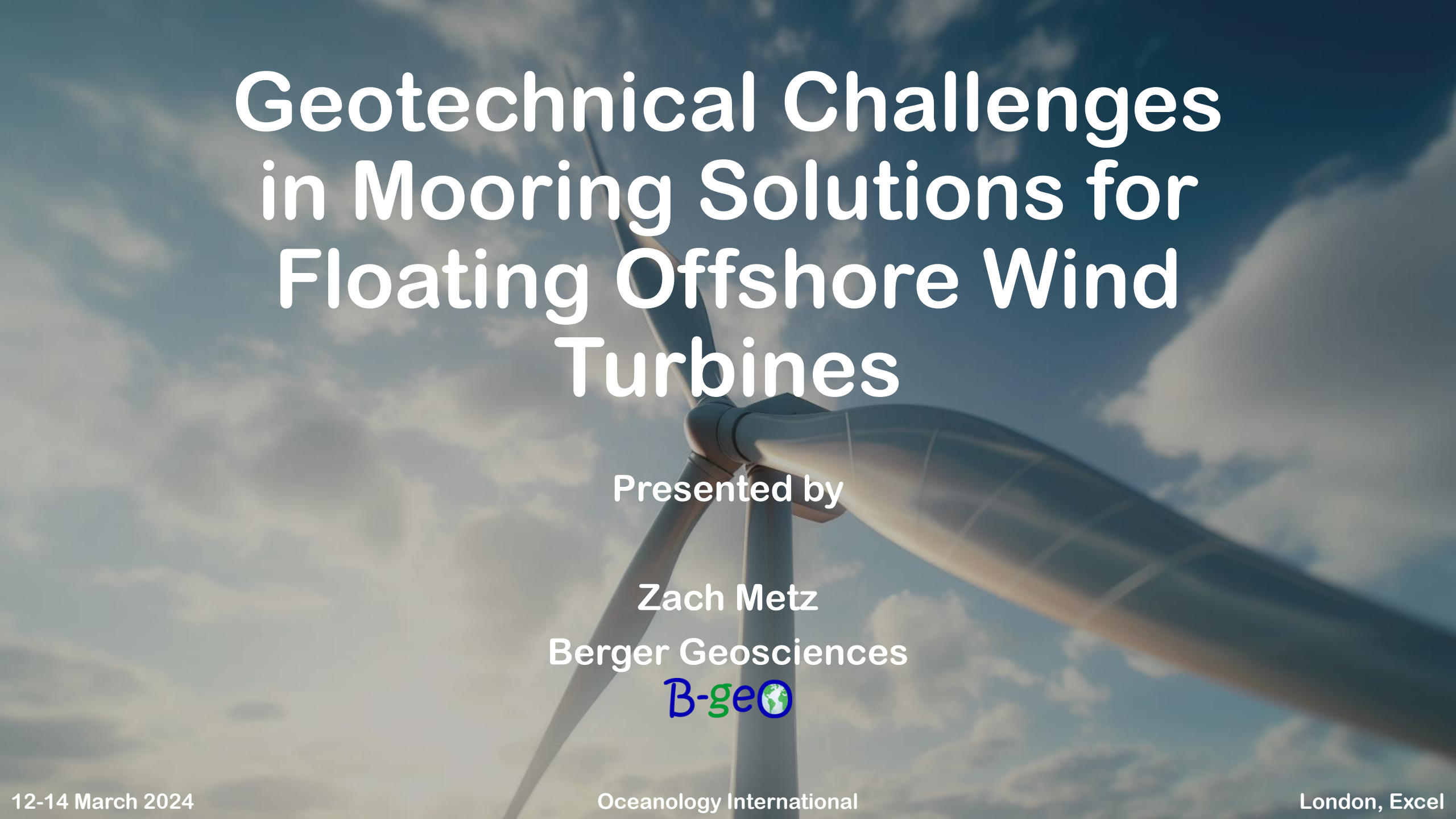
Geotechnical Challenges in Mooring Solutions for Floating Offshore Wind Turbines



Presented by

Zach Metz

Berger Geosciences

Introduction

- Offshore wind energy market grew by 15% in 2022, reaching 52.7 GW capacity
- Floating offshore wind capacity projected to exceed 10 GW by 2030 globally
- U.S. aims to reduce floating wind energy costs by over 70% by 2035
- Technological, investment, and policy decisions critical for industry's next five years

Image Source: Bauer – NREL (2017)

Introduction

- Installing FOWTs comes with complex geotechnical challenges
- Other considerations include stability, harsh marine environment, and maintenance

