# Holistic design experiences in floating wind turbine structures

7th Wind Energy Systems Engineering Workshop

Michael Borg, 04.12.2024

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# The Company purposes

The Company purposes seek to address key challenges

### Climate change mitigation

The main purpose of the company is to develop and commercialize climate change mitigation technologies that have significant impact

### Job creation

The secondary purpose of the company is to create jobs, within the countries where the solutions will be deployed, including both desktop jobs and manual labor jobs

### Shareholder value

The company growth and development must be backed by solid, long-term investors rewarded by attractive shareholder value growth



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# Stiesdal fields of activity

Developing climate solutions within three distinct fields of the energy transition


## Hydrogen

HydroGen industrialized electrolyzers


## SkyClean

SkyClean pyrolysis plants combining $CO_2$ capture and storage with green fuel production

## Offshore

Tetra industrialized floating offshore wind systems



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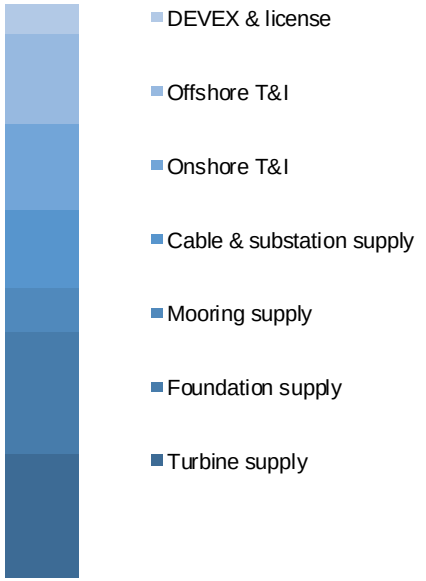
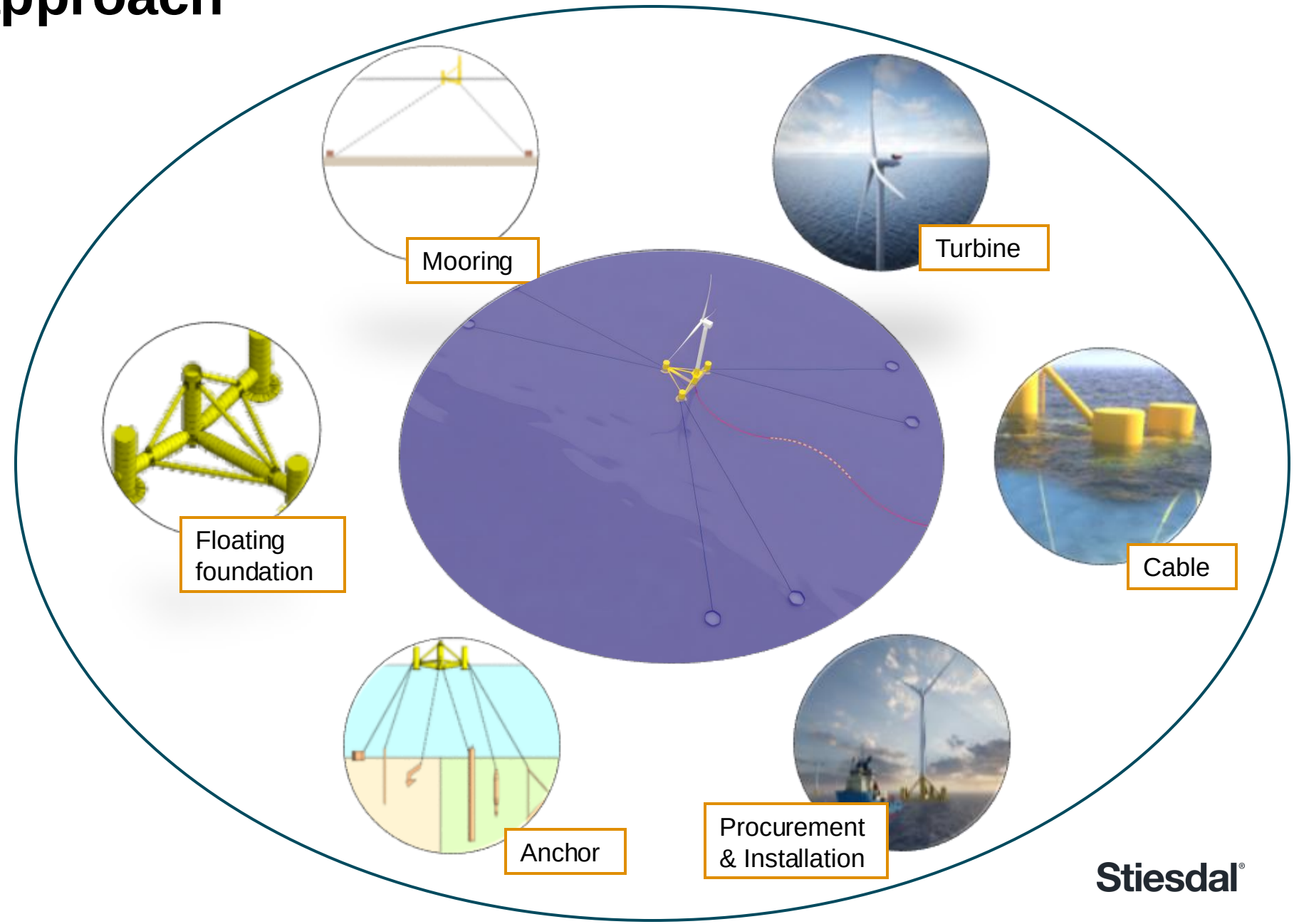
# Holistic design approach



