cfms
COMITÉ FRANÇAIS DE MÉCANIQUE
DES SOLS ET DE GÉOTECHNIQUE

Journée parrainée par

FUGRO

eDF renouvelables

anteagroup

Flotteurs et lignes d'ancrage

Jean-Baptiste Marcq (SBM Offshore)

Eoliennes flottantes
Flotteurs et lignes d'ancrage

Jean-Baptiste MARCQ
Execution Framing Manager
SBM Offshore

Sommaire de l'intervention

- **Flotteurs Classification**
- **Mooring system classification**
- **Floating wind floater: Specificities**

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ENERGY TRANSITION COMPANY

REDUCE COSTS AND EMISSIONS FROM O&G PRODUCTION

DEVELOP COMPETITIVE RENEWABLE ENERGY LIFECYCLE SOLUTIONS

VALUE PLATFORMS

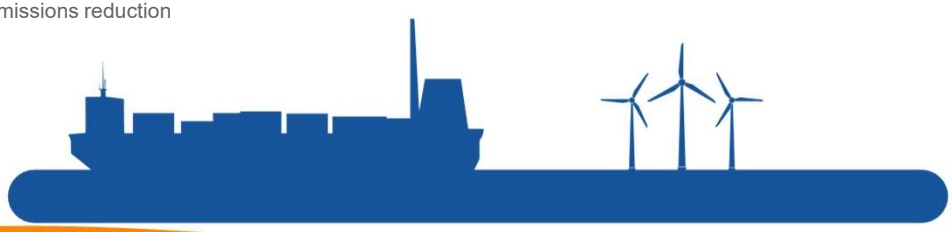
OCEAN INFRASTRUCTURE

On-time delivery & reliable operations

Emissions reduction

TRANSITION THE CORE

emissionZERO®



NEW ENERGIES

FLOAT4WIND

Digital services

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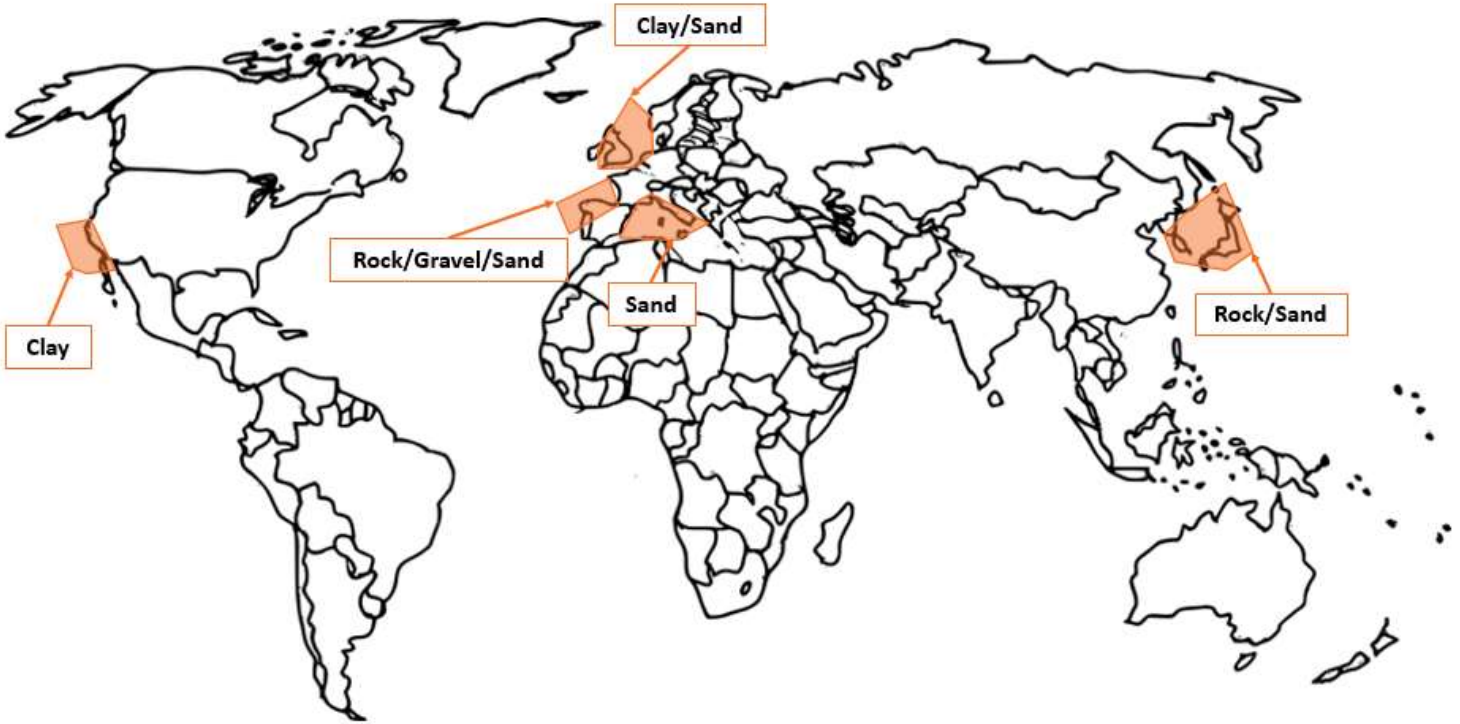
What are the type of soils related to floating wind projects?



