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Design and engineering of two concepts of large Offshore Wind and Tidal Stream platforms (OWTPs)

TSI, COMPASS, TIDETEC, ENEROCEAN, BV, CIMNE, ULIM, IXBLUE, TUCO, INEGY

Cristobal Garcia Pariente, TSI SL

First Information Day
1/07/2021 - Online

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1. Objectives of WP4

W2 Power Wind Turbine

Concept	FRP applications
W2POWER wind turbine	Towers
	Floating platform structure

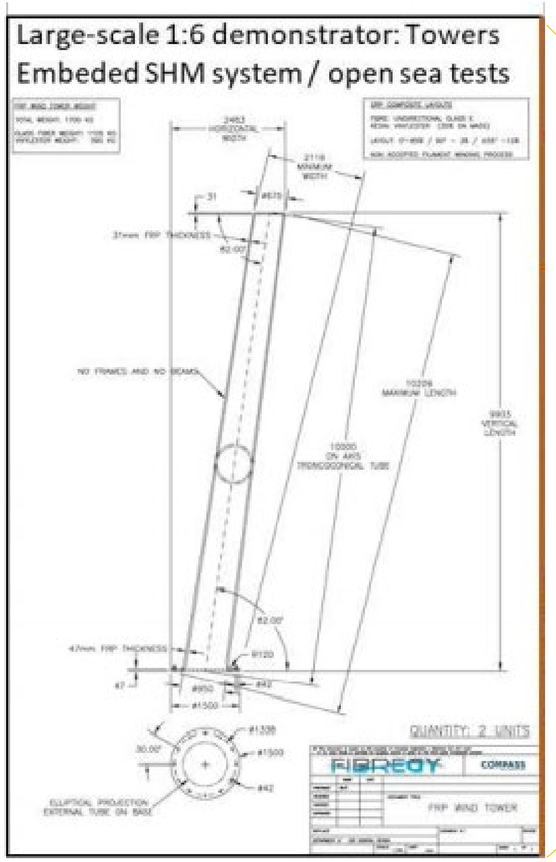
TIDETEC's tidal turbine

Concept	FRP applications
TIDETEC's tidal turbine	Turnable turbine housing

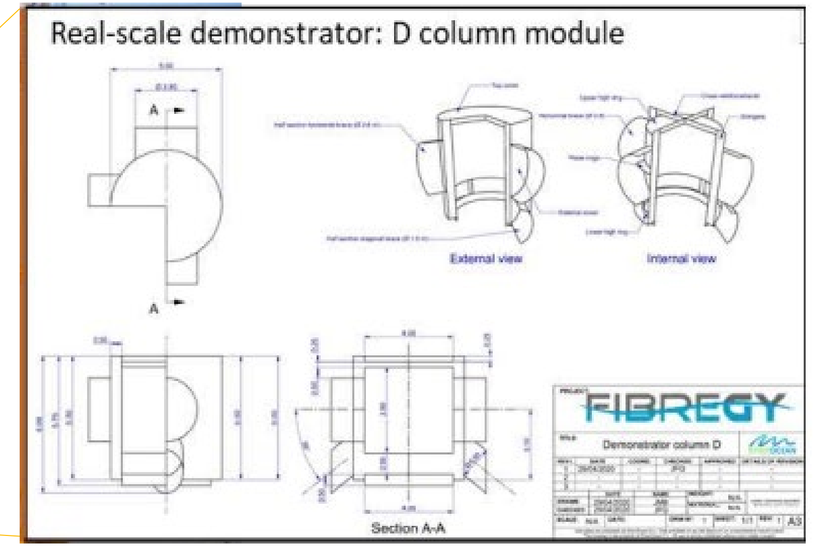
O1: Re-design of the towers and floating platform of the W2 Power Platform in FRP

O2: Re-design of the housing of the Tidal Turbine Platform in FRP materials.

