Floating offshore wind turbine design stage summary in LIFES50+ project

Germán Pérez (TECNALIA)

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Qualification of innovative floating substructures for 10MW wind turbines and water depths greater than 50m

The research leading to these results has received funding from the European Union Horizon2020 programme under the agreement H2020-LCE-2014-1-640741.

Outline

- LIFES50+ project overview
- WP1 Concepts Design
- Design Basis
- Concepts Design process
- Conclussions & Challenges

LIFES50+ project overview

Qualification of innovative floating substructures for 10MW wind turbines and water depths greater than 50m

Grant Agreement: H2020-LCE-2014-1-640741

OBJECTIVES:

- Optimize and qualify to a TRL 5, of two innovative substructure designs for 10MW turbines
- Develop a streamlined KPI-based methodology for the evaluation and qualification process of floating substructures

FOCUS:

- Floating wind turbines installed in water depths from 50m to 200m
- Offshore wind farms of large wind turbines (10MW) – identified to be the most effective way of reducing cost of energy in short term

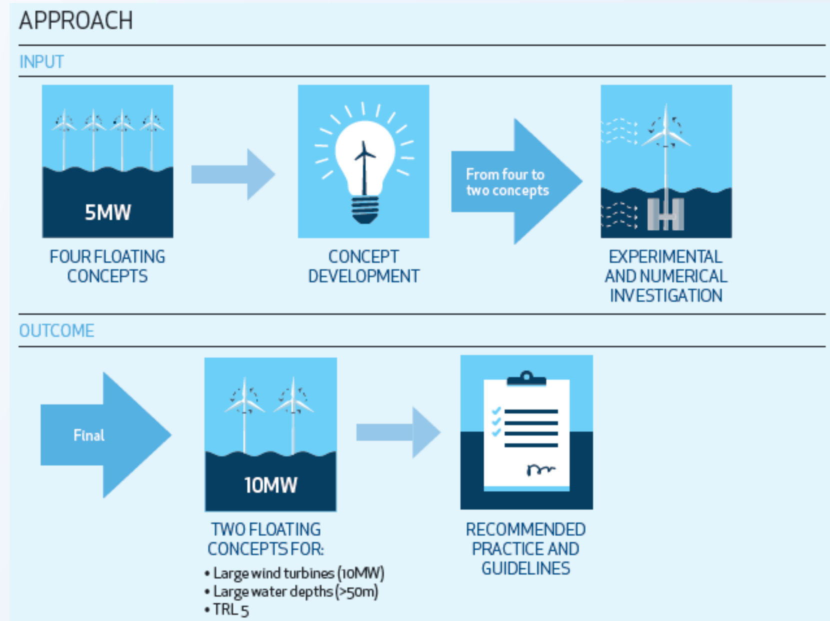
BUDGET:

- 7.3 MM€

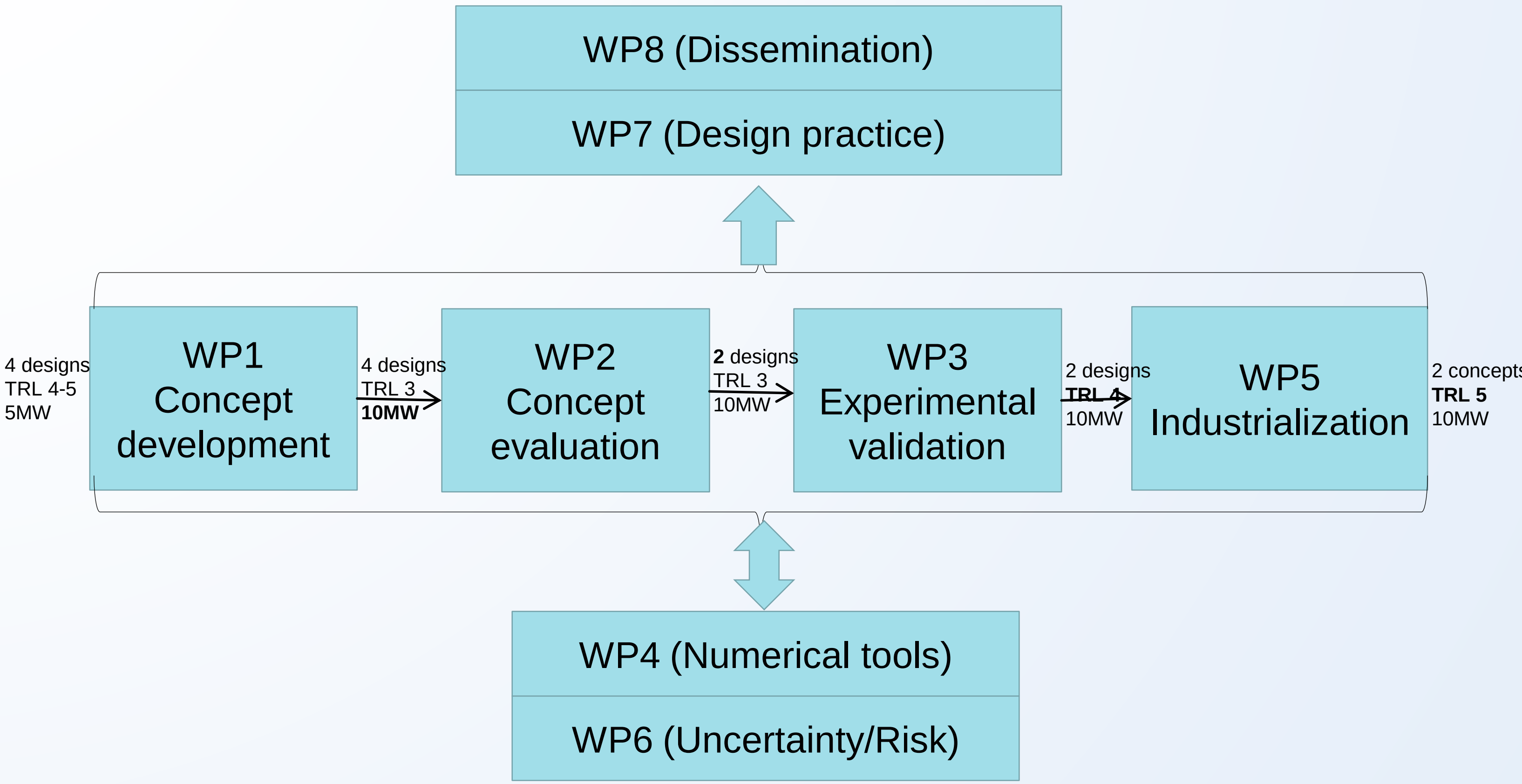
40 months duration staring June 1, 2015

Project leader MARINTEK, Partners:

DNV·GL, DTU Technical University of Denmark, MARINTEK, RAMBØLL, POLITECNICO MILANO 1863, IREC, University of Stuttgart Germany, CATAPULT Offshore Renewable Energy, tecnalia Inspiring Business, DR. TECHN. OLAV OLSEN, ideol winning solutions for offshore wind, IBERDROLA Ingeniería y Construcción



LIFES50+ project overview



First stage of the project: design and evaluation of four concepts, for three sites, 10 MW reference wind turbine and considering 500 MW wind farm.

WP1 Concepts Design

WP1 - Concept development and optimization

M1-M40

176 PM, 23% of total budget

Work organized in three stages:

1. Design Basis
2. Concepts design
3. Selected concepts optimization

Stage 2 focused on the concepts design for their assessment

WP1 Concepts Design

MS1: Design Basis ready for starting design (June-November 2015)

Task 1.1 Definition of the target locations: business cases.

Results: D1.1 Oceanographic and meteorological conditions for the design (Public)

Task 1.2 Wind turbine specification.

Result: D1.2 Wind turbine models for the design (Public)

MS2: Concepts design ready (December 2015 – March 2017)

Task 1.3 Concepts development for a 10MW wind turbine.

Results:
D1.3 Concepts design.
D1.4 Wind turbine controller adapted to each concept.
D1.5 Marine operations.
D1.6 Upscaling procedure (Public)

Task 1.4 Concepts design assessment.