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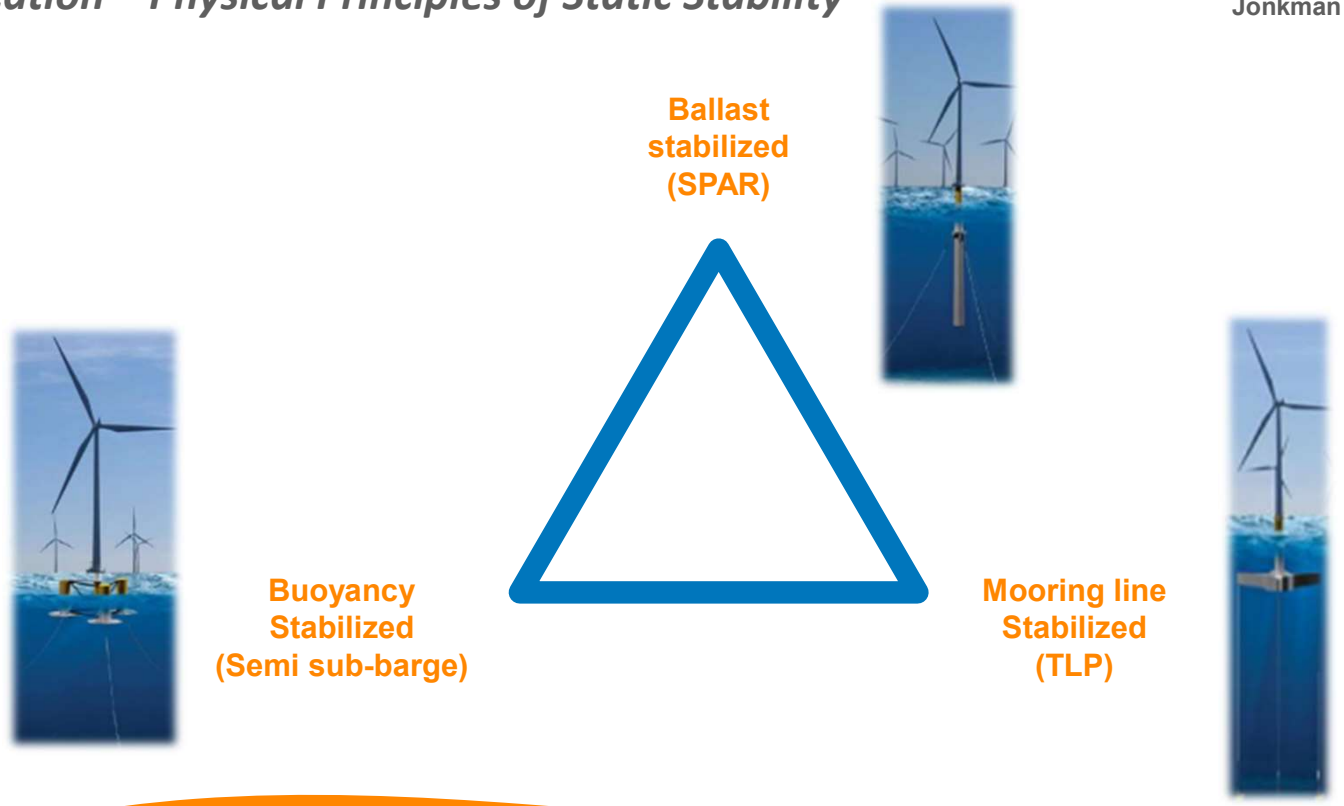
Floater Classification – Physical Principles of Static Stability