- DEVEX & license
- Offshore T&I
- Onshore T&I
- Cable & substation supply
- Mooring supply
- Foundation supply
- Turbine supply



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# Example #1: Industrialised mooring design



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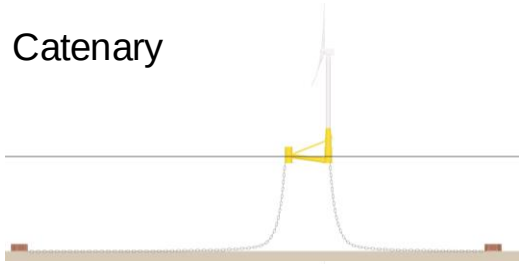
# Example #1: Industrialised mooring design

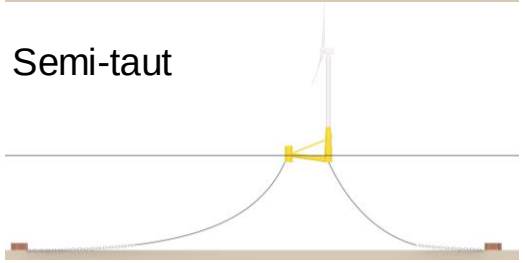
## Mooring line type and configuration

Line types:

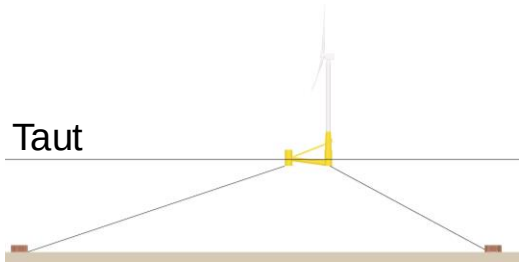
Catenary

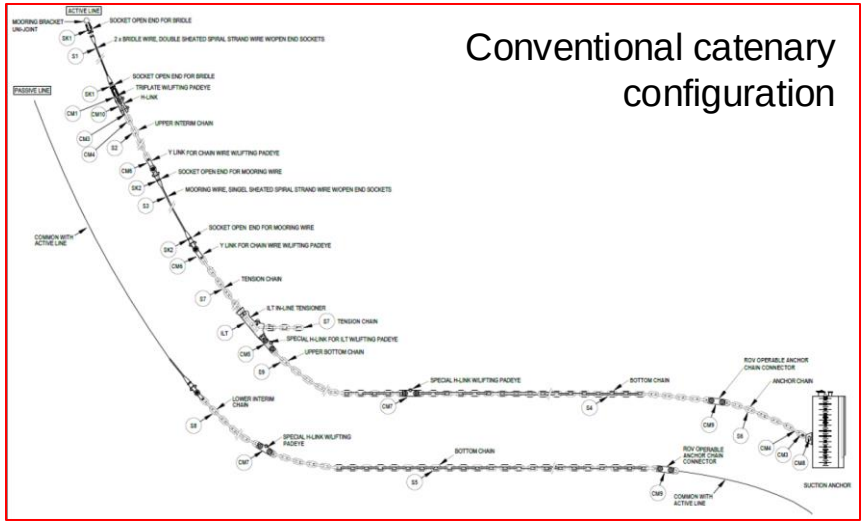


Semi-taut



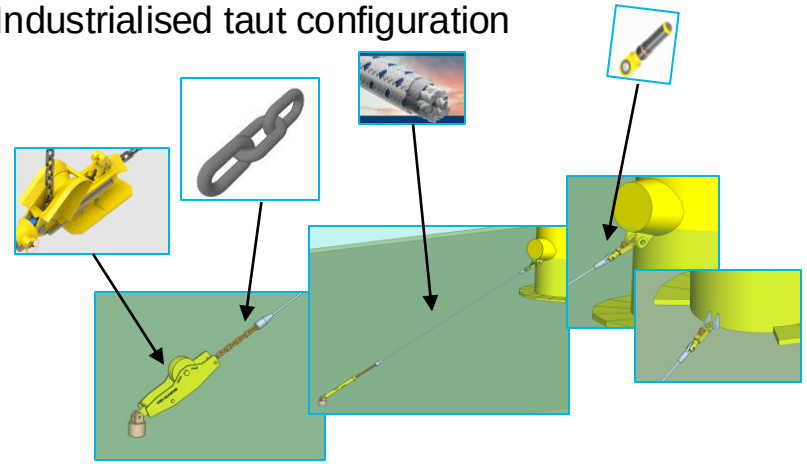
Taut

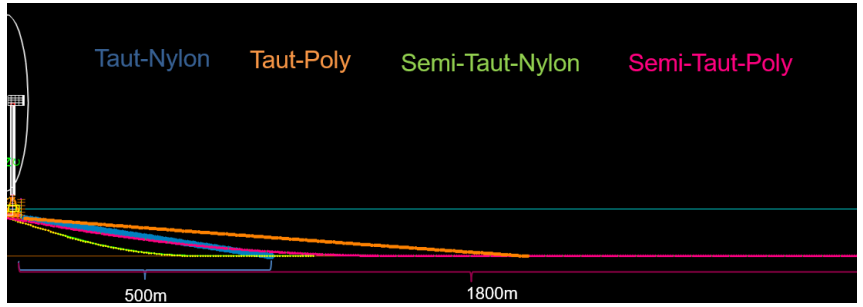




