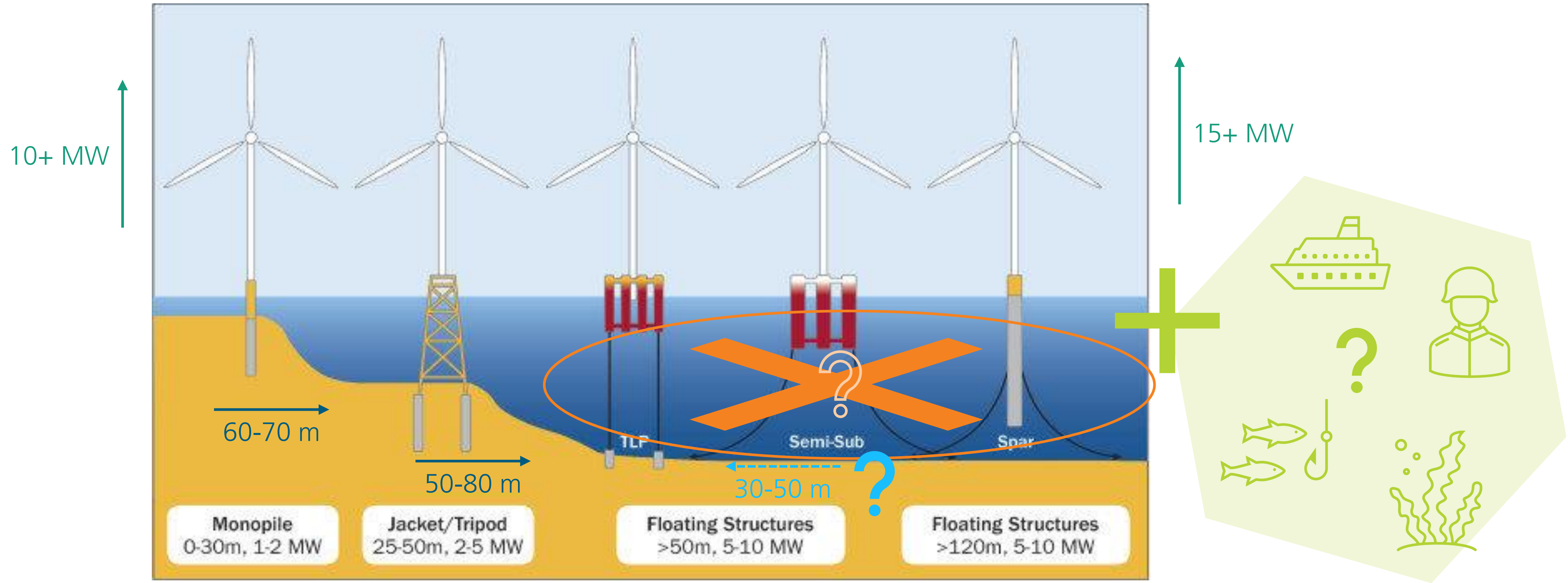

**18 January 2024 / EERA DeepWind Conference 2024**

# Investigating Alternative Application Ranges for Floating Offshore Wind

Dr.Eng. Mareike Leimeister

# Investigating Alternative Application Ranges for Floating Offshore Wind

## Technological Developments



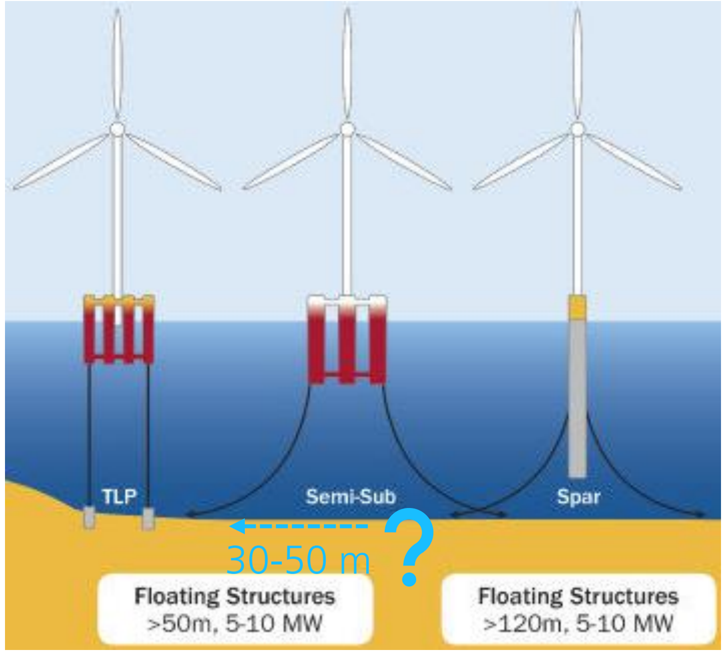

Bailey H., Brookes K. L., and Thompson P. M., 2014. *Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future.* Aquatic Biosystems 2014, 10:8. p. 9

Fraunhofer IWES

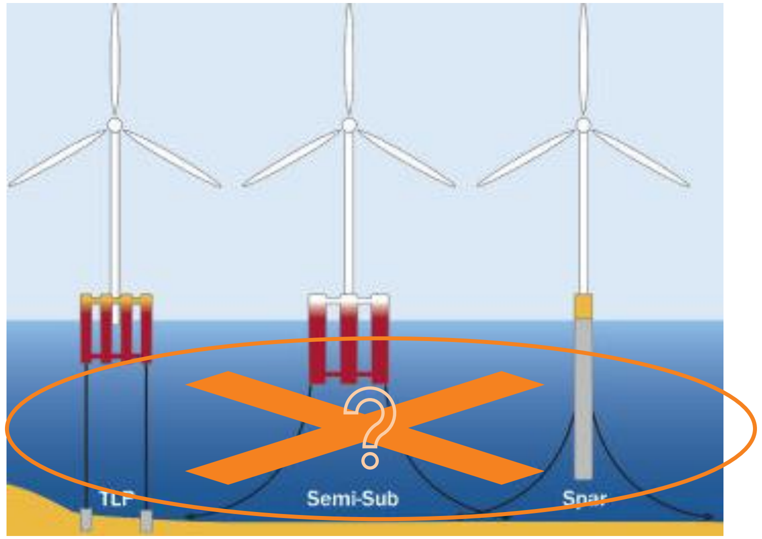
# Investigating Alternative Application Ranges for Floating Offshore Wind

