FLOATING WIND INSTALLATION CHALLENGES

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FLOATING OFFSHORE WIND TURBINE (FOWT) TYPES

FIXED vs FLOATING (ref [1])

Monopile Jacket Tripod Semi-Submersible TLP Spar

Crossover from fixed to floating is 60m to 80m water depth

Criteria:
- WTIV 60m plus
- Substructure cost
- Maintenance cost

Note that the wind turbine generator (WTG) is the same whether fixed or floating

BARGE TYPES (ref [2])

Concrete
Damping barge
3 Blades
2MW
France

Built on pontoon
Float off in dry dock

Land based crane
for topsides

Steel
Damping barge
2 Blades
3MW
Japan

Built in drydock

Floating crane
for topsides

OTHER FOWT OPTIONS

MULTI TURBINE
ON SEMI SUBMERSIBLE
SUBSTRUCTURE
(Ref [3])

SUSPENDED BALLAST WEIGHT
NEEDS OFFSHORE CRANE VESSEL

(Ref [4])

WATER DEPTHS

FIXED BOTTOM VS FLOATING WIND (T-A)

	Water Depth (m)		
	Lower	Upper	Possible
Wind turbine installation vessel (WTIV) waterdepth limit 60m, but new vessels will be 80m			
Fixed Monopile	0	20	
Fixed Tripod	15	30	40
Fixed jacket	10	60	80
Barge	50	100	125
Semi Submersible	50	250	300
Spar	70	400	500
Suspended ballast	60	300	350
TLP (tension leg platform)	60	300	350

ADVANTAGES AND DISADVANTAGES DURING CONSTRUCTION AND INSTALLATION

ADVANTAGES-DISADVANTAGES (t-b)

FOWT TYPE	Advantages	Disadvantages
Barge	Water ballast only	Long mooring lines
	Standard anchors	
Semi Submersible	Based on Oil technology	Long mooring lines
	Standard anchors	
	Water ballast only	
Spar	Low motions in tow out	Long mooring lines
	Standard anchors	Needs solid ballast
		Deep water required for inshore construction
		Requires crane vessel to install turbine
		Deep water required for tow to site
TLP (and suspended ballast type)	Short mooring lines	Low intact stability
		Need for temporary buoyancy
		Requires specialised offshore crane vessel

STEEL FOWT WEIGHTS (5MW) (t-c)

		Semi-Sub	Spar	TLP
Material		Steel	Steel	Steel
Substructure weight	t	1,800	1,400	1,000
Solid Ballast	t	0	3,600	0
Water ballast	t	3,700	2,500	0
5MW wind turbine	t	500	500	500
	t	6,000	8,000	1,500

CONSTRUCTION

SUBSTRUCTURE CONSTRUCTION (t-d)

FOWT TYPE	Semi Submersible or Barge	Spar
Comparison of inshore mooring requirements for turbine fit out	Quay moorings	Inshore Moorings - Installation
		> Install mooring chains, anchors, marker buoys
		> Hire fit out barge
		> Add solid ballast to the base of the Spar
		> Pump water ballast into Spar

FOWT STATUS (t-e)

Name	Type	Sub Structure Built	Sub Structure Material	Turbine Outfitting	Final location	Status
Wind float	Semi sub	Spain	Steel	Portugal	Portugal	Operating (3 * 8.4MW)
Wind float	Semi-sub	Spain	Steel	Netherlands	UK (East coast of Scotland)	Under construction (5 * 9.6MW)
Hywind	Spar	Spain	Steel	Norway	UK (East coast of Scotland)	Operating (5 * 6MW)
Hywind	Spar	Norway	Concrete	Norway	Norway	Under construction (11 * 8MW)
Barge	Damping pool	France	Concrete	France	France	Demo (1 * 2MW)
Barge	Damping pool	Japan	Steel	Japan	Japan	Demo (1 * 3MW)

INSHORE vs OFFSHORE WORK (t-f)

