INTEGRATED MONITORING PROGRAM

Deliverable nº 6.2

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Deliverable Nº 6.2

Integrated monitoring program

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WP leader: ECN

Task: 6.2 Monitoring program development

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Brief Summary

This document outlines the integrated monitoring program that will be implemented for the floating wind turbine during the different phases of its life.

The detail of each phase will be detailed for every main sub assembly taking into account environmental conditions.

This program will gather all the data required to confirm the behaviour of the system and to be used to validate the concept, design models, tools and methods.

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 4

2. INTRODUCTION 5

2.1 DOCUMENT REFERENCES 6

2.2 ACRONYMS 6

3. CONSTRUCTION AND PRE COMMISSIONING PHASE 7

3.1 ENVIRONNEMENT CONDITIONS 7

3.2 FLOATING FOUNDATION 8

3.3 WIND TURBINE 11

4. INSTALLATION AND COMMISSIONING PHASE 13

4.1 ENVIRONMENT AND METOCEAN 13

4.1.1 Basis 13

4.1.2 Particularities: 14

4.2 MOORING SYSTEM 15

4.3 FLOATING FOUNDATION 20

4.4 WIND TURBINE 21

5. PRODUCTION PHASE 24

5.1 ENVIRONMENT AND METOCEAN 24

5.2 MOORING SYSTEM 25

5.3 FLOATING FOUNDATION 27

5.4 WIND TURBINE 28

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1. EXECUTIVE SUMMARY

In order to ensure a comprehensive monitoring coverage of the FLOATGEN floating wind turbine within its environment, a full program of monitoring has been developed by the partners of the project, detailing how the data collection described in the Monitoring Concept Report (deliverable 6.1) will be used. The present document describes which data sequences will actually be used to validate rigorously operating conditions (e.g for access, lifting, or turbine production) and build representative physical models of the floating wind turbine in its actual environment. Ensuring the safety of the navigation and the Users is a core part of the project that is also required by Maritime authorities.

This document aims at presenting the Task 6.2 “Integrated monitoring programme” works, jointly done by ECN, and IDEOL. This document describes for the parameters that will be validated and the measurements / records used toward that goal. The monitoring programme is broken down into three main sections, each corresponding to a phase of the project:

- Construction and pre commissioning phase
- Installation and commissioning phase,
- Test phase,
- Operational phase.

In each of these phase, the programme is split between:

- Environment and metocean data,
- Wind turbine,
- Floating foundation,
- Mooring system.

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2. INTRODUCTION

Reasons for monitoring the floating wind turbine demonstrator are (by order of priority):

a. Safety of Personnel and equipment
b. Environment protection
c. Production
d. Wear
e. Physical models validation

The monitoring program described in this deliverable allows the organization to meet these requirements. Although limited modification of the wind turbine was done to meet the functional requirements underlying objectives a, b and c above, a specific monitoring programme needs to be set due to the novelty of the deployment of the wind turbine.

The emphasis of this prototype unit monitoring is placed on turbine/floater interactions, scaling cost-saving estimates, operating procedures and ageing estimates. During commercial phase, the monitoring will mainly aim at ensuring the safe and effective operation of the FWT. A number of sensors are used to characterise the dynamic response of the floating wind turbine, but log books will also be used to provide a consistent and rigorous record of how maintenance operations (access, lifting, parts replacement in the nacelle, etc.) were performed.

The implementation of the monitoring program will gather the conditions to reach the TRL level 7 (Technology Readiness Level): Data reporting and analysis of full scale demonstrator which is delivrable D6.3.