## Content



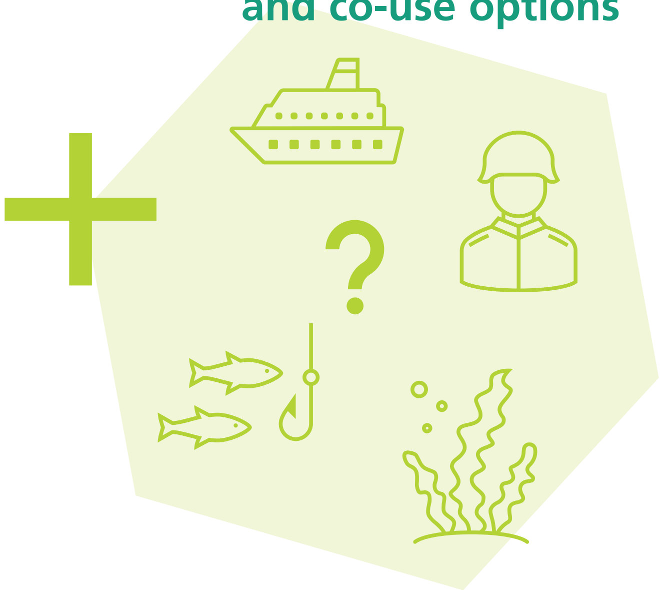

**Should and could floating offshore wind be extended to shallow water regions?**

**Going beyond traditional floating**




**offshore wind technologies**

**Motivations, challenges, and co-use options**



# Should and Could FOW be Extended to Shallow Water Regions?

# Should and Could FOW be Extended to Shallow Water Regions?

## Motivations and Advantages

### Environment

- Low noise pollution during installation
- Less impact on the environment
- No remaining structures after decommissioning

### Installation, O&M, decommissioning

- Quick and rather silent installation
- Less and relatively uncritical scour issues
- Easier O&M and heavy lift operations
- Simple and complete decommissioning

### Infrastructure

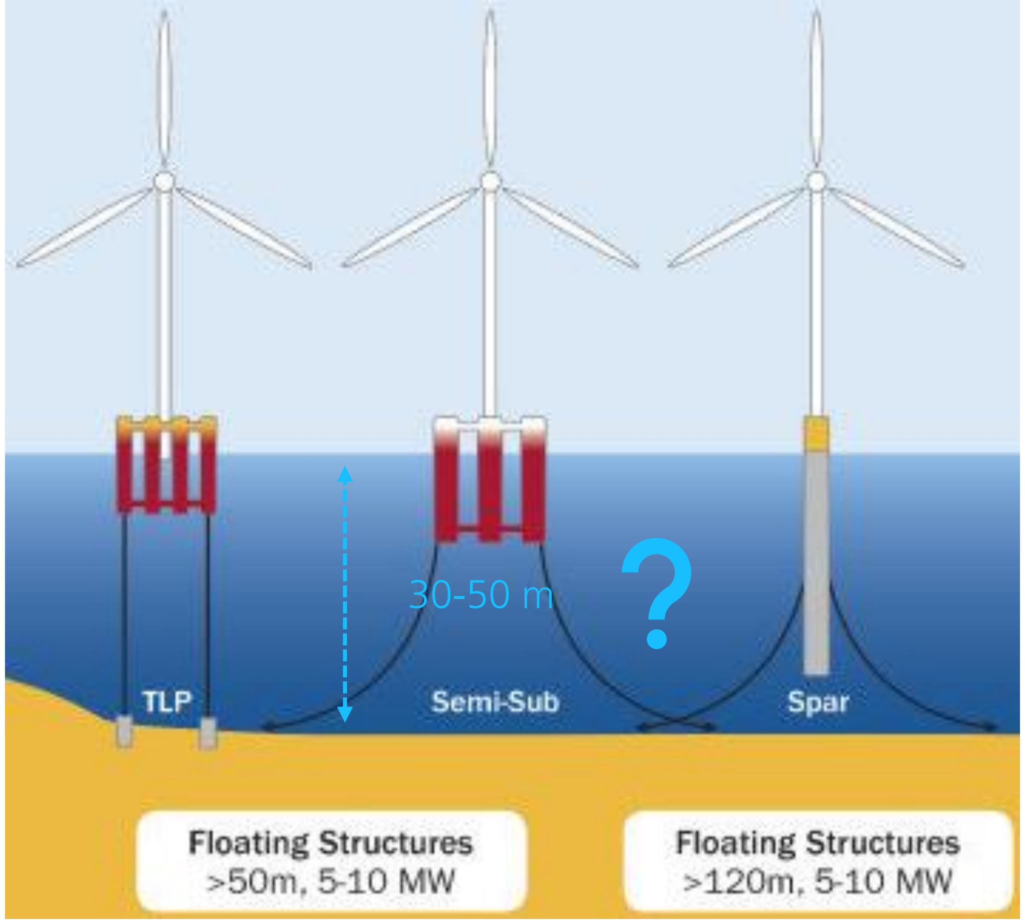
- For some countries more affordable option without additional bottom-fixed offshore wind infrastructure
- Use of existing harbor infrastructure
- No need for special heavy lift vessels

# Should and Could FOW be Extended to Shallow Water Regions?

## Feasibility Criteria

Tides

Safety clearance




Floater draft

Floater motion

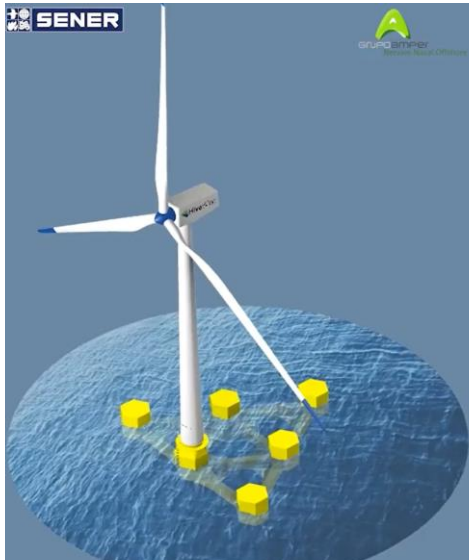
Mooring system functionality and feasibility

# Should and Could FOW be Extended to Shallow Water Regions?

## Shallow-Draft FOW System Designs

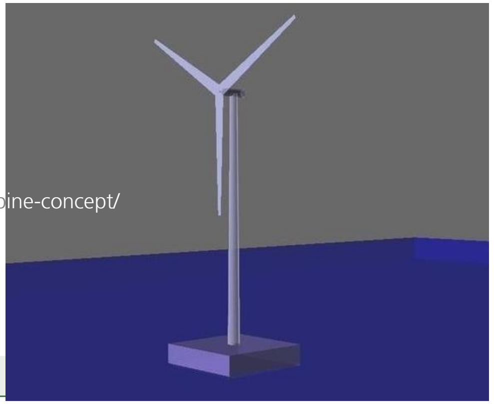

© Mareike Leimeister



https://www.youtube.com/watch?v=0col_oDEPnI

| Concept | Turbine-class | Draft | Water depth |
|---|---|---|---|
| MC021 (Marino Consulting) https://www.marino-consult.eu/en/best-more/mc-021-shallow-water-floating-wind-turbine-concept1198_mc-021-shallow-water-floating-wind-turbine-concept/ | 2 MW | 0.922 m | |
| Ino 12 (InSPIRE Ph I) | 2 MW | | 30 m |
| Floatgen/Damping Pool (Ideol) https://www.bw-ideol.com/en/floatgen-demonstrator | 2 MW | 7.5 m | 33 m |
| Gicon-SOF | 2.3 MW | | 35 m |
| Eolink | 5 MW | | 30 m |
| TH Floater (CTG) | 5.5 MW | | 27 - 30 m |
| nezzy² (Demo/OceanX) | 8.3 MW | | 40 m |
| Nerewind | 10 MW | | 30 m |
| Ino 12 (InSPIRE Ph II) | 12 MW | | 30 m |
| HiveWind https://www.group.sener/project/hivewind-floating-platform-offshore-wind/?lang=en | 15 MW | 8 m | |

Floating Wind Energy Projects of the World 2023: https://questfwe.com/




First floating wind turbine off China heads for installation at CTG project off Guangdong province Photo: MYSE

**Is this floating wind turbine the start of an offshore energy revolution in China?**

Typhoon-proof unit made up of a MingYang turbine and Wison platform heads out for China Three Gorges 'shallow water' project off south-east Guangdong province

11 July 2021 17:08 GMT UPDATED 12 July 2021 7:22 GMT

By Darius Snieckus

China's flagship floating wind turbine is in-tow for installation at developer China Three Gorges' Yangxi West Shapa phase 3, a 400MW project being built around monopile-based machines off Yangjiang, in south-east Guangdong province.

