EUSKAMPUS - VII Marine Energy Conference

09-11-2021

Innovative solutions for foundations, towers and auxiliary systems of high-power offshore wind turbines

Proyecto financiado por el Departamento de Desarrollo Económico e Infraestructuras del Gobierno Vasco (Programa HAZITEK) y el Fondo Europeo de Desarrollo Regional (FEDER)

Eusko Jaurlaritzaren Ekonomiaren Garapen eta Azpiegitura Sailak (HAZITEK Programa) eta Eskualde Garapenerako Europar Funtsak finantziatutako proiektua (EGEF)

SEAPOWER.- The Basque Country, a region with a high level of technological intensity, represents one of the largest industrial clusters in Europe

GDP PER CAPITA PPS	INDUSTRIAL GDP	PRODUCTIVITY PER WORKER
€35,104 BASQUE COUNTRY (119%)	24.3% BASQUE COUNTRY (126%)	123.3% BASQUE COUNTRY
€29,499 EU-28 (100%)	19.3% EU-28	100% EU-28

R&D INVESTMENT TO GDP RATIO	EXPORTS TO GDP RATIO
1.96%	32.2%

The Basque Country is the Autonomous Community with the highest intensity in R&D in Spain

Source: SPRI – Invest in Basque Country, Eurostat, Eustat

SEAPOWER.- The Basque Country is a worldwide reference in floating wind development, with up to four platform developers and several suppliers that have participated in existing demo projects.

Floating wind test centre

bimep

Offshore wind farms developer

IBERDROLA

WTG

SIEMENS Gamesa RENEWABLE ENERGY

Floating foundations

nautilus

NAUTILUS Floating Solutions

saitec offshore technologies

SAITEC

ISATI engineering solutions

enerOCEAN

W2Power

ESTEYCO

TELWIND

Components and service suppliers for floating wind

VICINAY marine

CoreMarine

ALERION

INALIA

aerblade

mugape

GAINZA FORGE

commercial diving activities

ditrel Industrial S.L.

Liftra

Lumiker

Ingeteam

euskalforging

LAULAGUN bearings

HWS

NAVACEL

IDOM

SENER

sidenor

ceit

Tekniker

WINDRAGON

ikerlan

tecnalia

SEAPOWER

SEAPOWER.- Innovative solutions for Bottom Fixed and Floating foundations, towers and auxiliary systems of high-power offshore wind turbines

Objectives:

- Promote collaborative and integrative research and development of technologies, components and solutions for bottom fixed and floating foundations, towers and auxiliary systems for the new generation of high-power wind turbines.
- The Basque industry acquires knowledge and provides added value through integral designs that incorporate its own innovations.

WPs:

WP0.Main Coordination: **SENER**

WP1.Design Basis: **SENER**

WP2.Towers XXL: **HAIZEA WIND**

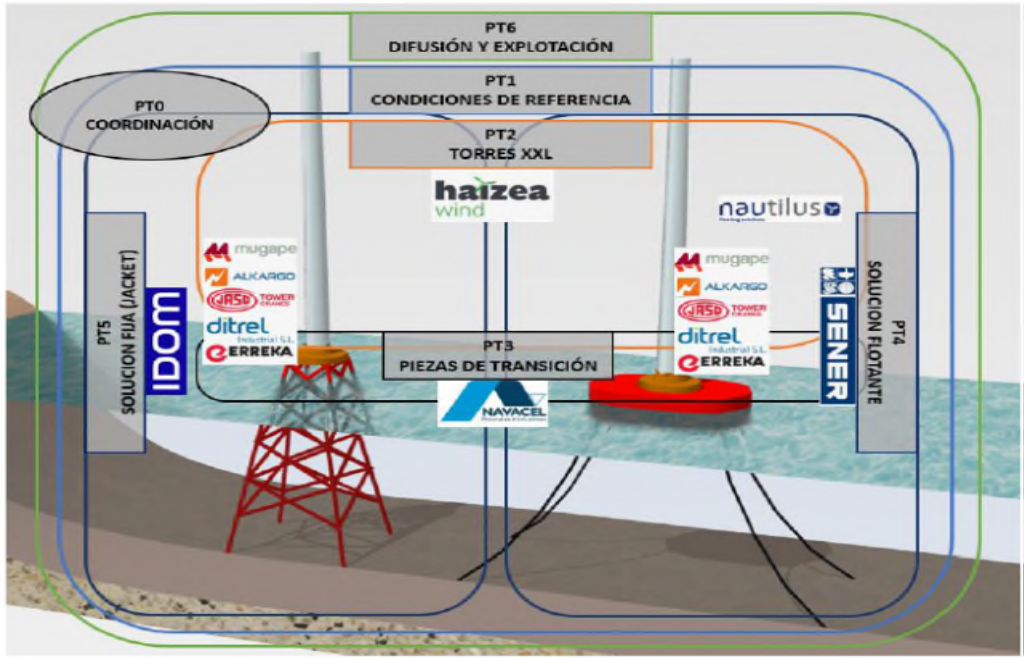
WP3.Transition Pieces (TP): **NAVACEL**

WP4.Floating Foundations: **SENER**

WP5.Bottom Fixed Foundation: **IDOM**

WP6.Disemination: **SENER**

Bottom Fixed and Floating Foundations



SEAPOWER

SEAPOWER.- Consortium

Leader

SENER — Engineering

ditrel Industrial S.L. — Electrical connector

ERREKA — Fastening solutions

haizea windgroup — Offshore Wind towers

IDOM — Engineering

JASO TOWER CRANES — Lifting systems

mugape estalki corporation XXI — Surface treatments

nautilus floating solutions — Floating foundation developer

NAVACEL Process Industries — Offshore Wind structures

tecnalia Inspiring Business — MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Tekniker — MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

Research Centers

SEAPOWER

SEAPOWER.- Innovative solutions for foundations, towers and auxiliary systems of high-power offshore wind turbines

Market Pull:

- Increase in wind turbine size
- Development of floating solutions to access wind resources in deeper sites
- Assurance of the behavior in harsh environment (corrosion, fouling,…)
- Reduction of the LCoE (both CAPEX and OPEX)

SEAPOWER:

- Development and validation of numerical models for offshore wind turbine substructures.
- Digital twins development based on numerical models.
- Development of advanced design tools for the evaluation of substructures and auxiliary systems.
- Innovative designs of towers and bottom-fixed & floating foundations for large wind turbines
- New designs of auxiliary elements: Lifting systems, bolted joints and electrical equipment
- Development of anticorrosive and biofouling resistant coatings