FOWT = DO CONSTRUCTION WORK ONSHORE

Item	Work	Port Laydown and storage time	Offshore Installation Operation time
		Based on Barge/Semi-Sub/Spar	
Electrical Cables	Storage	25%	75%
Anchors	Storage	15%	85%
Mooring	Storage	35%	65%
Substructure	Shipyard (land or drydock)	95%	5%
Tower	Inshore fit-out quay	85%	15%
Nacelle	Inshore fit-out quay	80%	20%
Blades	Inshore fit-out quay	80%	20%

TOPSIDE INSTALLATION INSHORE (t-g)

FOWT Type	Semi Submersible	Spar
Topside construction	Large capacity onshore crane lifts topside directly onto the substructure	Complete tower built on land using large capacity onshore crane
Inshore		SSCV lifts turbine off quay and installs turbine tower on to Spar
Alternate inshore	Floating sheer leg crane vessel	

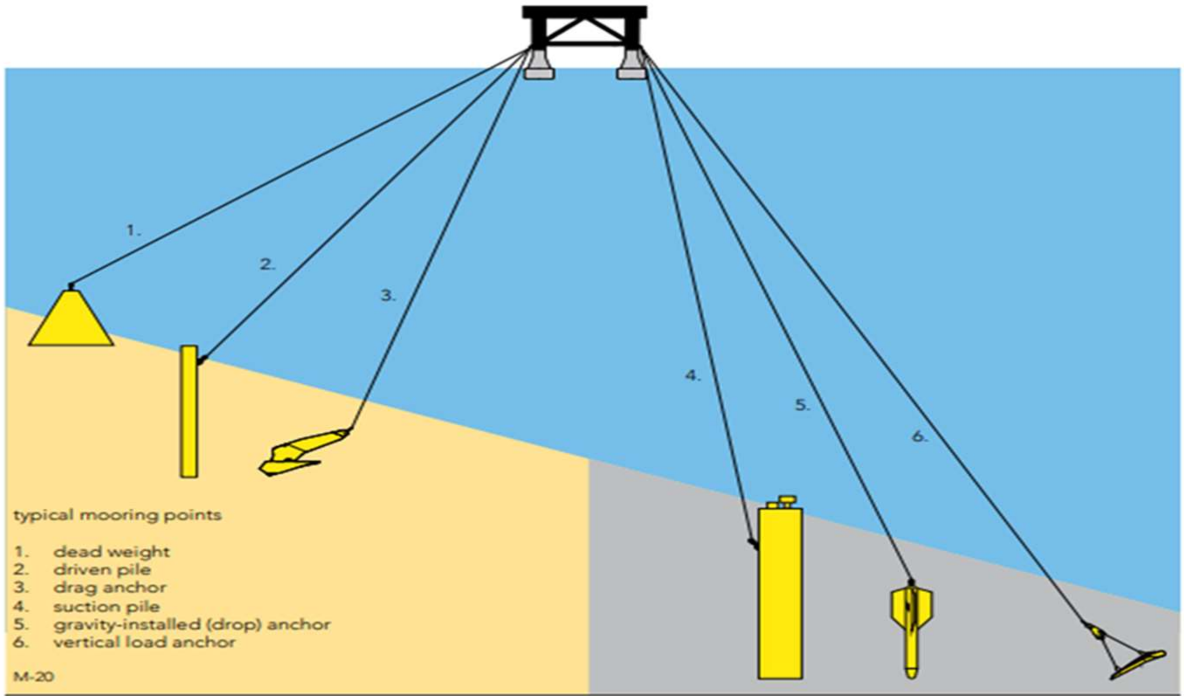
MOORING INSTALLATION

ANCHOR TYPES INSTALLATION (t-h)

Anchor Type	Vessel for anchor	Vessel for mooring line laydown	Advantages	Disadvantages
Gravity-base anchor (dead weight)	Floating crane vessel	AHT	OK for temporary moorings in sheltered waters	Very heavy
Driven pile anchor	Floating crane vessel	AHT	All types	Underwater vibrations
Drag-embedded anchor	AHT	AHT	Very Experienced	Not for TLP
Suction pile	Floating crane vessel	AHT	Some experience	Needs soft/medium soil
Gravity installed drop anchor	AHT	AHT	Lightweight	Limited experience
Vertical loaded anchor	AHT	AHT	Lightweight	Limited experience

