Innovation Projects WF Commercial

Lisbon, June 7, 2017

KIC Innoenergy Project

The Project

WindFloat – Path towards Commercialization

Financiability

Competitiveness

Market Opening

WindFloat Proven Technology

2007-2012 | **2013-2018** | **> 2018**

Work Packages
(2015-2018 Implementation)

Work Package	
Feasibility Study & Project Management	WP1/ WP0
Market Competitiveness and Technology Cost Reduction	WP2
WindFloat Engineering	WP3
Certification of Technology by Independent Entity	WP4
Business Development & Technology Dissemination	WP5
Complementary Activity - 1st Floating Wind Farm – WindFloat Atlantic	WP6

WF Commercial Project

PRINCIPLE POWER

EIT InnoEnergy

Priority: sustainable energy

EIT InnoEnergy's mission has a high impact on innovation specially in Renewable energies.

EIT is improving the reliability, integration and commercialization of Offshore wind - very important for Principle Power and WFA

Scope of the project

The strategy is to build pre-commercial projects (25-50 MW projects) in different key geographies within the next 3 years. Thereafter, the goal is for the technology to be fully commercial and be included in tenders for offshore wind projects world-wide.

Objective of the project

The main focus of the project is to develop the WF technology towards Commercial, evaluate and create opportunities in keys markets by delivering 3 major products:

-WindFloat Technology - A semi-submersible platform for offshore wind energy

-Offshore Wind Technology Consulting Services

-WindFloat Integrated Support Services

To complement those activities, the WFA, a pre-commercial project using the WindFloat technology with 25 MW located in Viana do Castelo, will be deployed taking benefit of the activities developed during the InnoEnergy Project.

Project 2015-2018

Internships

PPP engages students in the process of technological innovation, working on a technology or process applicable on our business.

Interns are showing creativity, innovation, entrepreneurship skills and competences and for that they are welcome in Principle Power.

Principle Power Overview

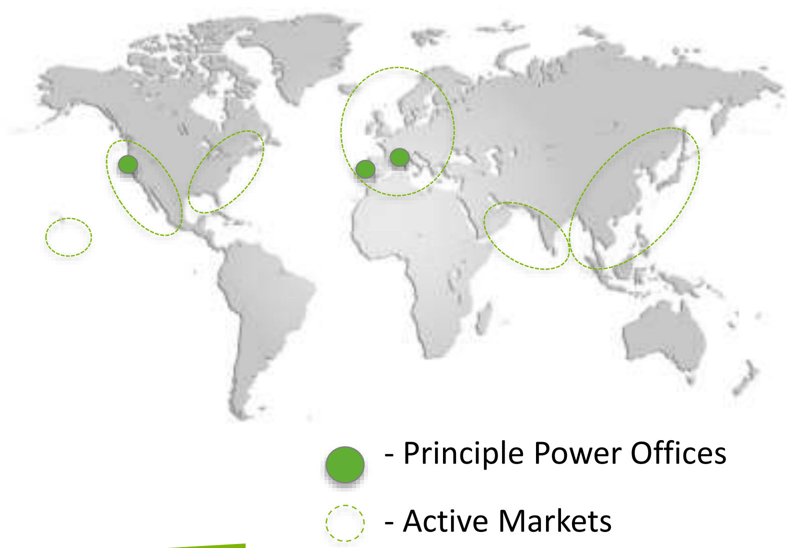
Our Vision: ***Be the global leader in deep water wind technology***

Our Mission: ***To make the WindFloat the most competitive, safe, reliable and environmentally friendly floating technology and unlock the global renewable energy potential***

Industry Challenges: Further from Shore; Deeper; Larger Turbines; Reduction of LCOE

The WindFloat, a Key part of the solution…

- Globally Patented, Proven Floating Technology: 5 years 2MW Pilot;
- Projects in Europe, US, Asia, w/ highlight for advanced 25 MW Project in Portugal and 24 MW in France
- Global presence with offices in US, France, Portugal (30 employees)
- Leading in Cost and Performance; LCOE competitive with currently commercial technologies
- Paradigm Shift => Reduction of Cost and Risk for the Industry



… To Bring Offshore Wind to its Global Potential

Floating Offshore Wind is an Industry Game-Changer in Two Ways

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Key Industry Trends

- **Further from shore**
- **Deeper waters**
- **Larger Farms**

While… Reduction of costs and risk needed to truly globalize the Industry!