1. Objectives of WP4

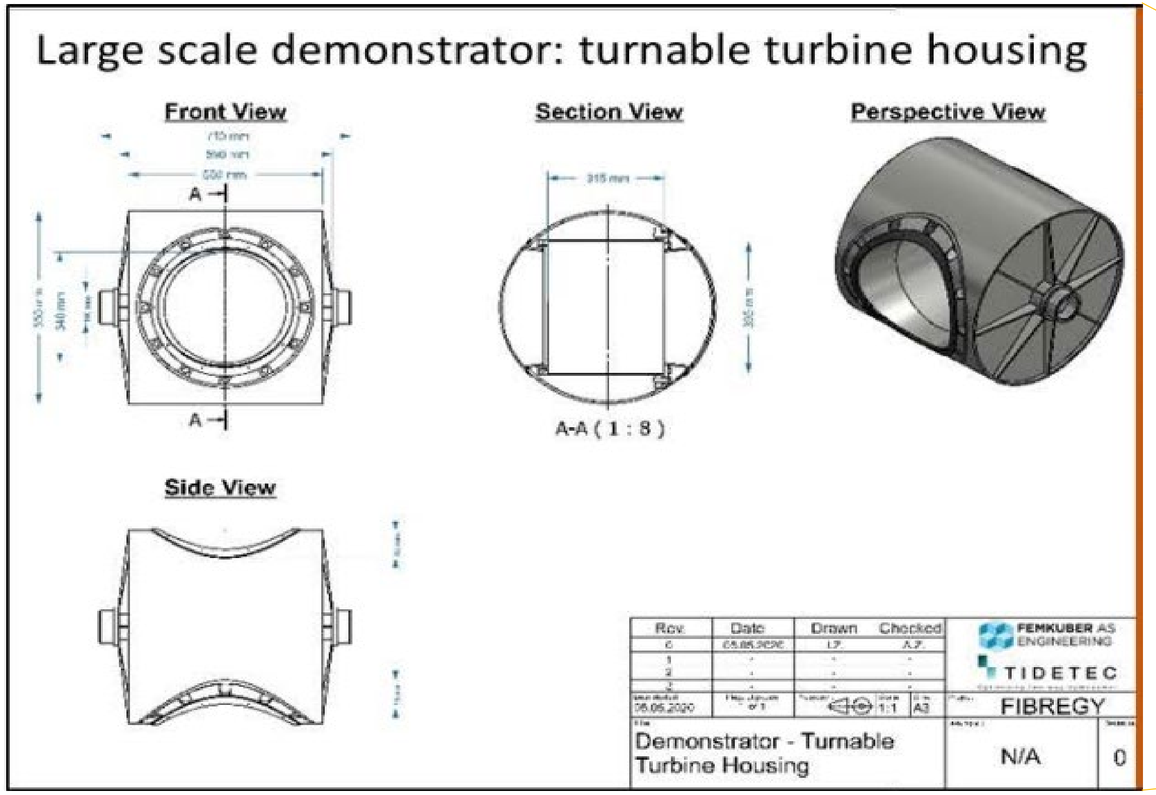


W2 Power Wind Turbine

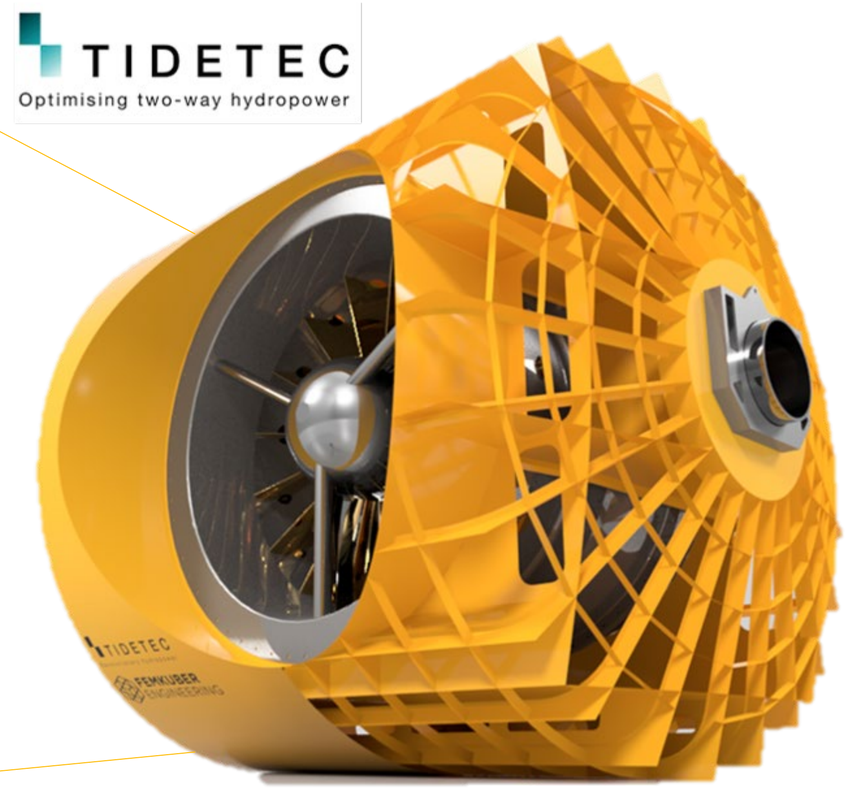


O3: Design of the towers and D column demonstrators of the W2 Power Platform in FRP materials. The main purpose is to verify the technical and economic feasibility of using FRP mats in the design and construction of certain elements of the OWTPs.