ANCHOR TYPES

(Ref[5])



DRAG EMBEDMENT ANCHOR

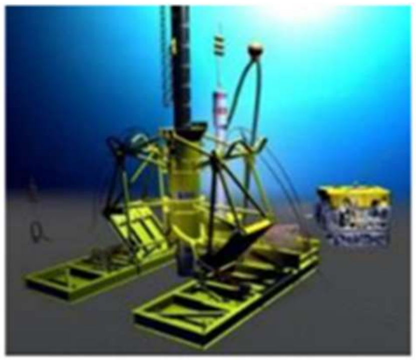
DRAG ANCHOR TENSIONER

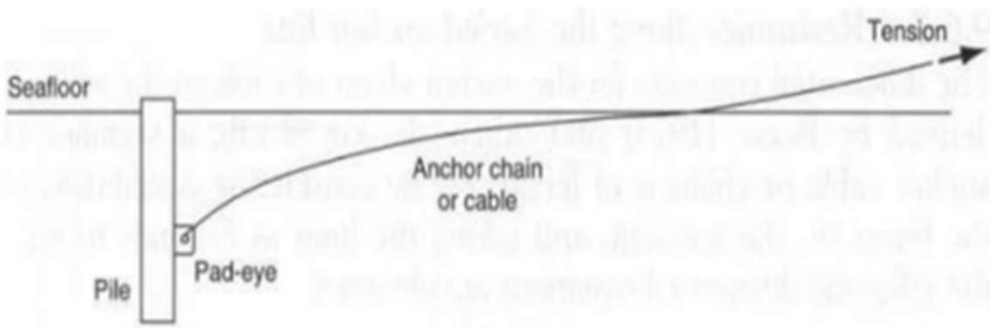
For Spar, Semi Submersible and Barge

Catenary mooring lines:

- Chain
- Wire
- Synthetic fibre

DRIVEN PILE

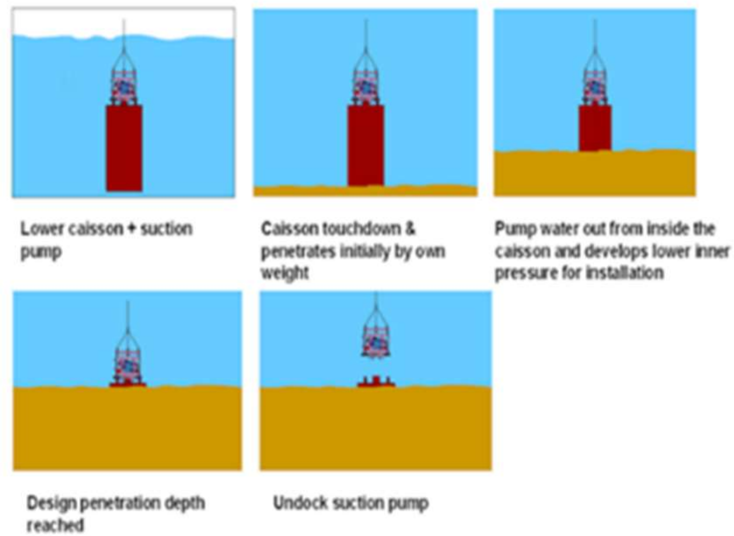




For all Floating
Offshore Wind
Turbine types

SUCTION PILE

Possible for all options
but depends on soil condition



Work Class Rov
To Disconnect Pump

GRAVITY BASE ANCHOR

For temporary moorings

COMPARE SUBSTRUCTURE (t-i)

FOWT TYPE	Semi Submersible	Spar
Construction	On shore or in a dry dock	On shore
Loadout	Loadout onto HTV or floatout from drydock	Loadout onto HTV
Transport to fit out quay	Transport to fit out port	Transport to fit out port
Seabed check	Check seabed at quay for debris	Check seabed at quay for debris
Float off from HTV	Float off vertically	Float off horizontally