Conventional catenary configuration

Industrialised taut configuration






| *Mooring System Type* | *Taut* | *Semi-Taut* | *Taut* | *Semi-Taut* |
|---|---|---|---|---|
| *Rope Type* | Nylon | Nylon | Polyester | Polyester |
| *Front Radius [m]* | 700 | 1000 | 1400 | 1800 |
| *Rope Minimum Breaking Load (MBL) [t]* | 1500 | 2200 | 1500 | 2500 |
| *Chain Size [mm]* | 132 | 165 | 132 | 185 |
| *Relative hardware cost [-]* | 1.00 | 1.60 | 1.11 | 1.84 |



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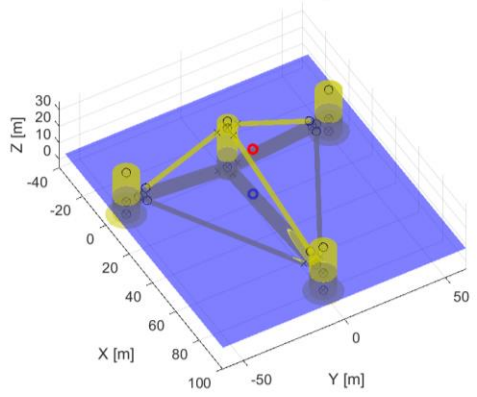
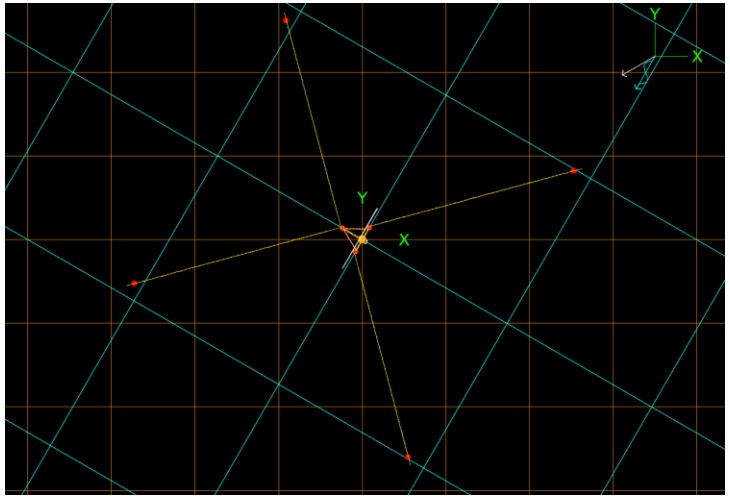
# Example #1: Industrialised mooring design

