC + and -	1		1	
GIS DC neutral				1

Equipment distribution per module



Location of I-Tubes (top view)

General Arrangement

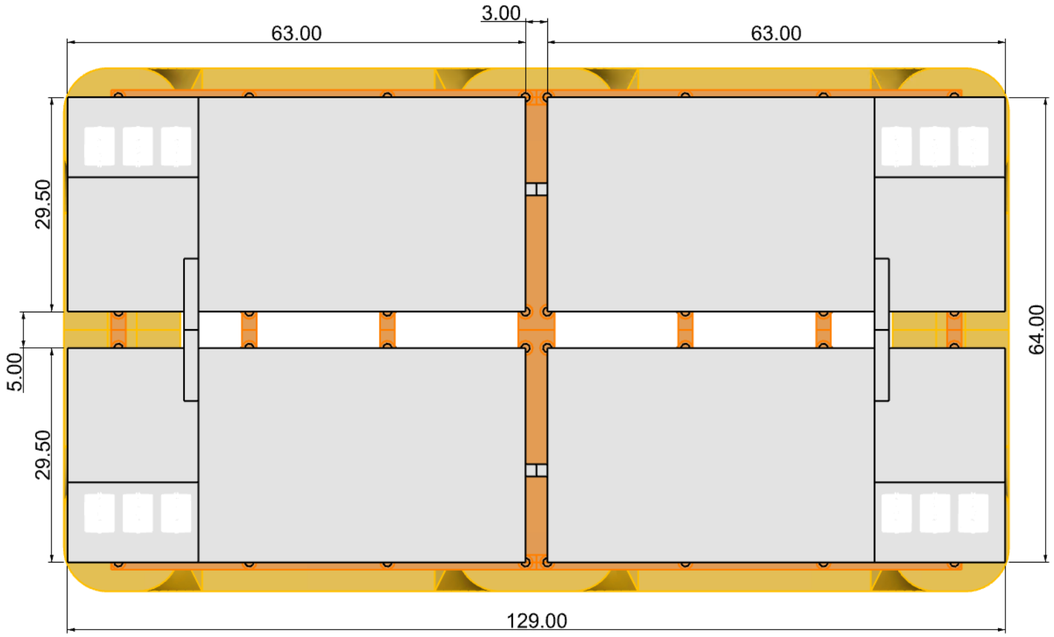
Topside description

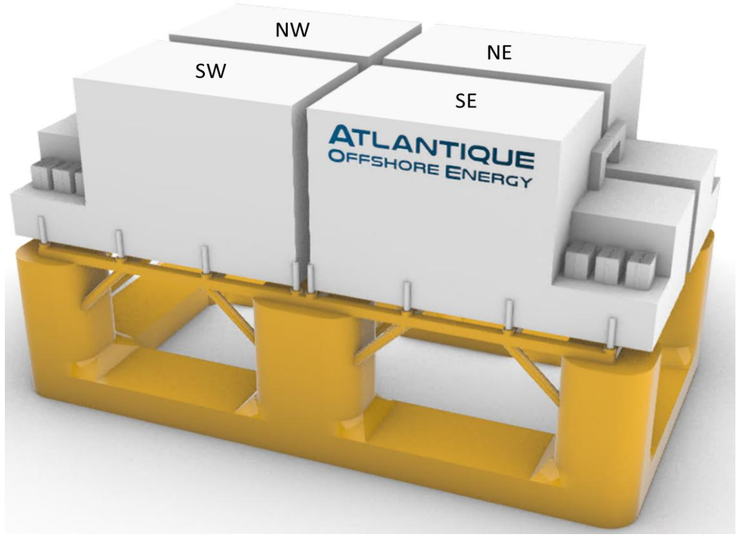
- Outside dimensions: 129m x 64m x 36.5m
  - 4 modules of 63 x 29.5m
  - Central spacing for access, stairs, lay down areas

- Overall topside mechanical properties

Module	Gross weight (t)
NE	5212
SE	5284
NW	5735
SW	5228
TOTAL TOPSIDE	**21458**

  - Topside radius of inertia (Rxx = 22m, Ryy = 38m, Rzz = 41m)





Semi-Submersible Floater Design

Semi-submersible floater design

Objectives/Criteria

- Design Semi-submersible and Tension Leg Platform floater concepts suitable for the defined topside
- Design corresponding mooring systems, cable configurations for different water depths
- Maximum dimensions are defined to ease construction
  - Maximum width based on Forme B of Chantiers de l'Atlantique
- Stability requirements following DNV-OS-C301 to fulfill
- Maximum acceleration levels are defined for electrical equipment
- Wave clearances:
  - Positive air gap at topside bottom
  - Vertical distance between wave elevation and keel superior to 3m