The typhoon-proof unit, a MingYang MySE5.5MW machine mated to a semisubmersible platform from Wison Offshore & Marine, will be trialled for the next six months at the site in 30 metres of water, making it an ideal candidate to test the role of floating wind turbines – generally thought-of as a technology for depths of 50 metres and greater – for 'shallow water' projects.

'Who will be the Orsted of Asia-Pacific floating wind power?'
Wind
18 November 2020 8:54 GMT

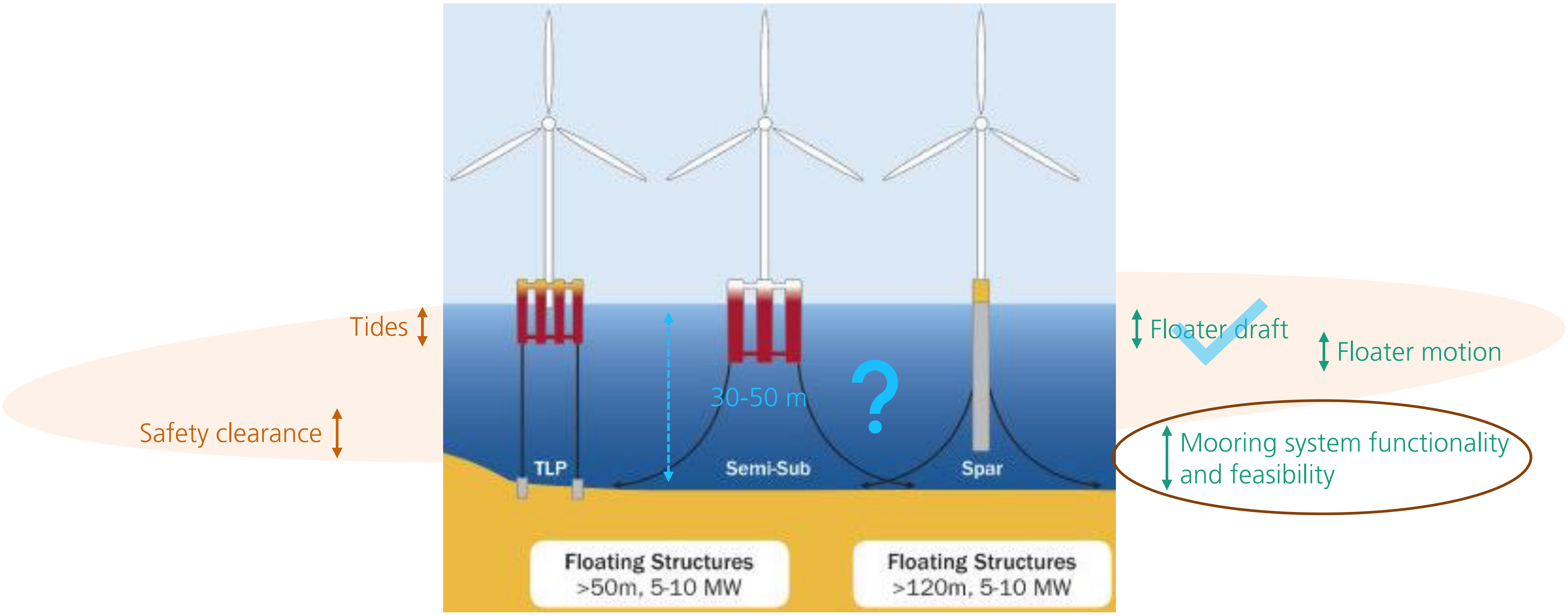
https://www.rechargenews.com/wind/is-this-floating-wind-turbine-the-start-of-an-offshore-energy-revolution-in-china-/2-1-1038516