Floating wind: a game changer

Open the market for deep water exploitation (>60m)

- Open coastal markets with high power demand, high prices, high population density and deep waters
- Expanding total market for offshore wind

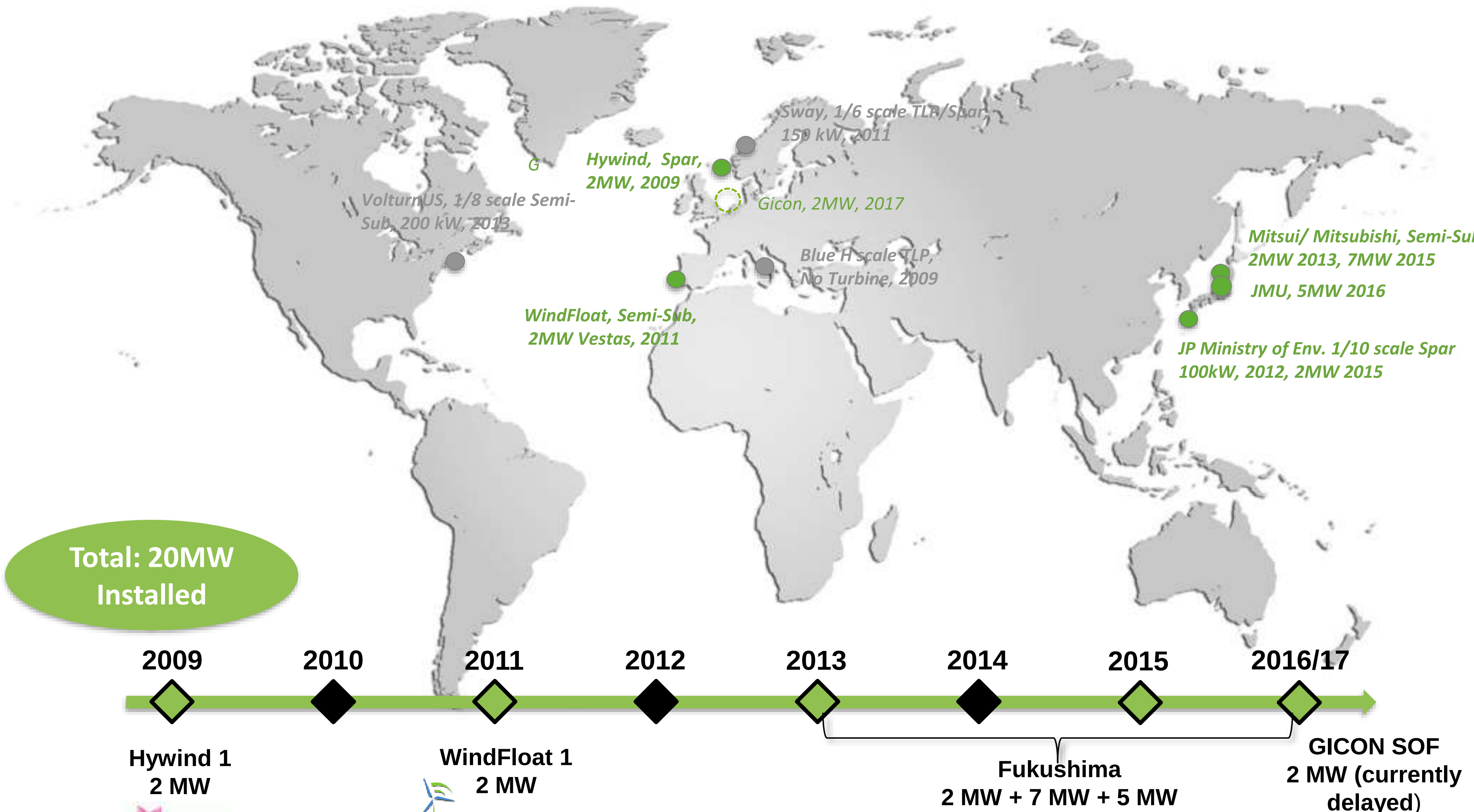
Substitute existing technologies in transitional waters (40-60m)

