Floating Wind Ports & Vessels - Inspiring Innovation

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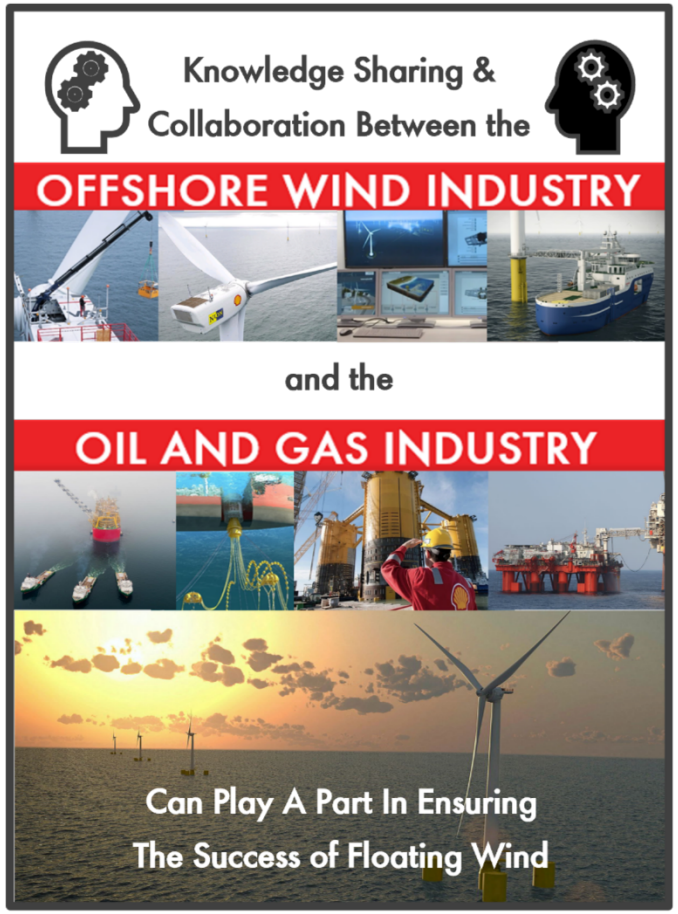
- For Offshore Floating Wind to be the success story which it shall be, Wind Developers, OEMs, Ports, Vessel Owners, and other key local, regional, regulatory, government stakeholders must collaborate and work together to solve many of the challenges which lie ahead
- Embracing a balance of new ideas/ ways of working, combined with established knowledge and lessons learned from the Deepwater Oil & Gas Industry should enable the Offshore Floating Wind Industry to build on scale beyond the current R&D sized developments delivered to date
- Moving to commercial scale floating wind parks, i.e. 100+ FOWT ("Floating Offshore Wind Turbines") will not be without its challenges, with the associated supply chain and logistics likely requiring development from the ground up in order to support the sheer scale of Floating Wind
- Offshore Floating Wind's challenges will hopefully **"Inspire Innovation"**



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- Ports will need to be built or redeveloped which have the capabilities required to support the full lifecycle of a commercial scale floating wind developments, which may potentially include spanning pre-staging, construction, assembly, storage, commissioning, O&M, and much longer down the road refurbishment and/or decommissioning of FOWTs.
- Port development will very likely involve building of new quayside facilities, in port/ away from port laydown yards, warehousing, storage, road & rail connections, berth and channel dredging, upgraded or new core supporting infrastructure (i.e. - power, water, fuel, communications, etc)
- Port facilities will need to be scaled properly to ensure that they can accommodate sheer size of the FLU ("Floating Unit a.k.a. Floater"), FOWT ("FLU with WTG erected on it"), WTG ("Wind Turbine Generator") and crane(s) required to support assembly, as well as accommodate the sheer scale/ volume of all the other supporting materials/ kit as required for ultimately installation of the FOWT in the field, namely cables and anchors/ moorings
- FOWT will likely leave ports assembled in whole for installation in the field. As such, port facilities will ideally be in locations with no limitations relating to under keel draft, beam, or air draft above (i.e. - deep berths/ channels and with no bridge restrictions).