Budget: 5,3M€

Duration: 34 month

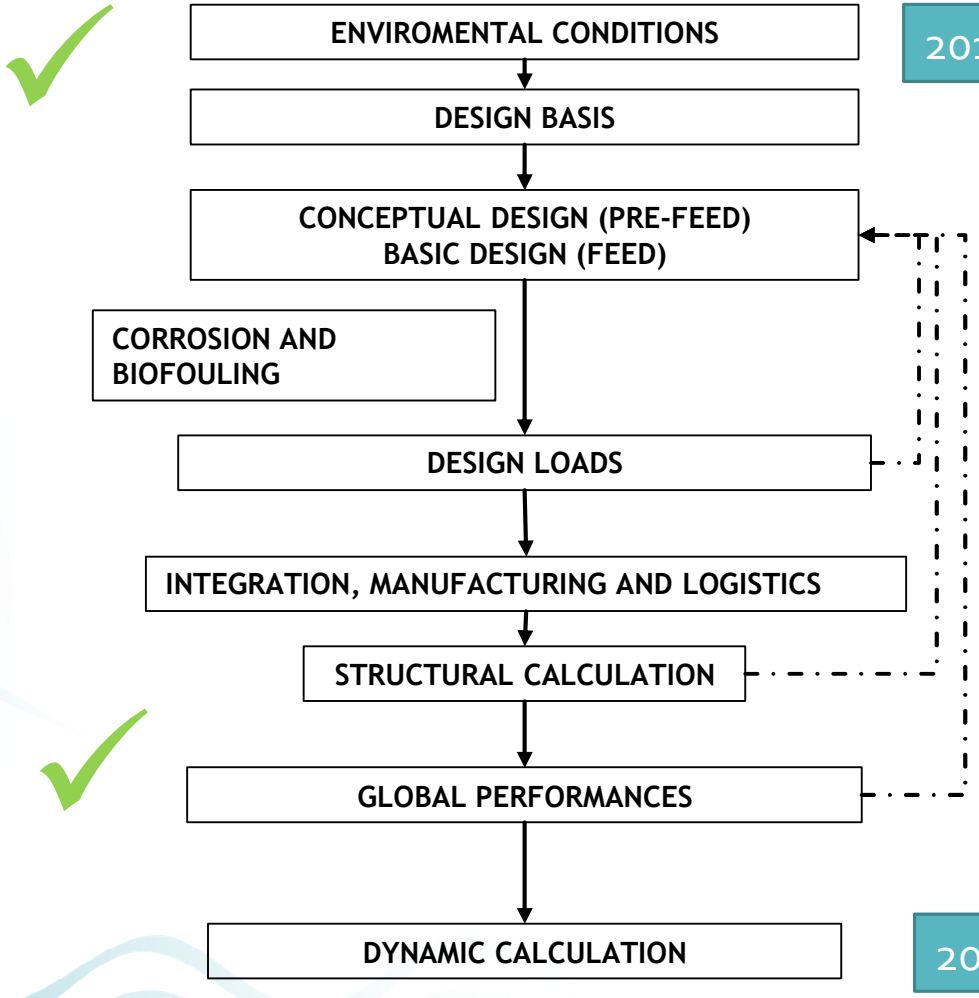
From The Design Basis……

……To validation Test

2019												2020												2021											
E	F	M	A	M	J	J	A	S	O	N	D	E	F	M	A	M	J	J	A	S	O	N	D	E	F	M	A	M	J	J	A	S	O	N	D

WP1.Design Basis

Working Process:



2019

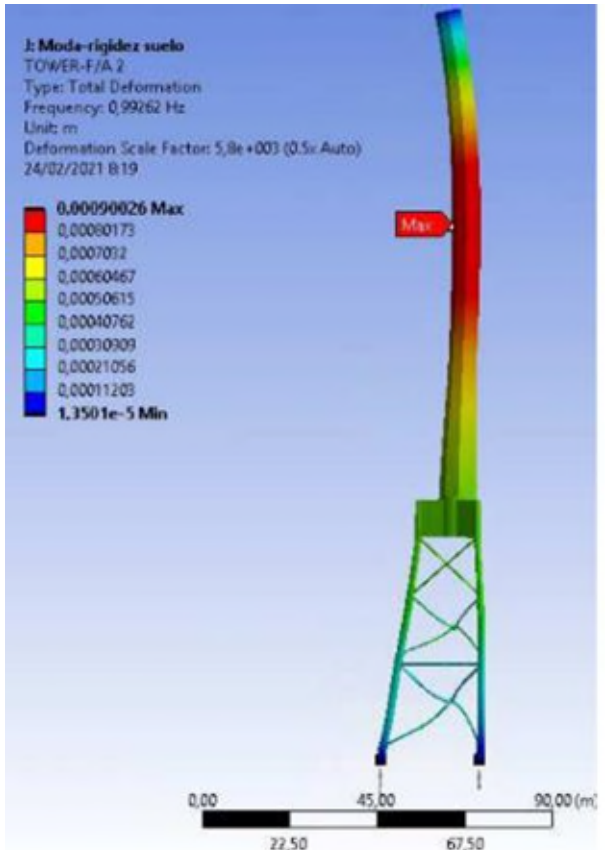
2020

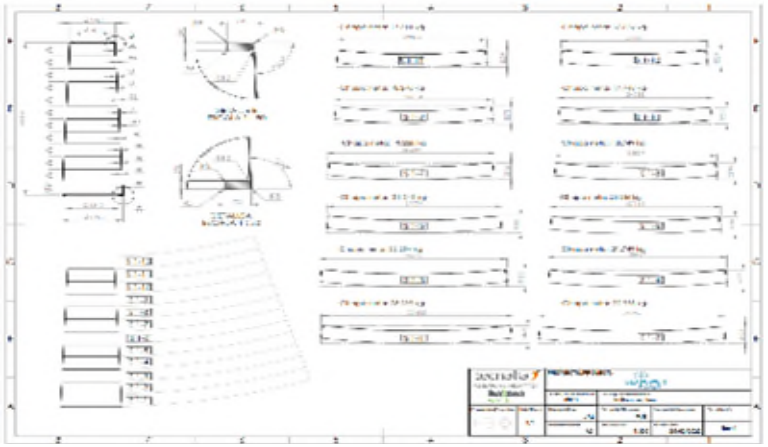
2021

VALIDATION TEST AND STUDIES

WP2- Towers XXL (10-15 MW)

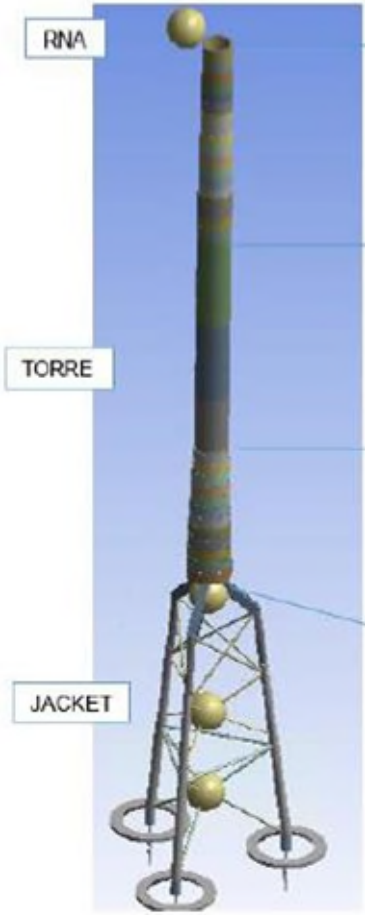
- **Objective:** Innovative Design reducing tower section and joints
- **Results:**
  - Finalization of the Design of 3-section tower optimized for Haizea Wind capabilities
  - Top OD: 6.500mm
  - Bottom OD: 9750mm
  - Max Section Length: 50.000mm
  - Max Section Weight: 327t
  - **11,4% Cost Savings achieved** compared to equivalent 4-Section tower
  - Additional Savings in Logistics (To be quantified)