Fraunhofer IWES

# Should and Could FOW be Extended to Shallow Water Regions?

## Feasibility Criteria



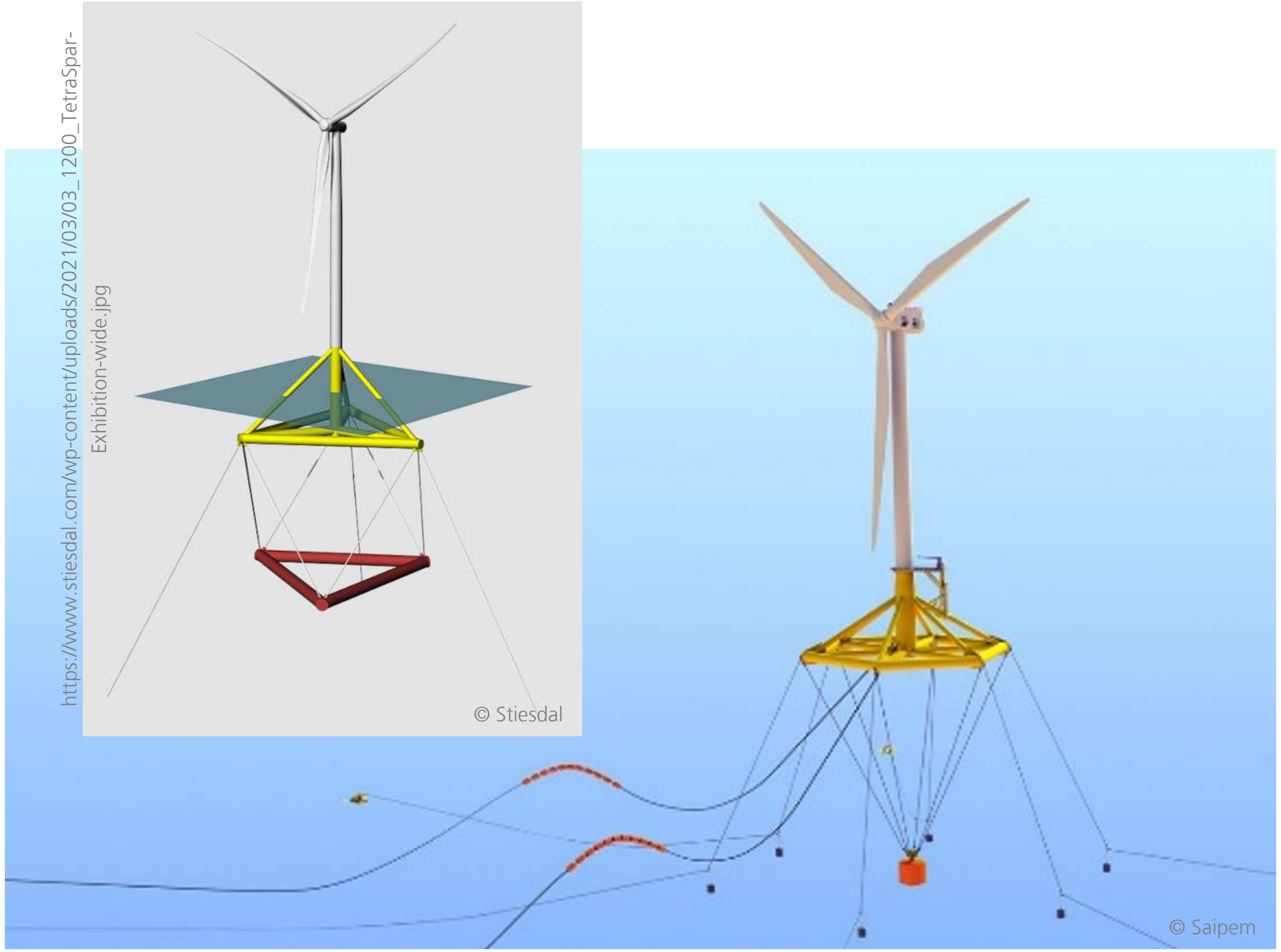

 

# Should and Could FOW be Extended to Shallow Water Regions?

## Development Challenges

### Safe system operation

- Relevance of tides at site
- Motion response of floating system
  - Heave plates for reduced heave motion
  - Relevance of outer dimensions
- Additional features for low system motion
  - Active ballast system for low roll and pitch motions
  - Wave-predictive control
- System design for allowable seabed contact?
  - Imaginable for pendulum-stabilized floater concepts
  - Structural and environmental impact investigations required




https://www.stiesdal.com/wp-content/uploads/2021/03/03_1200_TetraSpar-Exhibition-wide.jpg

https://guidetofloatingoffshorewind.com/wp-content/uploads/2023/01/saipem-hexafloat.png

# Should and Could FOW be Extended to Shallow Water Regions?

## Development Challenges

### Feasible and functional mooring system

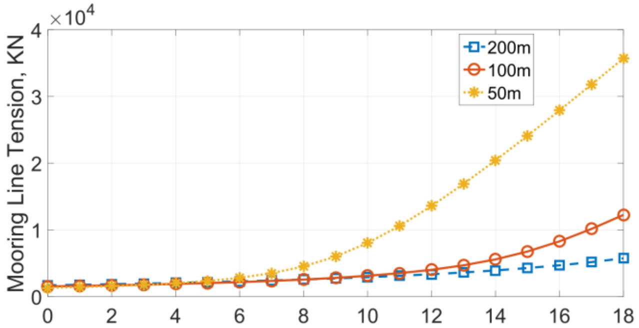
**Challenging design of well-performing mooring system for shallow-water applications (with acceptable line tensioning)**

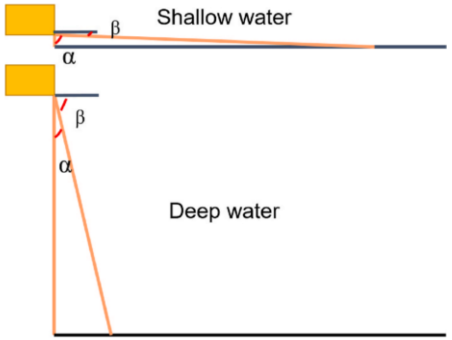
- Declared as one of the long-term research challenges in wind energy as part of the research agenda 2016 by eawe

- Small distance between fairlead and seabed
  → Larger chains required to deal with low inherent pre-tension

- Horizontal motion causes larger mooring line length to be lifted
  → Stronger response to difference-frequency wave loads and risk of line break

- Higher risk of mooring line stretching (loss of catenary shape)
  → Larger footprints required as prevention for vertical loads on anchors




Xu, K., Larsen, K., Shao, Y., Zhang, M., Gao, Z., & Moan, T. (2021). Design and comparative analysis of alternative mooring systems for floating wind turbines in shallow water with emphasis on ultimate limit state design. Ocean Engineering, 219, [108377].

# Should and Could FOW be Extended to Shallow Water Regions?

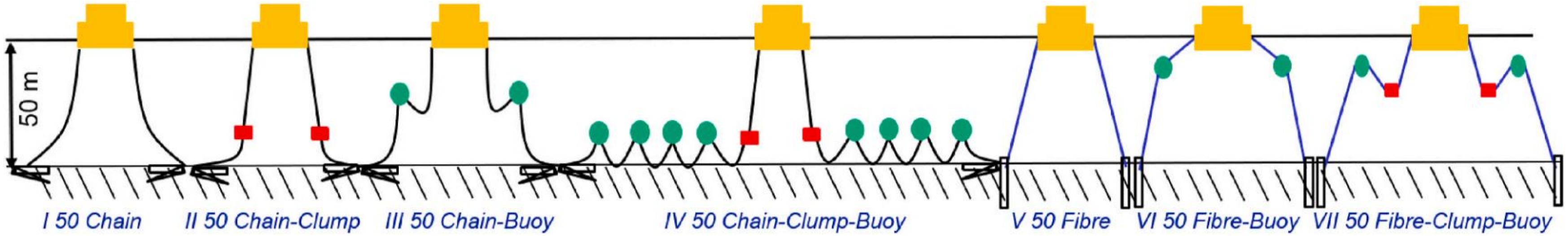
## Development Challenges

### Feasible and functional mooring system

**Investigations and research studies**

- Shallow-water FOW mooring system with polymer springs
  - Characteristics of polymer springs
    - Stiffer response at low loads
    - More flexible response at higher loads
  - Benefits
    - Reduced peak tensions in mooring lines (~60%)
    - Reduced fatigue loads in mooring systems

- Alternative mooring concepts for shallow-water FOW




Xu, K., Larsen, K., Shao, Y., Zhang, M., Gao, Z., & Moan, T. (2021). Design and comparative analysis of alternative mooring systems for floating wind turbines in shallow water with emphasis on ultimate limit state design. Ocean Engineering, 219, [108377].

# Going Beyond Traditional FOW Technologies

# Going Beyond Traditional FOW Technologies

## The "What" and "Why"

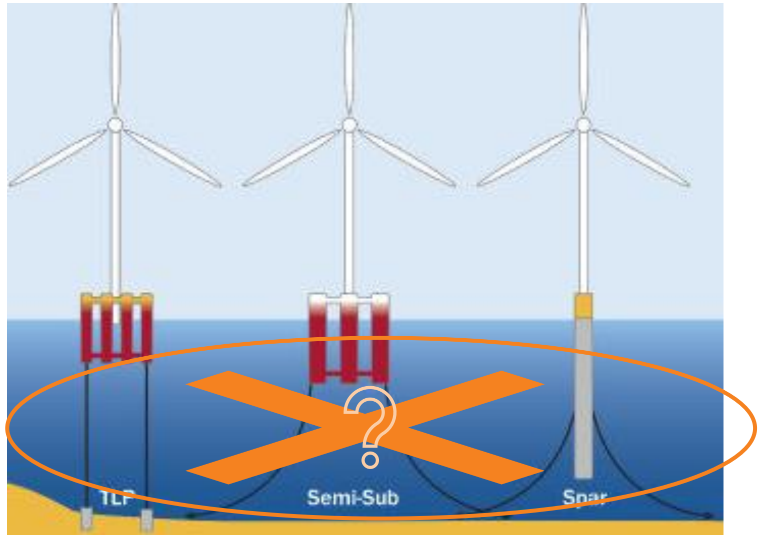
### Meaning

**System**

- Unmoored floating renewable energy conversion system
- Harvesting of different renewable energy sources
- Included conversion and storage