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For general insight, below is the approx. space required for 1GW FLU Fabrication (for 1GW) and associated sample floater characteristics

ITEMS	REQUIREMENTS
Quay for unloading FLU components	160 to 200 m length - 8 to 12 m depth - 6 T/sqm load bearing
Assembly storage area	8 to 12 Ha at 5T/sqm
Construction surfaces	12 to 20 Ha at 15T/Sqm
Grounding surface	1 Ha per FLU
Launch area	100 to 150 m – 30 to 35T/sqm
Commissioning platform	100 to 150 m - 8 to 12 m depth – 6T/sqm

	STEEL (TRIANGULAR)	CONCRETE (TRIANGULAR)
LENGTH	90.00 m	90.00 m
WIDTH	83.00 m	83.00 m
HEIGHT	30.00 m	30.00 m
WEIGHT (DRY)	4000 T	20000 T
DRAFT FLOATER ONLY	7.00 m	10.00 m
DRAFT WTG INSTALLED	10.00 m	13.00 m
CONTACT POINTS	3 columns (1 each on each angle of the triangle) – Approx diam 10 m	All the floater surface (including the pontoons connecting the 3 columns (1 each on each angle of the triangle – Approx diam 20 m) will be in contact with the soil

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For general insight, below are the potential requirements for a FOWT Integration Yard (FLU + Tower + WTG):

- Space for "parking" up to 20 FLU outside the harbour or nearby (max 10 nm distance)
- Capable of supporting integration of one complete FOWT per week
- Water depth min >12 m and with no air draft restrictions
- Quayside length for WTG integration min: 300m at 15 t/sqm
- Lay down area min: 200,000 – 300,000 m2
- Bearing and place for min PTC200 Mammoet crane: bearing 25 ton/m^2 (there are solutions to reduce this requirement), built up area 150 m x 50 m (diameter crane base is min 45 m)
- Depending on project planning 2 to 4 commissioning slots will be required (250 m flat quayside each)
- A second crane would be needed for WTG integration activities, depending on project planning (requiring an additional of 250m flat quayside)

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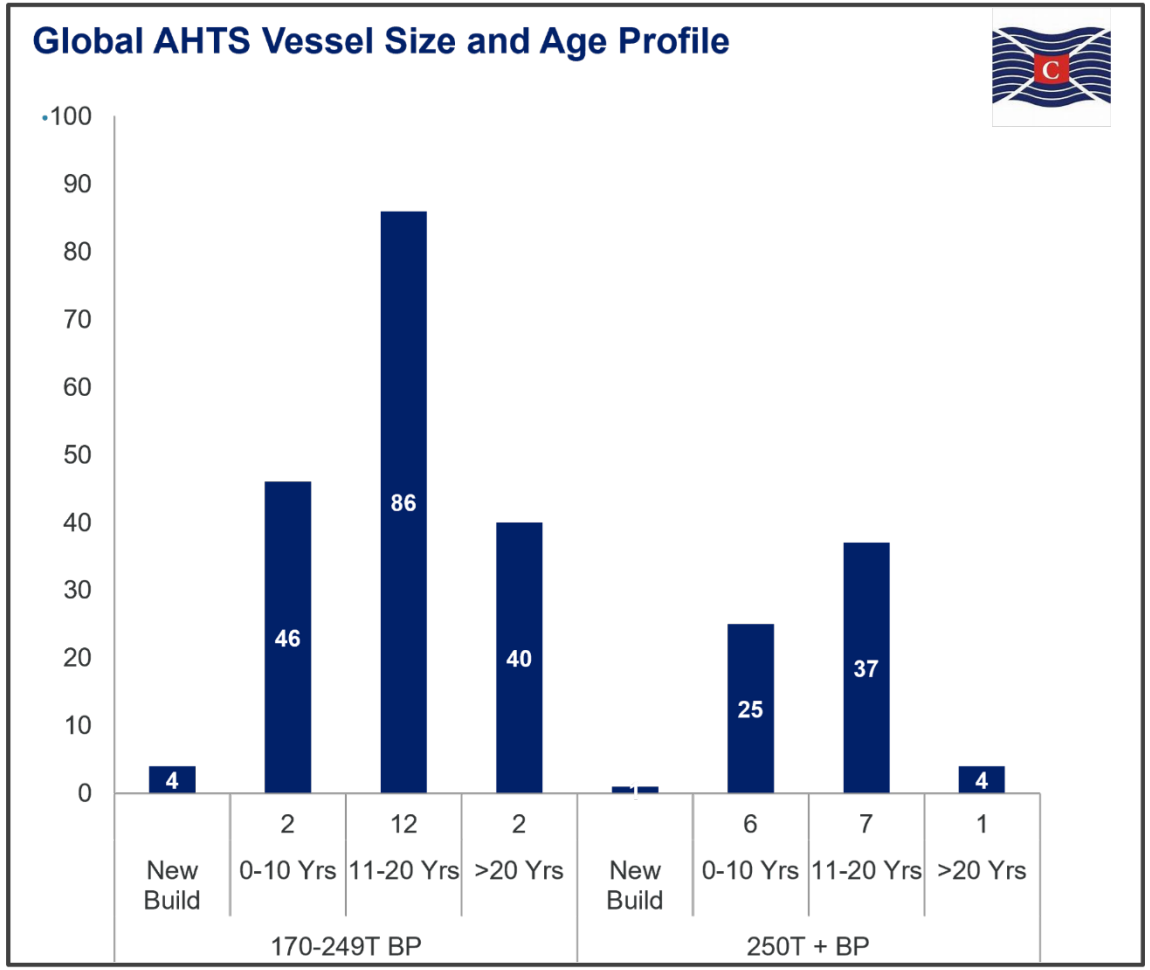
- New vessels will be required to ensure the operational tempo is maintained of offshore floating wind developments
- Such new vessels will likely be equipped with capabilities differing from and/or exceeding those inherent within the current Offshore Support Vessel (OSV) fleet, i.e. Anchor Handling Tugs ("AHTs"), Service Operations Vessels ("SOVs"), etc
- AHTs are particularly ripe for further development and evolution, perhaps most notably given the limited number of such vessels, the age of this fleet, and for many their capability/ capacity limitations
- At present the green credentials of the global AHT are currently lacking, with only a single AHT (Maersk Supply Services) committed to be equipped for lower emissions operations employing a hybrid battery energy storage system