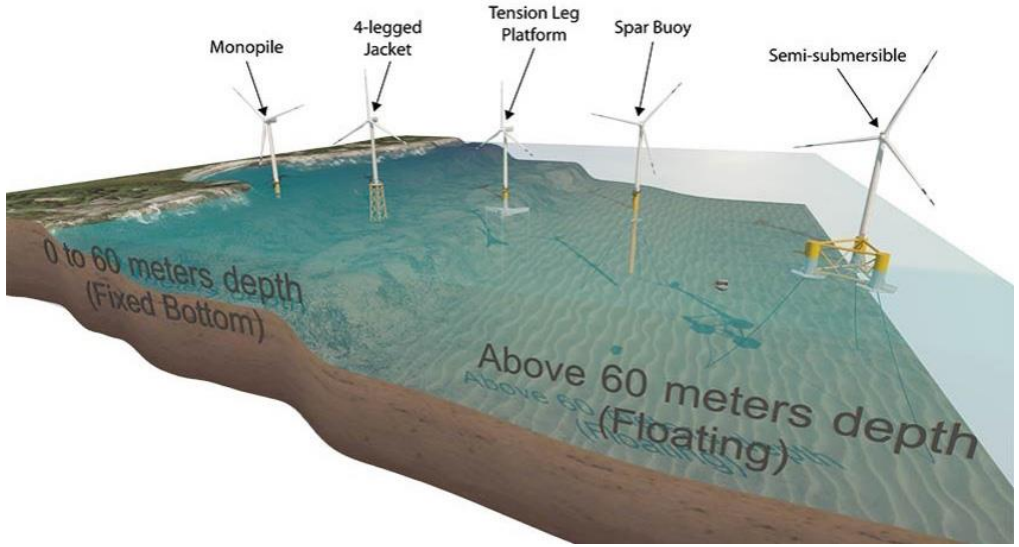


Image Sources: Bauer – NREL (2020); EDP Renewables

Need for Thorough Geotechnical Investigation

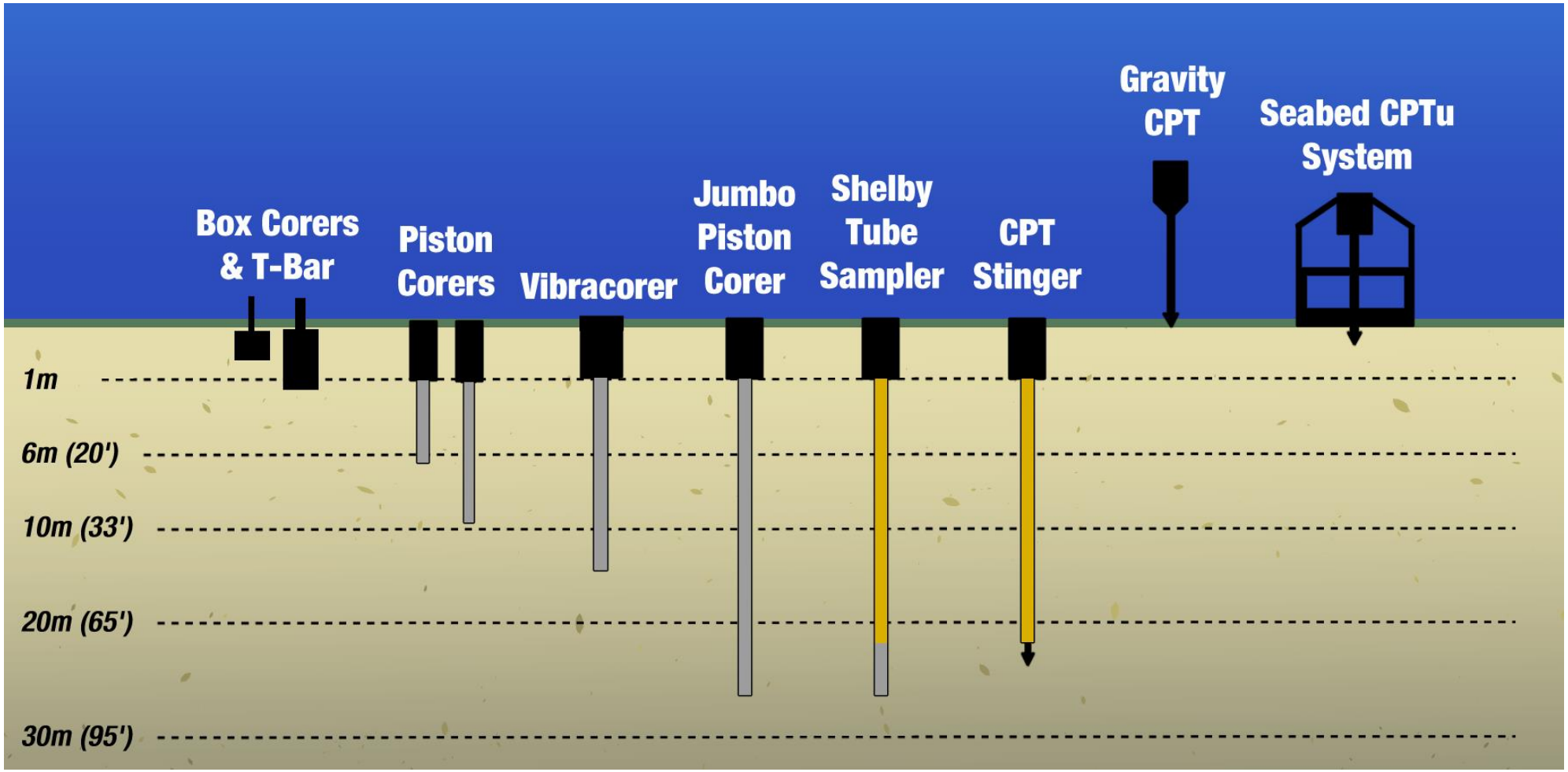


Image Source: Modified from TDI-Brooks, 2021

Need for Thorough Geotechnical Investigation

- Results are used to design and analyze the effects of:
  - Anchor Design
  - Aerodynamic Loading
  - Hydrodynamic Loading

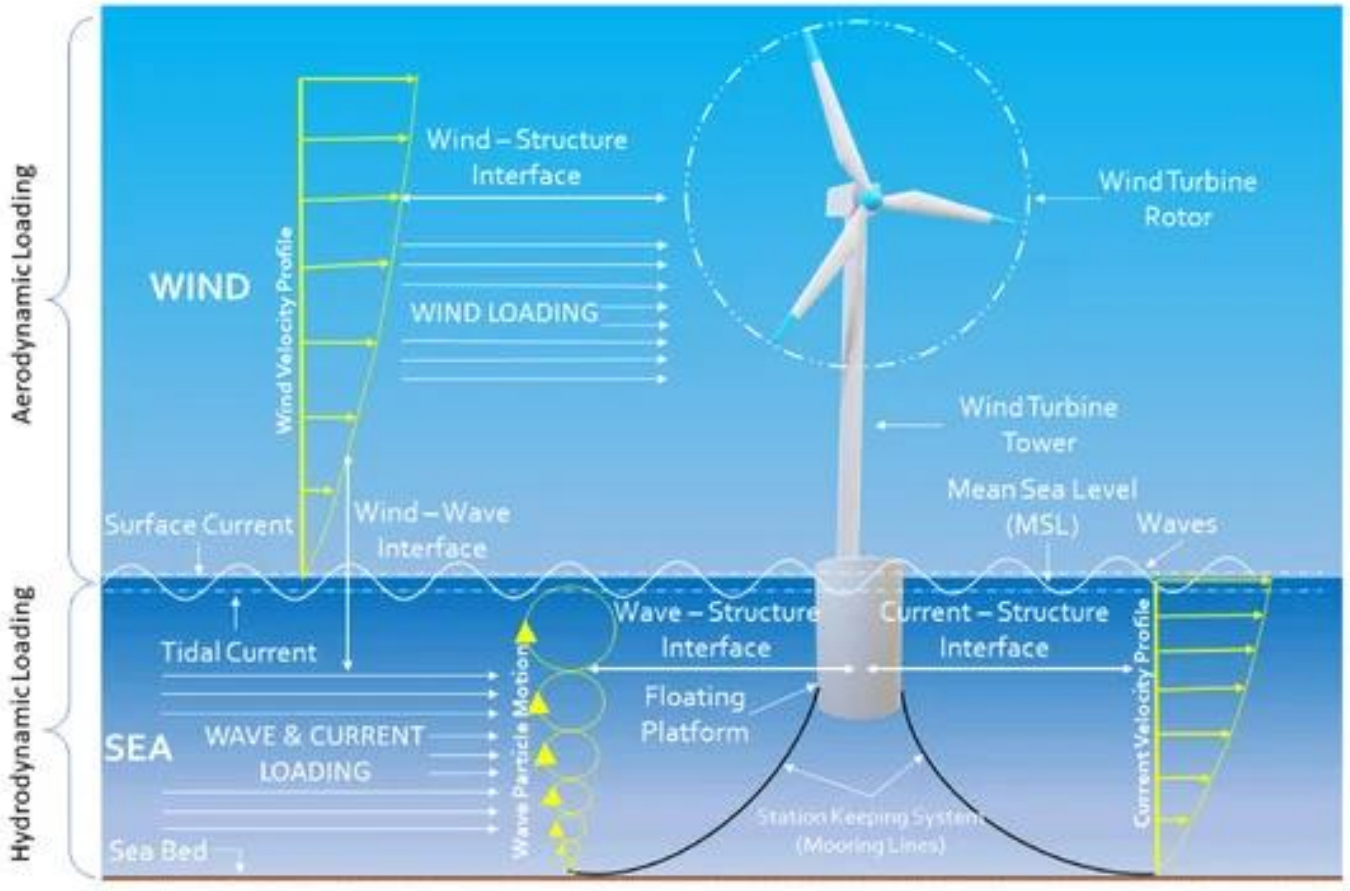


Image Source: Clement et al. (2021)