Classification principle by S. Butterfiled, W. Musial, J. Jonkman (NREL) & P. Sclavounos (MIT) (2005)



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Buoyancy Stabilized Units

- Platforms that achieve stability through the use of **distributed buoyancy**, taking advantage of wet **water plane area** for righting moment

- **Compliant** floater
- **3 or 4 columns** connected via braces or pontoons
- Various possible design: **Steel** (tubulars or flat panel) or **concrete**,
- **WTG centered** or **decentered**
- **Floater control system** required in some cases - **Ballast system** passive or active
- **WTG Integration at quayside**


Olav Olsen OO-Star


PPI Wind float


TEN INO15

Projects Installed:
Windfloat 1
Windfloat Atlantic
Kincardine
Floatgen/Hibiki Demonstrator
*Fukushima fwd (*1- Fukushima Shimpuu, 2- Fukushima Mirai)
Haiyou Guanlan floating wind
China Three Gorges demonstrator
Saitec demoSATH


Kincardine Project


BWIdeol Barge


GustoMSC Tri-floater


Eolink

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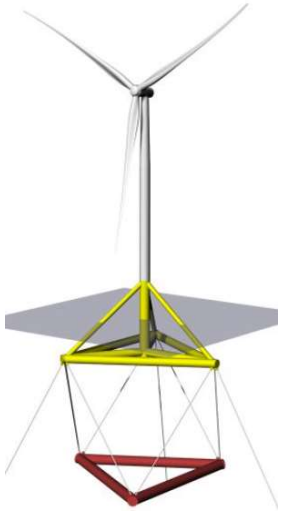
Ballast Stabilized Units

- Platforms that achieve stability by using **ballast weights hung below a central buoyancy tank** which creates a righting moment and **high inertial resistance to pitch and roll** and usually enough **draft** to offset heave motion

- **Compliant** floater
- Various possible design: **Steel** (tubulars) or **concrete**
- **Counterweight** included **in the central column** (concrete, Iron Ore) or **connected with a lines arrangement** to provide geometrical stiffness up to a certain angle
- **Floater control system** required
- Require **high draft for WTG Integration** (offshore or in Fjord)

Projects Installed:
Hywind 1
Goto Sakiyama
Hywind Scotland
Tetraspar Demonstrator
Hywind Tampen

Hywind Tampen



Stiesdal Offshore Technologies Tetraspar

Saipem Hexafloat

Equinor Spar

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Mooring Line Stabilized Units

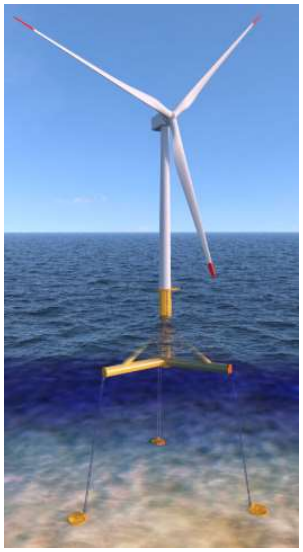
- Platforms that achieve stability through the **use for mooring line / tendon tension**

- **Restrained** floater
- Various possible design: **Steel** (tubulars or flat panel) or **concrete**,
- **WTG centered** preferred to harmonized tensions in mooring lines
- **No Floater control system** required, **no ballast system** required
- **WTG Integration at quayside or offshore**