- Floating Semi-Sub technologies will be a competitive alternative to current foundations (eg. Jackets / gravity based foundations)
- Opportunity to capture market share from existing technologies

Today, floating Wind has now deployed 20 MW, proving itself as a key RE solution

Multi Megawatt prototype

Scaled model installed offshore



Floating is already large market → Close to 400 MW of Demos and 7 GW of Large Scale Projects in development

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Current MW Installed: 20MW

Current Floating Wind Farms (Announced) under Development

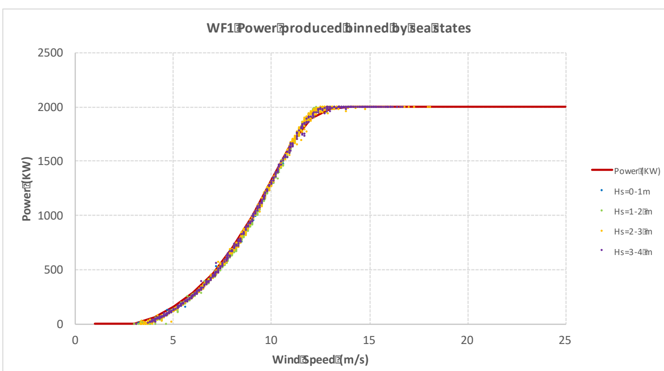
	Demo Projects	Large Scale
US	12 MW	> 2 GW in Hawaii and CA
Europe	France, 100-150 MW UK, 80 MW Portugal, 25 MW	France, 3.5 GW with commercial tenders starting to be prepared
Japan	Up to 100 MW	TBD (Target 8GW by 2030, with mostly floating)
Taiwan/Korea	Up to 30 MW	1.5 GW


Floating and the WindFloat now a Proven technology, Operated for 5 years; Meeting Manufacturers Specification; Producing c. 17GWh of Energy; Tested in Extremes

WindFloat 1 performance proven over 5 years operation

Project Description

- **Vestas 2MW turbine**
- **Operation**
  - ~ 17 GWh produced in 5 years
  - Operated in Hs of 7 m
  - No production losses overall
  - 17 m waves
  - Reliable O&M and inspection program
- **Decommissioning**
  - July 2016
  - Reversible operation
  - Sole use of local tugs (No AHV)
  - Removal of the turbine at quay side (hull floating)
  - Life extension of the platform possible



Prototype Objectives

✓ Demonstrate the ability to: Fabricate, commission at quayside and install fully-assembled WindFloat

✓ Produce power up to the one-year storm

✓ Survive large winter storms

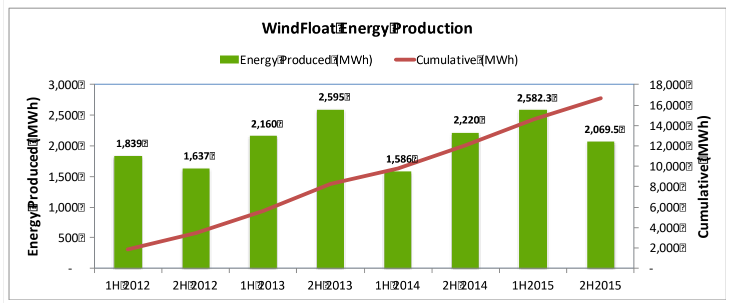
✓ Withstand wave- and wind-induced fatigue