Soil (Seabed) Conditions

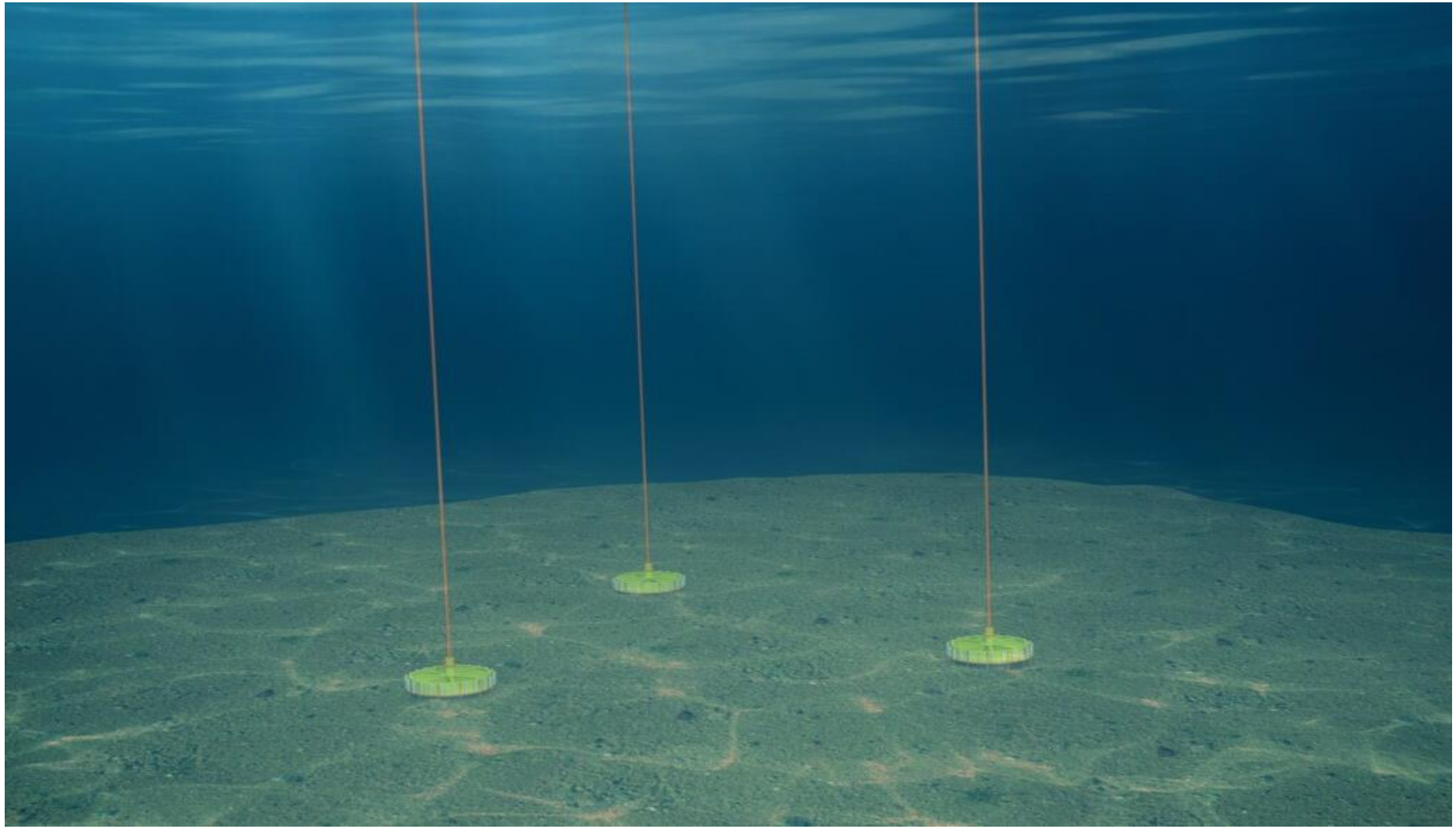


Image Sources: Offshore Wind Design AS

Soil (Seabed) Conditions

- Soil stiffness could also influence the anchorage performance of the FOWT
- For anchor piles, the soil-pile stiffness can be expressed using p-y, t-z, and q-z curves

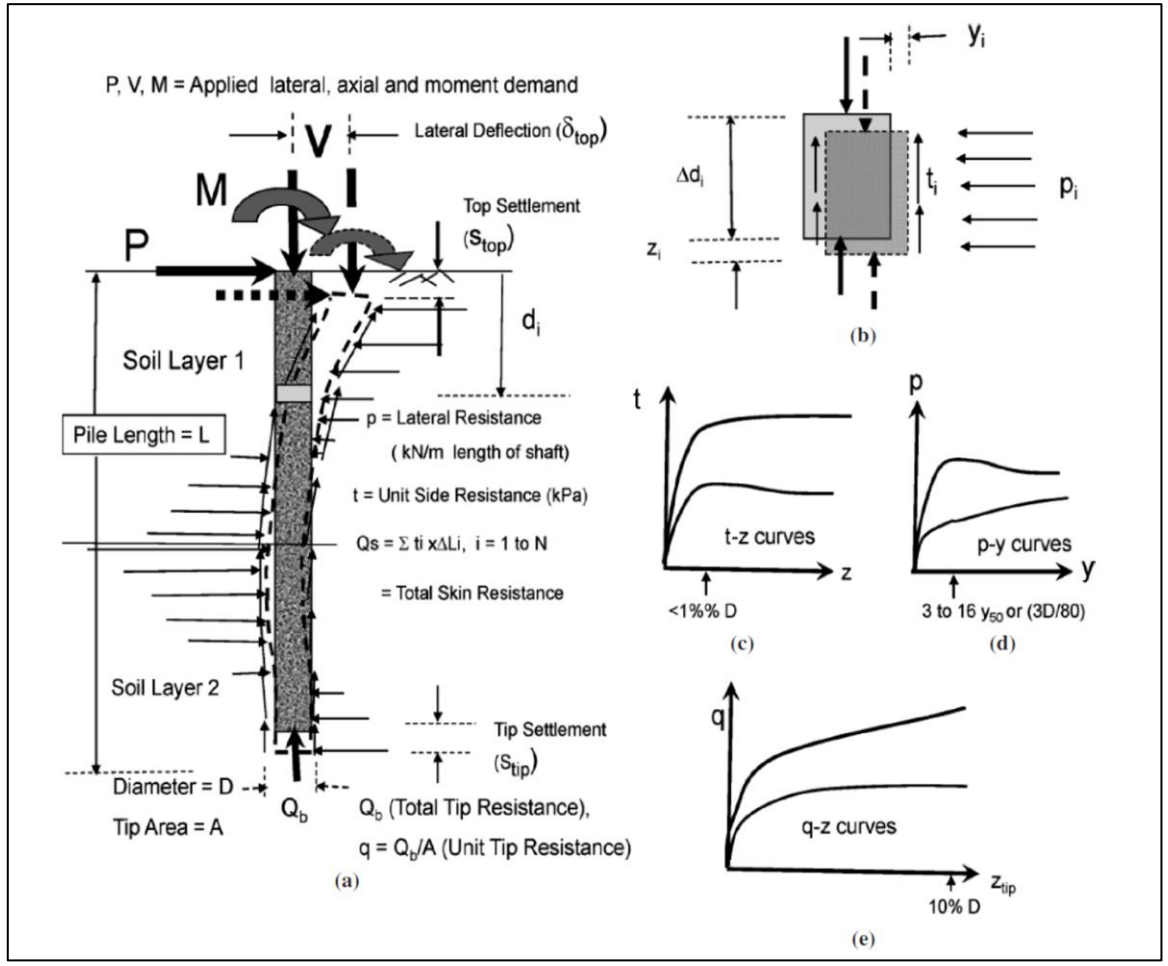
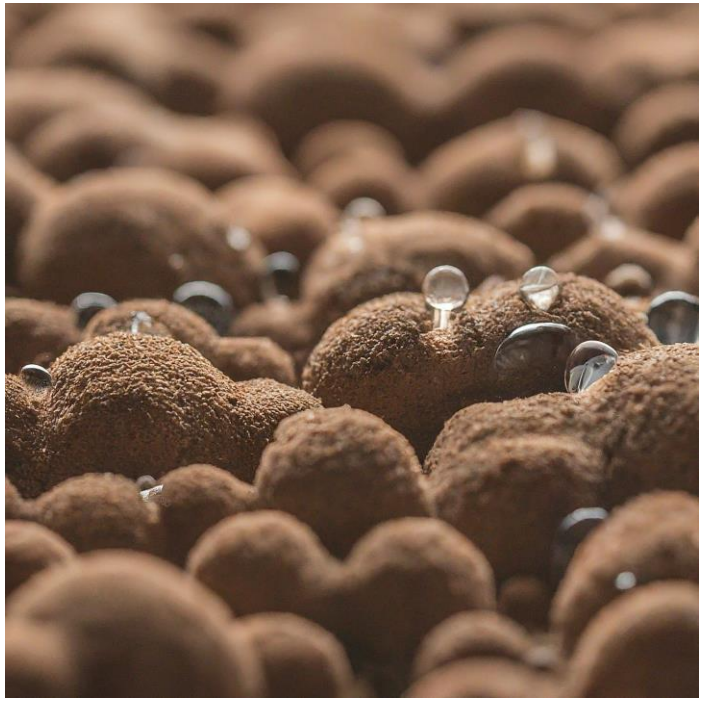


Image Source: Malek & Islam, 2010

Soil (Seabed) Conditions

- Permeability of the soil can influence the drainage conditions below the seabed
- This could influence the installation depth of suction caisson anchors



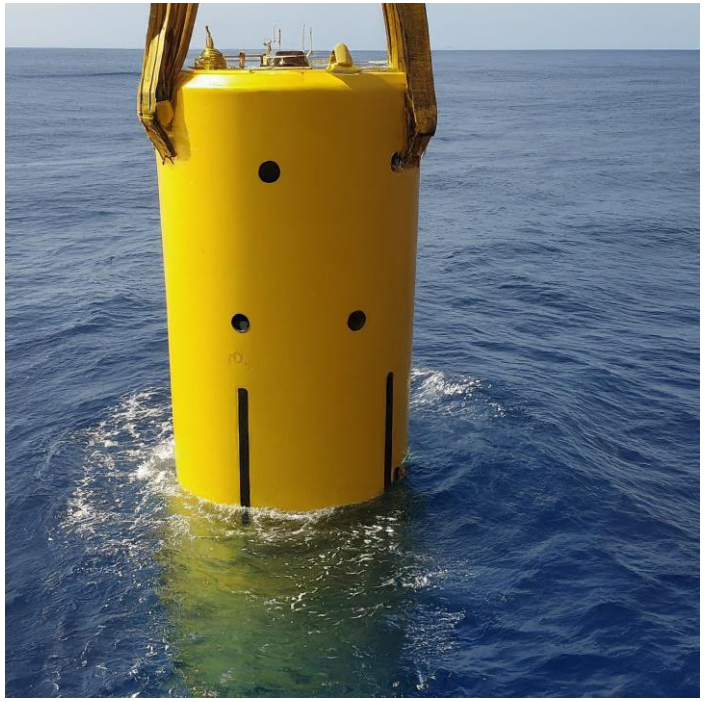


Image Source: Gemini

Anchor Selection

1. Gravity-Base Anchor
2. Pile Anchor
3. Drag-Embedded Anchor
4. Suction-type Anchor
5. Torpedo-Embedded Anchor
6. Anchor Plates