WP2- Towers XXL (10-15 MW)

- **Objective:** Innovative Design adapting the bolting to new tower design
- **Results:**
  - Basic for bolting design Bottom Fixed Jacket. Main features:
    - 4 flanged transitions: Tower Base – S1-S2– S2-S3m – S3 Nacelle
    - Loads on the bolt
    - Flange dimension
    - Bolting maximum diameter: M72
  - Higher mechanical performance bolting
  - New flange bolting designs

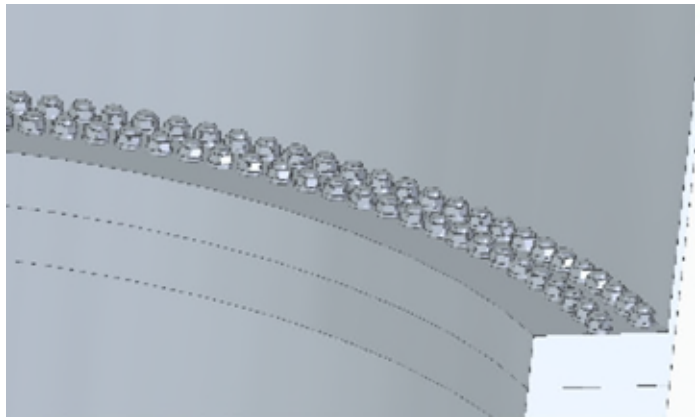


Transition S3-Nacelle

Transition S2-S3

Transition S1-S2

Tower base



WP2 – Elevator system

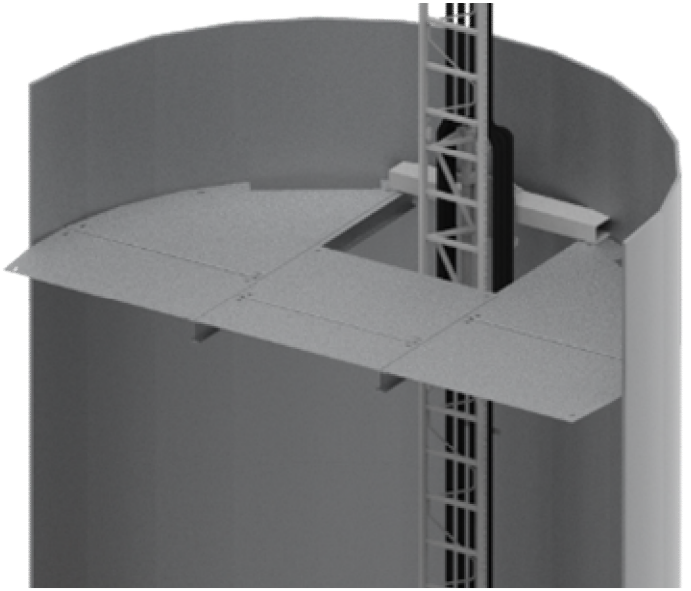
- **Objective:** Innovative Design of Elevator

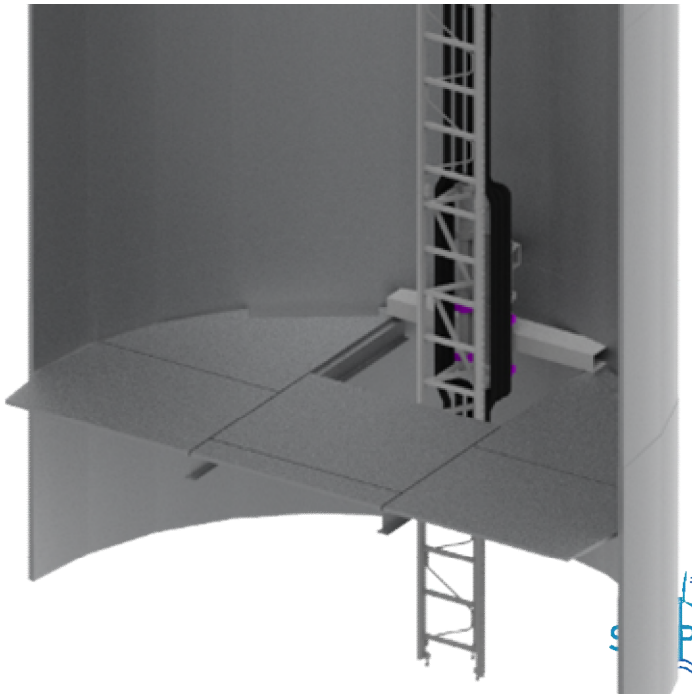
The elevator design has been made taking into account the **most unfavorable situation**, which would be the case of a **floating turbine**, due to the loads of the vertical and horizontal accelerations that are generated, apart from the usage loads.

WP2 – Elevator system

The aim is to avoid the union of the mast directly with the tower, making the unions at the level of the internal platforms, so as not to interfere with the design of the tower or create additional areas of transmission of efforts.

This leads us to a **mast design that is capable of supporting design loads with bracing distances of more than 20 m**, when the current maximum distances are of the order of 6 m.

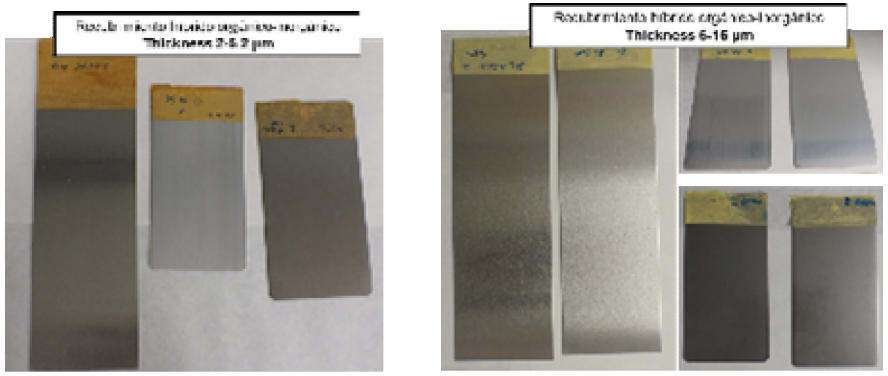




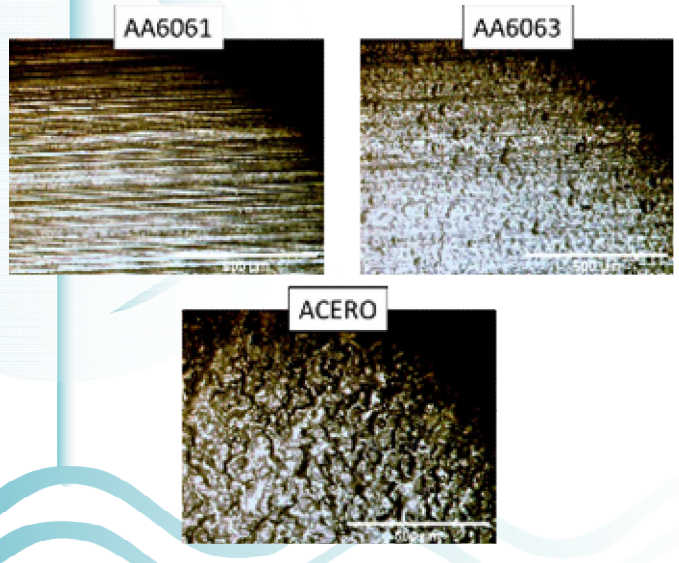
WP2- WP5 – Coatings

- **Objective: Biofouling, Corrosion and impacts coatings**
  - Impact Resistant Coatings
  - Application process optimization
  - Coating Layers reduction
  - Coating Layers Thickness reduction

