Meeting the Anchoring Challenges for Floating Wind

Tom Fulton, Head of Renewables and Mooring Development

FLOATING WIND SOLUTIONS
From pre-development to decommissioning, we maximise cost efficiencies by providing our customers with all-in-one project support and reducing project footprint while minimising environmental impact.

Our integrated engineering solutions optimise capital and operating expenditure to lower the life-cycle levelised cost of energy, and include large and floating structures.

Our deep domain knowledge leads to innovative nearshore construction installation methods, increased efficiencies and decreased costs.
## Presentation Contents

- Why is anchor selection important?
- Current anchor types for floating wind
- Anchor sizes and weights
- Anchor total installed cost
- New anchor concepts
- Take aways
Why is anchor selection important?

- **Cost of the anchor**
  - Can be 50%+ the cost of a mooring system

- **Installation time**
  - For a commercial scale wind farm can be many months

- **Complexity**
  - Changing seabed conditions across the wind farm
  - Hard bottoms / rock
  - Logistics for large anchors
# Anchor Types for Floating Wind

## Performance of Various Anchor Types in Different Soils and Their Positioning Accuracy

<table>
<thead>
<tr>
<th>Anchor Type</th>
<th>Soil</th>
<th>Vertical Load Capable</th>
<th>Precision/Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Suction embedded plate anchor (SEPLA)</td>
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<tr>
<td>2. Drag VLA</td>
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<td></td>
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<tr>
<td>3. Drag anchor</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. Suction anchor</td>
<td></td>
<td></td>
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<tr>
<td>5. Unven anchor</td>
<td></td>
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<tr>
<td>6. Drilled and grouted anchor</td>
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<tr>
<td>7. Gravity (clump weight)</td>
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Many variables are taken into consideration when choosing anchoring options, including:

- soil and geotechnical properties
- required precision of the embedment location
- installation vessel capabilities
- type of asset and mooring system
- metocean conditions and environmental regulations
- cost and availability of mooring components.
Case Study
Parameters

Anchors studied:

- Drag anchors
- Suction anchors
- Suction Embedded Plate Anchors (SEPLAs)
- Driven piles
- Drilled and grouted piles
- Gravity anchors

Anchor load: 1,000mt at 25°

- Except drag anchors – no angle

Soil type: Medium clay

- Except drilled pile - rock
Size and weight comparison

Drag Anchor
7.3m x 6.6m

- Drag anchor: 20 metric tons
- SEPLA
- Drilled Pile
- Driven Pile
- Suction Anchor
- Gravity Anchor

Weight (metric tons)

Floating Wind Solutions
Size and weight comparison

- Drag anchor: 20 metric tons
- SEPLA: 46 metric tons
- Drilled Pile
- Driven Pile
- Suction Anchor
- Gravity Anchor

SEPLA 10m x 5m

Floating Wind Solutions
Size and weight comparison

Drilled Pile
3m dia x 20m

Gravity Anchor
Suction Anchor
Driven Pile
SEPLA
Drag anchor

Weight (metric tons)

0 200 400 600 800 1000

Floating Wind Solutions
Size and weight comparison

Suction Anchor
5m dia x 27m

Drag anchor
20

SEPLA
46

Drilled Pile
70

Driven Pile

Suction Anchor
162

Gravity Anchor

Weight (metric tons)

Floating Wind Solutions
Size and weight comparison

Driven Pile
2m dia x 56m

Weight (metric tons)

- Drag anchor: 20
- SEPLA: 46
- Drilled Pile: 70
- Driven Pile: 124
- Suction Anchor: 162
- Gravity Anchor:

Floating Wind Solutions

The Marriott Marquis, Houston  1-3 March 2022
Size and weight comparison

Gravity Anchor 18m dia x 9m

- Drag anchor: 20 metric tons
- SEPLA: 46 metric tons
- Drilled Pile: 70 metric tons
- Driven Pile: 124 metric tons
- Suction Anchor: 162 metric tons
- Gravity Anchor: 904 metric tons
How many fit on a 40m x 20m deck?
How many fit on a 40m x 20m deck?

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<tr>
<td>SEPLA</td>
<td>7</td>
</tr>
<tr>
<td>Drilled pile</td>
<td>5</td>
</tr>
<tr>
<td>Driven pile</td>
<td>4</td>
</tr>
<tr>
<td>Suction anchor</td>
<td>3</td>
</tr>
<tr>
<td>Gravity anchor</td>
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Floating Wind Solutions
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Installation Time for 150 anchors (days)

- Installation can take a considerable amount of time
- Depends greatly on:
  - Distance from port
  - Anchor size
  - Vessel deck space
  - Can anchors be transported and transferred by supply vessels?
  - Can anchor be towed?

FWS
The Marriott Marquis, Houston 1-3 March 2022
Total Costs for 150 anchors

Main assumptions:
- Use for comparative purposes only!
- No base port costs included
- No engineering included
- Cost assumes 1 non-stop installation campaign
- Site 100mn from base port

Drag Anchor

SEPLA

Driven Pile

Suction Anchor

Drilled Pile

Gravity Anchor

$0  $50  $100  $150  $200

Millions

Procurement  Installation
Total Costs for 150 anchors

**SOME COMMENTS**

- Drag anchor tensioning needs subsea tensioner (such as Bruce tension) and temporary reaction anchor
- Drag anchors cannot withstand vertical loading (some allowed in soft clays)
- Drag anchors, SEPLAs, and Suction Anchors are recoverable
- Drilled and driven piles have installation noise
- Gravity anchors cost can vary significantly due to materials used and volume needed for ballast
New Anchor Concepts

- Subsea micropiles (drilled)
- Triton Systems Helical Anchor Group Installation System (HAGIS) – rotation
- Texas A&M Deeply Embedded Ring Anchor (DERA) – (suction/driven)
- Oceanetics/Aubin Liquid Anchor (gravity anchor with dense liquid)
- Olav Olsen AS OO Anchor (vibratory embedded)
Anchor selection is important!

- Study options early
- Driven by local seabed conditions

More than one anchor type could be efficient across a wind farm

Make sure design, procurement, installation and risk are all considered

Logistics is critical due to space constraints and time

Anchors are a significant portion of overall mooring cost
For any questions, please contact:

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