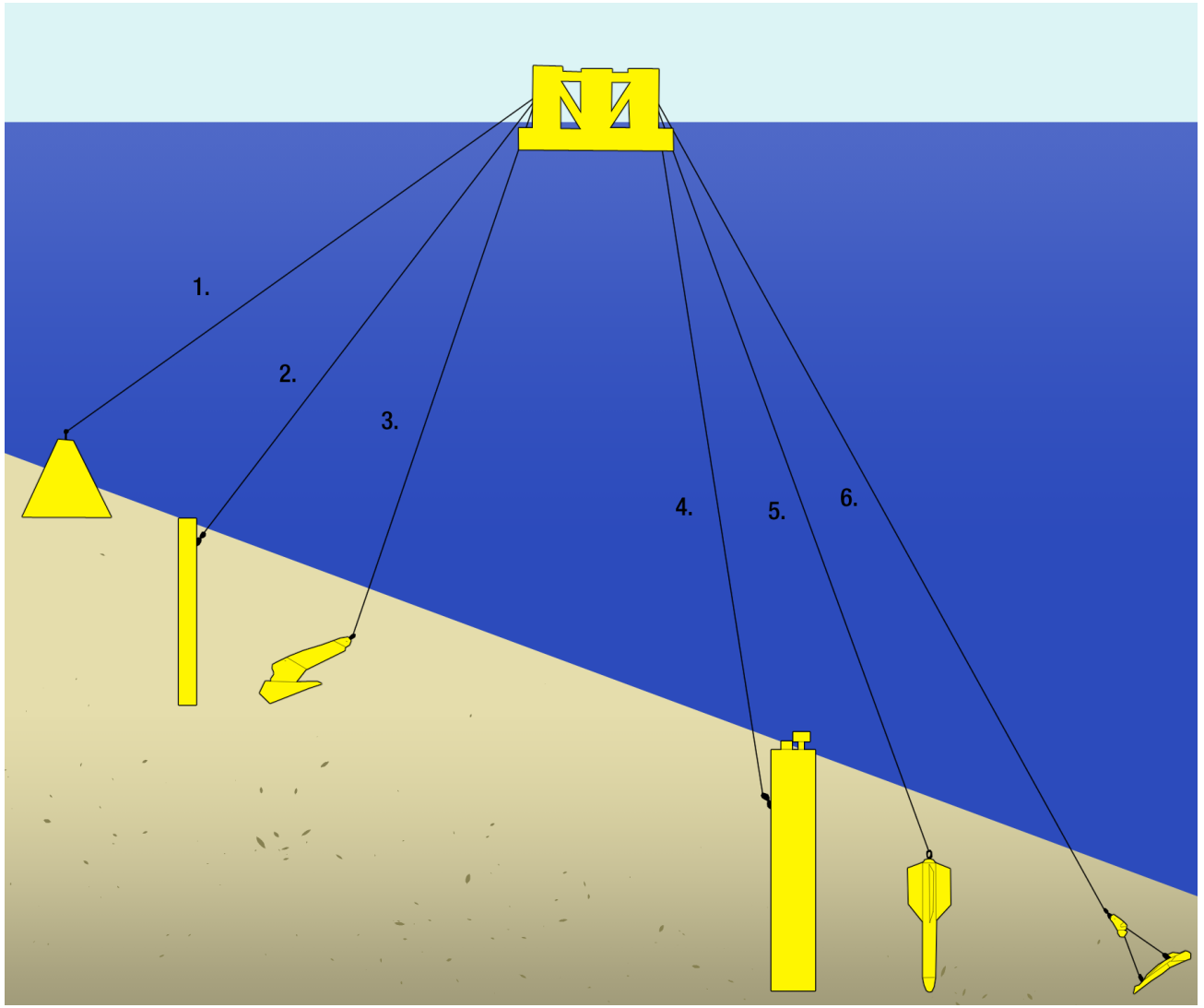


Image Source: Modified from Vryhof, 2018

Anchor Sharing

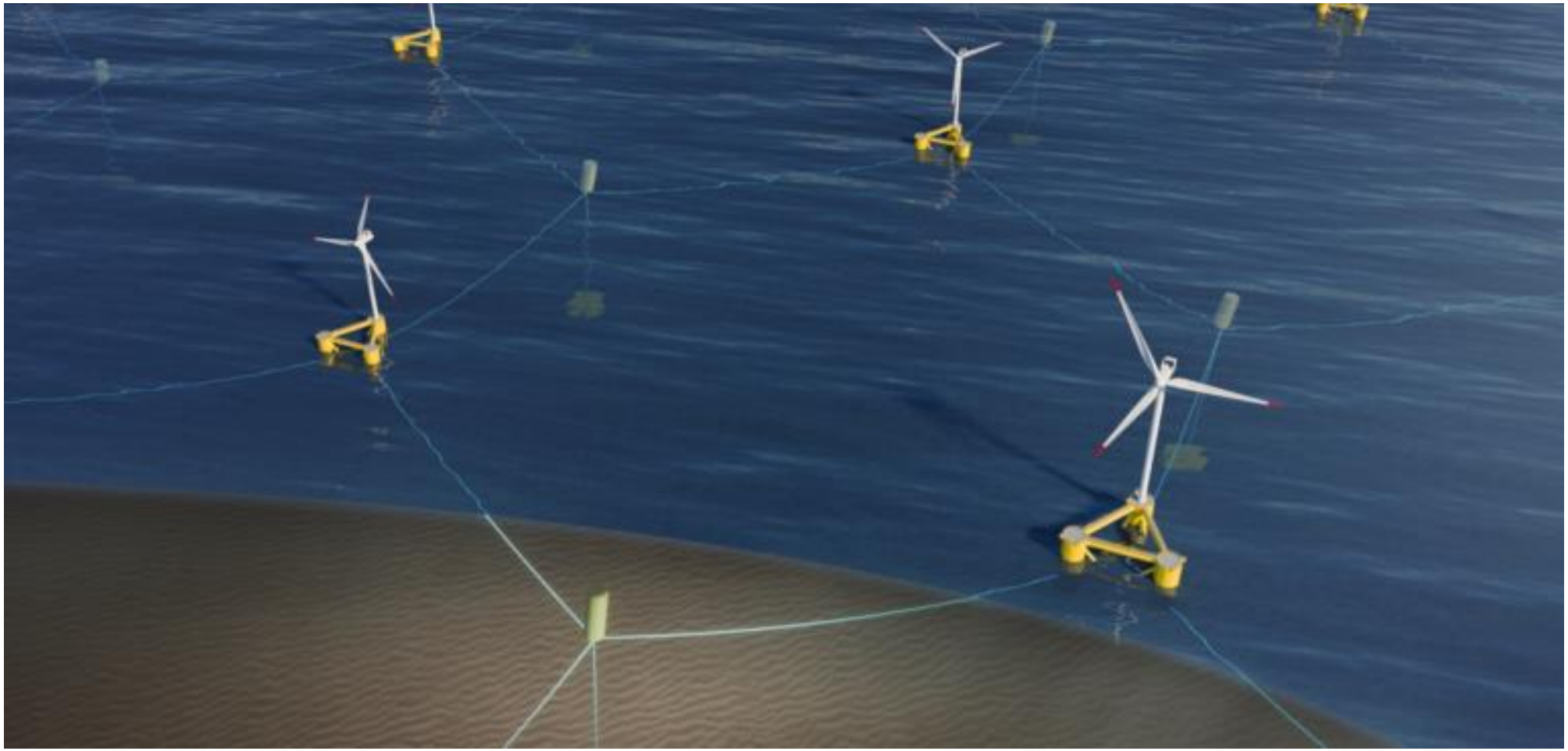


Image Source: Semar AS

Installation Method: Drag Embedded Anchors

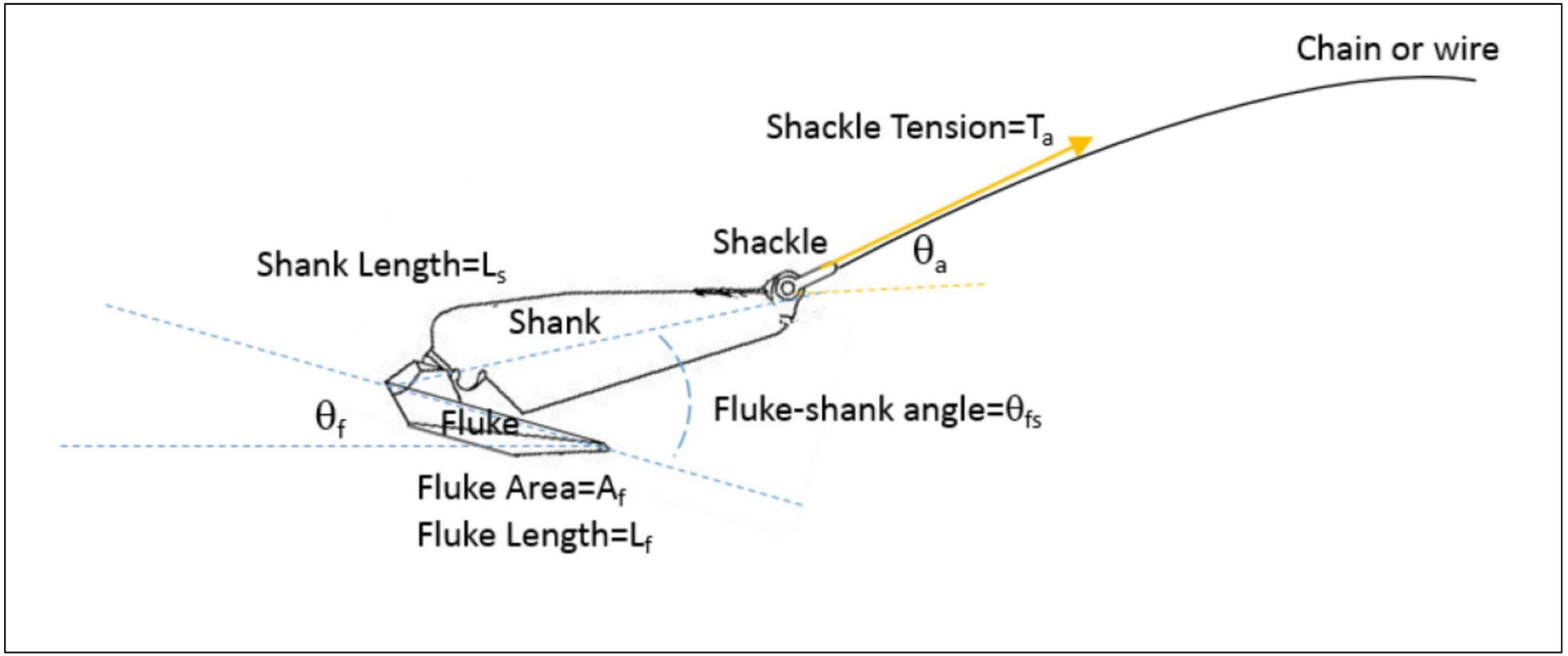


Image Source: ABS, 2017

Installation Method: Anchor Plates - SEPLAs

1. Anchor plate inserted to position using a suction-caisson
2. Suction caisson is withdrawn from the assembly
3. Anchor plate is keyed into position
4. Tension is applied on the anchor plate through the mooring line