INSTALLATION

OFFSHORE INSTALLATION (semi/spar)

(t-j)

FOWT Type	Semi Submersible (or barge)	Spar
Step		
1st	Connect catenary moorings	Connect catenary moorings
2nd	Adjust moorings and re-tension	Adjust moorings and
3rd	Cable connection	Cable connection
4th	Commission turbine	Commission Turbine
5th	ROV seabed survey after installation	ROV seabed survey after installation
Draft during towout and installation	10 to 15m	75 to 100m

OFFSHORE INSTALLATION (TLP) (t-k)

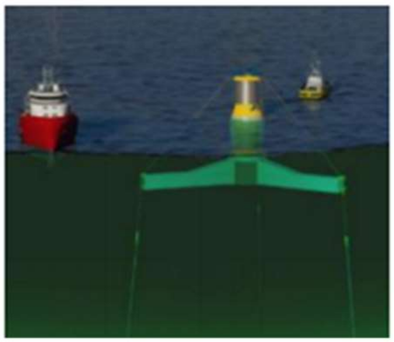
FOWT Type	TLP	TLP
	Assumes sufficient intact stability with the addition of temporary buoyancy	Installed turbine components piece small offshore with a crane vessel
Step		
1st	Connect tendon moorings	Connect tendon moorings
2nd	De ballast substructure hull Tension tendon moorings	De ballast substructure hull Tension tendon moorings
2a	Remove temporary buoyancy	
		Using heave compensated lift hook to fit the tower, nacelle and blades from a floating crane vessel (under development)
3rd	Cable connection	Cable connection
4th	Commission Turbine	Commission Turbine
5th	ROV seabed survey after installation	ROV seabed survey after installation

TEMPORARY BUOYANCY FOR TLP

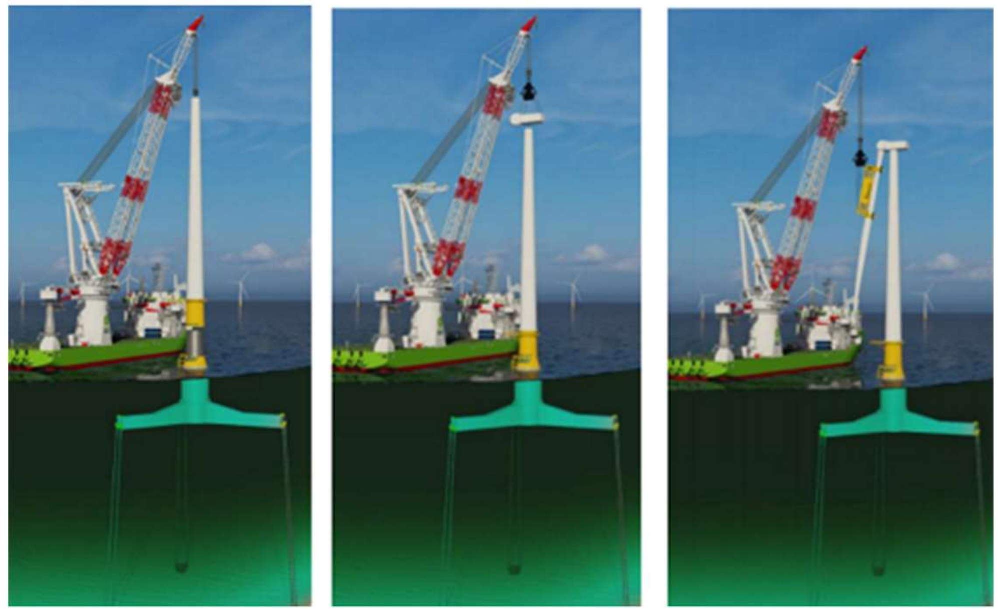
(Ref [6])

CRANE VESSEL INSTALLATION OF TLP

(Ref [7])