**Operation**

- Autonomously operating sailing vessel
- Weather routing
  - Following suitable wind trajectories
  - Avoiding severe environmental conditions
- Operational in large fleets




### Motivation

**Energy security**

- Harnessing of offshore wind energy in international waters
- Opening offshore energy utilization even by landlocked countries

**Environmental and economical aspects**

- Small footprint (neither mooring lines nor cables)
- Optimal energy yield
- Opportunities for multi-purpose systems
  - Harvesting, conversion, and storage of different renewable energy system
  - Offshore refueling station
  - Other applications (cleaning ocean waters, research platform, …)
- Co-use suitability

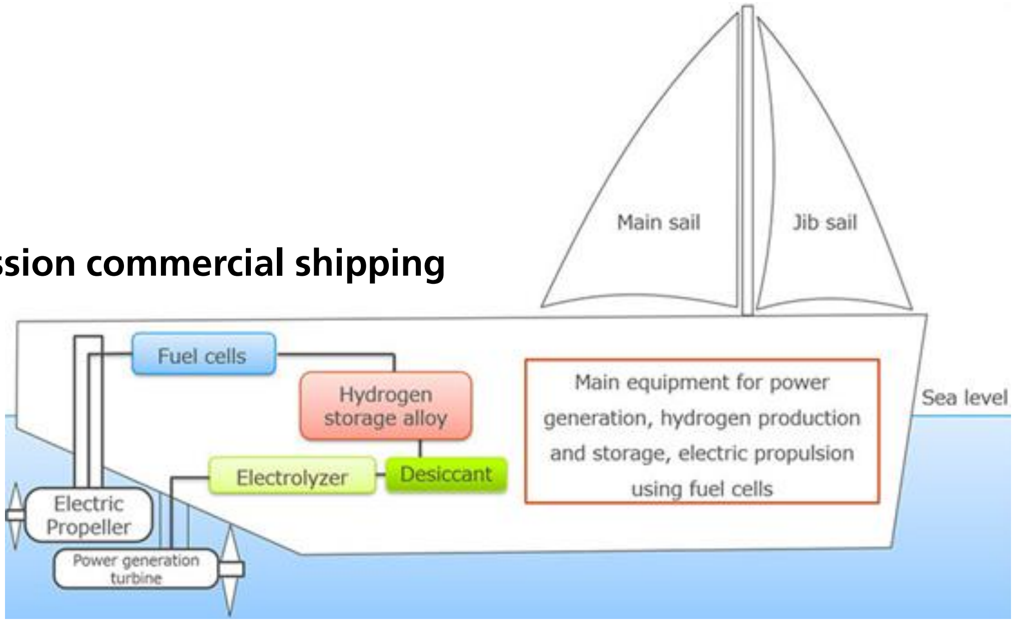
# Going Beyond Traditional FOW Technologies

## Concepts

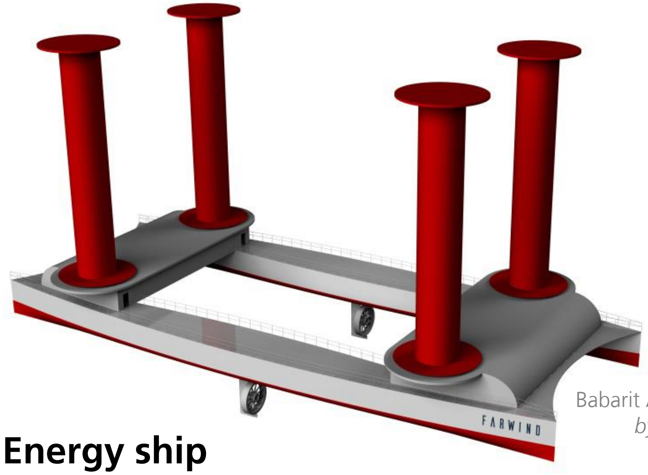
### Floating wind farm

Manabe H., et al., 2008. *Development of the floating structure for the Sailing-type Offshore Wind Farm*. doi: 10.1109/OCEANSKOBE.2008.4531100.

### Zero-emission commercial shipping




Mitsui O.S.K. Lines, 2020. *"Wind Hunter Project" Starts—Zero-Emission Project with Wind Propulsion and Hydrogen*. https://www.mol.co.jp/en/pr/2020/20080.html.



### Energy ship

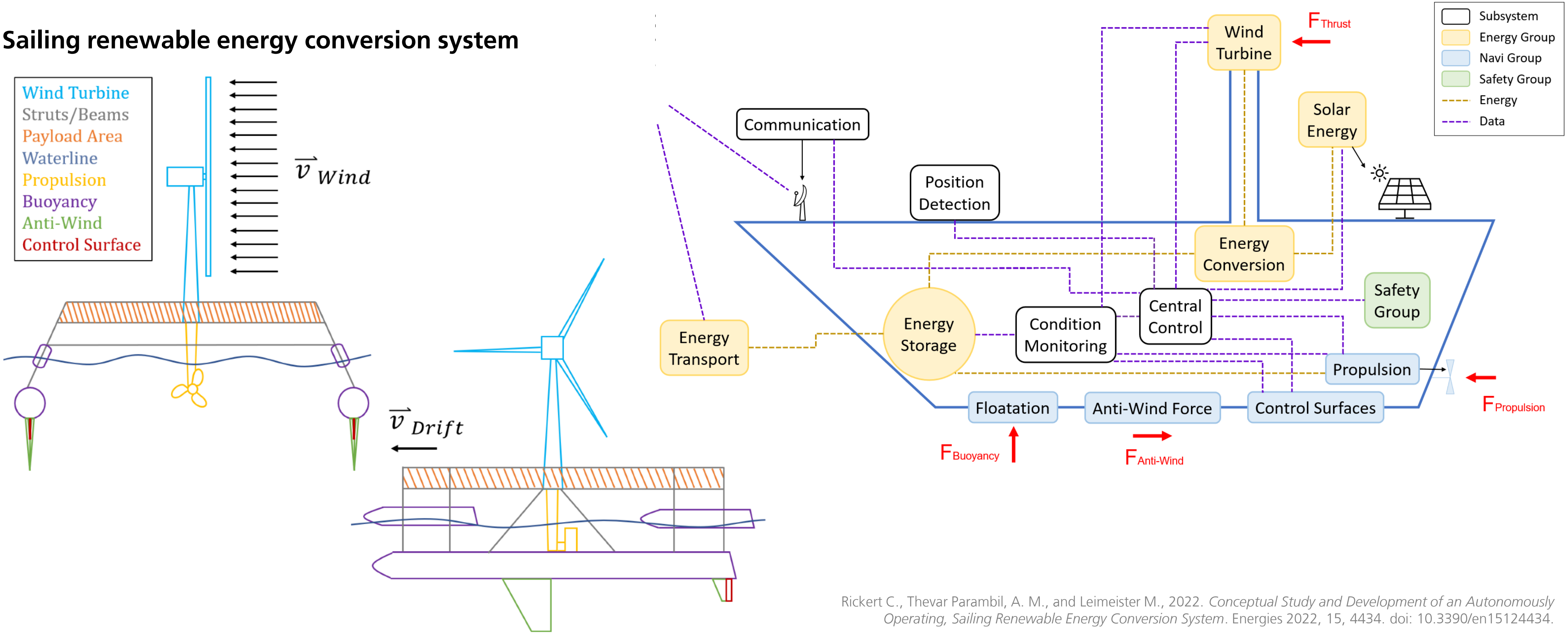
Babarit A., et al., 2020. *Exploitation of the far-offshore wind energy resource by fleets of energy ships - Part 1: Energy ship design and performance*. Wind Energy Sci. 2020, 5, 839–853. doi: 10.5194/wes-5-839-2020.