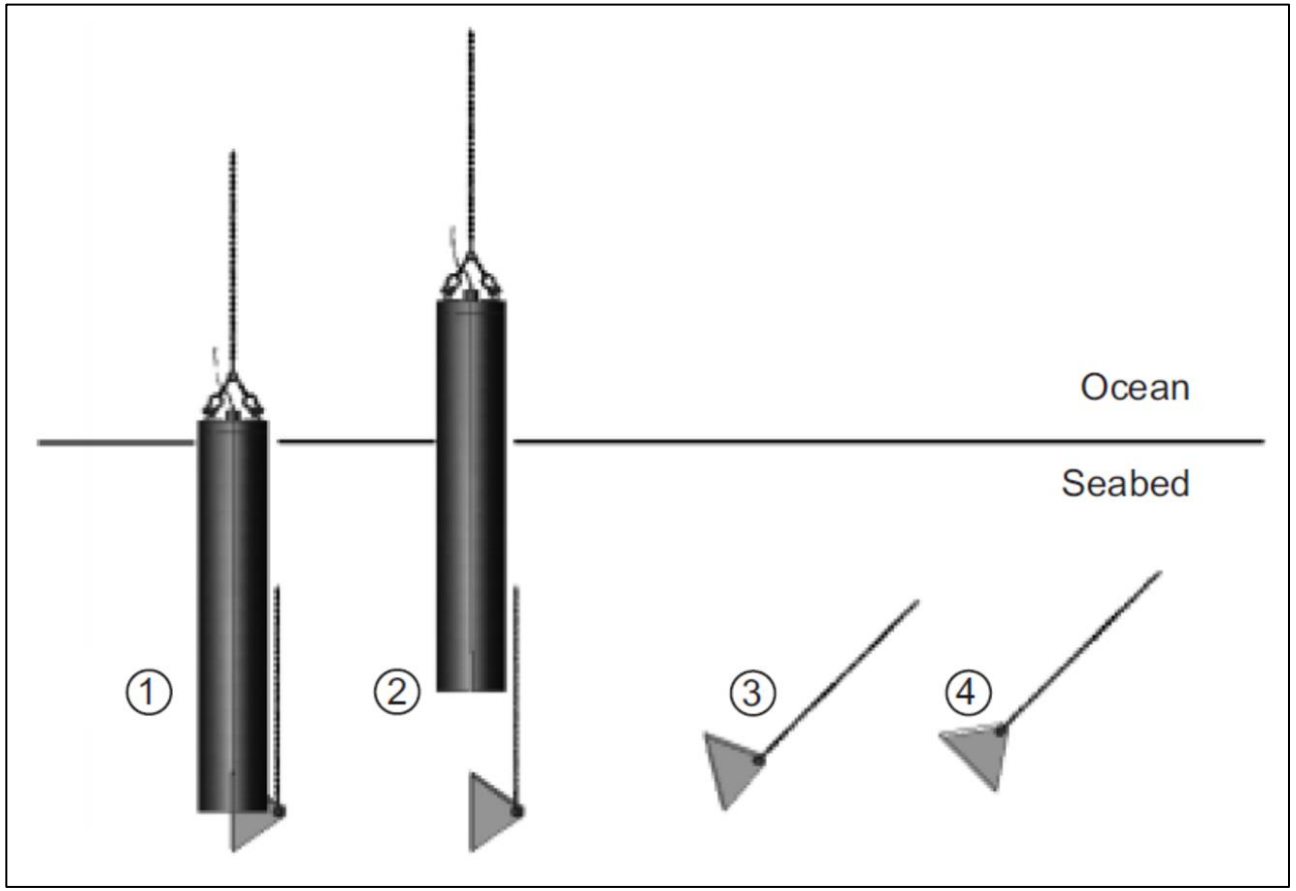


Image Source: Gaudin, 2006

Installation Method: Anchor Plates - DEPLAs

a. DEPLA-follower assembly before installation

b. DEPLA assembly is dropped from the vessel under gravity

c. The follower is withdrawn, and the DEPLA is installed in place and mobilized

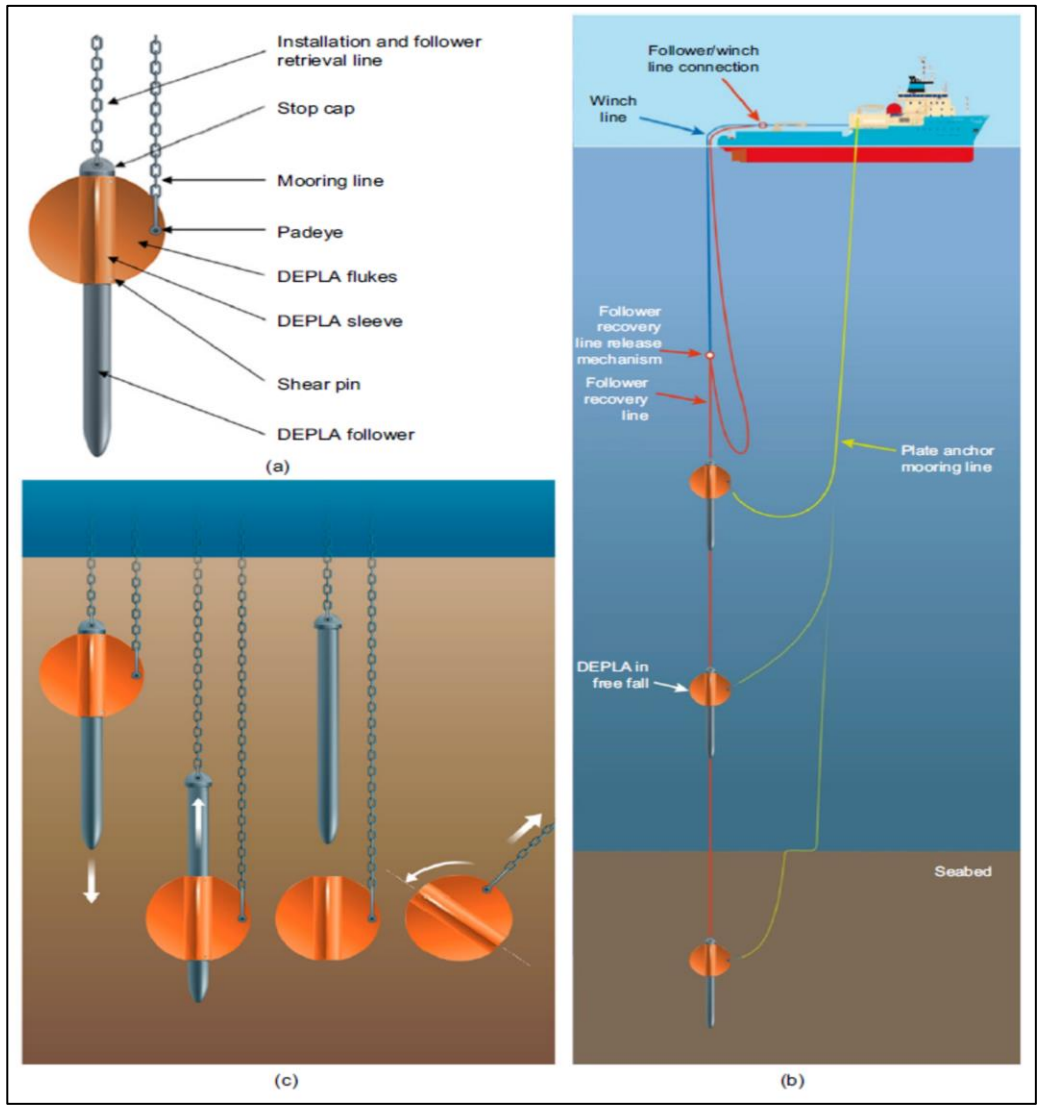
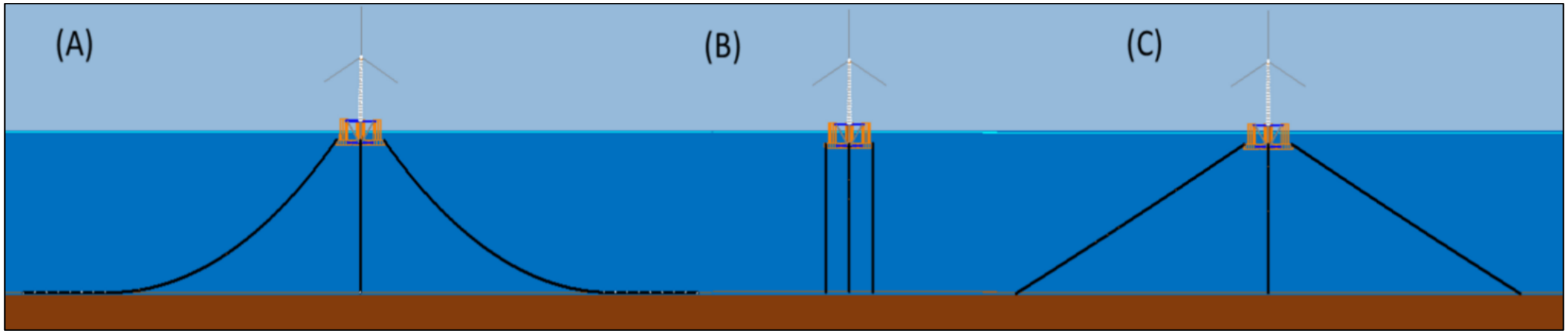