1. Objectives of WP4



TIDETEC's tidal turbine



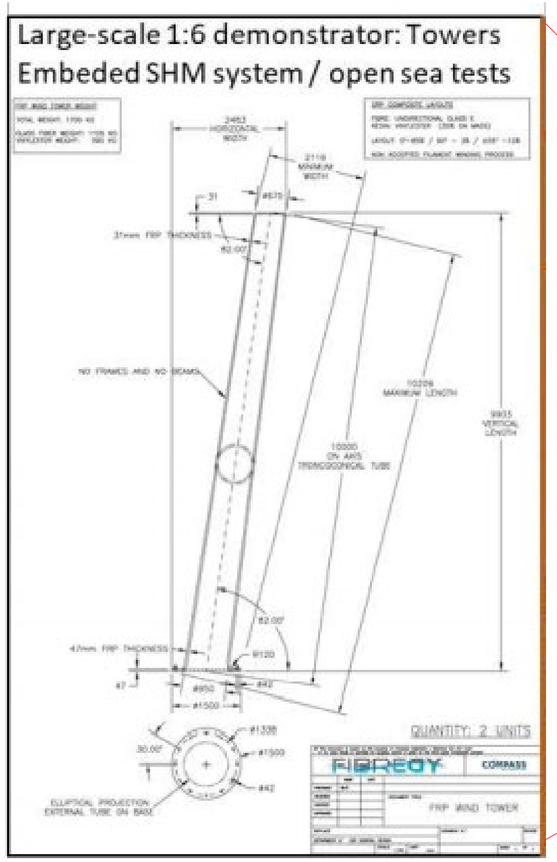
O4: Design of Turnable Turbine Housing demonstrator in FRP materials with the aim to verify the technical and economic feasibility of using FRP materials in the TIDETEC turbine housing.

1. Objectives of WP4

O5: Development of project guidelines and recommendations for design and construction of steel-FRP hybrid platforms.