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2.1 DOCUMENT REFERENCES

[D01] Code for construction and equipment of mobile offshore drilling units" 2001 IMO MODU code

[D02] G02-RP-NAV-0500_Floating_Foundation_Design_Requirements

[D03] Sensors-ranges and frequencies_TCH_2013-09-12

[D04] D2.2 Requirements for the wind turbine _Demo 1_

[D05] D2.3 Requirements for the floating structure _Demo 1_

[D06] G02-PL-OPE-9902-00_Inspection and Maintenance Plan

[D07] Wave Resource Characterization Deliverables D2.2 & D2.7 Equimar Project

[D08] D4.5: SEM-REV Test Site Exploitation Rules

2.2 ACRONYMS

AIS	Automatic Identification System
ACH	Anti-Condensation Heater
BYTP	Bouygues TP
DGNSS	Differential Global Navigation Satellite System
FWT	Floating Wind Turbine. The whole floating system producing power to the grid. In place it includes the wind turbine, the floating foundation, the mooring system and the umbilical system.
H_S	Significant wave height
MRU	Motion Reference Unit
PLC	Programmable Logic Controller
TP	Transition Piece
SCADA	Supervisory Control and Data Acquisition
TRL	Technology Readiness Level
USTUTT	University of Stuttgart

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3. CONSTRUCTION AND PRE COMMISSIONING PHASE

The construction phase includes floater construction with associated testing and WT integration. The pre-commissioning phase includes the tests performed onshore, alongside in port on the floater and the wind turbine.

3.1 ENVIRONNEMENT CONDITIONS

During construction phase main environment conditions which will be monitor will be:

- Ambient temperature, meteo conditions and relative humidity for concrete pouring
- Wind speed for lifting approval, harbour mooring calculation,
- Water density for floater float-off
- Wind conditions for WT on shore testing and stand-by

The floater construction and WT integration will be performed with the aid of main cranes, installed on the wharf, which will bring the loads from the transport truck to the barge alongside or the floater. To respect local legislation and be safe at all times it is crucial to constantly monitor the wind speed to safely work. Depending on the size and surface of the item lifted up, the Contractor will have to stop the works if the wind is coming over some limit. Wind speed probes are available on each crane, with repeater on the crane driver cabin; in such case the crane driver informs the Foreman who decides if the work will carry on or must be reconsidered.

An additional wind speed measurement is done at the nearest airport (Montoir, 5km away from the site), which is readable in real time or post processed through the internet.

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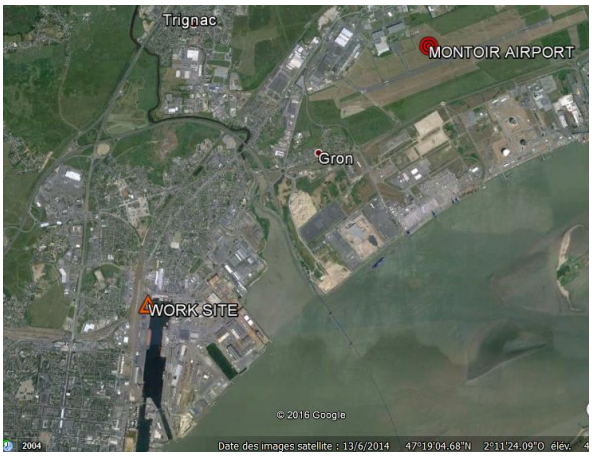

FIGURE 1 LOCALISATION OF THE WIND RECORD STATION

It is of importance to ensure the barge and the floater will not be an obstacle for commercial traffic of the port. The mooring cables are closely monitored (several times a day) by experienced crew. They are tightened where necessary.

The port authority is in charge of the surveillance of the water level in the main basin of the port, behind a lock door, thus the water level is varying very poorly (typically 0.50m maximum), depending on the lock passages of commercial traffic, and also the spring / neap tides that can affect the water level.

3.2 FLOATING FOUNDATION

This section outlines the monitoring programme that is implemented on the construction site, in order to grant the floater quality in respect with the specification.

The Floatgen floater is being built on a barge of dimension 66m x 46m x 4m, moored alongside in Saint-Nazaire port (France).

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The construction duration depends also on the weather on site (most of the duration is autumn / winter condition).

Building a heavy concrete structure on a barge demand special technique to keep the support horizontal at all times, with no deflection. For this, IDEOL and BYTP defined a series of procedures to make the construction safe and within the tolerance described into the specification.