Image Source: O'Loughlin et al., 2016

Installation Method: Common Mooring Configurations



A. Catenary;
B. Tension-leg
C. Taut

Image Source: Yang et al., 2022

Installation Method: FOWT Platforms

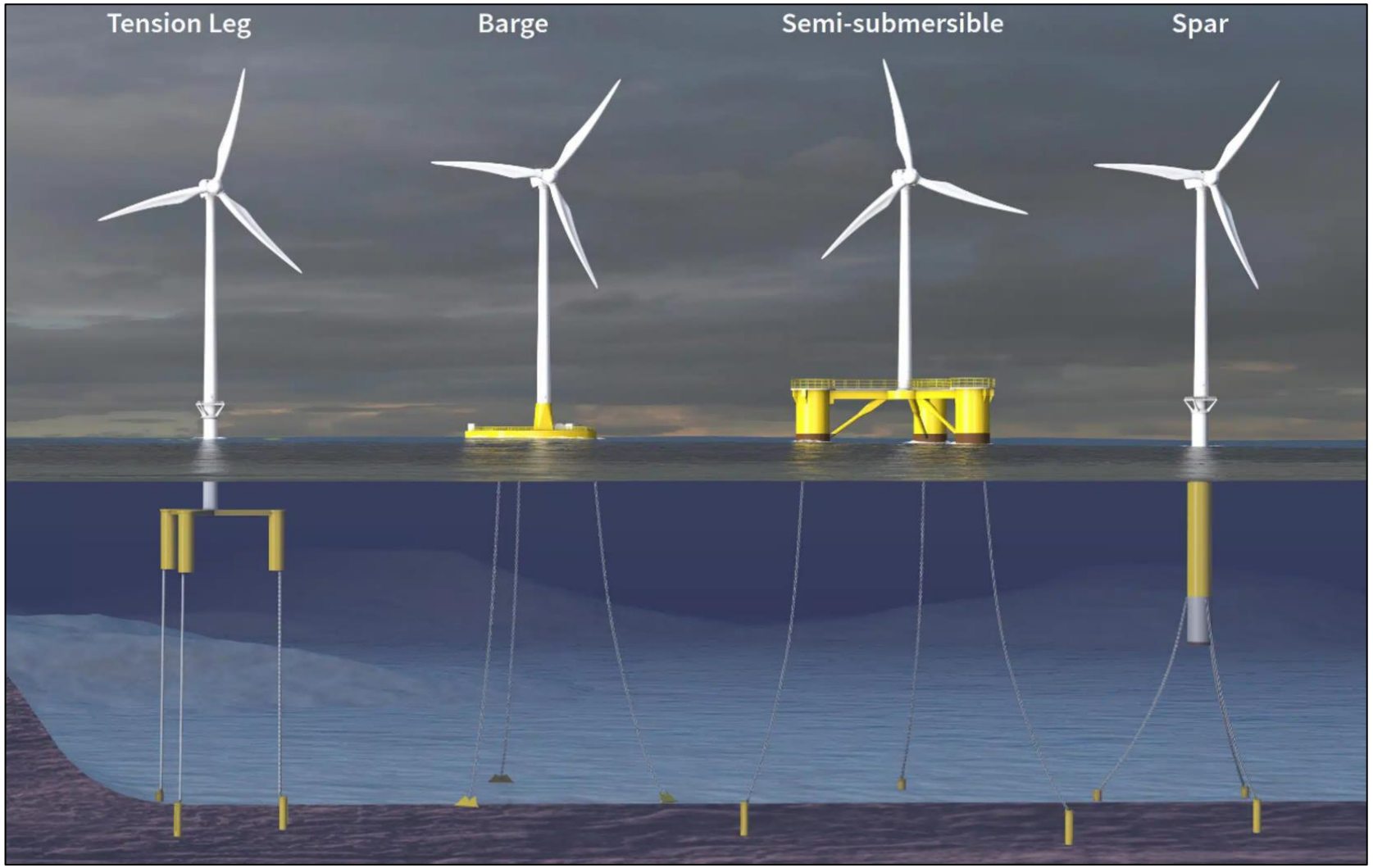


Image Source: Acteon, 2023

Installation Method: FOWT Platforms

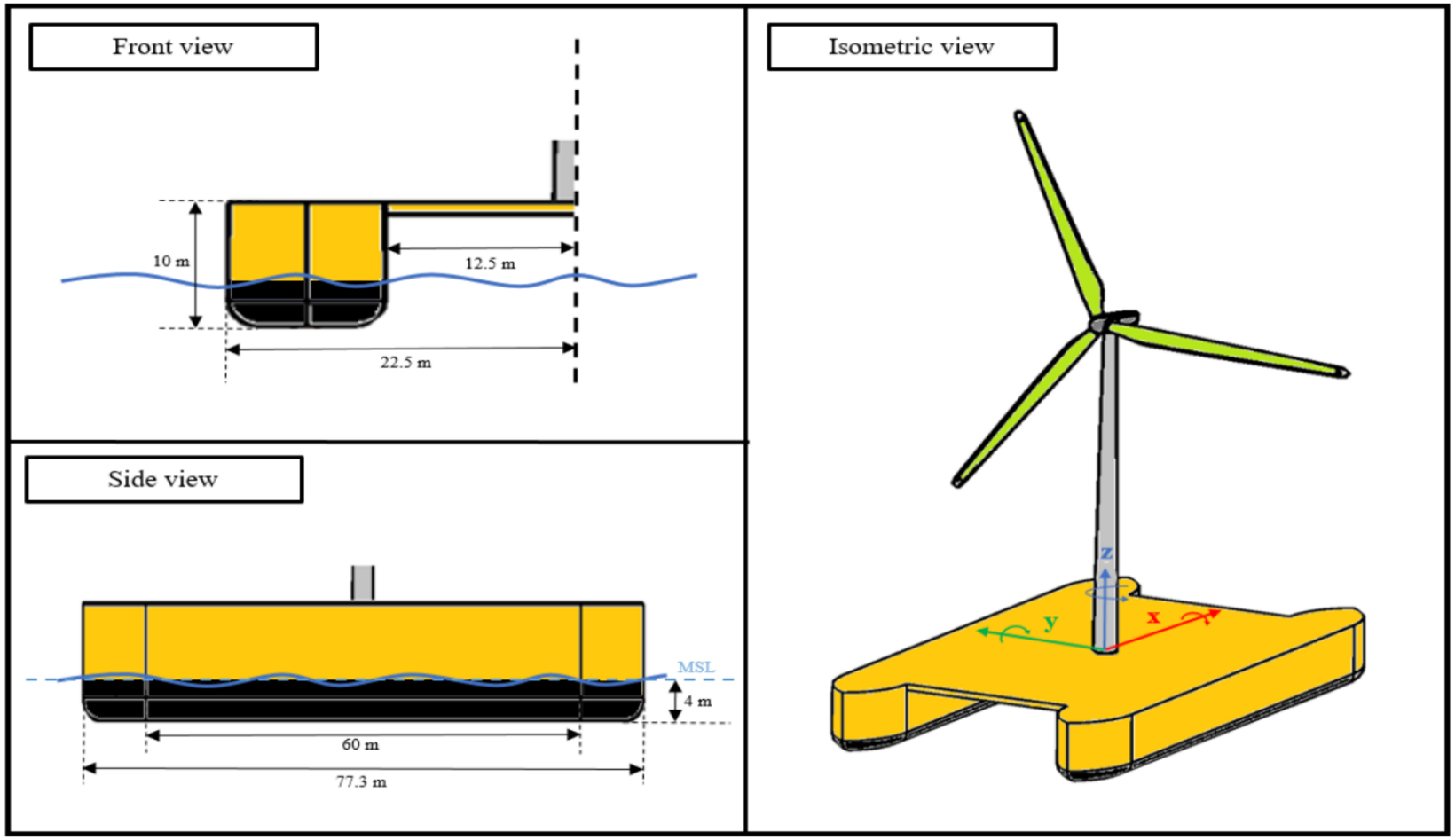


Image Source: Cutler et al., 2022

Monitoring

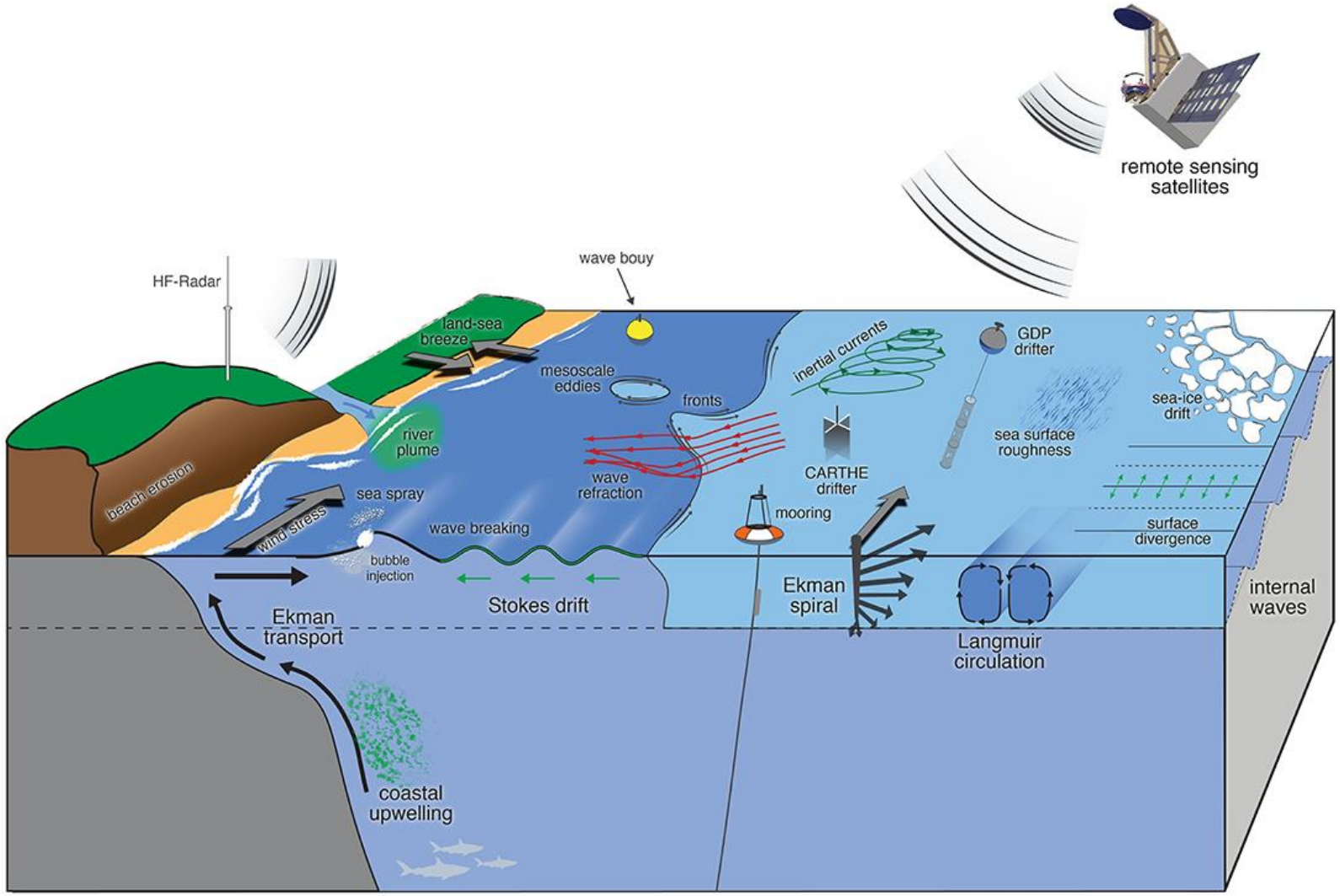


Image Source: Boas et al., 2019