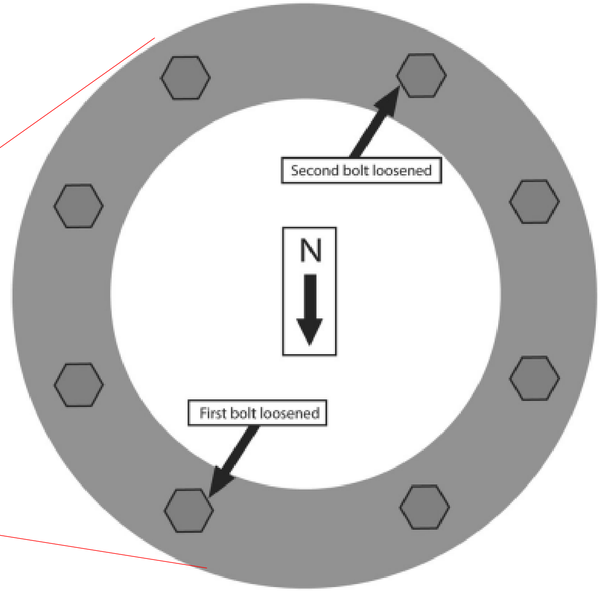
1. Objectives of WP4

FRP Tower inspection



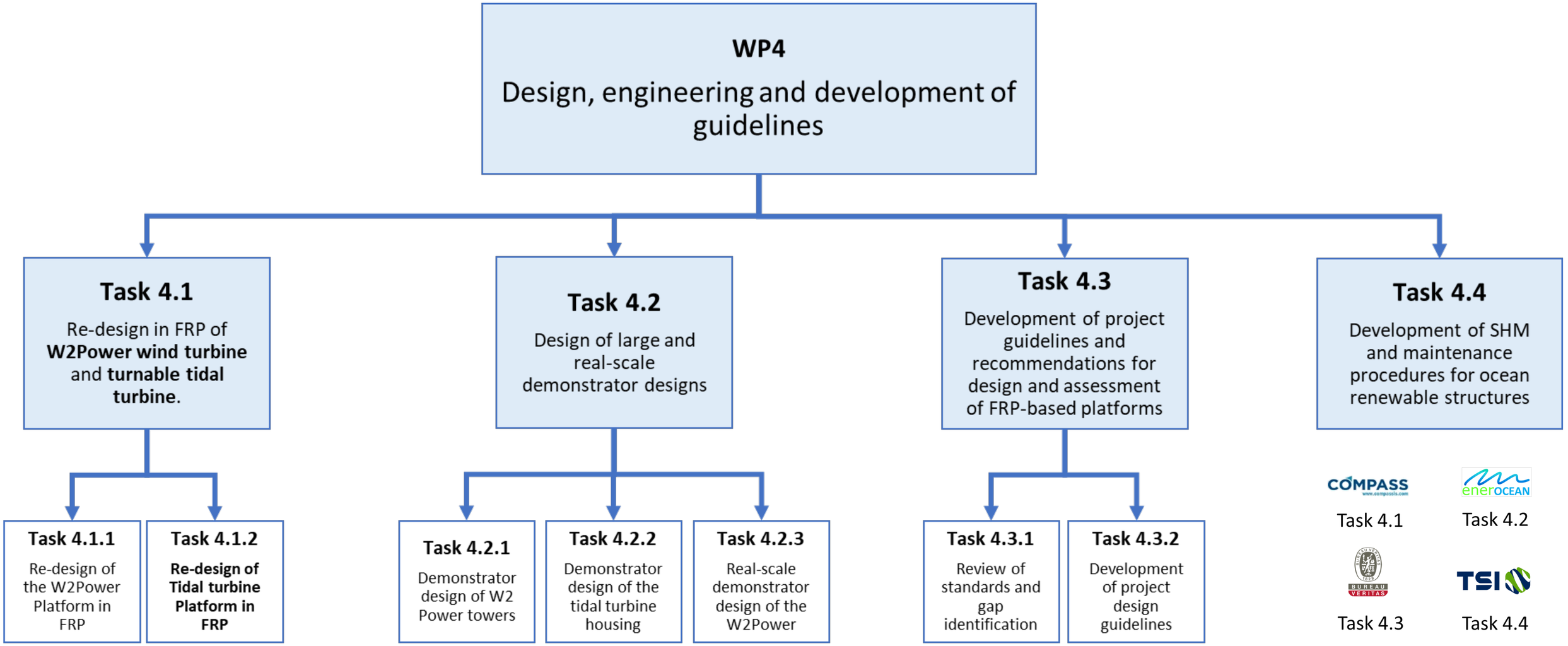
Union of FRP tower and nacelle

Union of FRP tower and floater



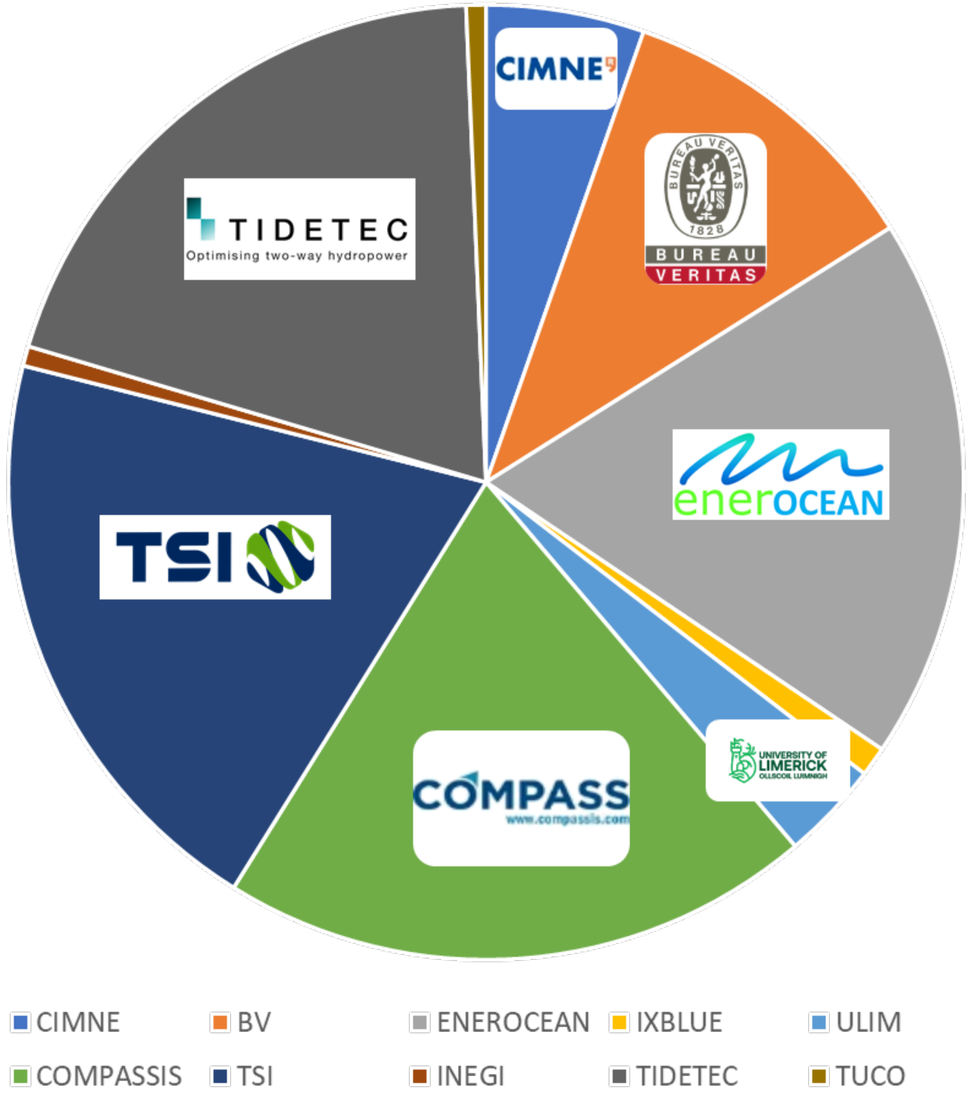
O6: Inspection and Maintenance of the condition of the W2 Power platform in the open sea with special emphasis in the damage condition of the FRP towers and FRP-steel unions

2. Description of WP4



3. Tasks Participants Overview

Participant	Person Months
CIMNE	8
BV	16
ENEROCEAN	27.5
IXBLUE	1.5
ULIM	5
COMPASSIS	30
TSI	30
INEGI	1
TIDETEC	29.5
TUCO	1