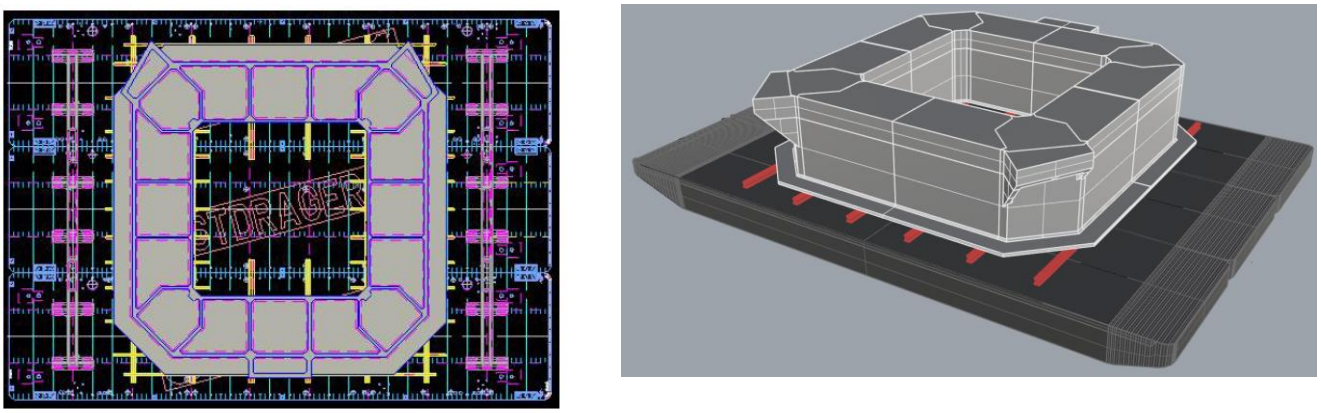

FIGURE 2 CONSTRUCTION OF THE FLOATER ON A BARGE

BYTP is in charge of the weight monitoring procedure during construction, in order to grant the final weight and CoG position of the floater are consistent with the specification.

The **weight monitoring programme** is based on:

- The concrete trials made at the concrete plant (including density test at factory)
- The concrete density measurement: tests are made on every concrete batch, on construction site (fresh concrete) and at the laboratory (hardened concrete)
- The thickness of the structure (slabs and walls) measured with a total station installed on the barge deck (the automatic compensator for inclination is disabled).
- The weight information of the steel reinforcement is done at the steel factory and indicated in the bending schedule of the drawings.

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The weight monitoring document, issued by Contractor, is written in a dedicated procedure and remains open during the construction process.

Finally an **inclination experience** is carried out to measure the naval parameters of the floater, after float out:

- GM
- Draft
- CoG position (X, Y, Z),
- List
- Trim

In addition the following will be performed:

- Dummy access in port for boatlanding
- Water ingress detectors test
- Bilge system functional tests
- Mooring line connector trial fitting and functional tests
- Motions in port to identify heave, roll and pitch natural frequencies

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3.3 WIND TURBINE

WT Manufacturer provides manuals and procedures for transportation, handling, assembly and erecting of the WTG according to worksite constraints regarding:

- Road access,
- Components delivery, storage, preparation and repair,
- Lean management of Assembly and Erecting operations
- Restricted area to optimize Safety and Security, permitting access control of people and goods.

Geotechnics of Quay soil will be consider thanks to a Calculation Note of Loads sharing factor realized by Crane provider.

Crawler crane, with lattice boom tower and extra jib to add clearance under hook, is planned as Main Crane for its availability, stability and cost efficiency, in comparison with Tower crane or mobile/telescopic crane.

For WT integration onto floater, the WT is prepared and erected according to WT Manufacturer Procedures and IDEOL Ballast Method Statement using constant trim method. The Principle is kipping Trim at 0° during whole operation to keep Draught / Displacement constant.

Record of the **real weight of the WT components** (tower sections, nacelle, hub, blades) will allow to define accurately the weight of the Floating Wind turbine. This will be done through the weight measurement device of the cranes.

This is will allow to adjust in detail the passive ballast weight inside floater compartments.

Pre-Commissioning can begin to be achieved when WT is producing.

Taking into account WT Manufacturer Start Up Procedure and IDEOL Pre Com Statement, Pre-commissioning is realized in 2 phases.