Maintenance & Decommissioning

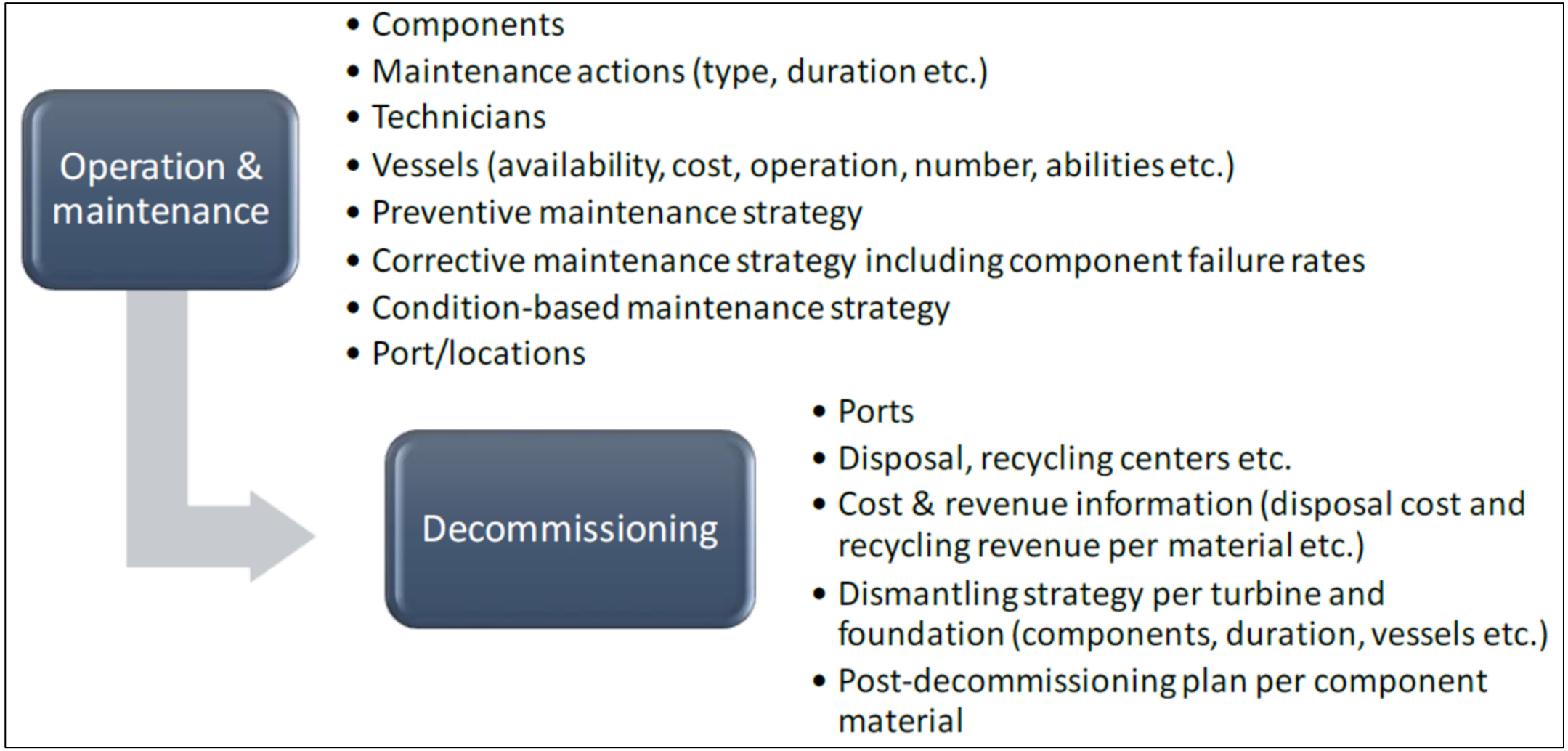


Image Source: Judge et al., 2019

Case Studies

- Hywind Tampen, located in Norway, is one of the largest floating wind farms in the world.
- Its unique location, turbine size, and trailblazing configurations posed several geotechnical challenges

Image Source: Equinor

Case Studies

- Kincardine Offshore Wind Farm can power 35,000 homes in Scotland with a 50MW capacity

Image Source: Principle Power

Case Studies