Projects Installed:
Provence Grand Large

Provence Grand Large Project

Bluewater TLP



SBM F4W™

Modec TLP

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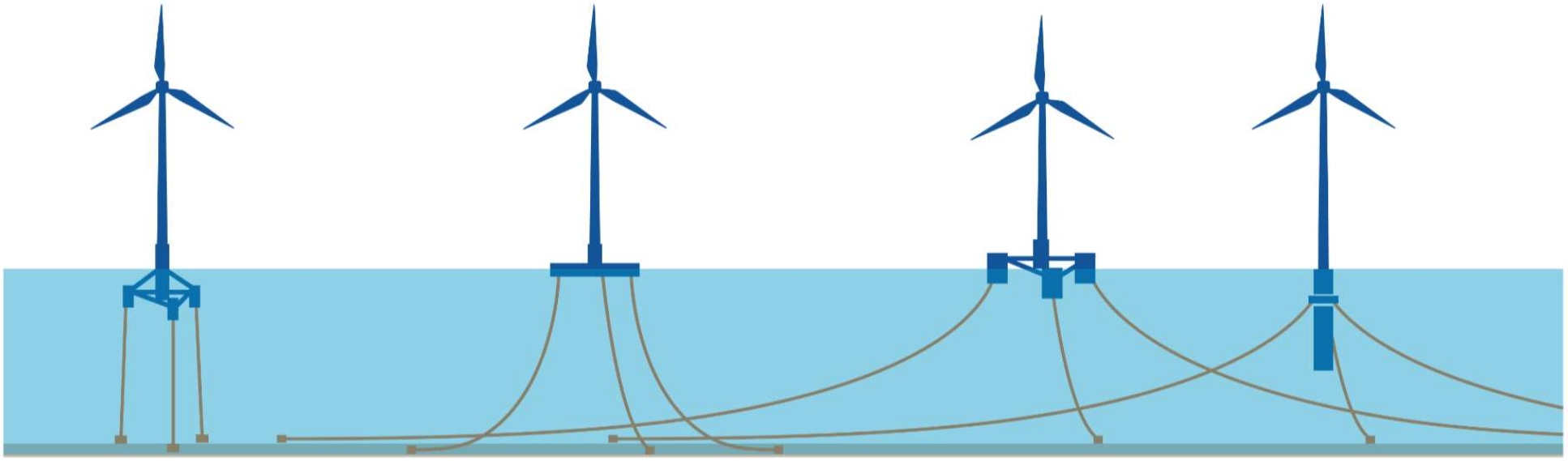
Mooring Systems Categorization

Catenary | *Semi-Taut* | *Taut* | *Tethered* | *Single Point* | *Dynamic Position*



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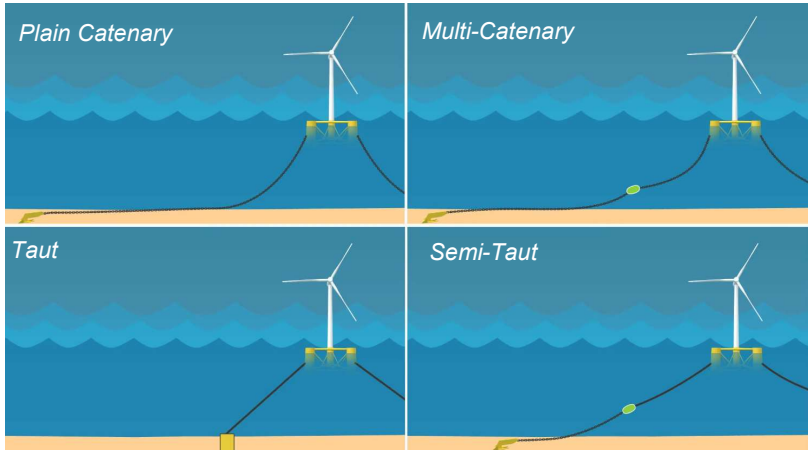
Catenary, Semi-Taut, Taut Mooring Systems