4. Milestones & Deliverables submission for the first year (M1-M12)

		2021												2022												2023						
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31
WP4	*TSI*																															
4.1	COMPASS													D 4.2					MS 6													
4.2	ENEROC										D 4.3																					
4.3	BV								D 4.6																							
4.4	TSI																															

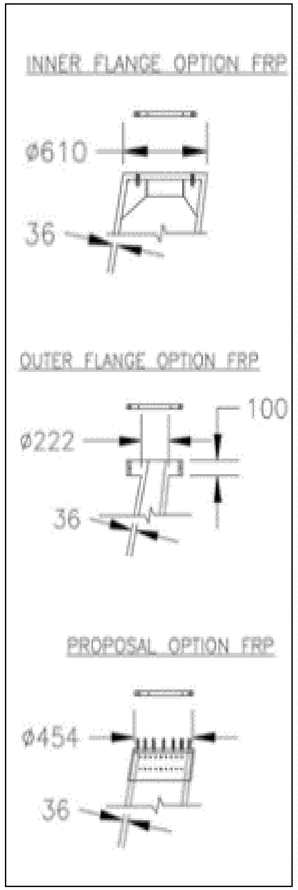
Number	Deliverable Title (Leader)	Due Date
D4.6	Critical review of applicable standards and gaps identification in FRP offshore structures (TSI)	8
D4.3	D4.3: W2Power tower's demonstrator design for its construction in FRP (ENEROCEAN)	10
D4.2	D4.2: Turnable Tidal Turbine design for FRP adaption of components (TIDETEC)	13

Number	Milestone Title	Due Date
MS6	Redesign of the targeted OWTP concepts	18

5. Initial Results of WP4

Task 4.1.1: Redesign of the W2 Power Platform in FRP materials

COMPASSIS (L), ENEROCEAN, BV (M2-M18)



Initial Results of WP4 (M1-M6)

- A complete CAD/CAE model of the steel-based W2Power multi-wind turbine has been already been implemented in Ram-Series FEA software.
- The analysis of the steel-based design is currently ongoing (i.e. modal analysis, stability analysis, hidro-elastic dynamic analysis).
- The joining alternatives between the FRP towers and the floating platform and the turbine have been discussed within the context of the W2Power demonstrator in Task 4.2.1.

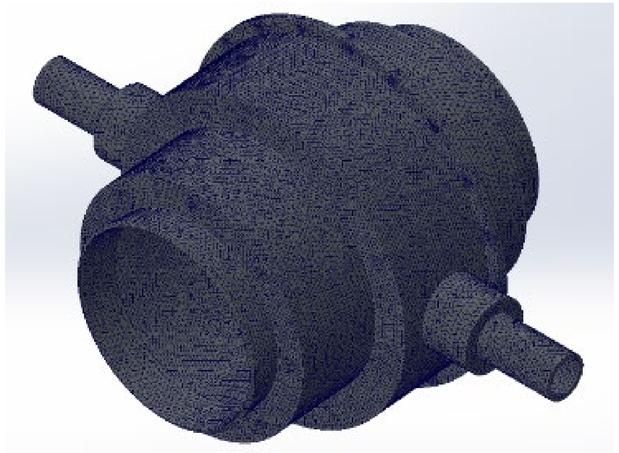
Work Plan for next 4 months:

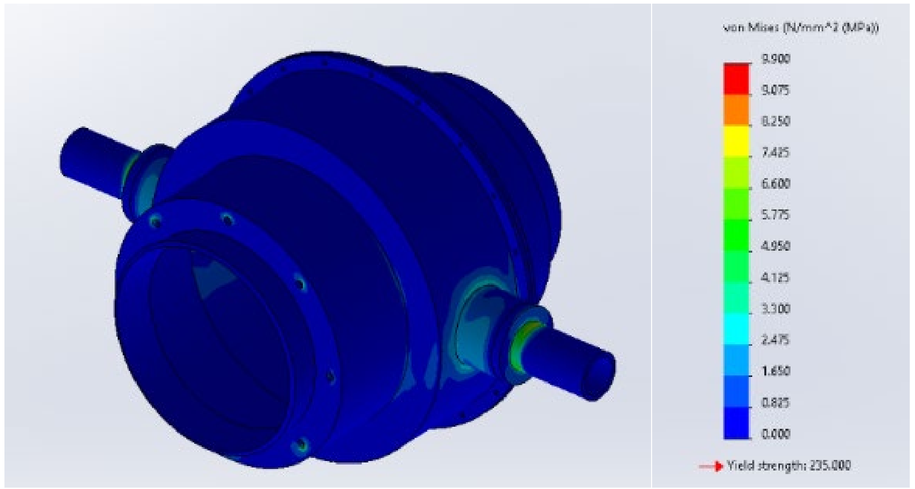
Item	What	Who	When
1	Start the re-design of the tower and floater introducing the joining techniques and FRP materials selected in WP2	COMPASS / ENEROCEAN	M7-M10