1. Evaluation of optimized location to proceed

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In coordination with Port Operation Administration, IDEOL considers changing workstation location.

2. Pre com operations

In this operation WT is not necessarily located wharf alongside because FWT can be placed with WT at the opposite side or lateral side.

Workstation is prepared to allow specific pre-commissioning works by IDEOL and providers staffs, managing co-activity on deck and in WTG.

IDEOL will implement safe access to the FOWT and safety awareness on site.

Pre commissioning operation are described in **WT Manufacturer Start Up Procedure** and hereafter summary described.

- Internal cabling
- Final tightening
- Power connection (grid, external Genset, Charges Bench)
- Start Up of processors
- Test preparation
- Meteorological parameters
- Turbine Start Up
- Production counters
- Hydraulic Systems
- Security Functions
- Test of cabinets, hub, pitch, yaw, sensors, heaters, fans, etc.,
- Remote Control and Condition Monitoring System (CMS)
- Run test to achieve.

All **electrical parameters** will be checked, adjust if necessary in order to comply with the grid requirements. Specific load benches will be used to download the power produced on shore.

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4. INSTALLATION AND COMMISSIONING PHASE

This chapter aims at presenting the data that will be collected during the installation and commissioning phase. As the subcomponents of the floating wind turbine are in unique conditions during offshore installation, a number of records are possible that could not be recorded otherwise in real scale. One of the objectives of the monitoring tasks in this phase will be to validate certain data independently of the coupling with other structures.

The installation phase includes mooring lines deployment, testing, FWT transit, floating foundation hook-up and position adjustment.

The commissioning phase includes the tests performed offshore, when the platform is installed, prior to produce electricity.

4.1 ENVIRONMENT AND METOCEAN

4.1.1 BASIS

The same basis in terms of environmental monitoring is anticipated for all the installations and commissioning phases: MS Pre-installation, Abandonment, Towing, ML Hook-Up, umbilical Hook-up, and Commissioning. Based on the physical means presented in D6.1 it includes information concerning the:

- **Metocean forecast**:

A specific forecast company will be hired for insurance cover purpose in order to supply metocean window.

- **Physical Environment on site:**

Wave (Directional Wave Rider Buoy) and Wind (Onshore Lighthouse) measurements for contractual objectives during the installation.

Current (non-real time) and local wind measurements (Surface Water Level +3m) are considered as additional measurements for post-treatment purposes.

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- **Human Activity:**

AIS, VHF interfaces will be closely monitored during operations in order to ensure the coactivity with other users is mastered at any time.

Footage of the operations will be recorded by video camera for security (for example in case of an intrusion inside the operation area) and communication objectives.

4.1.2 PARTICULARITIES:

In addition to the basic environmental monitoring, some particularities are forecasted depending on installation phases.

4.1.2.1 MS PRE-INSTALLATION

Layout pre-survey at the abandonment lines corridors as well as the temporary, reaction and permanent anchors locations will be undertaken.

An acoustic campaign is forecasted during the pre-installation as it will occur roughly 1 year after the initial state carried out on SEM-REV in 2016. The hydrophone will be implemented on based on MOSAIC (Module for Observation Surveillance & Acquisition Submersed and Connected), a specific monitoring device developed by ECN.

Layout post-survey at the reaction anchors locations will be undertaken.

4.1.2.2 ABANDONMENT

During the abandonment several patrols together with survey will be planned to ensure the integrity of the mooring systems.

4.1.2.3 TOWING

A refined forecast model or extra wind measurements access (nacelle, offshore lighthouses…) will be considered during this sensitive journey in order to provide to most accurate data to the convoy.

4.1.2.4 ML HOOK-UP

Layout pre-survey at the definitive lines corridors will be undertaken.

Layout post-survey at the temporary lines corridors as well as the temporary anchors locations will be undertaken.

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4.1.2.5 UMBILICAL HOOK-UP

Layout pre-survey between from point 8 (extreme TDP position) to point 9bis (actual location of the dry-mate connector) and between point 8 and point 9 (future location of the centre of the FWT) will be carried out before any handling of the dynamic cable. The survey of the laying umbilical is performed before the operation with a high-resolution multi-beam sonar. The data is used to confirm the actual configuration of the cable to prepare the cable hook-up operation.