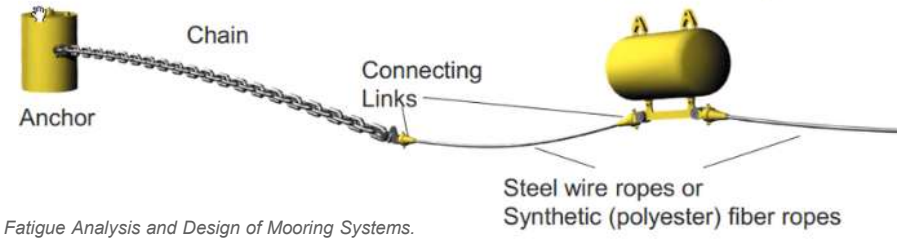
- Catenary mooring:
  - Near **horizontal loads at anchor points**
  - Restoring forces ensured by **weight of the line**

- Semi-Taut/Taut:
  - **Combination of horizontal and vertical loads at anchor points**
  - Restoring forces ensured by **elasticity of the mooring line**



Guide to a Floating Offshore Wind Farm, BVG Associates, 2023.

- Mooring line components: chain, connecting links, steel wire ropes, synthetic fiber ropes, buoys, clump weights etc.



Fatigue Analysis and Design of Mooring Systems. Assessment and comparison of different methods, M Saidee Hasan, 2015

Steel Wire

Arcellormittal.com

Polyester Rope

Bridon-Bekaert.com

H-link

Vicinay.com

Clump Weight

Courtesy FMGC

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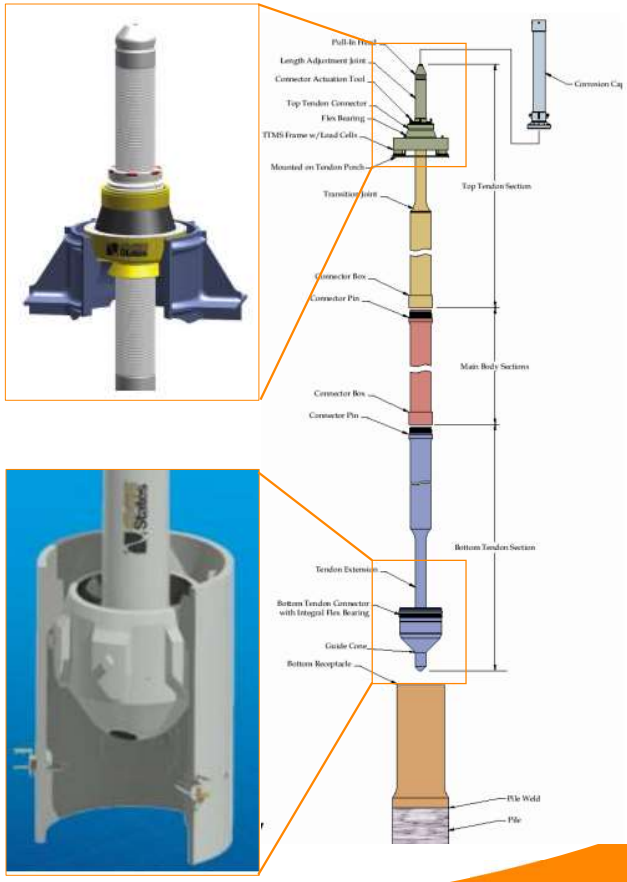
Tethered Mooring Systems

Tendons system:

- **Vertical loads** at anchor points
- Sensitive to **Compression**
- 20" to 48" steel pipe sections
- **Mechanical connection system** (screw on top, receptacle at bottom) for accurate tension setting & monitoring

Conventional Mooring system:

- **Vertical loads** at anchor points
- Insensitive to **Compression**
- **Mooring line components** similar to Catenary/Semi Taut/ Taut



"Integrity Management Process of Tension Leg Platforms"
Energo Engineering, 2018

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Classification by type of soil