Active Heave Compensation Of Hook



SEMI SUBMERSIBLE INSTALLATION

(Ref [8])

Subcomponent Production

Assembly, Load-out, Transport

WTG Integration at Quayside

Operations (in-place & O&M)

STEEL SPAR INSTALLATION (Ref [9])

Onshore
Construction
Of the
Substructure

Loadout
Onto
Heavy
Transport
Vessel (HTV)

Onshore
topside
construction

Substructure
- ➢ Floated off HTV
- ➢ Upended
- ➢ Sold ballasted

Large crane vessel
- ➢ Lifts topside off the fit-out quay
- ➢ Crosses fjord
- ➢ Install topside on the floating substructure

INSTALLATION VESSELS

INSTALLATION VESSELS (t-l)

Vessel	Comment	Average Number Of Vessels Required			
		Spar	Semi-Sub	TLP	TLP
			Barge Similar	with temporary buoyancy	with crane vessel
Anchor handling vessel	Drag anchors	1	1		
Offshore crane vessel	Suction piles or drive piles			1	1
Heavy Transport Vessel	For ocean voyage of substructure	1	1	1	1
Harbour tug	Yard assistance	2	2	2	2
Anchor Handler for installation	Minimum of 2	3	3	4	2
Cable Lay Vessel		1	1	1	1
Large onshore crane		0.9	1	1	1
Inshore Crane Vessel	Lift turbine from shore	1	0.1	0.2	
Large offshore crane vessel					1

CONCLUSIONS

LOGISTICS ISSUES (t-m)

To facilitate the installation process and minimize costs, the main logistical aspects have to be considered:

- > Floating offshore wind turbine Type
- > Inshore vessel requirements
- > Shipyard location
- > Distance from the shipyard to the Fit out port distance
- > Distance from fit out port to offshore wind farm site
- > Weather downtime during installation
- > Number of anchor handling vessels
- > Offshore crane vessel

FOWT INSTALLATION COMPARISON (t-n)

FOWT TYPE	BARGE	SEMI SUBMERSIBLE	SPAR	TLP
Construction Land Area	Medium	Large	Medium	Medium
Ease of onshore construction compared to fixed structure	Medium	Medium	Medium	Complicated
Seabed area	Large	Large	Large	Low
Intact stability in tow	Medium	Large	Large	Low
Attachment of moorings	Standard	Standard	Standard	Complicated
Offshore crane vessel	No	No	No	Yes

INSTALLATION CHALLENGES (t-o)

- Ease of towing of the completed substructure
- Making mooring connection operations more weather tolerant
- Simplification of installation methodology
- Reduce risks to personnel working offshore during installation
- Easy electrical connection

THANK YOU FOR YOUR TIME

ANY QUESTIONS ?

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3	www.hexicon.eu
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5	www.intermoor.com
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7	www.bluewater.com
8	www.PrinciplePower.com
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APPENDIX QUESTIONS

1.How to achieve areas of improvement in Installation campaign schedules and find out real reduction in time spent offshore by construction vessels in FOWT Projects to reduce project cost?

a. Mass production on land of substructures. This will result in better scheduled work for the offshore installation vessels.
b. Use the largest possible turbine which minimizes to number of substructures and hence reduces the number of installation operations

2.To what extent, will Offshore renewables benefit from captured Lessons Learned of Offshore Oil & Gas construction and Installation projects execution and expertise?

a. The main lesson learnt from O&G installation is to not use small installation vessels that can only work in limited weather conditions.
b. It is much more efficient and overall cost benefit to use the best offshore installation equipment which can extend the weather installation window.

3. How feasible is it to share resources of O&M Vessels between Nearby FOWF and offshore Oil & gas fields to reduce OPEX?

a. As Floating offshore wind turbines are installed in deeper water, long distance from maintenance ports then the sharing of crew transfer vessels with other platforms becomes feasible.

b. This common maintenance vessel operation will probably happen for the Hywind Norway project where electricity will be used to power existing O&G facilities, rather than sending the electricity ashore.