5. Initial Results of WP4

Task 4.1.2: Re-design of the Turnable tidal platform

TIDETEC (L), TSI, BV (M2-M13)





Initial Results of WP4 (M1-M6)

- Sensitivity of the mesh has been tested (element types and connectivity)
- Set up three load case scenarios with static loads
- Evaluated stress and deformations of turret for different load case scenarios.
- Modal analysis (ongoing) to study the dynamic behavior of the turret

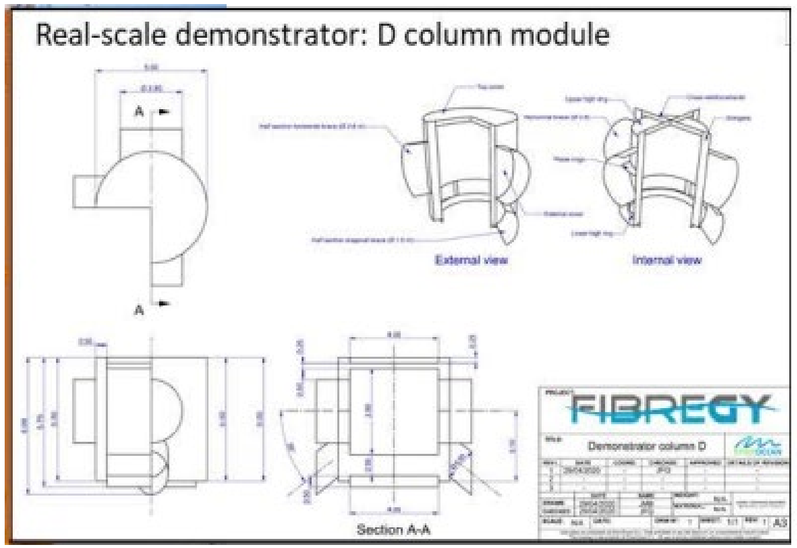
Work Plan for next 4 months:

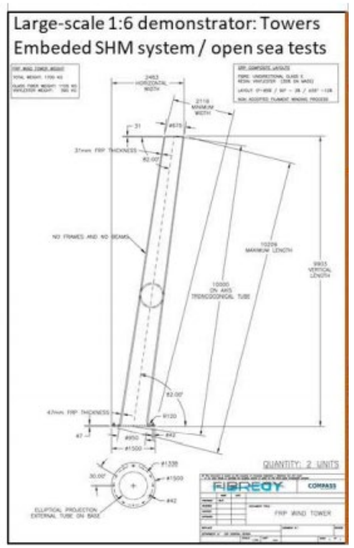
Item	What	Who	When
1	Complete modal analysis of turret and deliver results to TSI	TT	M6
2	Redesign with composite materials	TSI	M6-M9

5. Initial Results of WP4

Task 4.2.1: Design of demonstrator of the W2Power towers

ENEROCEAN (L), COMPASSIS, CIMNE, TSI, IXBLUE, BV (M2-M10)





Initial Results of WP4 (M1-M6)

- Collection of Cad and Structural design information of the prototype
- Implementation of hydrodynamic modeling (Sea Fem)
- Collection environmental data for sea testing conditions (I Form data)
- Analysis of different solution of FRP tower /platform union under the technical and economic feasibility perspective in prototype as well as in full scale:
  - Floater to tower interface
  - Tower to wind turbine interface

Work Plan for next 4 months:

Item	What	Who	When
1	The redesign of the W2POWER prototype concept and the feasibility of using FRP materials in offshore structures	ENEROCEAN	M2-M10
2	Collection and confirmation of design information	ENEROCEAN / COMPASS	M2-M10

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5. Initial Results of WP4

Task 4.3.1: Critical review of standards and gaps identification

BV (L), TSI, COMPASSIS, ENEROCEAN, TIDETEC (M1-M8)

Organization	Standard reference	Standard name
Bureau Veritas Marine & Offshore	Ni 572	Classification of Floating offshore Wind Turbines (With a listing of existing standards)
	NR546	Rule for classification of Composite Hulls
	Ni603	Rules for tidal turbines (with notions on fatigue of composites)
	Ni 631	General certification scheme for Marine and Renewable Energy technologies
	Possibly Helpful	
	Ni 432,	Fibre Ropes of offshore services
	NI 525	Risk based qualification of New Technology
	Ni 615	Buckling assessment of plated structures of steel ships and offshore units
	Ni 638	Long term calculations (general guidance on hydro structural calculations)
	Ni 611	Guidelines for fatigue assessment of steel ships and offshore units
	Ni 613	Adhesive joints (under rewriting)
Det Norske Veritas	DNV OS500	Composite components
	DNVGL-ST-0164	Tidal turbines
	DNV OS C101	Design of offshore steel structures, general method
	DNV ST 0126	Support structures for wind turbines
	DNV OS -J101	Design of Offshore Wind turbine Structures
	DNV DS-J102	Design & Manufacture Wind turbine blades
	DNV RPC203	Fatigue design of offshore steel structures
	DNV CP0086	Adhesive systems
	DNV ST0376	Rotor blades for wind structure
	DNV ST0490	TP52 Racing yachts
	DNV RP-C208	Determination of structural capacity by Non-Linear FE analysis method
Other Standard	ISO 19900 Series	Offshore structure standards
	IEC 61400	Standards for Wind Turbine
Lloyd's Register		Guidance Notes for the Classification of Special Service Craft Calculation Procedures for Composite Construction
		Guidance Notes for Offshore Wind Farm Project Certification