	Maximum dimensions
Maximum Length	200 m
Maximum Width	58 m
Maximum Height	66 m
Maximum Draft at yard	9 m

FOSS Maximum allowable dimensions

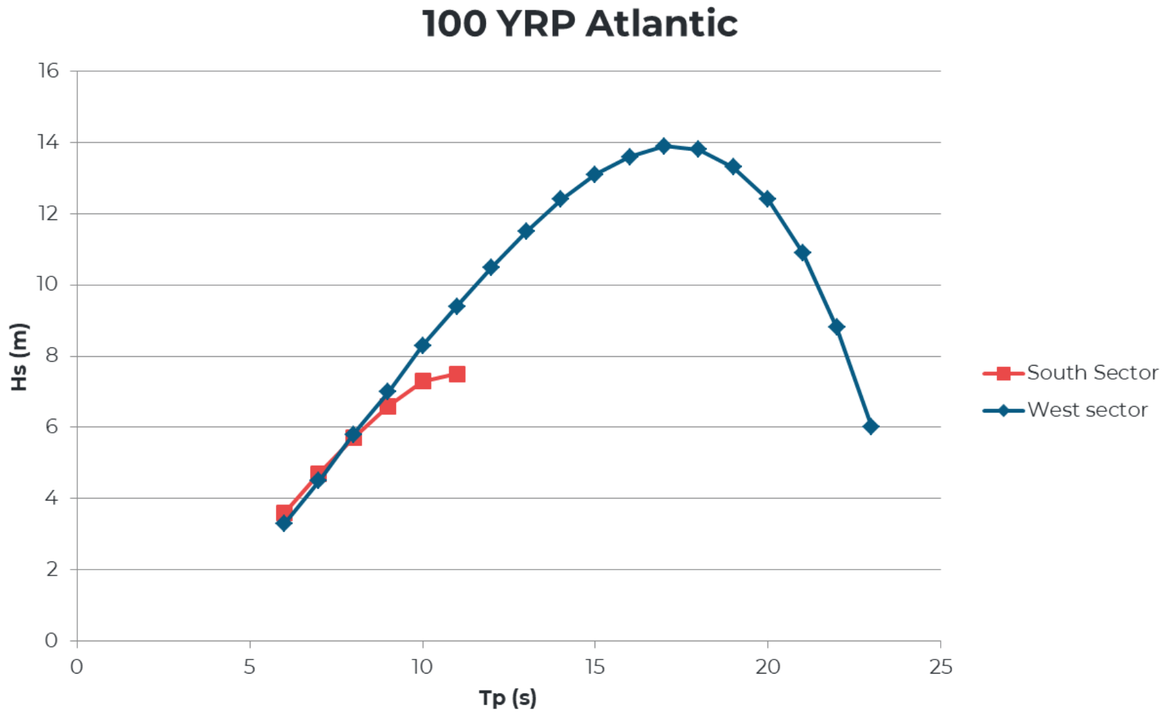
	Maximum allowable motion
Horizontal acceleration	4.0 m/s²
Vertical acceleration	3.5 m/s²
Tilt angle	15 deg
Horizontal offset	Max (30 m ; 10% of water depth)

FOSS Maximum allowable motions

Semi-submersible floater design

Environmental conditions

- Wave data representative of Atlantic coast
- 3 water depths: 400m (base case), 150m, 1000m
- 100-year Return Period Wind speed @10m: 28.5m/s
- 10-year Return Period current surface speed: 0.61m/s