Source: Clarksons Platou Offshore; Clarksons Research; "Top Owners" are the top 16 by total AHTS fleet size

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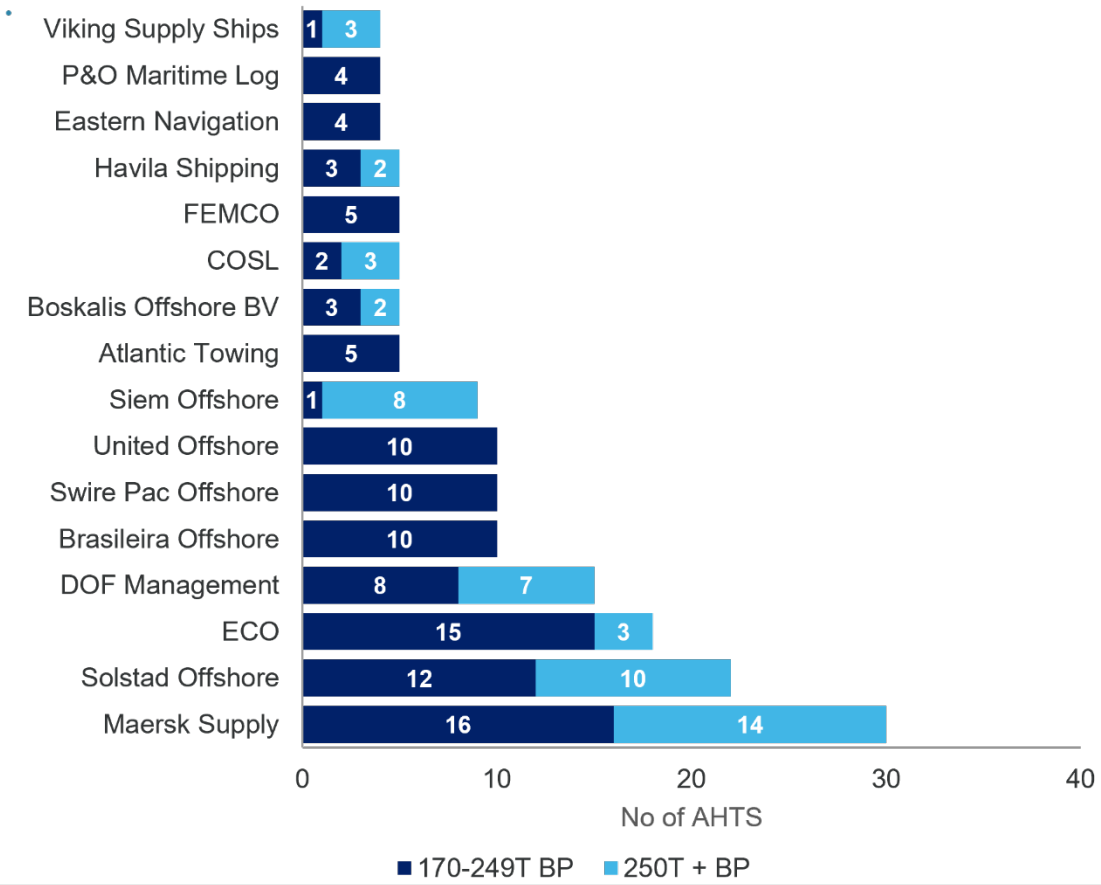
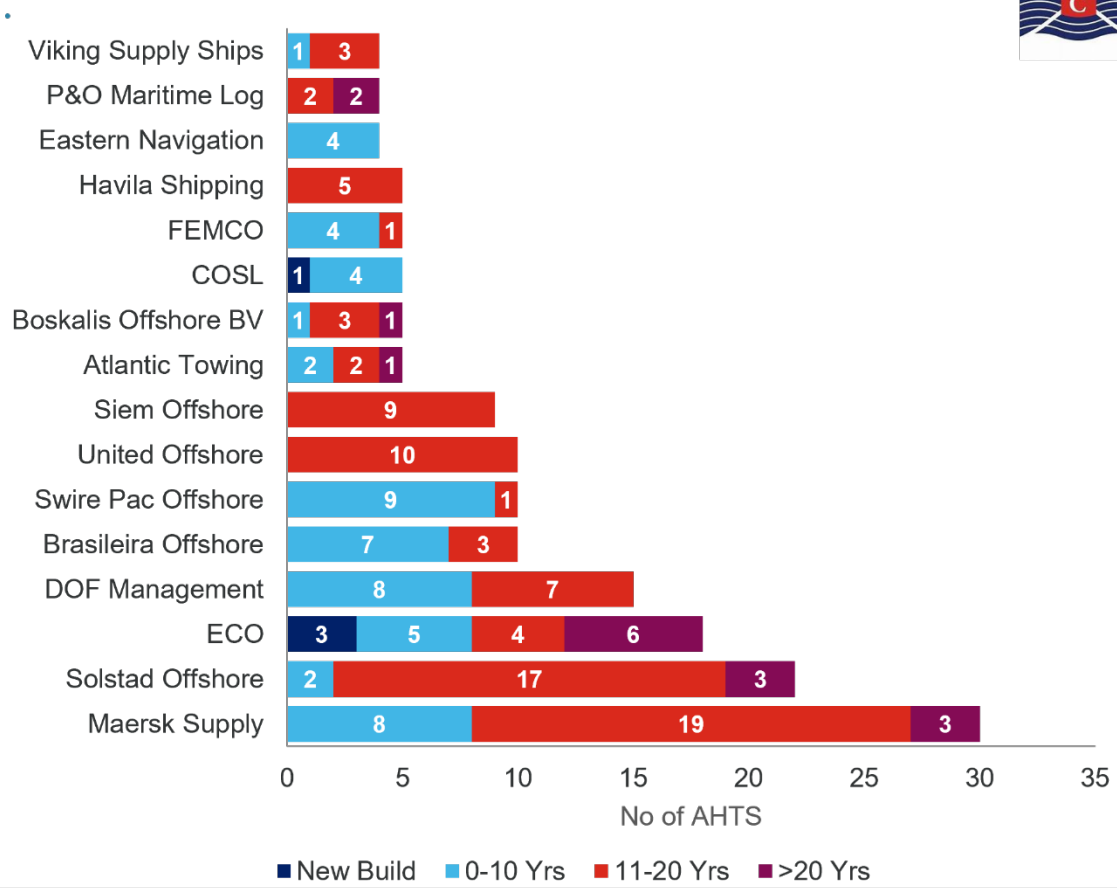
Below is an overview of the Top 16 global AHT Owners – *Note Fleet Limitations*