Initial Results of WP4 (M1-M6)

- Preliminary selection of the standards (BV, DNV, LR, etc)
- Definition of methodology for identification of GAPs
- Proposal of a preliminary index for Deliverable
- Beginning of the critical review of standards

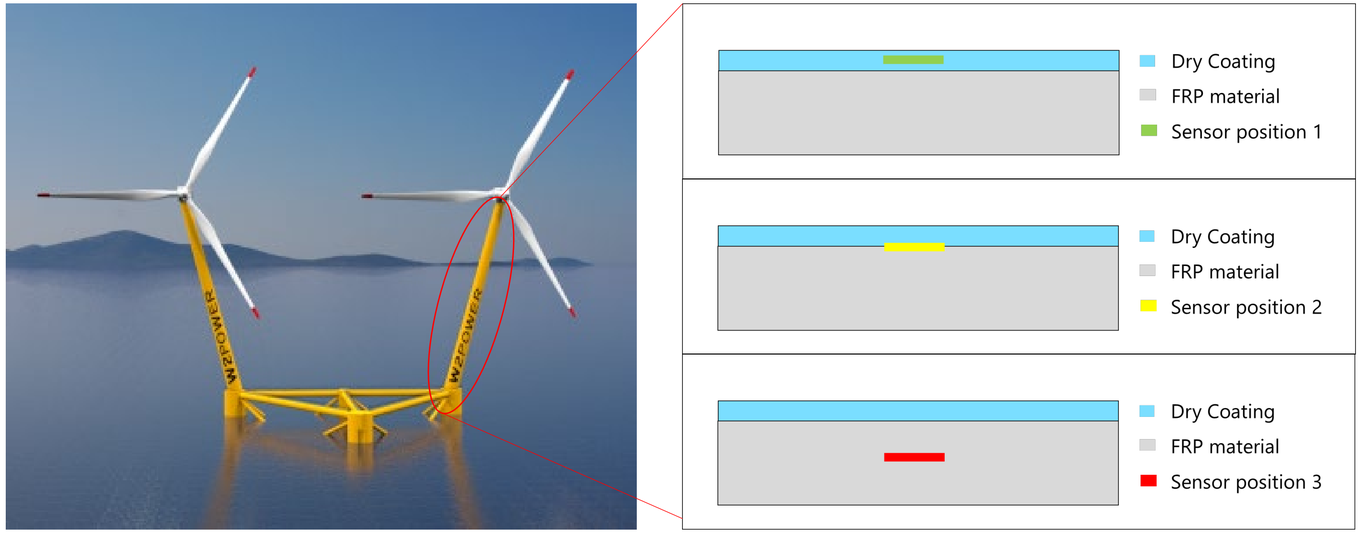
Work Plan for next 4 months:

Item	What	Who	When
1	Analysis of gaps and draft of deliverable D4.6 “Critical review of applicable standards and gaps identification in FRP offshore structures“	TSI	M6
2	Review of D4.6 by BV and consortium, which is expected to be submitted to the E.C by the end of M8.	ALL	M7-M8

3. Initial Results of WP4

Task 4.4: SHM and maintenance procedures for OWTPs

TSI (L), ENEROCEAN, BV, CIMNE, COMPASSIS (M2-M30)



Initial Results of WP4 (M1-M6)

- Definition of the most frequent causes of damage and failure modes in OWTP towers
- Selection of the best strategy for embedding the sensors into the dry coating of the FRP tower
- Initial screaming of sensors to be embedded into the FRP tower dry coating
- Review and appraisal of current inspection technologies for the monitoring of offshore platforms (tower, mooring lines, joints, etc.)

Work Plan for next 4 months:

Item	What	Who	When
1	Experimental trials on prototype tests with different damage conditions in Task 2.5.3 with special focus on connections and FRP tower.	TSI	M7-M10
2	Selection of the optimum KPIs to evaluate the structural integrity of the W2 Power.	TSI + All	M7-M10

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3. Initial Results of WP4

Task 4.4: SHM and maintenance procedures for OWTPs

TSI (L), ENEROCEAN, BV, CIMNE, COMPASSIS (M2-M30)