4.1.2.6 COMMISSIONING

Extra wind measurements will also be considered during the commissioning.

4.2 MOORING SYSTEM

The FWT mooring system will be pre-installed offshore in spring 2017, on SEM-REV site. It will be implemented with AHTS -type vessel that is able to install heavy sand anchors (approx. 15 tons) and lay mooring lines made of chain and nylon sections. The mooring system must be installed within position tolerance to ensure the dynamic behaviour of the FWT (FWT must not go out of calculated excursion) and the associated tension in mooring lines and the dynamic umbilical (all components have their own Minimum Breaking Load).

During offshore installation all the components of the mooring lines will be closely monitored, in position as well as the applied tension during anchor embedment and laying of cables. Surveys will be performed with ROV equipped with USBL / DGPS positioning system.

The nylon lines require to be stretched out, in order to remove the constructional stretch that is due to the construction process. Some testing has been carried out on subropes to predict the behaviour of the nylon line, but we will implement a stiffness test, offshore, in real condition, to measure precise stiffness of the nylon rope. Then we will be able adjust the final position of the anchors before connection of the FWT.

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ITEM	PROPOSED METHOD	SAMPLE FREQUENCY
ANCHOR POSITION	Fix with ROV DGPS based survey system	Several fixes per anchor
TENSION IN MOORING LINE	Load cell on vessel	Permanent
MOORING LINE EXTENSION	DGPS fix	Several fixes per line
CURRENT SPEED	Offshore sensor	Permanent
SWELL HEIGHT	Offshore data buoy	Permanent
WIND SPEED	Offshore anemometer	Permanent

Once the mooring system is installed offshore, a survey will be carried out to check for the good position and behaviour of the mooring lines that are abandoned at sea, waiting for the FWT hook up.

The collected information will be processed and compared to software prediction and model test in basin or in laboratory, made during the engineering period. This knowledge will be crucial for the development of future offshore installations with similar mooring system.

Therefore the following will be monitored:

Testing of prototype synthetic ropes (stiffness, weight, strength)

Testing of prototype chain systems (stiffness, weight, strength)

Record of anchors position and dragging when being set

Record of mooring lines tension during anchor testing (tension Vs displacement to check mooring stiffness)

Record of lines tension dynamic variations during testing to check mooring lines stiffness

Vessel motions toward dynamic behaviour analysis

4.2.1.1 MS PRE-INSTALLATION:

During all the phases of the mooring lines installation, the following parameters will be permanently checked & recorded:

Vessels identity, precise position, speed, course, depth (-> R&D Marine Operation)

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Angle between the line and the nautical mean outside the chute, unrolling Speed of the lines, tension on the lines (winch), lines TDP positions, anchors positions & lines subsea visualization.

For instance, the position of each anchor is measured first at the grounding, then at the end of the pre-installation phase, including the estimated depth of penetration. These positions are needed for the permanent anchors of the MS as well as for the temporary anchors.
The measurement is performed to get a position in a 3D volume (N,E,depth) with GPS equipment and a USBL beacon mounted on a ROV close to the anchor or by a specific reflective target localised by the vessel sounder.

A specific R&D project (detailed further in the production phase) is going to be implemented by ECN concerning the mooring System in order to record, from the beginning and during the different steps of the installation, the different loading cycles experienced by the composite sections and to assess the service life of the lines.

A particularity concerning the ML pre-installation is that it represents a critical step for the fatigue of the mooring lines (analysis which will be conducted throughout the project until the decommissioning of the lines). The MS monitoring during their installation is focused on:

- the towing tensions exerted on each line,
- the stretch of each line.