# Going Beyond Traditional FOW Technologies

## Concepts

### Sailing renewable energy conversion system




Rickert C., Thevar Parambil, A. M., and Leimeister M., 2022. *Conceptual Study and Development of an Autonomously Operating, Sailing Renewable Energy Conversion System*. Energies 2022, 15, 4434. doi: 10.3390/en15124434.



Fraunhofer IWES

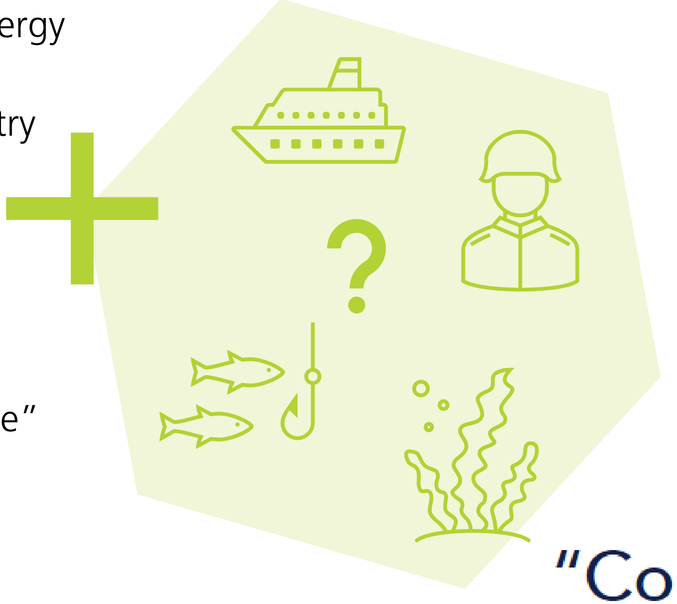
# Motivations, Challenges, and Co-Use Options

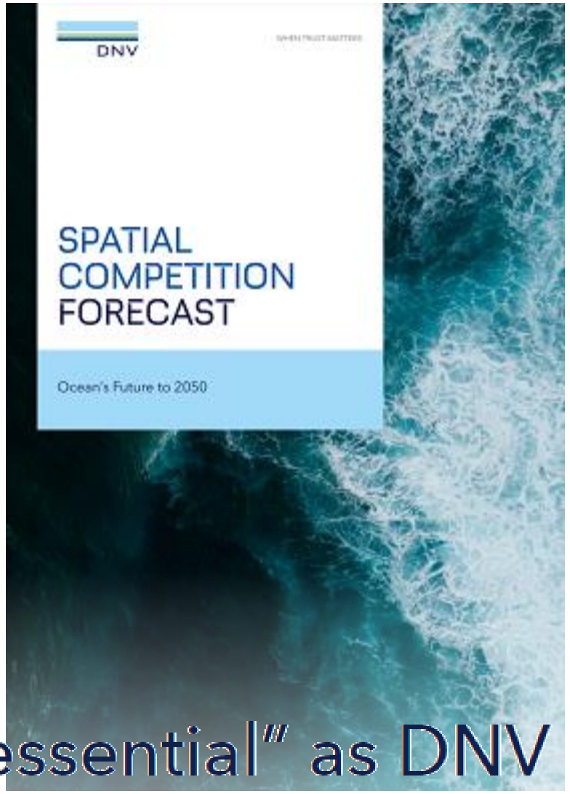
# Motivations, Challenges, and Co-Use Options

## Current Situation

- Various (competing?) interests in ocean space
  - Offshore wind energy
  - Aquaculture
  - Oil and gas industry
  - Shipping lanes
  - Fishing industry
  - Military use
  - Ecosystem

- Most activities "close" to shore






"Coexistence is essential" as DNV report shows demand for ocean space will grow 5-fold by 2050

https://www.dnv.com/news/-coexistence-is-essential-as-dnv-report-shows-demand-for-ocean-space-will-grow-5-fold-by-2050-240871

# Motivations, Challenges, and Co-Use Options

## Floating Wind and Other Renewable Energies

**Multi-purpose platforms**

- More power output per floating structure
- Share of logistics and infrastructure
- Beneficial effects to be investigated in more detail (e.g., wave energy converter on floating wind turbine)

**Co-use concepts**

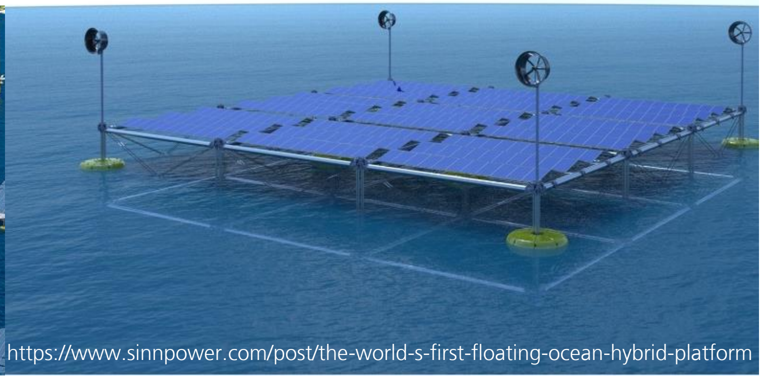
- Beneficial effect (e.g., reduced energy of waves behind wave energy converters already used for coastal protection)
- Share of logistics and infrastructure

http://www.pelagicpower.no/about.html

| | Demonstrator<br>Demonstration | Series 1<br>Pre-commercial | Series 2<br>Commercial |
|---|---|---|---|
| Wind | 4 MW | 8 MW | 12 MW |
| + Wave | 2 MW | 4 MW | 6 MW |
| = | **6 MW** | **12 MW** | **18 MW** |