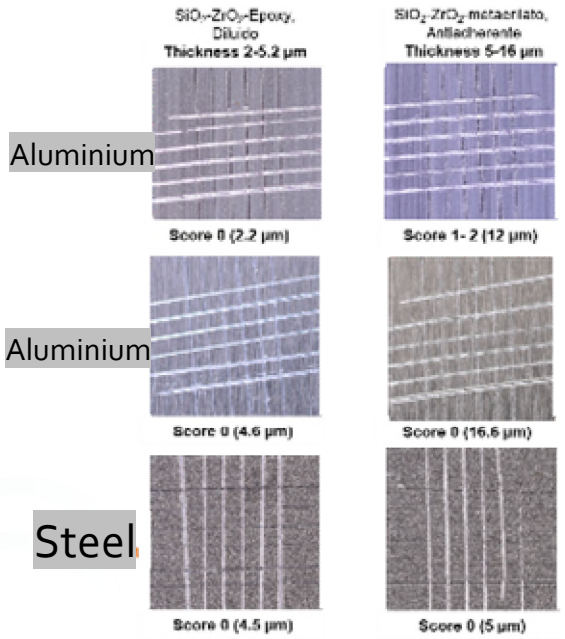
Spray application ✓



Homogeneous and thin coatings ✓



Excellent adhesion to substrate ✓



No cracking after impact ✓

Coatings	Thicknes s (µm)	Impact distance (mm)	UNE-EN ISO 6272-1:2012		
			Impact 1	Impact 2	Impact 3
Coating 1	2 – 5.2	150	No cracking	No cracking	No cracking
Coating 2	5 - 16	150	No cracking	No cracking	No cracking

WP2- WP5 – Coatings

- **Objective: Biofouling, Corrosion and impacts coatings**
  - Impact Resistant Coatings

HarshLab Corrosion and impacts coatings Test ✓

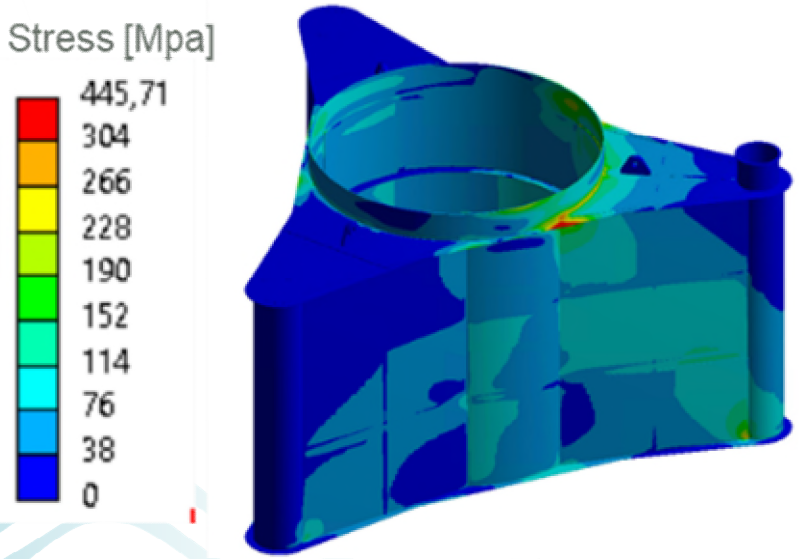
Figura 12. Aspecto de las probetas Nº 1 y 2 tras 6 meses de exposición en zona atmosférica.

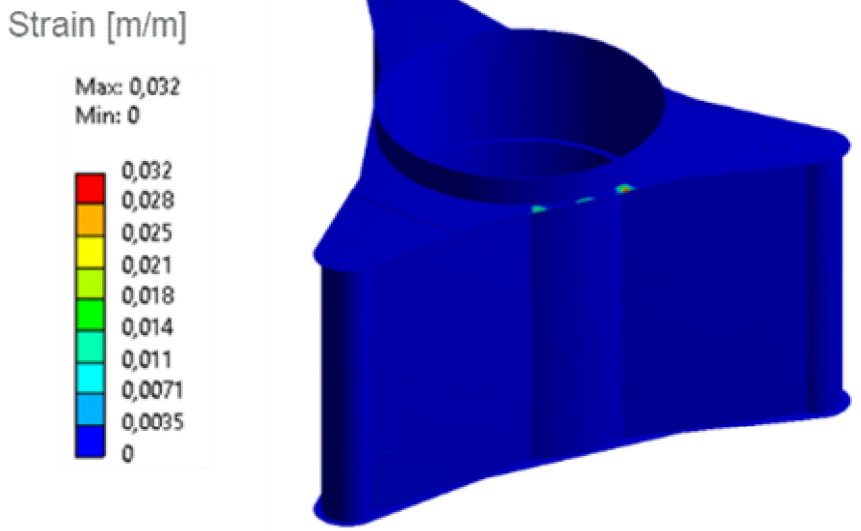
Figura 13. Aspecto de las probetas Nº 3 y 4 tras 6 meses de exposición en zona *splash*.

After six months of exposure, the specimens exposed in the atmospheric zone and in the splash zone show similar results. **The test samples do not show any deterioration,** only red corrosion is observed around the notch.

WP3. Detail design of the transition piece (TP)