AHT by Owner by Size



AHT by Owner by Age Profile



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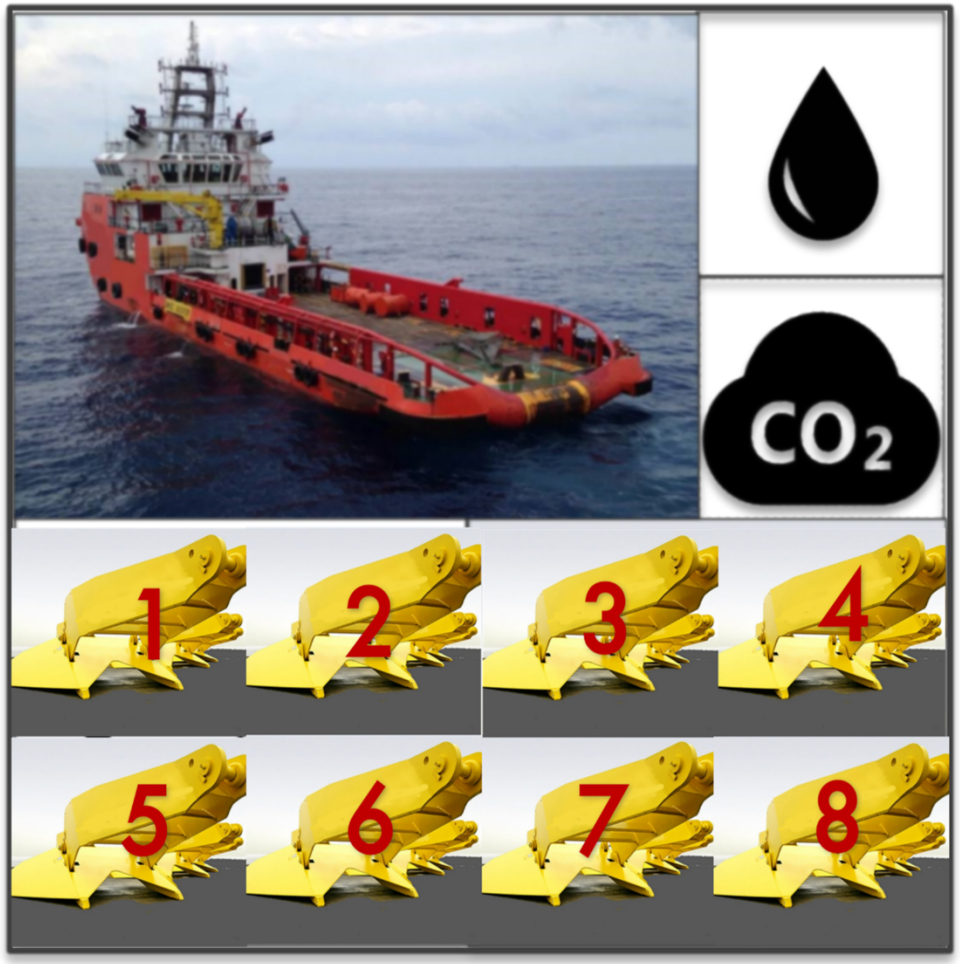
What is the Potential Impact of an AHT?



Approximately how much time does AHT pre-lay potentially take?

Assuming 8 anchors per trip

- 12 hrs mob in port
- 12 hrs transit to location
- 48 hrs for pre-lay (assume 6 hrs per anchor/line)
- 12 hrs transit back to port

Total Est. Time: 84 hrs or ~ 3½ days per round trip

What is the average potential fuel consumption?