✓ Perform O&M activities on the platform

✓ Operate the Active Ballast System and other systems and equipment

✓ Predict the important responses of the system with numerical tools

✓ **Decommissioned safely with minimal budget and negligible impact to the environment**



Now implementing demonstration scale projects, with state of the art turbines and optimized designs

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WF1

- larger turbines (x3-4)
- design life extension (x5)
- global sizing – “smaller” platform
- structural optimizations
- equipment improvement
- accessibility
- mooring improvements
- installation improvements

Current Generation

- **Capacity:** x4
- **Production:** X4.5
- **Unit Cost:** x1.75

Technology signed off by Key International Certification bodies in different markets, prepared for deployment

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WindFloat Pacific, US

- US West Coast – high wind, high wave
- 8MW turbine, Turbine TBD
- **Approval in Principle**
- **Full Document and Project Review with no critical findings**

ABS FOUNDED 1862

WindFloat Atlantic, Portugal

- Portugal – medium wind, high wave
- 8 MW turbine, Vestas
- **Approval in Principle**
- **Final stages of full certification / AFC stamped Drawings**

ABS FOUNDED 1862

Golfe du Lion, France

- France – high wind, medium wave
- 6 MW turbine, GE/Alstom
- **Approval in Principle issued**

BUREAU VERITAS 1828

WindFloat Japan

- Japan – medium wind, medium wave
- 5 MW downwind turbine, Hitachi
- Japan Model Testing performed
- Passed all technical committees with Class NK and NEDO
- **Approval in Principle issued**

ClassNK

Proving the industry is technically viable; now showing economic and financial viability to be commercial end of decade

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Maturity

Phase 1
Technology Demonstration

- Technology Development and patents
- Successful fabrication, installation and operation

Phase 2
Pre-Commercial

- Building demonstration scale farms in 1 or more geographies to prove concept financially and economically
- Focus on technology Roadmap and Levelized Cost of Energy Reduction

Phase 3
Commercial

- Competing in the Marketplace with other technologies and sources of energy

2007-2012	2013-2018/19	> 2018/19

Building on our lessons learned, the WindFloat Atlantic Project will be a key milestone in the floating offshore wind industry

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Project Overview

- **Total capacity: 25MW capacity**, (3 X Vestas V164),
- **Location: 20 km off the coast of Viana do Castelo**, in water depth of ~ 100m
- **Interconnection: to be constructed by REN**, allowing a direct connection at 60kV
- **Construction: shipyards in Portugal (same as WF1)**. Turbine installation quayside
- **Floating structure certification: designed for 25 years,** certified throughout design, construction and installation by ABS, an independent party
- **Detail design 90% completed** Q2 2016 by PPI Engineering

First Non-recourse financed FOW project

- **Equity financing completed in 2015;** 7 project partners
- **Non recourse financing expected completion mid 2017**
  - European Investment Bank – Selected for InnovFin Programme
  - Export Agencies; Commercial Banks
- **Strong Institutional Support:**
  - EU: NER 300; Portugal: Feed-in Tariff, APA

edp renewables powered by nature

ENGIE

Mitsubishi Corporation

REPSOL

PRINCIPLE POWER

Marubeni

CHIYODA CORPORATION

European Commission

GOVERNO DE PORTUGAL

Major customers and partners in different projects globally demonstrate credibility and maturity

US

Asia

Europe

Institutional Support

The WindFloat Atlantic present status and lessons learned identify areas of focus to move to the next Phase

Project Status

- Today, all permits are in hand
- All tariffs secured
- Very advanced in procurement
  - Strong certainty on cost
- Strong Financial Model

First Non-recourse financed FOW project

- Four Financial Institutions/7 equity participants
  - Structured as it is to expose project to full due diligence
- Now engaged in due diligence
  - Focused on development status and commercial conditions
- Expected Close mid year 2017

Due Diligence Focus

- Onshore transmission upgrades that caused delay
- The size of the Wind Farm
  - Deterred the project from getting ‘best’ offers (turbine supply an example)