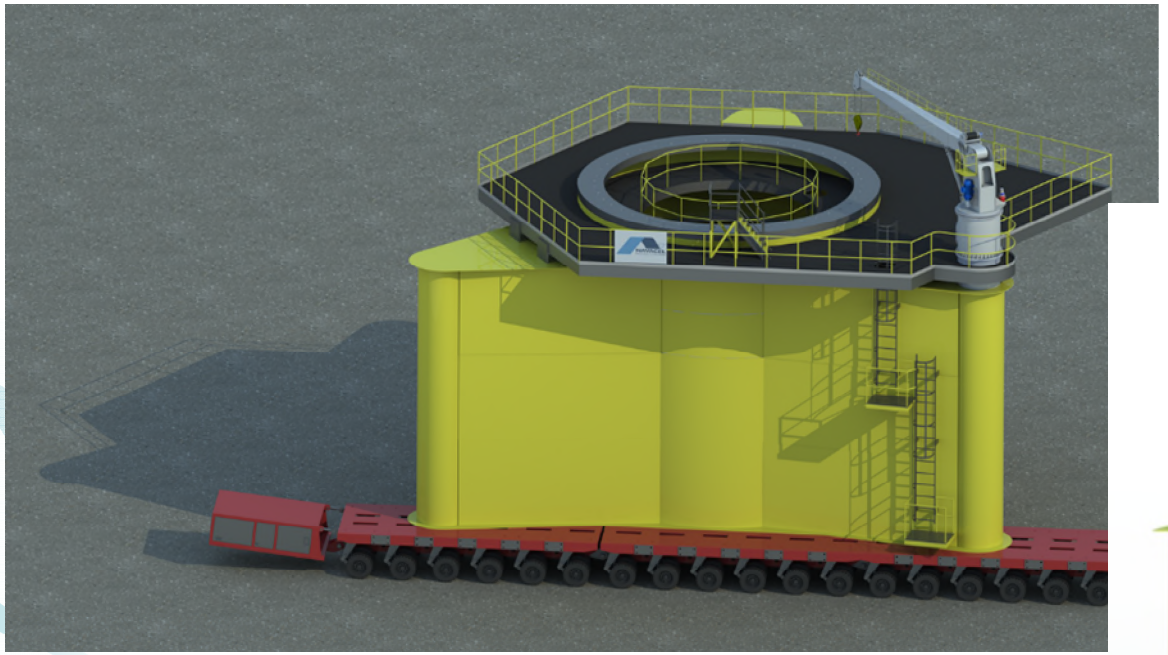
- Innovative design of a transition piece to connect the jacket foundation (IDOM) and the tower (HAIZEA Wind) for a 15 MW wind turbine.
- Designed to host the transformer and protection cells in order to save space in the tower and simplify the O&M operations.
- Four design steps:
  - Specifications and functional requirements based on the project Design Basis.
  - Conceptual Design considering different ideas and options.
  - Detail design, focused on the structural analysis considering two options, with different manufacturing restrictions.
  - Definition of the manufacturing means, procedures and logistics –ongoing work-

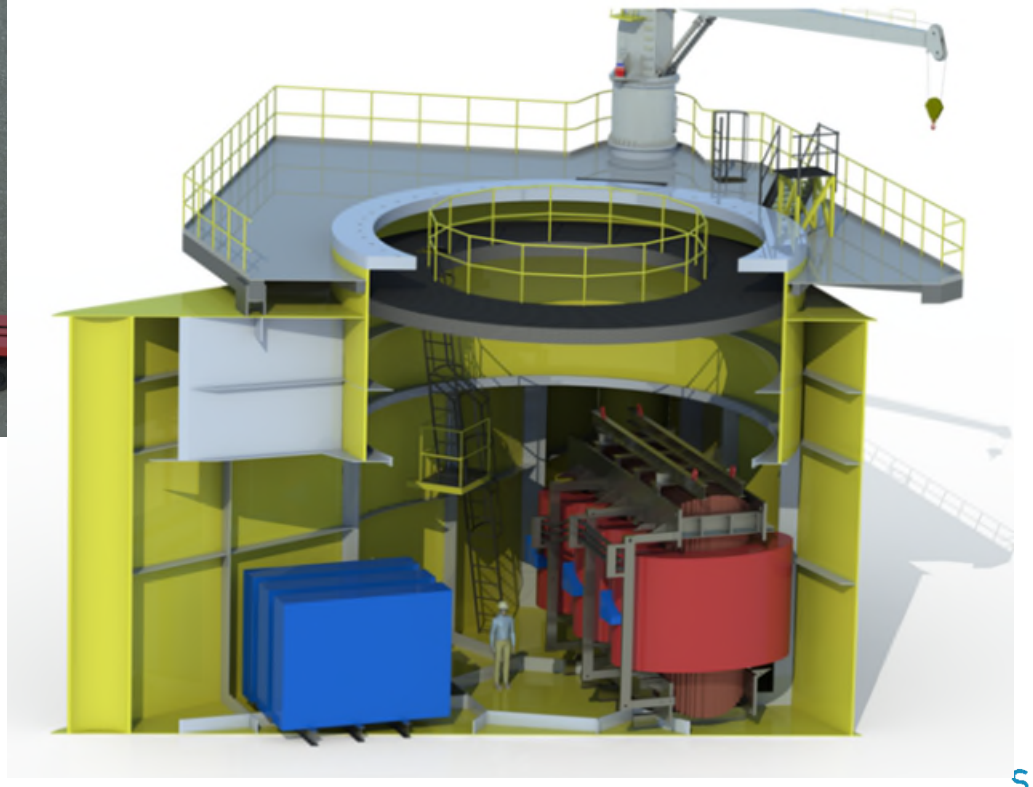




WP3. Detail design of the transition piece (TP)

Result: low weight-simple manufacturing TP to support a 15 MW wind turbine.

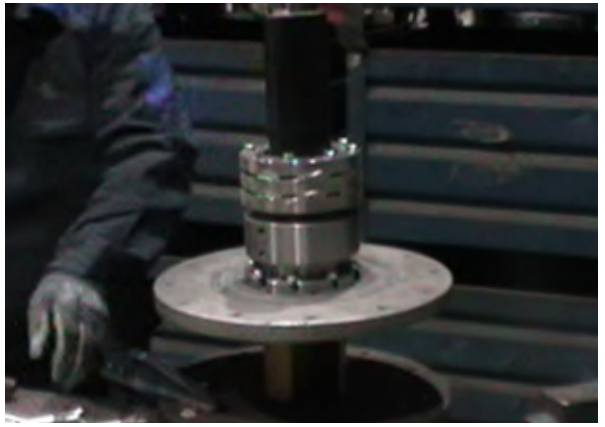




WP4-Wp5: DITREL. Electric 66kV pre-connector

- In 2019 and 2020 one preliminary design was validated for the 66kV preconnector, FEM analysis were performed.

- During 2021, one downscaled prototype has been manufactured for physical tests:
  - Working conditions were defined for one specific Floating Wind Platform (20kV)
  - Manufacturing drawings were created and prototype manufactured
  - Dynamic cable was acquired and assembled into the prototype
  - Tensile strength tests were performed
  - Offshore connection manoeuvre to be performed in late 2021

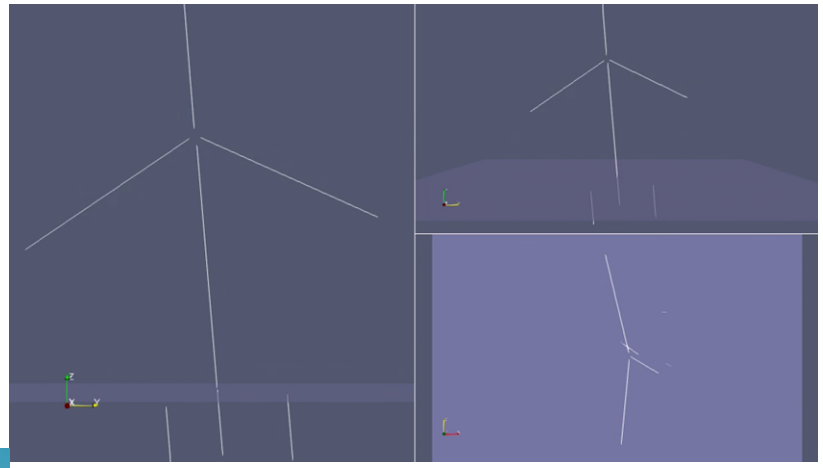


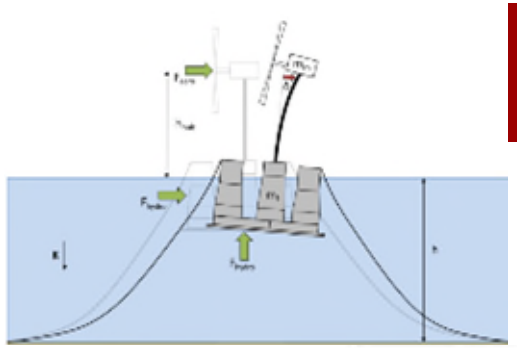
Prototype integration with dynamic cable