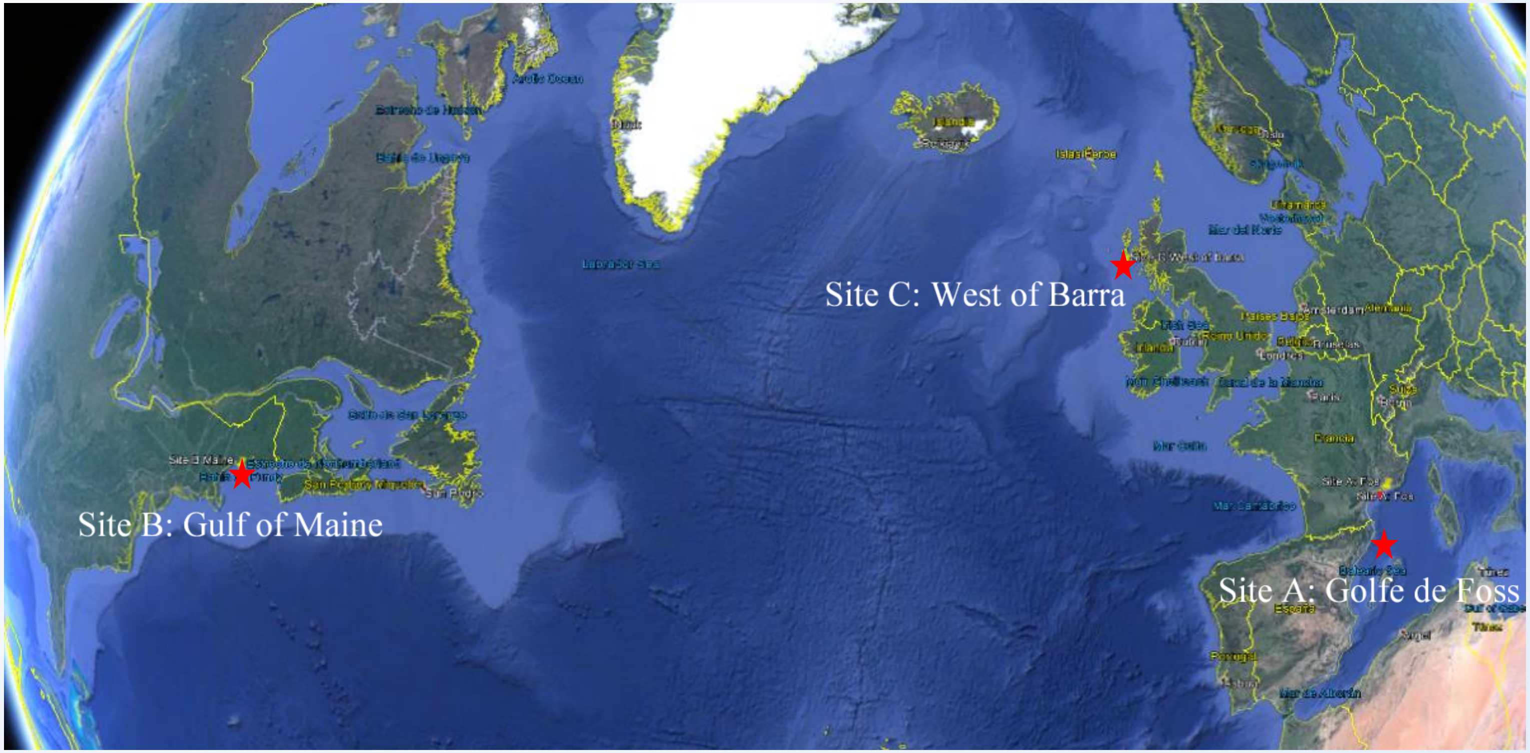
D1.7 Information for concepts evaluation.