Different stages of technology development require different types of support; floating ready to move to Commercial

Maturity

Phase 1
Technology Demonstration

- Government grants
- CapEx support
- Willing equity participants

2007-2012

Phase 2
Pre-Commercial

- Financing for a technology that is not fully mature
- Government should create as stable an environment as possible
    - Permitting
    - Interconnection
    - Offtake

2013-2018/19

Phase 3
Commercial

- Scale required to meet cost targets/expectations
- Volume for accompanying supply chain investment
- Options to reduce costs and financing
- Projects can take years to develop (2023 – 2035), so **SHOULD START BEFORE PHASE 2 'FINISHES'**

> 2018/19

Significant innovation under way that will drive WindFloat LCOE below the 100€/MWh target

General Design

1. Larger Turbines; power / weight ratio
2. Structural Optimization / Hull weight

Detailed Design

3. Optimize Ballast System
4. Optimization of controllers for Loads
5. Challenging Class rules for lighter / cheaper design

Fabrication

6. Industrialization / Serial Fabrication/ Minimize downtime (Communications, Access, etc.)

Operations

7. Improve reliability
8. Learning by doing / Continuous improvement

Other WF Innovations

9. Alternative Steels / Other Materials
10. Mooring Innovations

Other Offshore Wind Industry Innovations (Turbine Performance, Plant Design, Electrical Systems, Supply Chain)

Target: <€100/MWh By FID 2020

Government can take action today to effect Project Economics

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	Contributing Factors	Government Action
Capacity Factor	• Wind resource • Grid Connection • Water depth/distance from shore	• Identify and de-conflict multiple zones for bidding in high wind resource areas (e.g. RSPB endorsement) • Guarantee grid availability
Financing Cost	• Perception of technical risk • Development risk	• Institute technical qualifications to avoid speculation and delivery risk • Require supply chain plan to demonstrate 'realism' and localize benefits if desirable • De-conflict/permit ready identified sites
Project Scale/Supply Chain Effects	• Visibility and volume in pipeline to drive investment • Scale to lower unit costs across CapEx	• Set MW targets now rather than waiting for Phase 2 to complete • Carve outs for Floating OSW • Enable development of infrastructure – repurpose facilities

Key Take Aways

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1. The WindFloat and other floating wind is already proven technology, and is now proving its financial and economic viability

2. Reduction of Cost and Risk => Addressing the industry's challenges while enabling it to reach its full potential

3. Already several Pre-Commercial Projects ongoing worldwide, expecting to be deploying commercially in the marketplace by end of decade

4. Floating Wind expected to reach 11 GW by '26 worldwide and it can play a key role in the energy mix of certain markets

5. But the Key for market leadership is to continue pace of development and to prepare for commercial projects now; benefits to these investments will extend into the future and accrue to Scotland/UK