Tensile tests

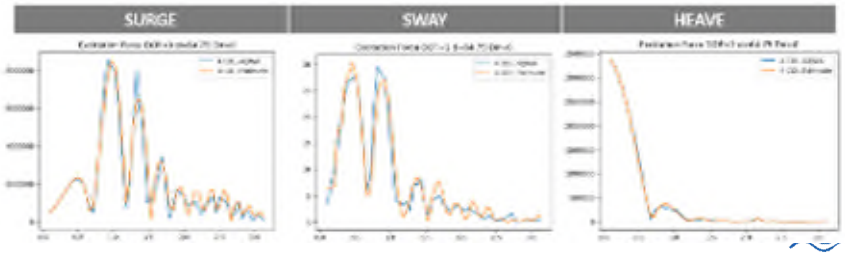
WP4: Floating Foundation (FFS)

- Objective: **Floating Foundation Design**.
  - Numeric Model Time domain Hydro-slasto-Aero-Servo.
  - SKS design. Dynamic Analysis.
  - Dynamic cable design. Dynamic Analysis
  - Numeric Model Frequency Domain: MQulaf.



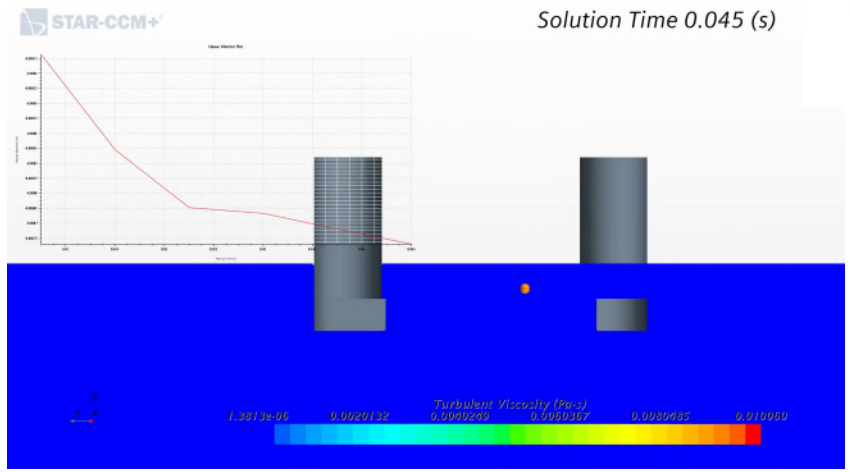


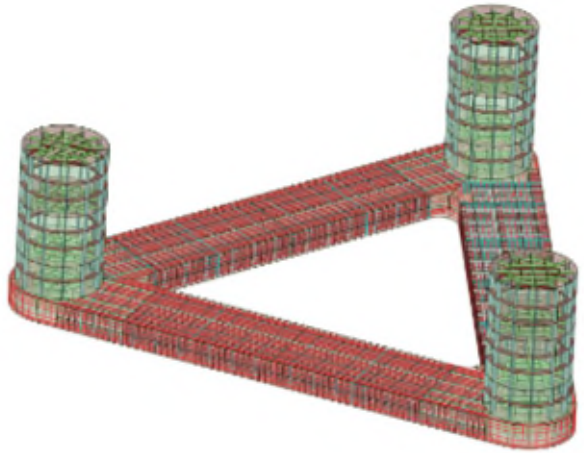
Similar to DTU Qulaf

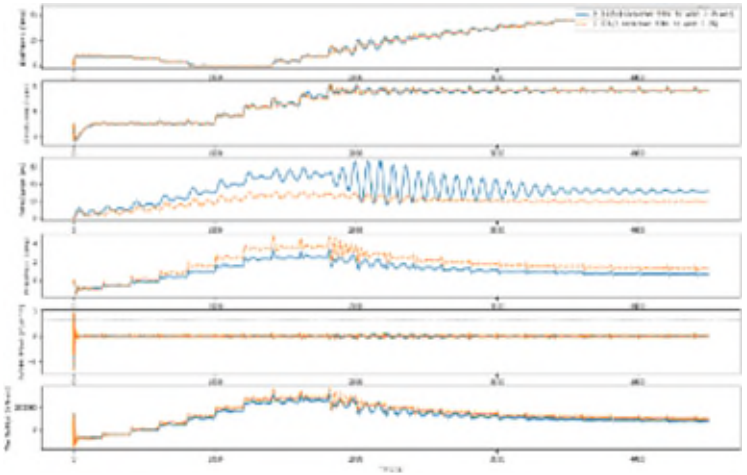


WP4: Floating Foundation (FFS)

- Objective: **Floating Foundation Design**.
  - Hydrodinamics full CFD
  - Numeric Servo Control Model
  - SemiSumersible Floating Foundation Basic Design
    - Naval architecture, structural and performance optimized
    - Ruled based design and Rationally based design.