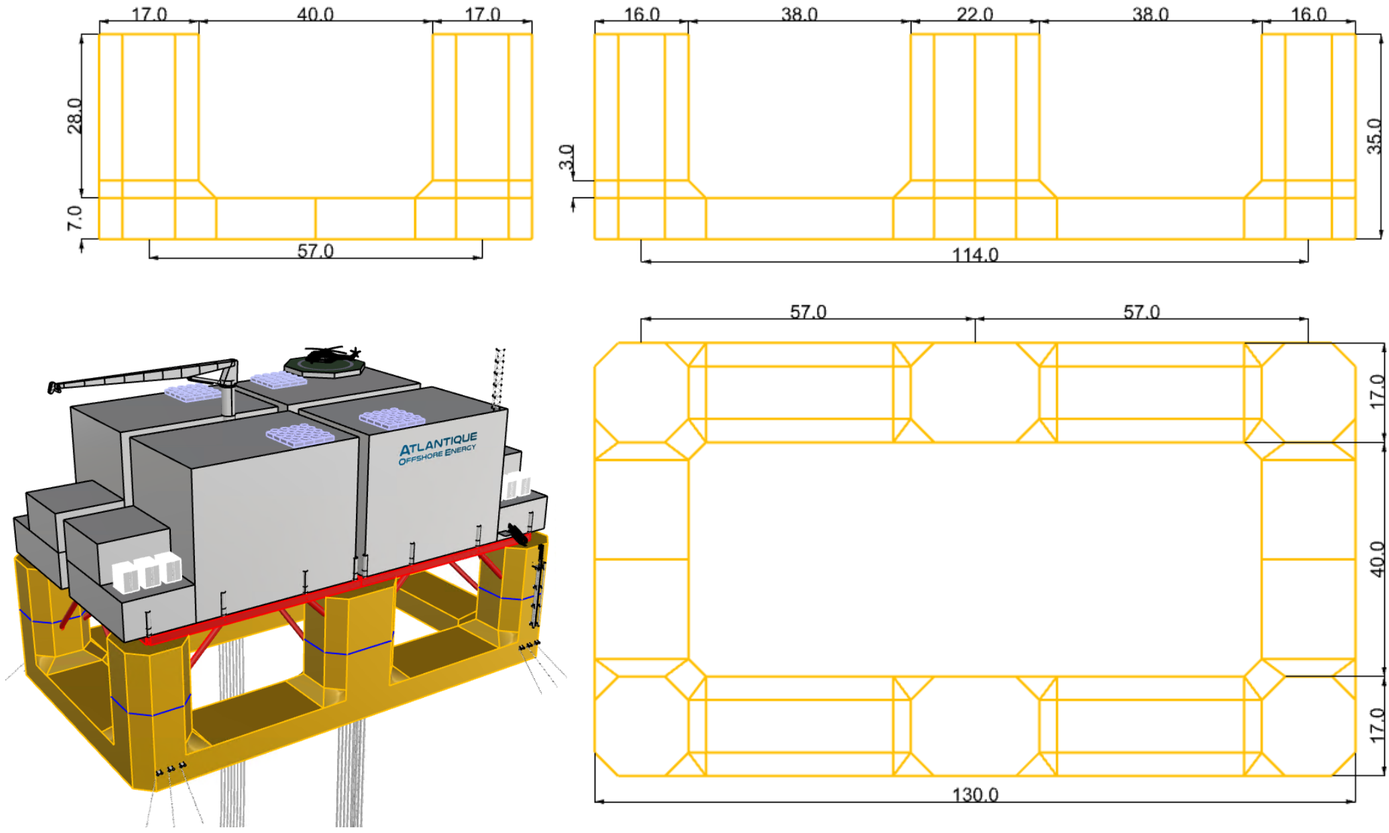


Wave data

Semi-submersible floater design

Floater description

- 6 octogonal columns linked by pontoons
- Overall dimensions 130m x 74m x 35m
- Central columns wider to host I-tubes (IAC and export cable)
- Drafts: 20m in-place, 14m for towing
- Dimensions and draft defined to find a compromise between stability and wave clearances



Semi-submersible floater dimensions

Semi-submersible floater design

Floater description

- Total weight of 64000t
  - Floater dry weight: calculated based on previous projects performed in CdA
  - Transition Piece mass based on structural verification
  - Ballast: seawater inside pontoons in order to reach the target draft

- Roll and pitch natural periods above wave periods

- Motion, air gap and keel emergence criteria are satisfied

Component	Mass (tons)
Topside	21458
Floater	15648
Transition Piece	1787
Ballasts (in-place)	24938
TOTAL	**63832**

Floating system mass

Degree of Freedom	In-place natural period
SURGE	81.4 s
SWAY	91.0 s
HEAVE	19.6 s
ROLL	36.2 s
PITCH	23.3 s
YAW	73.1 s

Floating system natural periods

	Maximum motion	Criterion
Heave	9.43 m	-
Roll	3.23 deg	< 15 deg
Pitch	5.05 deg	< 15 deg
X acceleration	2.05 m/s^2	< 4 m/s^2
Y acceleration	1.53 m/s^2	< 4 m/s^2
Z acceleration	2.00 m/s^2	< 3.5 m/s^2