WF Commercial- InnoEnergy MSc Student Interns 2016

	Structural Inspections	Industrialization	O&M
Research Project Title	***Inspection of WindFloat and Incorporated Wind Turbine using Automated Flying Vehicle***	***Industrialization potential and cost optimization for a commercial floating wind farm.***	***Installation and O&M optimization of the WindFloat***
Internship Details	**Dates:** Feb 29th ,– Aug 31th, 2016 **Location**: Toulouse, France **Supervisor**: Josh Weinstein **Cooperation**: Industry partners: Donecle & Tachyssema	**Dates:** April 4th ,– September 16th, 2016 **Location**: Lisbon, Portugal **Supervisor**: Cyril Godreau **Cooperation**: Ecole Polytechnique, Paris	**Dates:** April 4th ,– September 16th, 2016 **Location**: Lisbon, Portugal **Supervisor**: Tiago Godinho **Cooperation**: IST, Portugal
Relevance to PPI R&D / Deliverables	**Better, faster more reliable inspections** ▪ Fits with H2020 proposal to be submitted in September 201 ▪ Thesis report ▪ Proposal for H2020 proposal	**Part of LCOE reduction effort** ▪ Importance for understand the landscape of Fabrication solutions in Europe in terms of large capacity and industrialization ▪ Importance in assessing the cost reduction of a large project ▪ Importance in assessing feasibility to fabricate 40+ units per year ▪ Thesis / reports, maybe conference paper.	**Part of LCOE reduction effort** ▪ Information on how to optimize O&M for future WF projects ▪ Direct application to WFA ▪ Thesis / reports, maybe conference paper.
Current Status	**Muhammed Junaid** ▪ Final thesis delivered ▪ Final Presentation in Paris ▪ Valuable contribution to H2020 project	**Loris Canizares** ▪ Completed Fabrication model with ASAM ▪ Completed LCOE Assessment for commercial-scale project in the Mediterranean ▪ Final thesis delivered ▪ Final Presentation in Paris ▪ Contract extention with intention to hire as full time employee in Portugal	**Christian Lorenzo** ▪ Updated and improved O&M code (matlab) from WaveEC ▪ Developed input decks for component failures, response strategies, etc. from PPI and external sources ▪ Created series of output graphics/analysis to communicate results ▪ Currently running sensitivity Analysis and Finalizing Results

WF Commercial- InnoEnergy MSc Student Interns 2017

	Structural Optimization	Mooring System Optimization	Fabrication & Logistics Optimization
Research Project Title	*Structural optimization study of fatigue-driven floating offshore wind turbine foundation structure; WindFloat*	*Design optimizations of mooring system for floating offshore wind turbine foundation structure; WindFloat*	*Logistics study to optimize delivery of the WindFloat technology in immature markets*
Internship Details	**Dates:** March 6th – August 31th, 2017 **Location**: Emeryville, CA **Supervisor**: Hachan Jeong **Cooperation**: UPC	**Dates:** March 6th – August 31st, 2017 **Location**: Lisbon, Portugal **Supervisor**: Cyril Godreau **Cooperation:** IST, Portugal	**Dates:** March 6th – August 31st, 2017 **Location**: Lisbon, Portugal **Supervisor**: Aaron Smith **Cooperation**: IST, Portugal
Relevance to PPI R&D / Deliverables	**Lighter Stronger Structure** ▪ Optimization of WindFloat structural elements can result in a lighter and more efficient structure that can deliver equal levels of performance at lower cost ▪ The project will investigate optimization opportunities using Principle Power's suite of design software ▪ Thesis	**Efficient Mooring Systems for different conditions** ▪ Mooring system needs to be optimized to local conditions to minimize LCOE, balancing procurement and install/O&M costs ▪ Modeling to identify efficient mooring systems for different conditions ▪ Results inform PPI cost models ▪ Thesis / maybe conference paper.	**LCOE reduction and BD Support** ▪ Key challenge for the WindFloat will be to industrialize quickly in markets that lack established offshore wind supply chains (fixed and floating) ▪ Prospective customers want to see contract delivery/execution plans ▪ BD efforts seek to get WindFloat accepted for projects in several immature markets; this study will support RFI preparation and response ▪ Thesis / maybe conference paper
Intern Profile	**Victor Sanchez** ▪ Master: KIC RENE • Energy Engineering, UPC-Barcelona • MSc in EE & IT ▪ Bachelor: Industrial Engineering (UC3M) ▪ Airbus: Trainee – performance and improvement department	**Daniel Toledo Monfort** ▪ Master: KIC RENE • MSc in Eng. & Energy Mgmt., IST • MSc in Energy Engineering • MSc in Energy Systems ▪ Bachelor: Industrial Engineering (UPC) ▪ ETSEIB Racing (MotoStudent III Edition): Chassis & Swinging Designer	**Alex Peracaula** ▪ Master: KIC RENE • MSc Energy Engineering, UPC-Barcelona • MSc in Eng. & Energy Mgmt., IST ▪ Bachelor: Industrial Engineering (ETSEIB) ▪ Researcher: Advanced Power and Energy Program (APEP) UC Irvine, CA, USA

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