## Influence of WTG and FSS modelling

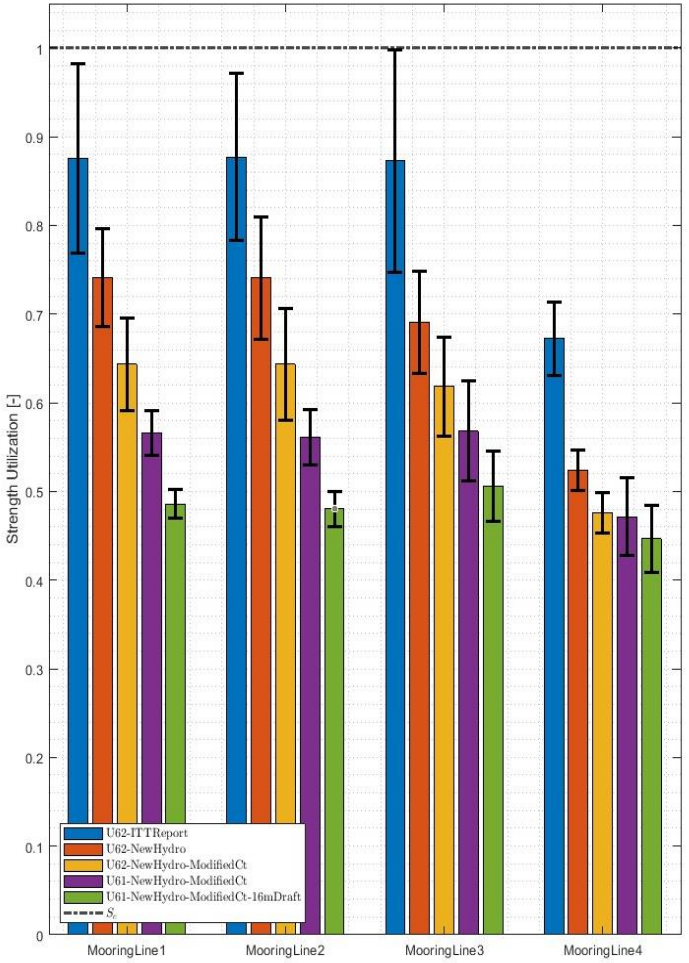
Example 15MW TetraSub, 200m water depth

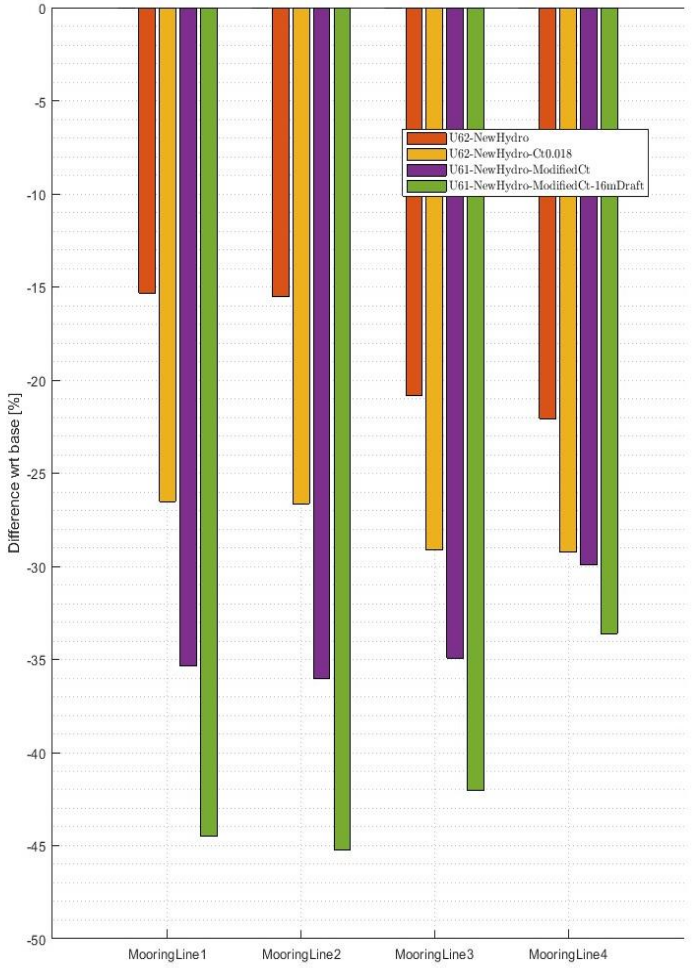



4ML taut polyester system, MBL2000T, 200mm R4S chain



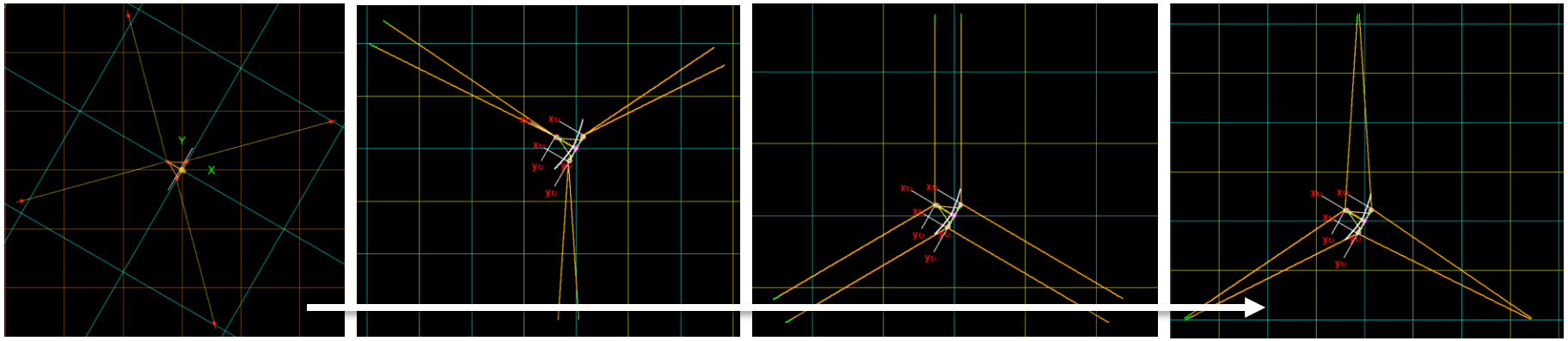
1. Refined FSS hydrodynamic modelling
2. Updated WTG model: from simplified drag disc to fully resolved WTG model
3. Excluding DLC6.2 (ie. WTG comes with yaw power back-up system)
4. Increasing FSS draft