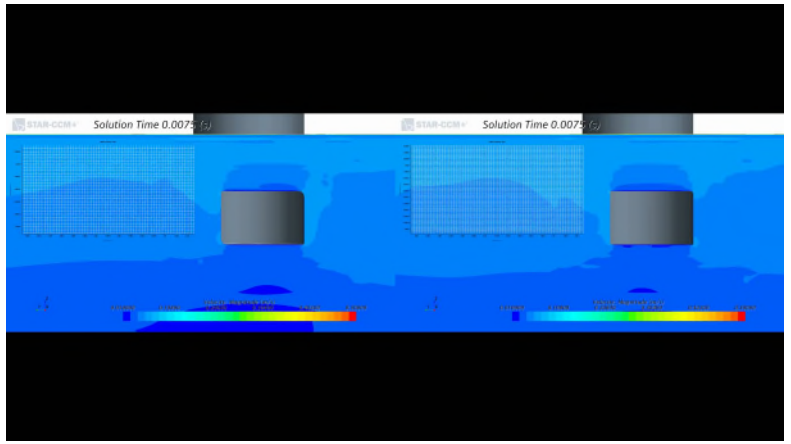
Basic

+

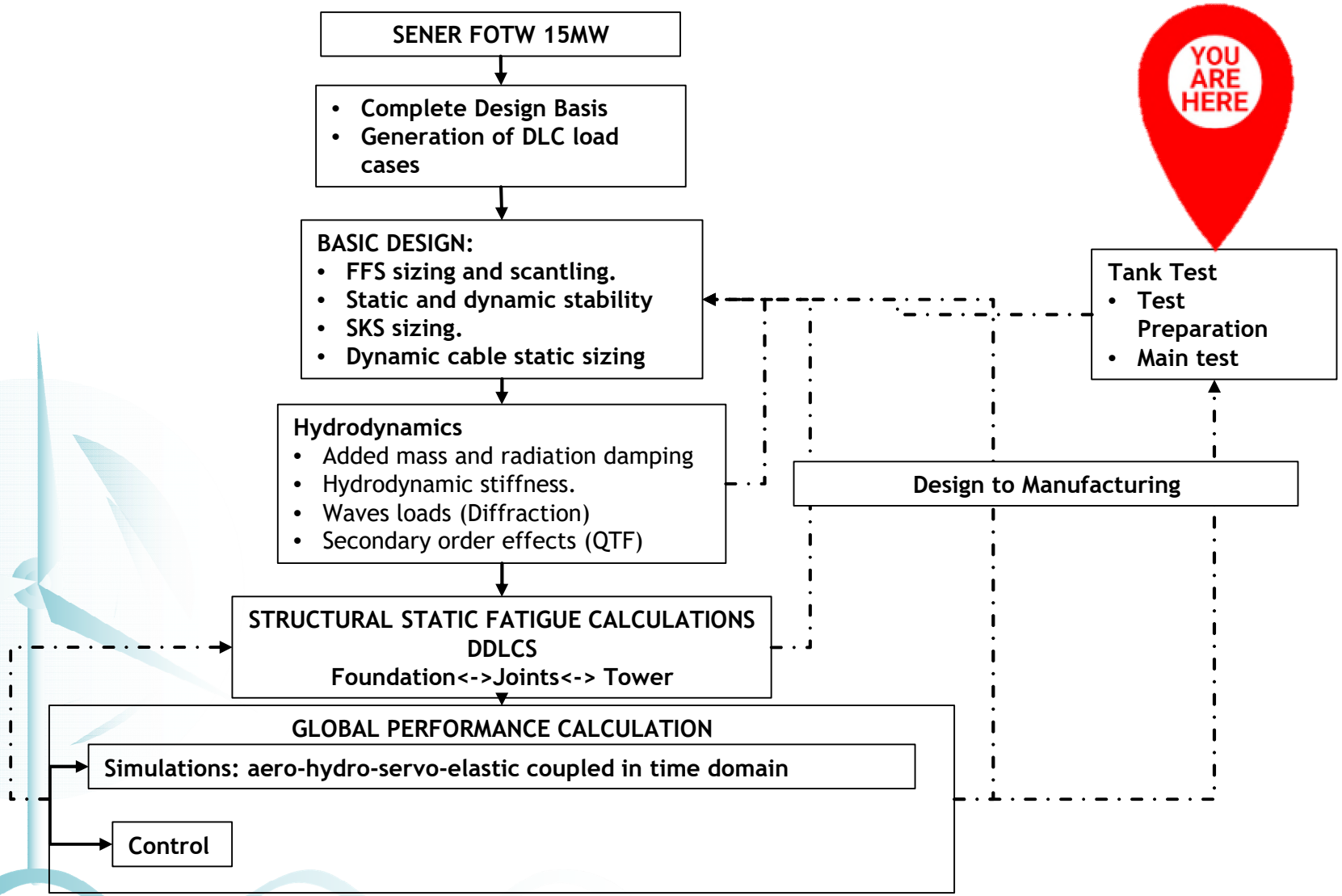
Additional functionalities

WP4: Floating Foundation (FFS)

- Objective: **Floating Foundation Design**.
  - Concept validation with University College Cork.- Tank test CFD correlation
  - Tank Test (Scheduled Dec 2021)



WP4: Floating Foundation (FFS)

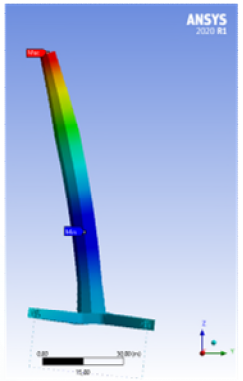


KEY FEATURES

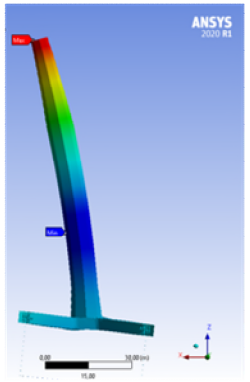
1. Modularity. Types & complexity of blocks are reduced.
2. Easy constructing:
3. Easy WT assembly, as the tower TP is at the edge of the quayside.
4. Low Draft
5. Foundation reduced dimensions compatible with NAVANTIA dry dock & shipyards worldwide - local content requirements.
6. Active ballast/ Passive ballast versions feasible.
7. Lightship weight less than 3000 Tons for 15MW WTG
8. Adaptability to site conditions and manufacturing capabilities
9. Innovative Concept

WP4 Floating Foundation

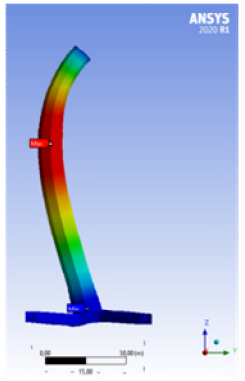
- Advanced Numeric and mathematical Models: SKS, Tower and TP IF.
- SKS Calculations models.
- Escalation models