Indicative Soil / Anchors Classification
Source: SBM Offshore

Floater type	Semi-Sub / Barge / Spar		TLP
Mooring type	Catenary	Semi Taut / Taut	Tethered
Load Application	Horizontal	Combi. Horiz./Verti.	Vertical
Clay	SA/DA	SA	SA
Silt	DA/DP	DP	DP
Sand	DA/DP	DP	DP
Gravel	DP	DP	DP
Rock	DG	DG	DG

DP: Driven Piles DG: Drill & Grouted Piles
SA: Suction Anchors DA: Drag Anchors
NB: Gravity Anchors would apply on all type of soils


Suction Anchors


Drag Anchors
Delmarsystems.com


Drilled Anchors

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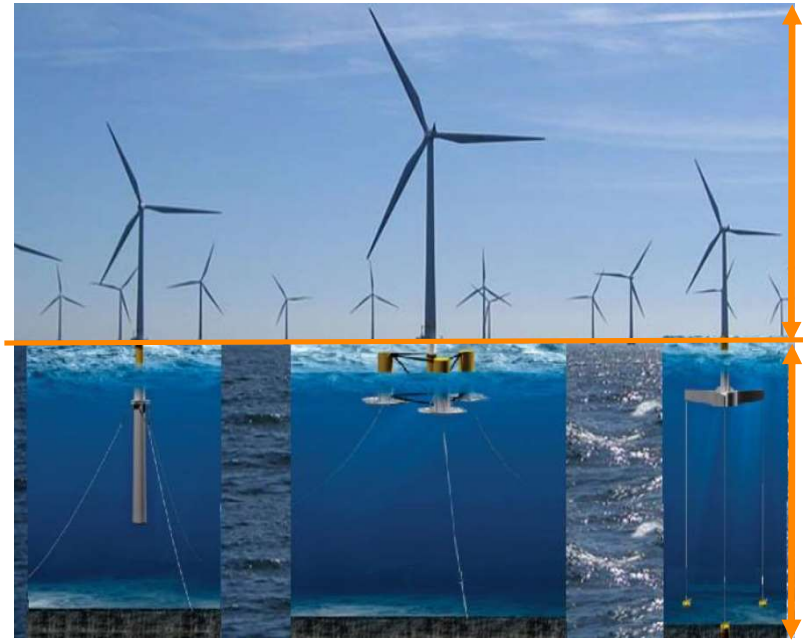
Floating Wind Foundations specificities: Design rules



IEC (International Electrotechnical Commission):

- **IEC 61400-1: Design requirements for wind turbines**
- **IEC 61400-3-2: Design requirements for floating offshore wind turbines**
- **IEC 61400-22: Conformity testing and certification**

Usual O&G certification bodies:

- **ABS Guide for Building and Classing Floating Offshore Wind Turbine Installations (Jul20)**
- **DNV-ST-0119 - Floating wind turbine structures (Jun21)**
- **BV NI 572 DT R02 E - Classification and Certification of Floating Offshore Wind Turbines (Jan19)**
- **NKRE-GL-FOWT01 Guidelines for Floating Offshore Wind Turbines – Classification Survey (Mar22)**

	DLC series	Turbine state
Based on IEC61400	DLC 1.x	Power production
	DLC 2.x	Power production plus occurrence of fault
	DLC 3.x	Start-up
	DLC 4.x	Shut-down
	DLC 5.x	Emergency shut-down
	DLC 6.x	Parked (standing still or idling)
	DLC 7.x	Parked and fault conditions
Floater specific	DLC 8.x	Temporary (assembly, towing, hook-up)
	DLC 9.x	Site Specific (Ice, Earthquake, etc..)