The line tension measurement is performed by a certified and calibrated dynamometer mounted on the towing rope on-board the vessel.
The position of the installation vessel is measured by GPS synchronously with the line tension. The stretch of each line is then deduced on board.
The positions of the 2 intermediate triplates of the fore lines are measured with an USBL beacon attached on them. The behaviour (motions, depth,…) of these 2 components is logged during all installation and abandonment steps. The data are collected real time by a main USBL base which is installed on board the ECN Meteocean buoy (BMTO3) deployed in

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the vicinity of the area. The data are also stored in the subsea module (MOSAIC) for safety and redundancy.

4.2.1.2 ABANDONMENT

In addition to the positions (hence the stretch of the lines) during the abandonment, frequent surveys (via divers) will be performed in order to keep a track on the integrity of the mooring systems.

The data collected during the abandonment stage will also be used to validate the numerical simulations and design assumption, especially because of the potential bio-fouling affecting the lines.

4.2.1.3 HOOK-UP ML

The Mooring System is monitored during hook-up on the similar basis than the pre-installation. The measuring devices are kept on the lines for this purpose.

The Autonomous Data Loggers (ADL) installed on several MS components are also kept in place to ensure a full redundancy and safety storage of the measurements even in case of a broken line or Wind Turbine electrical blackout.

After hook-up, the MS data monitoring system installed in the Transition Piece, at its first (ground) level, in a dedicated electrical cabinet will become the Main Data Logger (MDL).

From this moment, the Mooring System is monitored with the following elements:

- the USBL base is transferred from the meteo buoy BMTO3 to the Wind Turbine Floater and received data are recorded by MDL ;
- the direct line tensions are measured on 4 mooring lines (the 2 fore lines and 1 rear line on the 2 sides) each one by a dynamometric shackle pin at the Triplate 1 ;
- the USBL beacons mounted on the triplates are then transferring wireless positions and line tensions to the MBL ;
- an echo-sounder mounted on-board the floater is providing its instantaneous altitude with respect to the tide level ;

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- the GPS position of the floater is recorded as well to provide the spatial locations of the top connectors.

The MDL is composed of a specialised rugged computer with a real-time synchronising and processing software in charge of logging the data stemming from different and asynchronous measuring devices.

4.2.1.4 HOOK-UP UMBILICAL

Prior to any handling of the cable electrical and optical tests will have to be carried out from the electrical substation to validate the operability of the dynamic cable:

- Optical: Reflectometry & Dynamic flow
- Electrical: Insulation / tan delta / Echometry …

After the recovery of the cable, the same tests (E/O) will be performed on the deck of the FWT for comparison before progressing with the connection and the commissioning process (see WT chapter §3.2).

The operations during the umbilical connection is giving an opportunity to install a monitoring system on the dynamic cable equipment; the stabilisation anchor. The Extreme position of the TDP is a contractual location within the Floatgen project where no tension produced by the FWT shall be transmitted in direction to the Hub. Checks on a regular basis or after specific events (such as the hook up of the umbilical) will be performed

The monitoring devices are designed to provide a negligible effect on the hydrodynamic and mechanical behaviors of the umbilical and are are clamped on the cable upstream of the stabilization anchor (on the Hub Side). The data are both stored on Autonomous Data Logger and transmitted real time with an acoustic modem to the Main Data Logger on the WT Floater.

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4.3 FLOATING FOUNDATION

Concerning the floating foundation, the following records, test and data will be monitored during transit and hook up:

- Towing force at several speeds (1knot, 2knots, 3knots and maximum tugs pull)
- Motions prior to turbine start-up after hook-up (seakeeping performance verification, mooring system natural periods)
- Mooring line top angle prior to turbine start-up to ensure adequate length adjustment was performed

The equipment for which a commissioning plan is developed will be gathered in different categories independently from the project step at which they will be installed or commissioned. All equipment will be tested and calibrated at this phase:

- Safety and lifesaving equipment
- Permanent electric signalization and lights
- Communication and control devices
- Bilge and pumping systems
- Monitoring sensors
- Equipment for hook-up & O&M
- Power production and storage
- Umbilical hook-up and connection
- Miscellaneous works

These operations require a lot of Personnel transfer, with specialized equipment, on board the FWT. It is thus essential that a monitoring on the environment is done to allow a safe transportation and access to the offshore site. A series of cameras will be deployed on the FWT to assess the sea state, offshore, and help deciding if a safe transfer is possible.