# Example #1: Industrialised mooring design

## Mooring design improvements



4ML taut system
2000T MBL Polyester
200mm R4S chain

6ML taut system
600T MBL Polyester
120mm R4S chain



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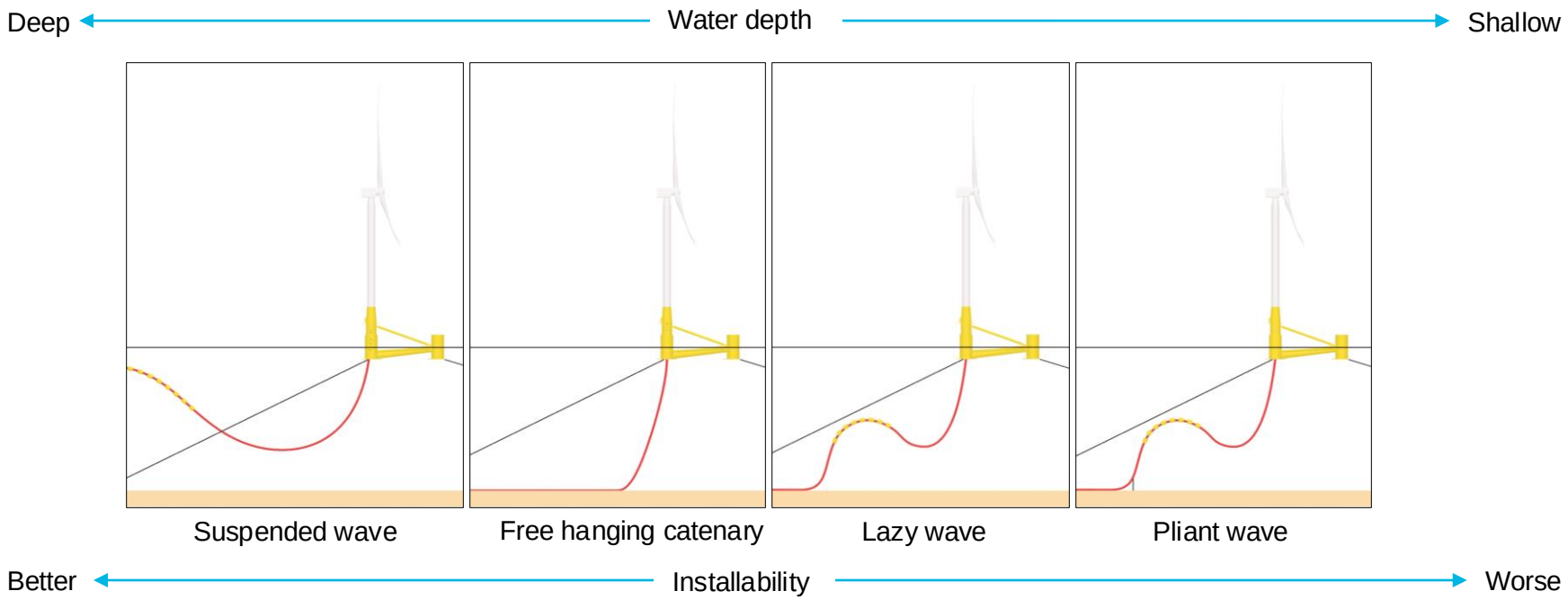
# Example #2: Dynamic cable & Mooring system co-design

- Conflicting design objectives between DIAC and SKS for lowest isolated sub-system cost.
- As offsets increase, DIAC cost and complexity increase, whilst SKS cost decreases



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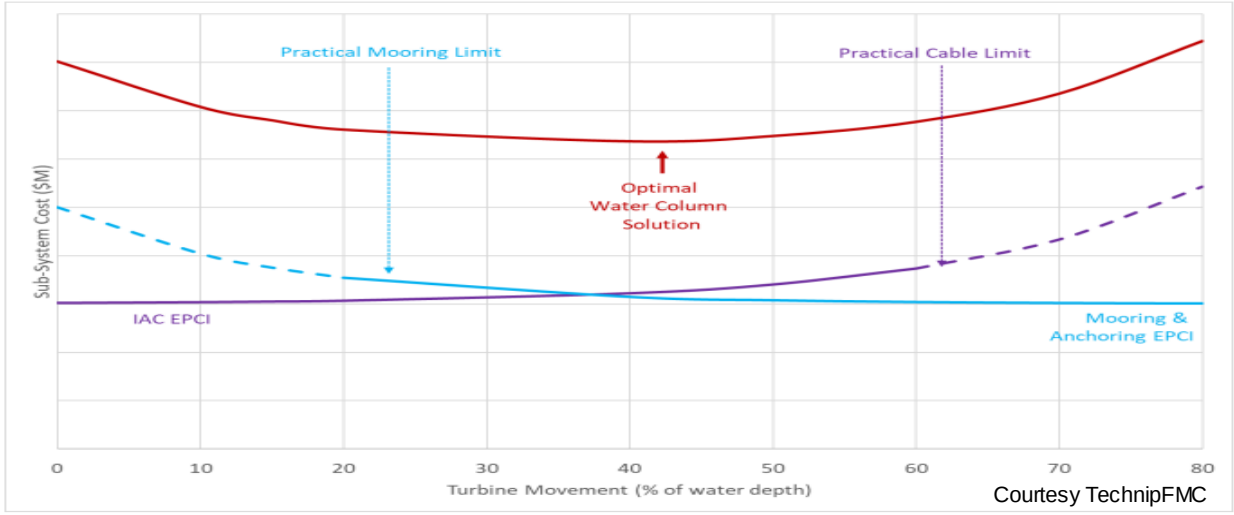
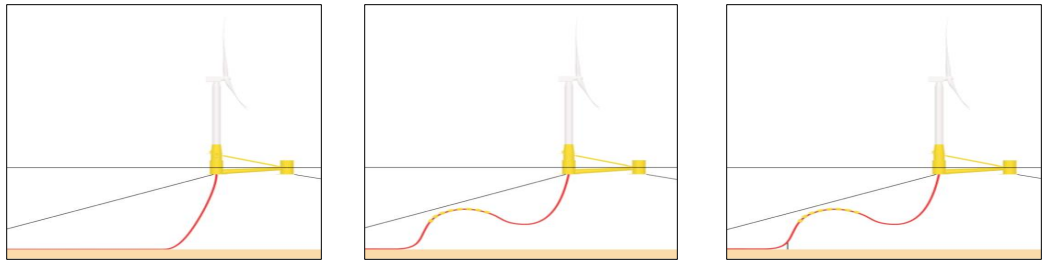



Courtesy TechnipFMC



Better ← Installation → Worse



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# Example #3: WTG & FSS co-design