Floating system maximum motions

	Minimum value	Criterion
Air gap	0.24 m	> 0 m
Distance wave elevation / keel	3.24m	> 3 m

Floating system minimum clearances

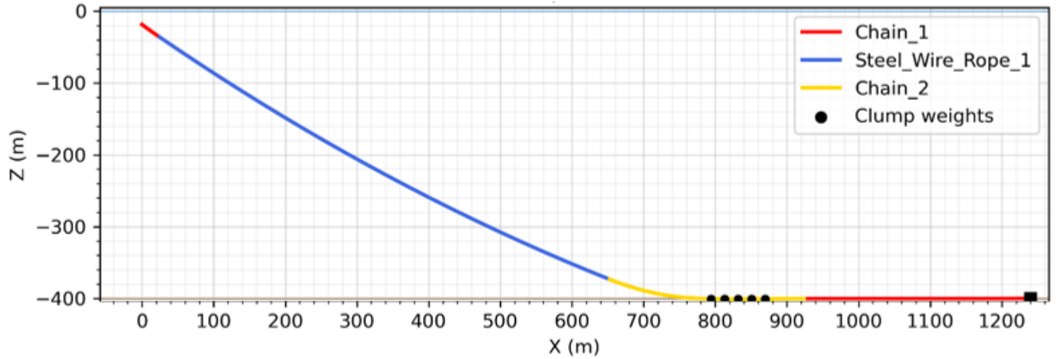
Semi-submersible floater design

Mooring system

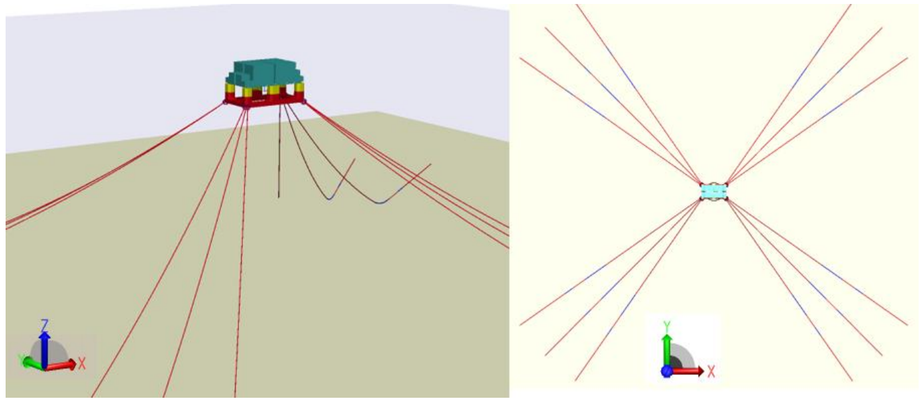
- 6 Mooring systems have been designed for different water levels and line materials:
  - Water depths: 150, 400, 1000m
  - Line composition
    - Chain and cable or polyester
    - Use of Clump Weights (CW) for a catenary behaviour of the mooring line
- 4 clusters of 3 mooring lines each
- Extreme Intact and Accidental (loss of one mooring line) cases verified
- Resulting line capacity levels (MBL) consistent with current production and installation capabilities
- Inter Array and Export Cables have been designed for each mooring system

Water depth + mooring line composition	Mooring type	MBL [kN]	Pre-tension [kN]	Mooring line length [m]
400m Chain/Cable/CW	Catenary	12 000	1 450	1 334
400m Chain/Polyester/CW	Catenary	10 000	1 460	1 307
400m Chain/Polyester	Semi-Taut	15 000	730	750
150m Chain/Cable/CW	Catenary	14 000	823	1 034
150m Chain/Polyester/CW	Catenary	13 000	790	1 028
1000m Chain/Polyester	Taut	12 500	860	1 514

Mooring systems description



400m Chain/Cable/CW mooring system profile



Mooring system layout

Conclusions

- Atlantic Offshore Energy are very satisfied of AFOSS-DC work and results
- A large amount of data have been produced through numerical simulations and testing
- All criteria for the design of the semi-submersible floater and the mooring systems are fulfilled except hull breadth
- Progress has been performed on the General Arrangement of the Topside for floating application
- A major step towards demonstrating the feasability of 2GW HVDC Floating Offshore Sub-Station has been achieved

FRANCE ENERGIES MARINES

Thank you for your attention!