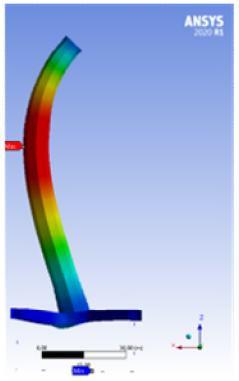
SS1



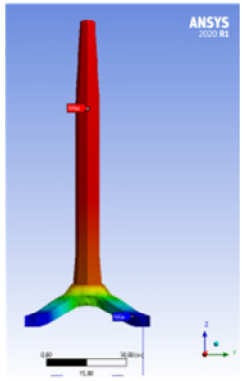
FA1



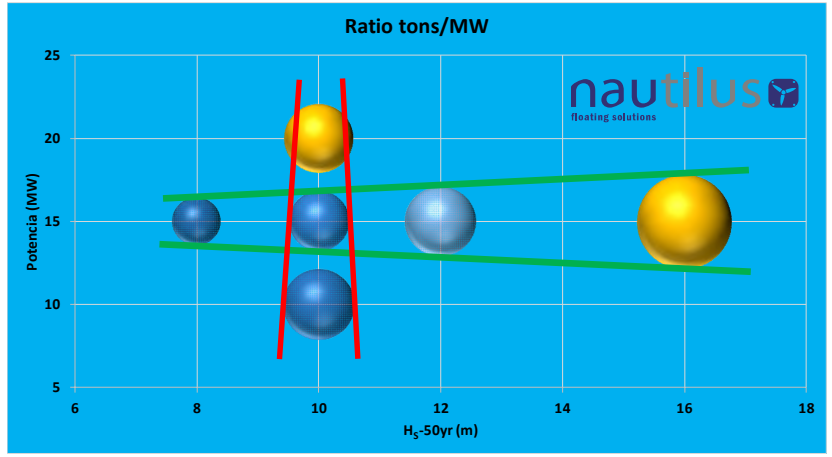
SS2

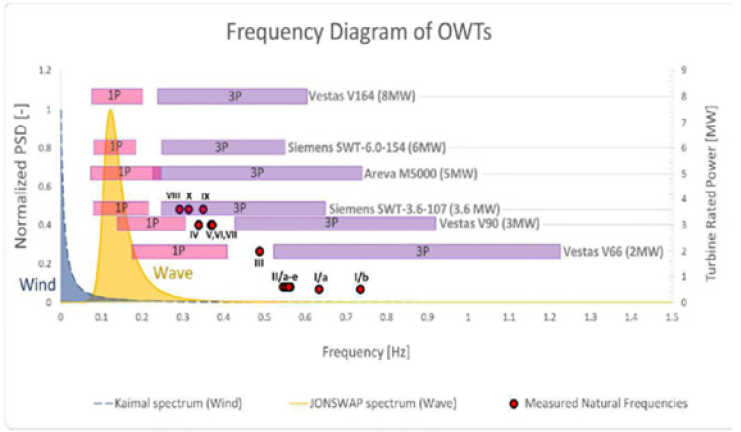


FA2



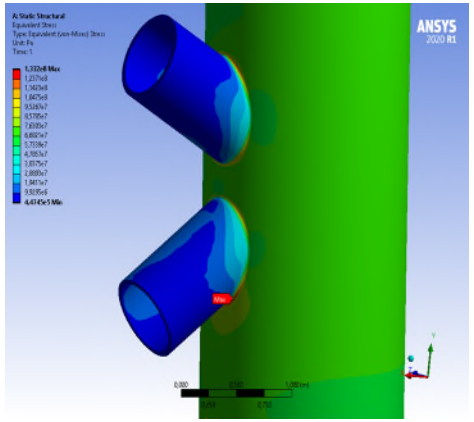
U&D

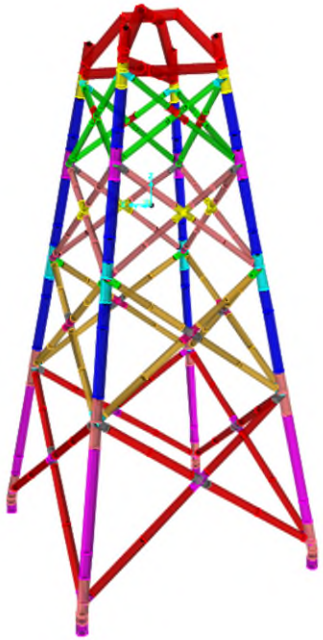


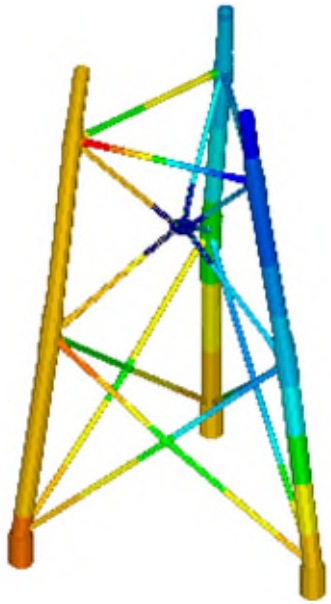


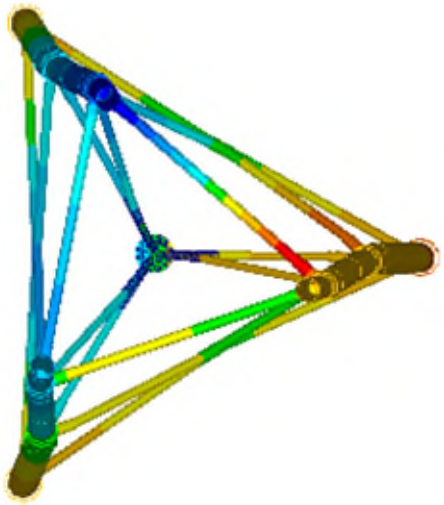
WP5. Bottom Fixed Foundation(jacket) for large WTGs

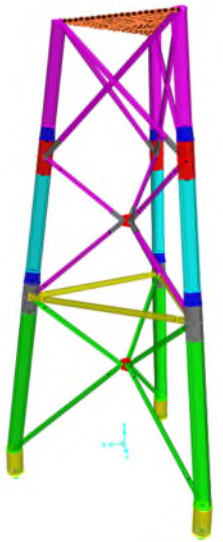
- **Objective:** development of a new concept for jacket foundations in which the whole process from design to construction and fabrication is considered with the aim of reducing both CAPEX and OPEX costs
- **Results:**
  - Numerical models and design Tools
  - Modularization
  - Joint, nodes and welding reduction
  - Digital twin







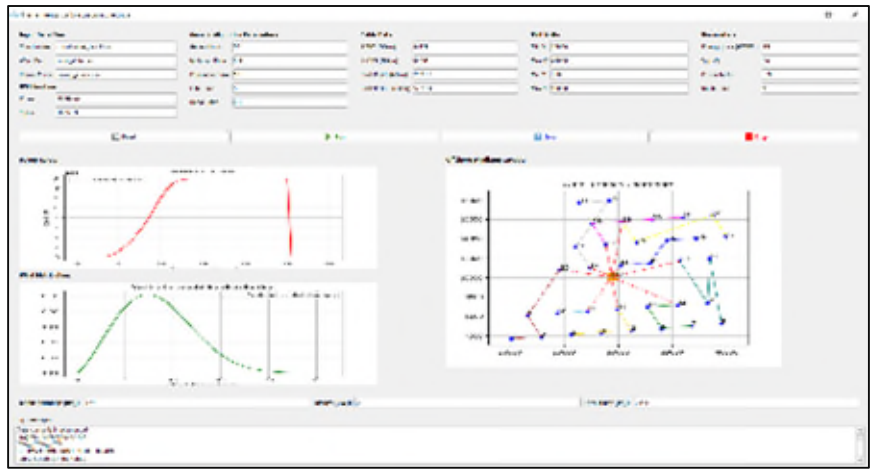




WP5. Jacket foundation and electrical lay-out tool

- **Results:**
  - **Validation of the Innovative design of a jacket foundation:** Tank test at IH facilities.

- **Results:**
  - Development of a **techno-economical analysis tool for the optimization of offshore wind farm electrical layout** with the aim of finding the most economical configuration



THANK YOU

Proyecto financiado por el Departamento de Desarrollo Económico e Infraestructuras del Gobierno Vasco (Programa HAZITEK) y el Fondo Europeo de Desarrollo Regional (FEDER)

Eusko Jaurlaritzaren Ekonomiaren Garapen eta Azpiegitura Sailak (HAZITEK Programa) eta Eskualde Garapenerako Europar Funtsak finantziatutako proiektua (EGEF)