- 0.75 MT during mobilization
- 5.5 MT during transit to location
- 50 MT during pre-lay activities
- 5.5 MT during transit back to port

Total Est. Fuel Consumption: ~61.75 MT per round trip

Based on the above, the potential CO2 footprint could be:

Assuming 1 mt fuel generates approx. 3.179 MT CO2

Total Est. CO2: ~196.3 MT per round trip

Source: Clarksons Platou Offshore

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High Level Overview Of AHT Employed During Pre-lay For Commercial Scale Offshore Floating Wind Development

If assuming installation of anchor/lines for 100 FOWTs (6 each) then potentially:

- A single 250T BP AHT may need to be on hire for roughly 262.5 days or 75 round trips (assumes no delays and perfect weather)
- Roughly~4,600 MT of MGO may need to be purchase to fuel this AHT
- This AHT may generate approx. ~14,700 MT of CO2 during pre-lay activities

If on the West Coast USA, the hire of an AHT to support pre-lay potentially translates into:

- Day Rate: Est. + ~$4.8M+- ($65K per day – only 3 Jones Act AHTs available)
- Fuel: Est. ~$4.2M+- ($900 per MT of MGO – Current LA pricing)
- CO2: Yet to be determined
- Total Potential Pre-lay Cost: Circa~$10M +- per every 100 FOWT

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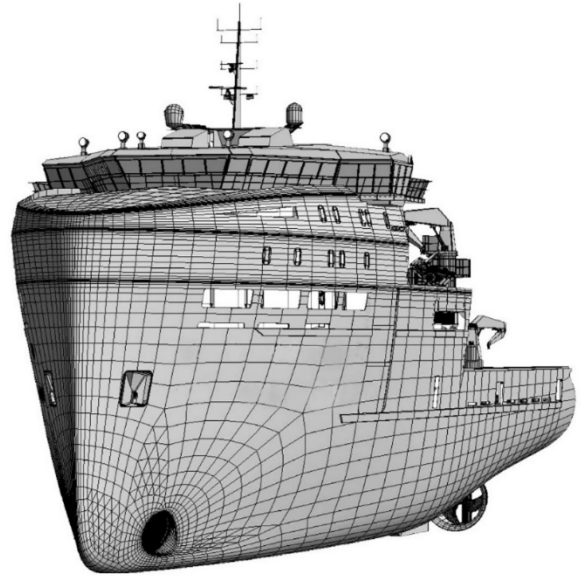
Look to the Future – General Thoughts Regarding AHTs Supporting Offshore Floating Wind

- AHTs should be equipped today to reduce their CO2 emissions and in future to eliminate their CO2 emissions
- Potential measures available today to help AHTs reduce their emissions include but are not limited to lower emissions fuels like biodiesel and methanol, in-port charging (cold-ironing), onboard battery energy storage solutions (BESS), and IoT based Vessel Performance Optimisation (VPO) solutions
- In future new zero emissions fuels and technologies such as H2, related fuel cells and offshore charging may potentially allow for net zero AHT operations
- Consideration should perhaps be made regarding the sizing of future newbuild AHTs, i.e. designing and equipping them with larger decks capable of carriage of a greater number of anchors/lines in order to minimize trips to shore and CO2.
- Should the offshore floating wind industry perhaps consider an alternative approach to AHTs, perhaps a new class of higher operability multi-role vessels purposed designed to supporting floating wind installation, commissioning, and O&M?
- Is a new class of Multi-Missions Support Vessel perhaps needed?



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Anchors & Lines, Anchors & Lines, Anchors & Lines.... New Records To Be Set

- The mooring anchor/line needs of the Offshore Floating Wind industry well exceed those of the Oil & Gas industry
- This manufacturing, storage, staging and transport of anchors and lines could potentially present monumental challenge for the Offshore Floating Wind industry as it seeks to scale up
- Oil & Gas offshore facilities on their largest scale required somewhere between 12 and 24+- anchors/lines, while a commercial scale floating wind development of 100 FOWT may potentially require between 300 to 600 anchors/lines (assumes 3 to 8 anchors/lines for each FOWT depending upon the design)
- The estimated space required for storage of anchors/lines for a 100 FOWT development could potentially range upwards~37,500 to 80,000 sqm
- Where are these new anchor manufacturing, distribution, storage hubs?
- How will the volume of anchors/lines be managed in the development ports?
- What measures can developers potentially take to reduce or simplify their FOWT anchors/lines?