- The 30 MW Hywind Scotland pilot park, the world's first floating wind farm, has been operational since 2017

Image Source: Equinor (Statoil)

Potential Solutions and Recommendations

Image Source: Damiani & Franchi, 2021

Potential Solutions and Recommendations

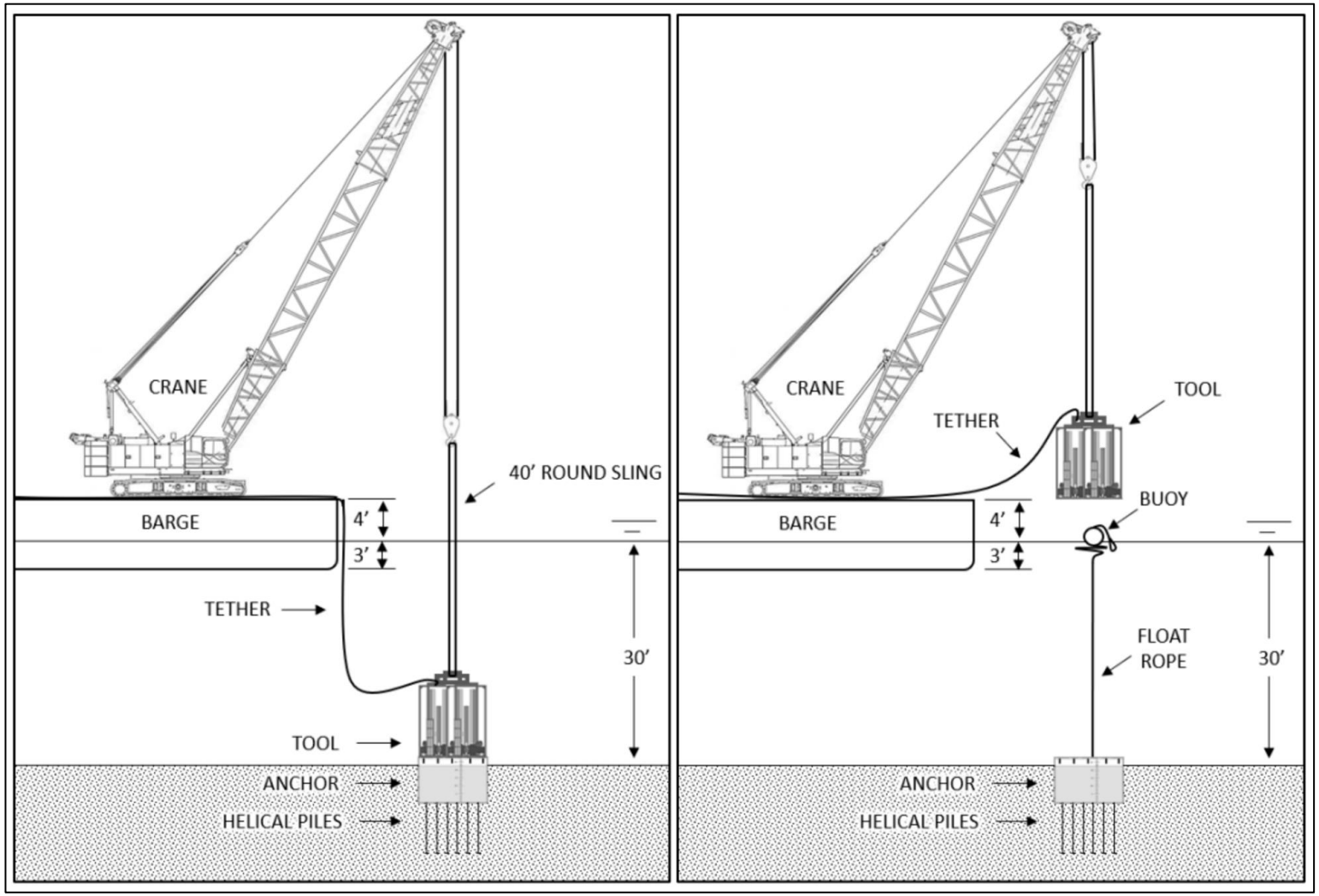


Image Source: NYSERDA, 2023

Conclusion

Image Source: CCI

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Thank you

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