MS4: Phase 1 qualification performed

Public deliverables available on the project`s web site www.lifes50plus.eu

Design Basis

- Oceanographic and meteorological conditions for the three selected sites.
  - Site A (moderate met-ocean conditions), offshore of **Golfe de Fos**, France
  - Site B (medium met-ocean conditions), the **Gulf of Maine**, United States of America
  - Site C (severe met-ocean conditions) **West of the Isle of Barra**, Scotland



Design Basis

- Information collected:
  - Sites location
  - Water Depth and Water Levels
  - Wind climate, wave climate and wind-wave combined conditions
  - Currents Data
  - Soil Conditions
  - Other Environmental Conditions (ice, sea water characteristics, marine growth…)

	50-year wind at hub height [m/s]	50-year significant wave height [m]	50-year sea-state peak period [s]	50-year current [m/s]	Extreme water level range [m]	Design Depth [m]	Soil Type
Site A	37	7.5	8-11	0.9	1.13	70	Sand/Clay
Site B	44	10.9	9-16	1.13	4.3	130	Sand/Clay
Site C	50	15.6	12-18	1.82	4.2	100	Basalt

Design Basis

- FAST model of DTU 10MW reference wind turbine.
- Generic controller for the wind turbine.
- Tower reference design.

Concepts Design process

Concepts design, driven by the information required for the evaluation:

- KPIs.
- LCOE and LCA figures. Forms for 50 wind turbines wind farms -3 excel sheets-, one wind turbine -1 excel sheet- and 5 wind turbines -1 excel sheet-
- Uncertainty forms for each of the sites.
- Information for risk analysis.

LIFES50+ Design Process conditioned for the concepts assessment and evaluation:

1. Onshore benchmark to validate WT models.
2. 'Design references' to select an justify the Load Cases for each site and each concept.
3. Design Briefs to validate the design process and the assumptions.

Concepts Design process

Numerical tools used in LIFES50+ consortium

	WAMIT	AQWA	FAST	BLADED	OrcaFlex	3DFloat	Flex5	HAWC2	SIMA (SIMO/ RIFLEX)	Sesam/ Wadam	Simpack Wind	SLOW
DNVGL	X			X								
DTU	X		X				X	X				
IBER		X	X									
IDEOL		X	X		X							
MARINTEK	-*								X			
OO	-*					X	X		X	X		
TECN		X	X		X							
USTUTT		X	X	X							X	X
POLIMI		X	X									
*WAMIT data is incorporated in the software tools SIMA, Sesam/Wadam and 3DFloat												

Ref.: D4.4 – Overview of the numerical models used in the consortium and their qualification. Public deliverable.

Concept developers followed their own design procedures and codes, validated at different levels in the consortium, to ensure a common framework for their assessment

Concepts Design process

Design Basis

- Met-ocean condictions - DLCs
- Wind Turbine model, including WTG controller
- Standards
- Design restrictions and assumptions

SW becnhmark

- Definition of the benchmark: Load Cases
- Comparison of model results

Design Briefs

- Review of the design procedures
- Qualitative assessment of the modelling approach

Concepts Design

- Design for the three sites
- Concept Developer provide figures: KPI, LCOE, LCA
- Evaluation Comittee review results and provide feedback
- Design summary collected in D1.3 to D1.5 deliverables

Concepts Design process

Concept developers considered all the **design topics**:

- Sizing and structural design –subtask 1.3.1-
- Mooring design –subtask 1.3.2-
- Aero-hydrodynamic simulations –subtask 1.3.3-
- Adaptation of the WT controller –subtask 1.3.4-
- Analysis of marine operations, including manufacturing strategy –subtask 1.3.5-