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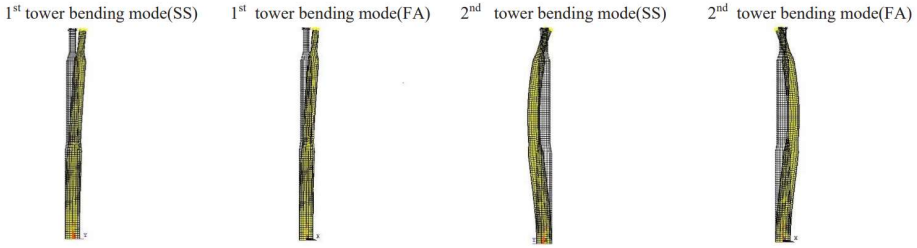
Floating Wind Foundations specificities: Frequencies setting

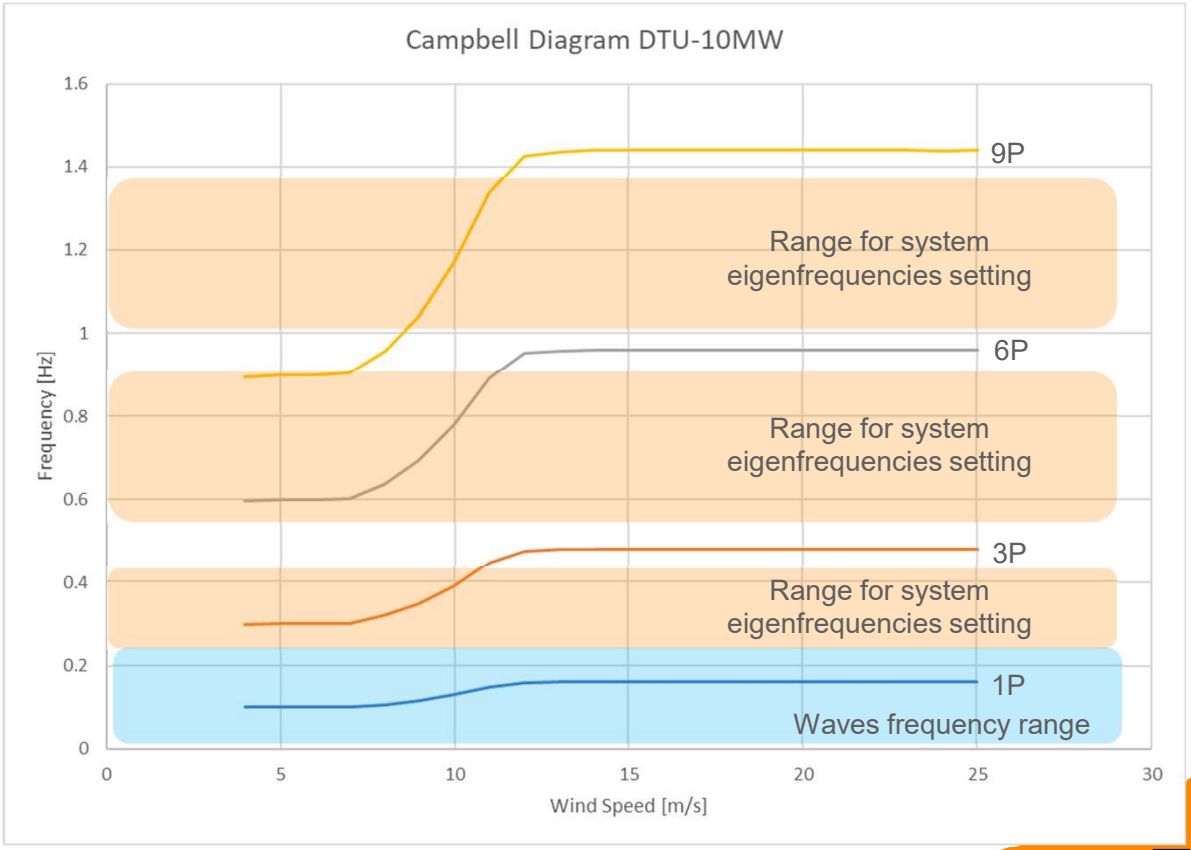
- Frequency setting **to minimize harmonic excitations**
  - Clearance around harmonics (Contractual)
  - Frequency avoiders setting in WTG control system

- Play on **geometry, weight/buoyancy distribution**

Tower Bending Modes



M, Tamizifar et al. / Journal of Theoretical and Applied Vibration and Acoustics 6(1) 143-158 (2020)



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Q&A