https://www.inspireoffshoreenergy.com/


https://www.sinnpower.com/ocean


https://www.sinnpower.com/post/the-world-s-first-floating-ocean-hybrid-platform

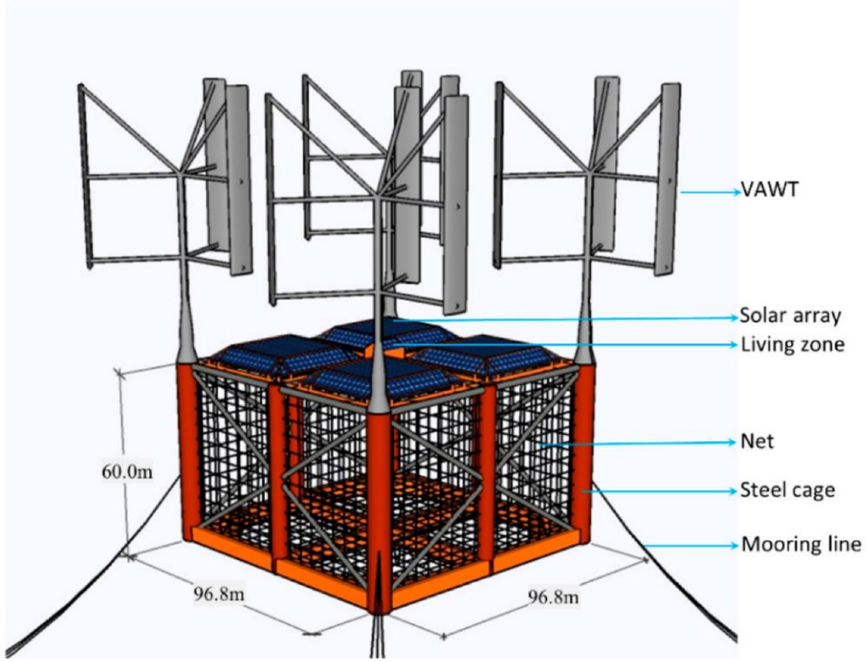
Fraunhofer IWES

# Motivations, Challenges, and Co-Use Options

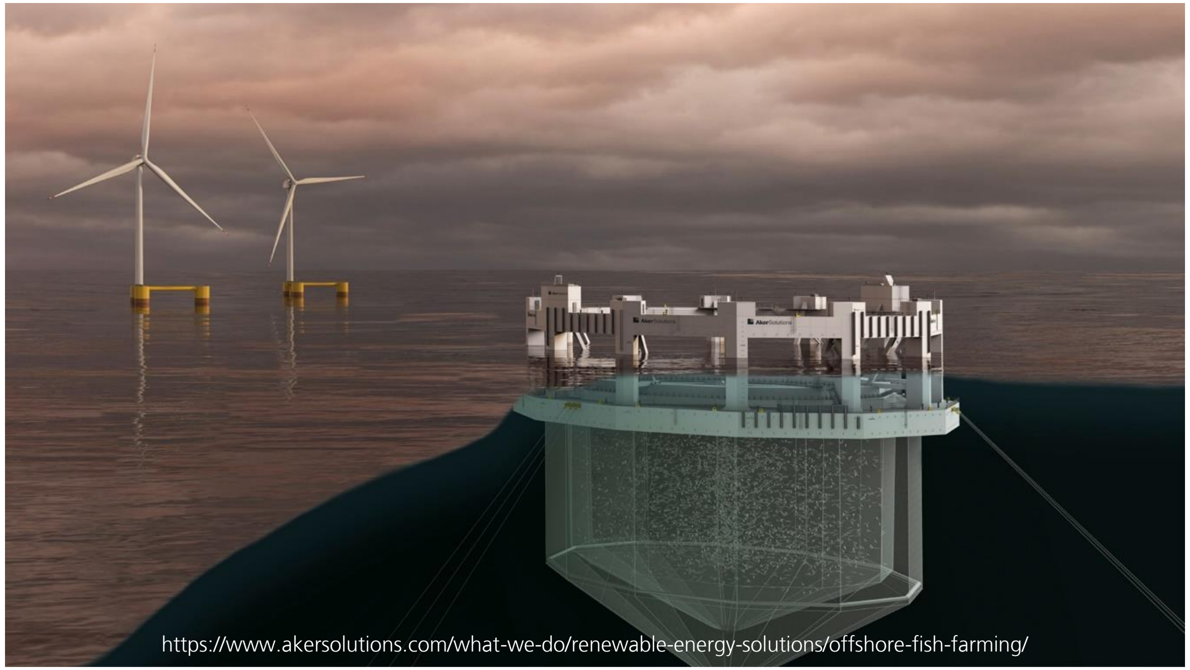
## Floating Wind and Aquaculture

**Multi-purpose platforms**

- Share of structural component
- Share of logistics and infrastructure
- Example: Floating wind-solar-aquaculture system




Zheng, X.; Zheng, H.; Lei, Y.; Li, Y.; Li, W. An Offshore Floating Wind–Solar–Aquaculture System: Concept Design and Extreme Response in Survival Conditions. *Energies* **2020**, 13, 604. https://doi.org/10.3390/en13030604.



https://www.akersolutions.com/what-we-do/renewable-energy-solutions/offshore-fish-farming/

**Co-use concepts**

- Synergies between offshore wind and aquaculture
  - Turbine distances due to wake effects
  - Fish farm distances for securing water quality
- Share of logistics and infrastructure
- Example: Aker Solutions Ocean Cage

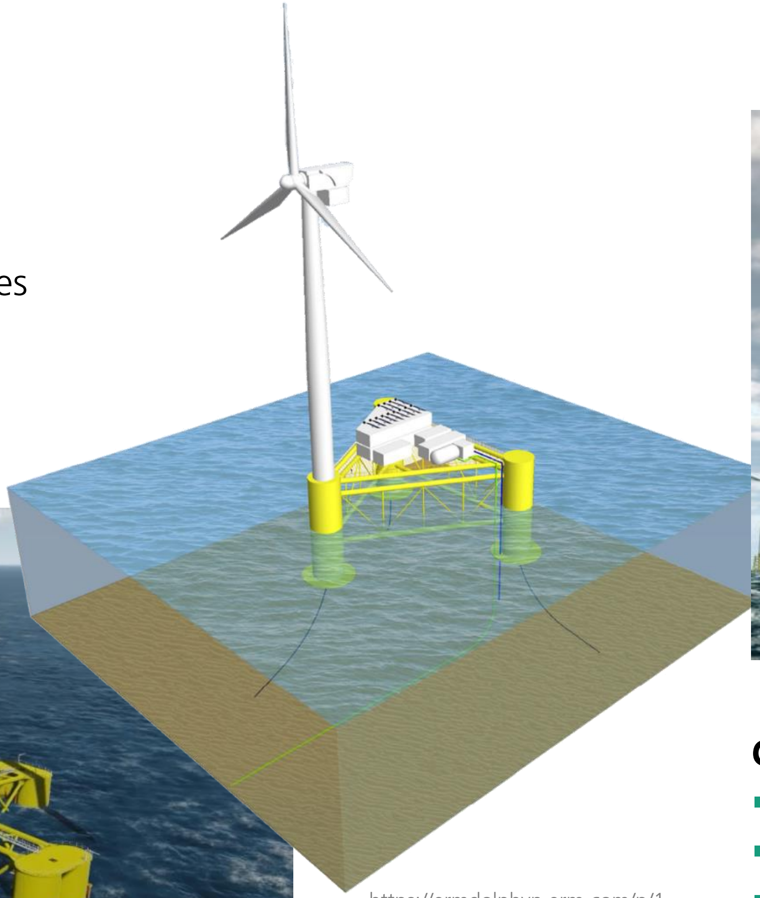
# Motivations, Challenges, and Co-Use Options