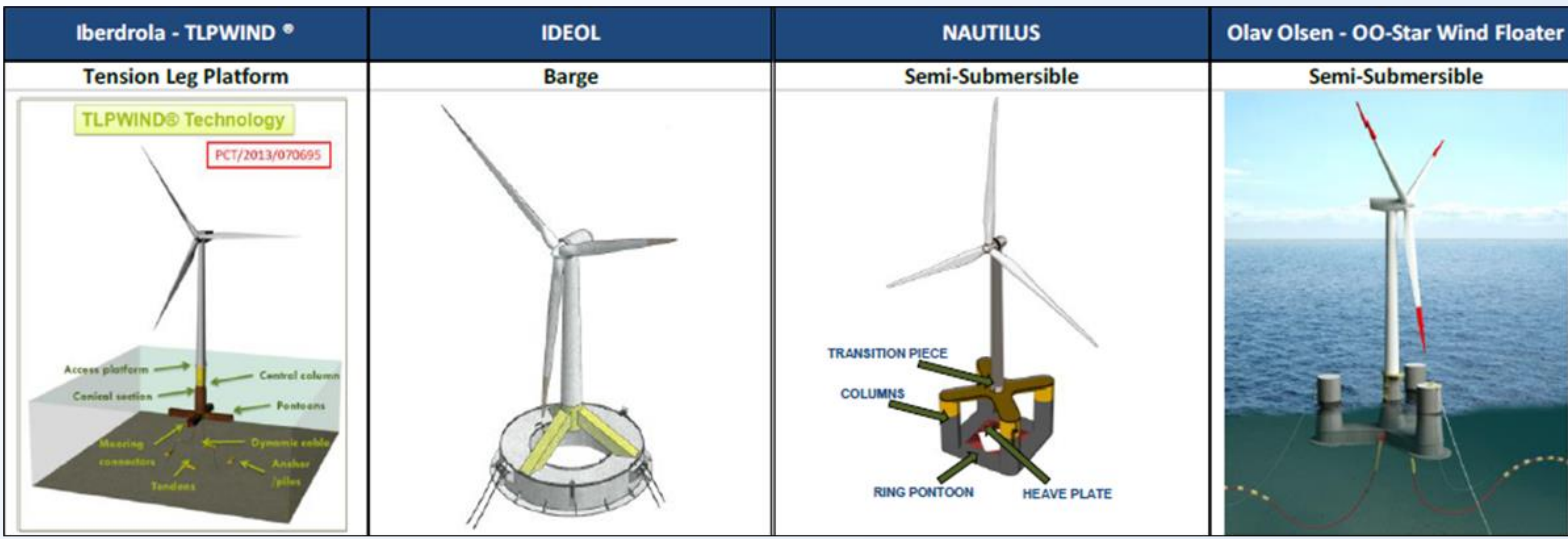
Several information submissions were stablished in order to facilitate the concepts evaluation and improve concepts design

Evaluation Committee gave feedback after each submission, and requested more information for specific topics.

Concepts Design process

Concepts Design results

No	Deliverable Name	Lead Beneficiary	Type	Dissemination Level
D1.3	Concepts design	5 – TECNA	Report	CO
D1.4	Wind turbine controller adapted to each concept	5 – TECNA	Report	CO
D1.5	Marine operations	8 – IBER	Report	CO
D1.6	Upscaling procedure	5 – TECNA	Report	**PU**



Conclussions & Challenges

Concepts design and design workshop main highlights:

- Same design methodology and considerations as for 5 MW-scale conceptual designs.
- The main challenge arisen by the four concept developers is related to tower natural frequencies and the challenge to avoid coupling with the 3P frequency of the WTG.
- Working in direct collaboration with a turbine manufacturer is critical for the optimum design of a floating structure for offshore wind.
- Control has been highlighted by all partners as a very important part of the design that might need additional attention.
- Logistics can be a bottleneck for the deployment of large wind farms, using next generation of large wind turbines. Working with the industry is very important for reaching a concept design that keeps on ‘standard’ industry elements.
- A global vision of the wind farm may be critical for reaching the optimum design. Aspects which were out of LIFES50+ scope like wind farm layout, wake effects, power production or O&M strategy may influence the substructure and moorings design.

Conclussions & Challenges

Specific to LIFES50+ work in the first stage of the project.

- It was difficult to establish the framework to assess and compare different types of substructures –technical point of view, KPIs-

General to the floating offshore wind design.

- Precise and clear information from the very beginning: design basis.
  - Wind turbine features and restrictions for the substructure developer
  - Site information
  - Standards
- Close collaboration between the different parties involved in the wind farm development, in order to ensure a global view of the project.
- Design and simulation tools adapted to each project stage.

THANK YOU!

Contact:
german.perez@tecnalia.com

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