A motion monitoring system will be installed on the floater as well as the WT, in order to help the safe access and commissioning of equipment on the floater and on the nacelle.

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4.4 WIND TURBINE

Concerning the wind turbine, the following records, test and data will be monitored during transit phase:

- Functional tests
- Auxiliary systems tests and regular logging
- Tower bending modes (confirmation that the mode is shifted as planned)
- Blades, Drive train mode in idling and brake condition (should not be changed)
- Objective to see no change of main modes

Towing of the FOWT follows both WT Manufacturer procedures regarding:

- Transport Guidelines X80 –Sea Transport- of Nacelle and Hub,

- Transport to and from Offshore Turbines.

- External Genset is switched on to support UPS to warranty permanence of remote control of communications and lights of the FOWT.

- Controllers are switch on to allow remote yawing of nacelle, fans and cooling, and, if necessary, emergency stop.

Blocks and brakes are released to ease freewheeling of the feathered rotor. Freewheeling can be assisted by a specific turning gear device.

Generator is disconnected from High Speed Shaft.

Once FOWT is anchored and grid connected, WT Manufacturer Start-up Procedure is applied.

- A full check down of the WT is completed by two operators (Electro-Mechanics)
- Turning gear device is substituted by High Speed Shaft flexible joint and Glass Fiber
- Composite cylinder to connect Gearbox and Generator. Alignment of both is checked and corrected if proceed.
- Run Test is launch
- Remote operation is initiated from Operation Offices

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During commissioning phase the start-up of the turbine and ancillary equipment will be performed, and which data will be used to ascertain the behaviour of the system.
This phase mainly includes components testing, running-in and step-by-step extension of the operating windows. The behaviour of the system at one of these steps and the extrapolation to the next step will be confirmed through the validation of the records against predictions.

The start-up phase is done offshore in floating condition for the wind turbine, but some auxiliary systems will be started before that, when the turbine is in the port (for example the bilge and water-ingress detection systems, the emergency power systems, etc.)

The start-up of the turbine will be performed step by step, increasing the operating window of the wind turbine until full production is met. The main environmental parameters influencing the operation of the wind turbine are the wind and wave conditions.
The wind turbine operates in at different rotation speed and load as a function of the incoming wind speed. During the first step of commissioning, the turbine will be authorised to run only at such wind speeds that the rotational speed is less than 80% rated. Once stable production and loads will be confirmed, the turbine will be authorised to run at rated speed, but will less than 50% its rated load. The next step will be to increase the power production authorised step by step to 100%.

In addition, to these wind speed limitations, the operating wave height of the wind turbine will be increased step by step from up to 1.0m, to the final operating wave height (up to the 1-year return period waves).

As stated in D5.3, after receiving the certification from the CONSUEL the First energizing will be authorised for supply only during the pre-commissioning of the WT (dedicated to all tests that do not required power injection).

Therefore the following tests, on WT and substation, will have to be performed:

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Test	Description	Estimated duration	Maximal duration
Protective relays	Commissioning and test of the protective relays if applicable	1 day	1 day
Telecommunication	Test of all the signals that shall be exchange between the stakeholders, SEMREV and MEC	2 days	3 days
SCADA	Commissioning of the SCADA is done in parallel of the telecommunication test.	2 days*	2 days*
Switching scheme for MV switchgear	Sequential switching is tested if required (cumulated power > 2MW)	1 day	1 day
Calibration of the active filter FAS 12	DSO send ripple control signal dedicated to the test. The active filter supplier will set the equipment in order to minimize the ripple control signal perturbation. Test shall be done with at least P_{injec}=20%$P_{nom\ (MEC)}$	1 day	1 day
Coupling scheme	Sequential coupling is tested (if applicable)	1 day	1 day
DEIE	Test done with the DSO in order to check the functionality of each ERDF notification	1 day	3 days
Power quality analysis	Test done according to the IEC61000-4-30 to check the power quality (flicker, harmonics, voltage wave form, inrush current….) with exception for certified machine (IEC 61400-21 report for example)	To be defined	To be defined
*Should be included within the telecommunication test.			
TOTAL		5 days	10 days

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5. PRODUCTION PHASE

This chapter details the checks that will be done when start-up is completed. In this phase, the main areas of interest will be to:

- Assess access and maintenance possibilities,
- Follow-up components wear and evolution,
- Follow-up wind turbine reliability rates,
- Provide a power curve.