## Floating Wind and Offshore Hydrogen

**Multi-purpose platforms**

- Share of structural component
- Share of logistics and infrastructure
- No need for any dynamic power cables
- Examples
    - ERM Dolphyn
    - NereHyd (Lhyfe and DORIS)

https://www.dorisgroup.com/wp-content/uploads/2022/10/20211130_Nerehyd.webp



https://ermdolphyn.erm.com/p/1


https://energycentral.com/c/cp/floating-wind-and-hydrogen-0

**Co-use concepts**

- Share of logistics and infrastructure
- No need of power cable to the shore
- Offshore hydrogen platform could serve as offshore ship refueling base (if hydrogen is further converted offshore to a suitable fuel)

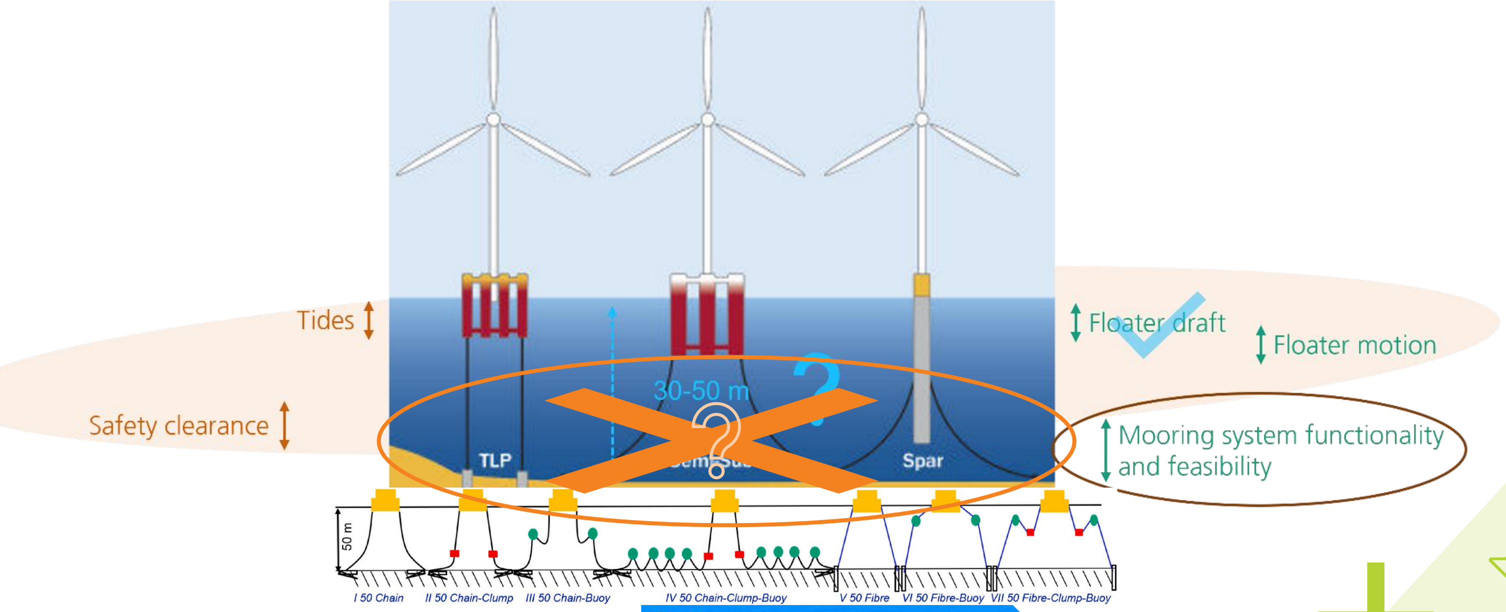
Fraunhofer IWES

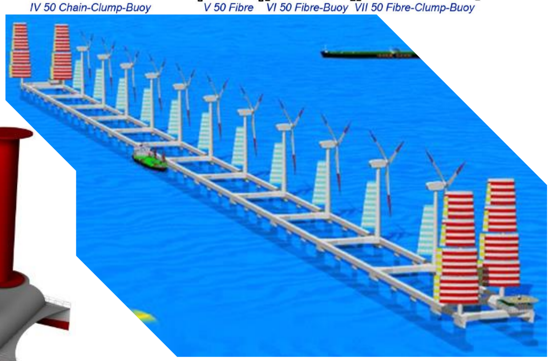
Fraunhofer IWES

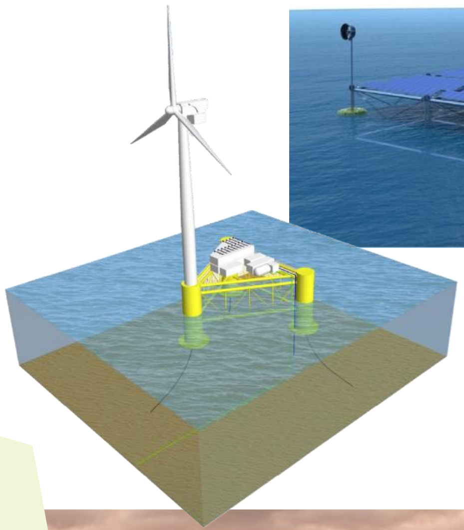
# Conclusions

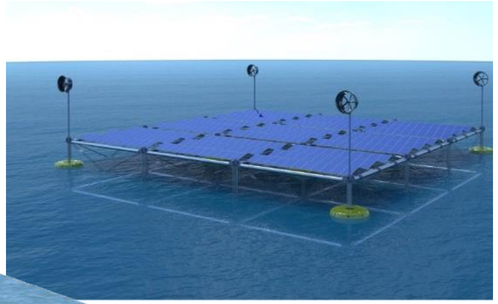
# Conclusions

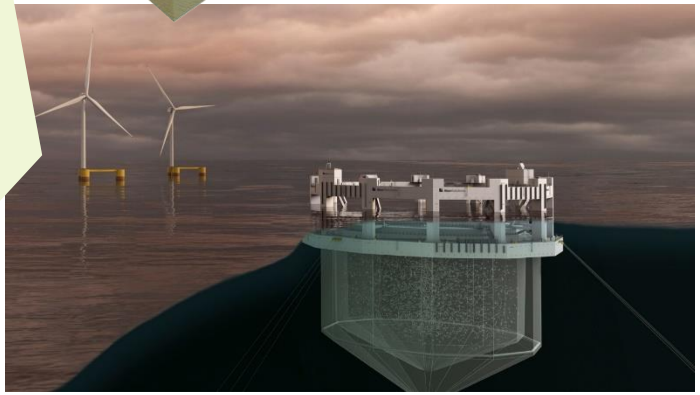
## Investigating Alternative Application Ranges for Floating Offshore Wind









 18 January 2024 

Fraunhofer IWES

# Thanks a lot for your attention!

© Fraunhofer IWES/Frank Bauer



Fraunhofer IWES

# Contact

**Dr.Eng. Mareike Leimeister**
**Group Global Turbine Dynamics**
**Fraunhofer Institute for Wind Energy Systems IWES**
**Am Seedeich 45**
**27572 Bremerhaven**
**Germany**

**Phone +49 471 14290-384**
**mareike.leimeister@iwes.fraunhofer.de**