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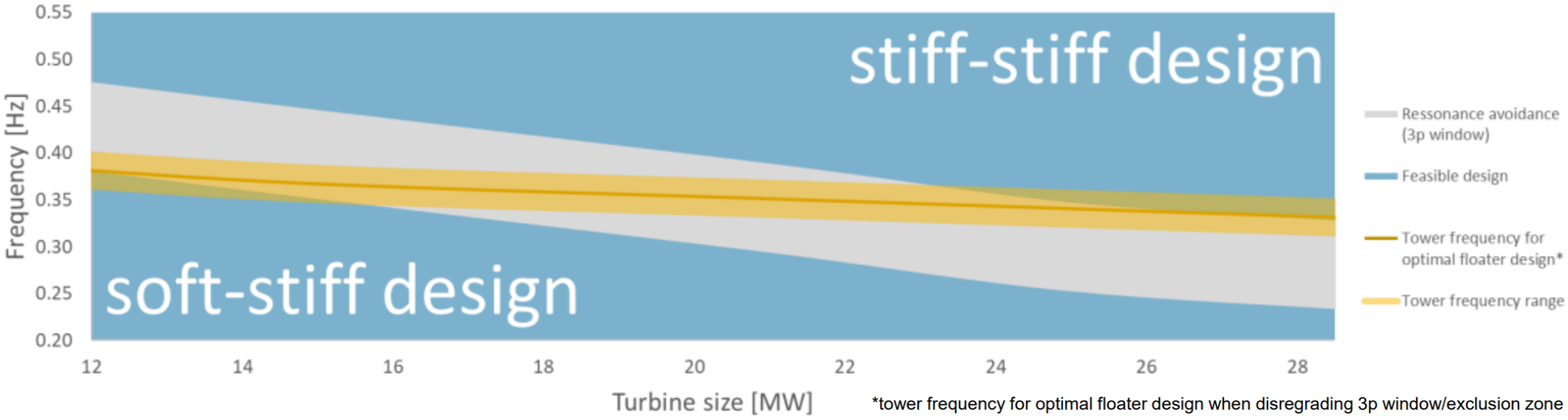
# Example #3: WTG & FSS co-design




*tower frequency for optimal floater design when disregrading 3p window/exclusion zone

Reference: Engebretsen et al. (2023) "*Design challenges and novel solution for tower designs of next generation floating wind turbines*, EERA DeepWind'2023 conference, Trondheim, Norway



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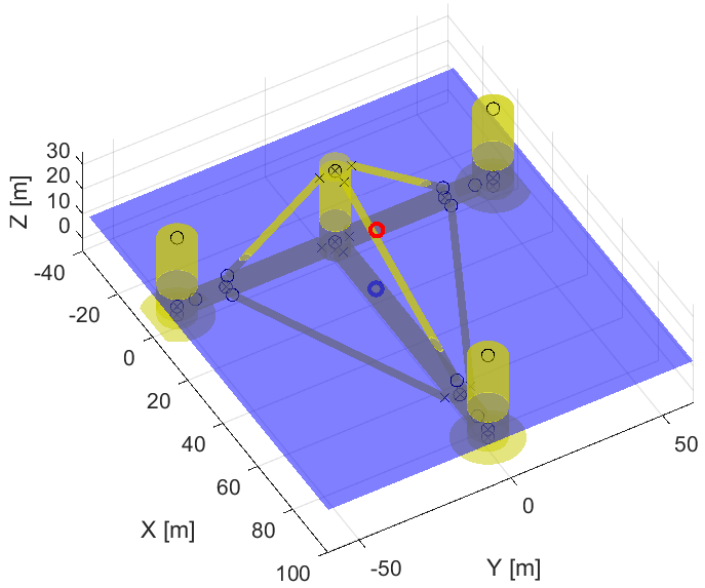
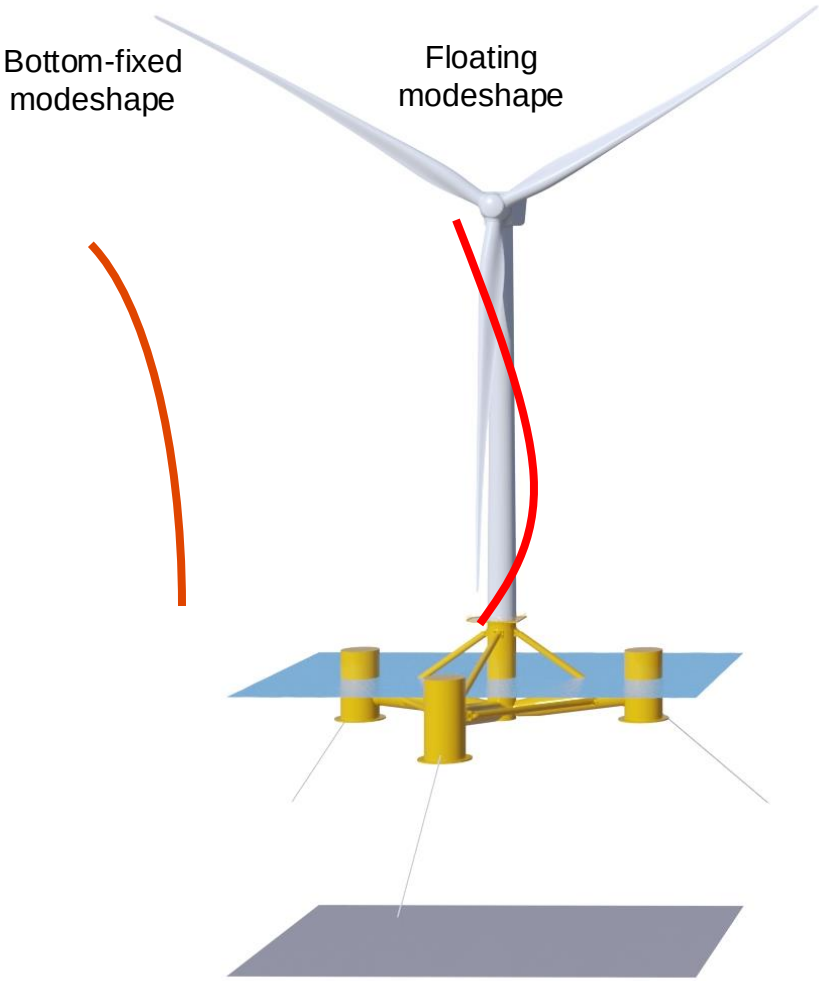
# Example #3: WTG & FSS co-design