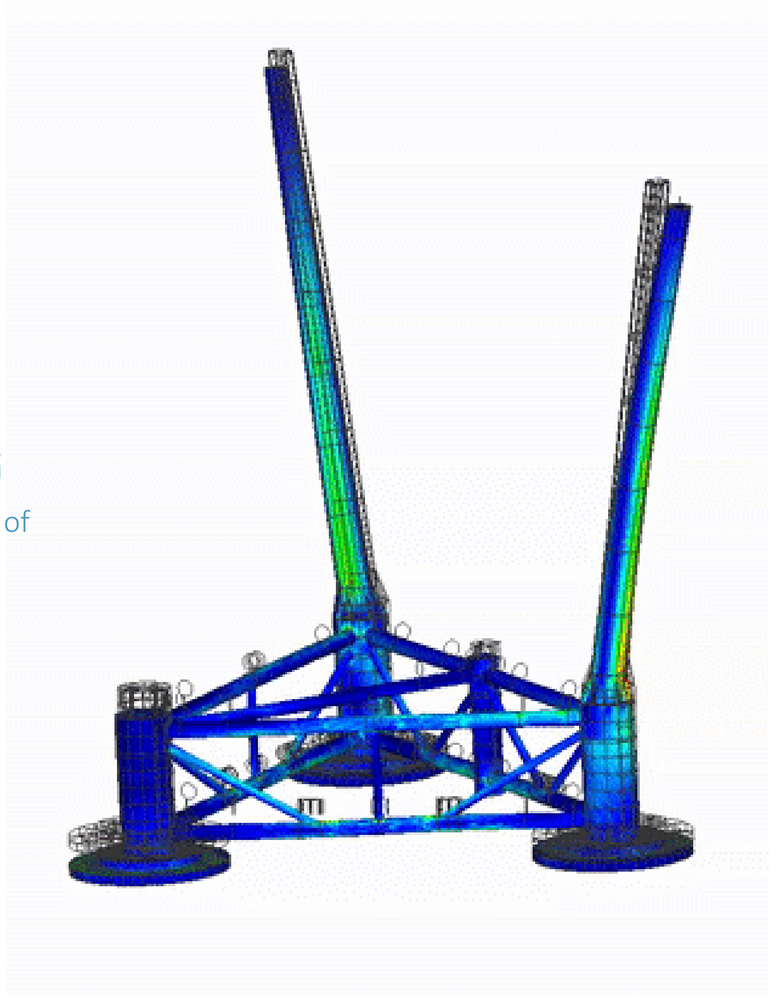
MONITORING SYSTEM

1. Sensors (accelerometers + strain gauges + fibre glass -optional-) installed in key ROM points.
2. Sea state monitoring.

STRUCTURAL HEALTH MONITORING

1. Integrate monitoring system and ROM by means of an IoT platform (OSI4IOT).

SI4IOT



STEPS to build the REDUCED ORDER MODEL

1. Compute the first n global eigen-modes of the structure (modal analysis)
2. Create a dynamic MOR, projecting sea and wind loads on the reduced modal space.
3. Resulting low cost operation model running in parallel. Current TRL 5-6.

Equation of motion → $M\ddot{x} + Kx = F$

Solution approximation → $x \approx \sum_{i=1}^{r} \lambda_i(t)\,\psi_i$

ψ_i Eigenmode

λ_i Temporal coefficients eigenmodes

Projection onto the modal space

System of r independent ODE's → $\ddot{\lambda}_i + \omega_i^2 \lambda_i = \psi_i^T F$

ω_i Natural frequency

Eigenmodes capture well the GLOBAL dynamics of the structure → Are we able to capture the LOCAL effects?

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3. Initial Results of WP4

Task 4.4: SHM and maintenance procedures for OWTPs

TSI (L), ENEROCEAN, BV, CIMNE, COMPASSIS (M2-M30)

Increase accuracy to compute local effects (e.g. hot spots)

Partitioned Singular Value Decomposition — Data-driven strategy

full scale FEM analysis → Snapshots matrix

$$\mathbf{X}_d = \begin{bmatrix} x_{11} & x_{12} & \cdots \\ \vdots & \ddots & \\ x_{N1} & & x_{NP} \end{bmatrix}$$

N Degrees of Freedom
P time steps

$$\mathbf{X}_d = [\mathbf{X}_1 \quad \mathbf{X}_2 \cdots \mathbf{X}_Q]$$

Partition into Q block matrices

$$\mathbf{X}_d = \mathbf{U}\mathbf{S}\mathbf{V}^{*T}$$

Truncated Singular Value Decomposition

Projection of the motion equation onto the reduced space → Computation of the temporal coefficients $q_i(t)$

$$x(t) \approx \mathbf{u_1} q_1(t) + \mathbf{u_2} q_2(t) \cdots \mathbf{u_k} q_k(t)$$

Solution approximation

STEPS to build the REDUCED ORDER MODEL

1. Compute the first n global eigen-modes of the structure (modal analysis)
2. Compute a set of representative load cases (i.e. those defined in the applicable norms)
3. Use the Model Order Reduction technique to calculate local (non-linear) modes (partitioned approach).
4. Build a Reduced Order Model combining the local and global models.
5. Couple the Reduced Order Model with a (reduced) seakeeping solver.
6. Run the model in operational mode (fed from monitoring info).

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THANKS FOR COMING