The power production phase is consequently mainly targeting at ensuring that the turbine remains operable, that its energy yield is optimum, and that maintenance can be performed under sufficiently broad environmental conditions.

5.1 ENVIRONMENT AND METOCEAN

In addition to the basic environmental monitoring, some particularities are forecasted during the production phase.

- Wind measurements (possible restraint campaign with LIDAR technology with a simultaneous qualification of the data from onshore locations (Hoëdic Island or Cardinaux lighthouse).
- Water Surface Elevation
- Meteorological Data (pressure, temperature…)
- Current measurements (upside down, i.e., from the floater)

In terms of environmental impact (anchors, cables described below) the following items will be also be monitored:

- Acoustics
- Visual Impact
- Biofouling

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5.2 MOORING SYSTEM

The main monitoring programme on the mooring system, for operation, is based on:

- The follow up of the marine growth development. This will be achieved by divers equipped with hand tools and cameras. Depending the biofouling increase, some additional floats could be installed. It is anticipated to visit the mooring lines once or twice a year.
- The progressive elongation of the mooring lines, that could require a re-tension every year, or after a severe storm. The collected information will be used to validate the hydrodynamics models tension – displacement of the moorings.

The monitoring of the underwater components of Floatgen project is challenging with respect to the following main aspects:

- The data collection from the components ;
- The electrical powering of the measurement devices ;
- The performance over time, at sea, of the measurement devices.

The monitoring devices are then designed in order to reach reliability as best as possible including a back-up approach in case of component failure.

However, a regular maintenance is mandatory to keep the monitoring system with optimal performances. The maintenance process is planned to be performed throughout the project and it includes tasks scheduled on a regular basis, every 2 to 6 months periods.

The maintenance aspects are covering at least the points hereafter:

- Change of batteries;
- Retrieval of collected data;
- Survey of the bio-fouling on the monitoring components and potential cleaning of the components (in relation with the biological monitoring procedures).

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Checks on a regular basis or after specific events through acoustic surveys (such as multi-beam bathymetries) will also be performed on equipment such as the anchors or the dynamic cable. The observations should be able to provide information as the displacements of the cable will be recorded by the surrounding sediments (mainly sand). Acoustic imagery can be completed with dedicated camera surveys from ROV or divers.

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5.3 FLOATING FOUNDATION

As described in the FLOATGEN D6.1 Data Monitoring Concept Report a set of monitoring sensors and probes will be installed on the FWT to study the behaviour of the floater and its components. In addition to this programme, we will implement an easy log book system with the objective to assess the real condition with which the access to the floater is safely possible. To achieve this, the log shall be completed by all user coming on board, from all Companies and for all purpose (maintenance, repair, equipment set up, installation of new equipment, visit …). As an example the information can be logged under the following form:

Date and Time of access	**Type of vessel**	**Location of access on FWT**	**HS/Tp**	**visibility**	**current speed**	**Wind speed**

Similarly a data base will be built up with the loading of equipment from a maintenance vessel to the FWT, and vice versa:

Date and Time of transfer	**Lifting crane used**	**Weight of parcel**	**Crane radius**	**HS/Tp**	**current speed**	**Wind speed**

The recorded data base will be used to improve the condition of the access on board for Personnel and equipment, for the prototype and the future pilot farms. Final data analysis will be processed as to highlight statistics that show the environmental condition favourable, restrictive, not safe, and forbidden.

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Concrete material testing (density, strength, permeability to chlorides, susceptibility to marine environment degradation)

5.4 WIND TURBINE

Standard on shore data will be monitored during the production phase including:

- Production Counters
- Hour Counters
- Availability
- Electrical Data
- Temperatures
- Warning Log
- Operation Log
- Alarm Log

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