- Influence of stiff-stiff design philosophy on WTG & Tower
  - Different tower design distribution & heavier tower
  - Push towards lower rated RPMs

- Influence of FSS on Tower design
  - Minimising rigid body rotational inertia at tower base



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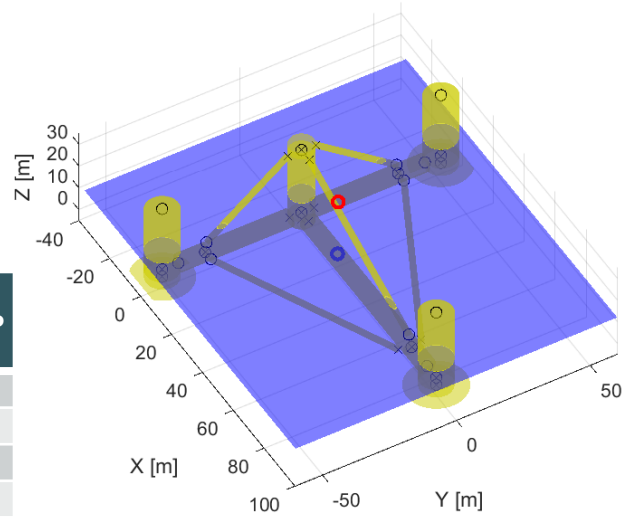
# Example #3: WTG & FSS co-design

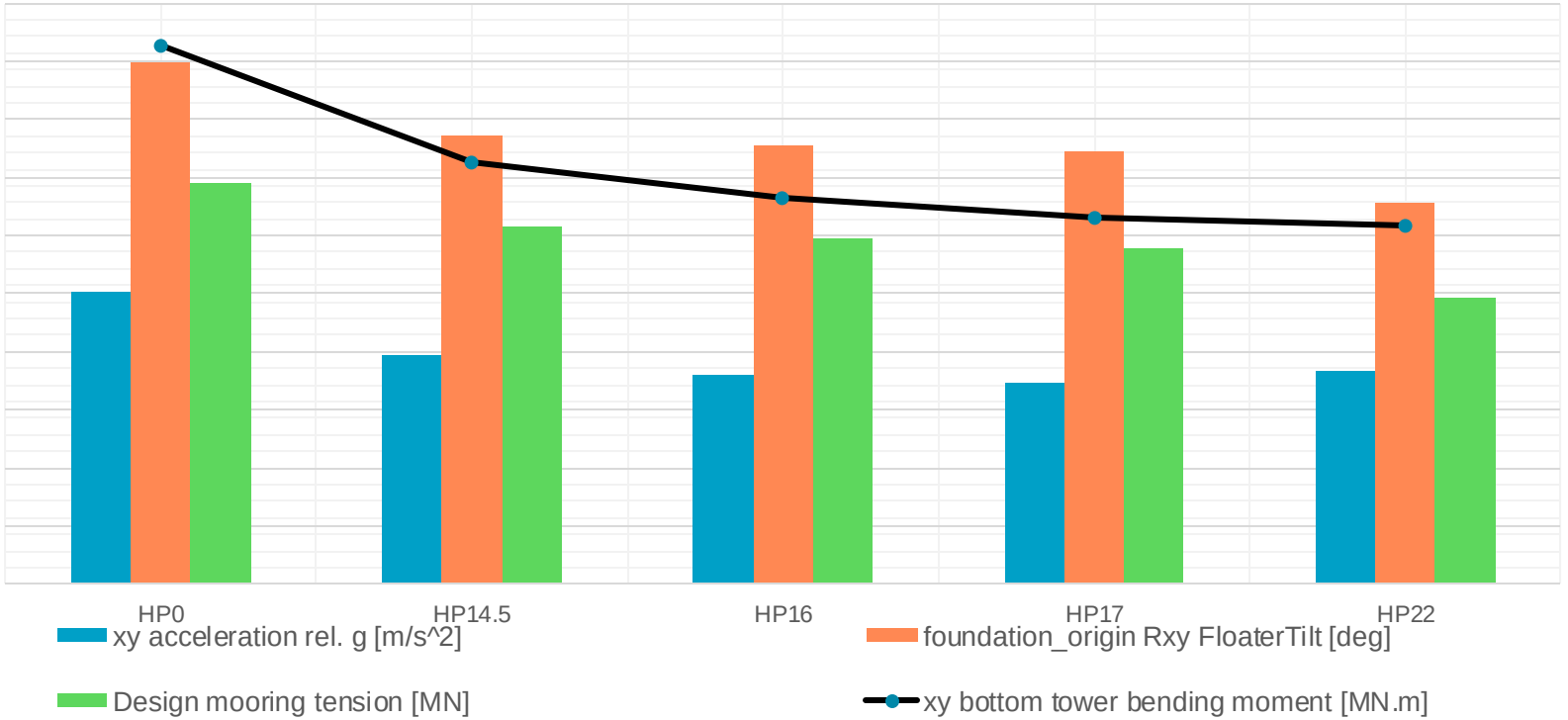
## Influence of Heave Plate size on coupled tower frequency

- Varying heave plate size to assess influence on:
  - Coupled tower frequency
  - ULS performance
  - FLS performance

| ID | Roll [s] | Pitch [s] | Coupled Tower frequency, % of 3P above 3P |
|---|---|---|---|
| HP1 | 23.0 | 23.1 | 48.0 |
| HP2 | 24.0 | 23.9 | 37.7 |
| HP3 | 24.5 | 24.2 | 34.0 |
| HP4 | 24.8 | 24.5 | 31.5 |
| HP5 | 27.3 | 26.3 | 19.2 |

Increasing HP size



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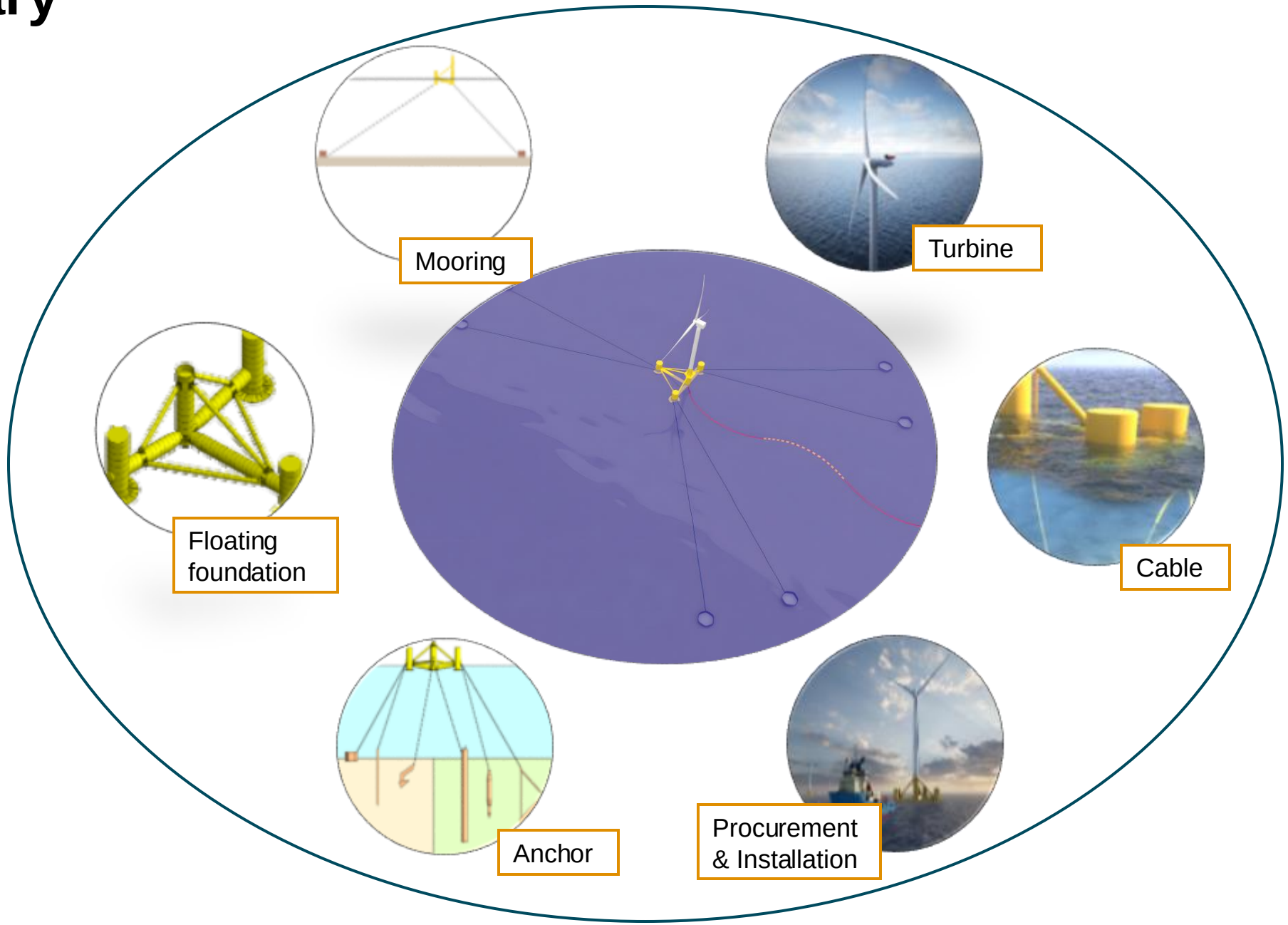
# Summary



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# Thanks for your attention

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QUALITY SYSTEM CERTIFICATION DNV ISO 9001