Offshore Wind in Greece

Prospects and Challenges for the supply chain and a sustainable growth

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In partnership with:

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Defining a typical Greek offshore wind farm, reference turbine and a set of technical specifications needed for the supply chain

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Summary and Scope

- Two reference wind farms and a reference wind turbine are defined, addressing typical offshore wind development characteristics in Greece.
- Using such references one can obtain a set of prerequisites / technical specifications (weights, staging area, minimum water depth, etc) necessary for assessing the specific needs for harbours and other elements of the supply chain.

Reference Wind Farms

- Two reference offshore wind farms are considered, one with bottom-fix and another with floating wind turbines. The metocean conditions used for the reference wind farms are typical for the Aegean Sea.
- The mean sea depth for the bottom fixed turbines is 50m with the offshore support structure being of the jacket type. The mean sea depth for the floating turbines is 200m with the offshore support structure being of the semisubmersible type with a chain catenary mooring system.
- For both bottom-fix and floating reference wind farms the installed capacity is 300MW, comprising 20X15MW turbines of the “reference” type.
- The reference turbine is the IEA 15MW offshore wind turbine. It is an IEC Class IB having 240m diameter and 150m hub-height.
- The 20 turbines layout assumes 7DX5D distances between the turbines, 7D (1680m) in the prevailing wind direction and 5D (1200m) in the normal to the prevailing direction. A 5X4 turbines layout requires a deployment area of ~25km2.

Metocean Conditions

WIND CONDITIONS

For bottom-fixed turbines

- Mean annual wind speed (m/s) : 8.2
- Weibull shape factor k : 2.4
- Prevailing wind direction (º) : 340

For floating turbines

- Mean annual wind speed (m/s) : 9.6
- Weibull shape factor k : 2.0
- Prevailing wind direction (º) : 305

WAVE CONDITIONS

For bottom-fixed turbines

- Mean significant wave height (m) : 0.8
- 50-years extreme SWH (m) : 4.6
- Spectral peak period (s) : 4.2
- Prevailing wave direction (º) : 8

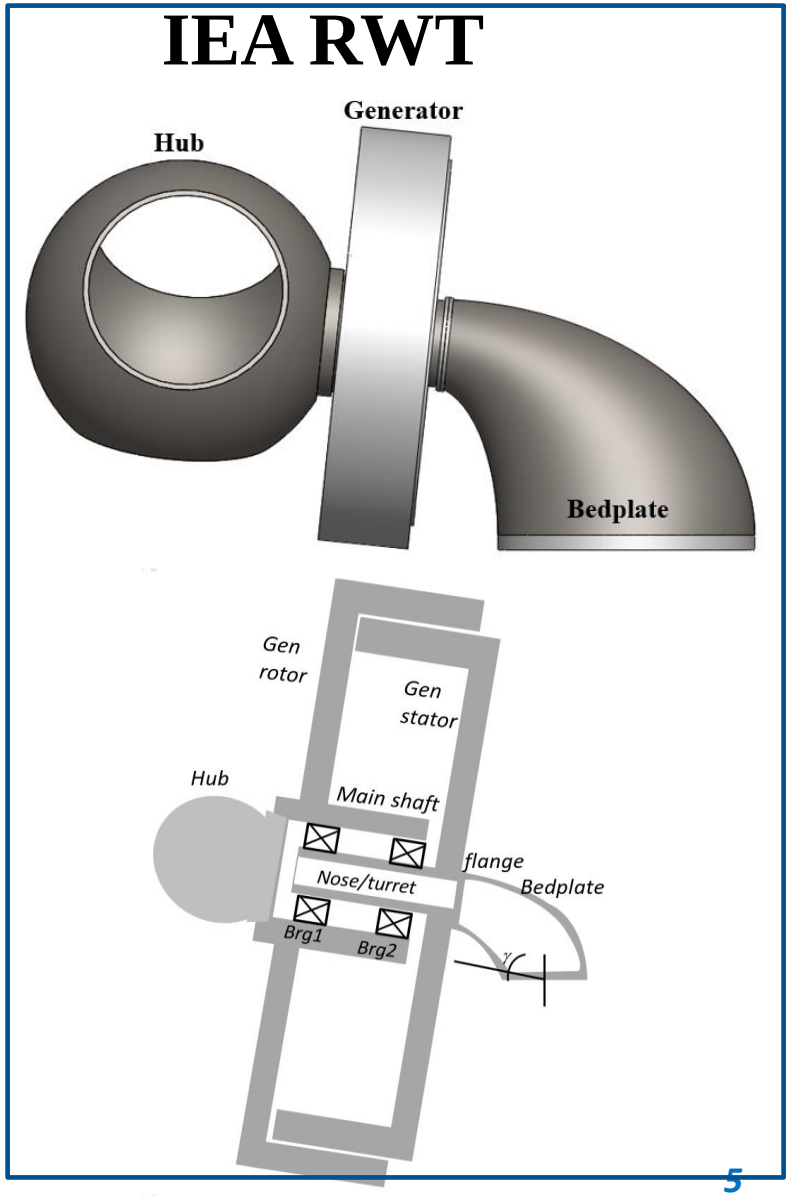
For floating turbines

- Mean significant wave height (m) : 1.2
- 50-years extreme SWH (m) : 6.9
- Spectral peak period (s) : 5.0
- Prevailing wave direction (º) : 314

Reference Wind Turbine

Key parameters for the 15MW Reference Wind Turbine

Key Parameters		IEA 15-MW Turbine	Innwind.EU
Parameter	**Units**	**Value**	**Value**
Power rating	MW	15	15
Turbine class	-	IEC Class 1B	IEC Class 1B
Specific rating	W/m2	332	.//.
Rotor orientation	-	Upwind	.//.
Number of blades	-	3	.//.
Control	-	Variable speed Collective pitch	.//.
Cut-in wind speed	m/s	3	.//.
Rated wind speed	m/s	10.59	.//.
Cut-out wind speed	m/s	25	.//.
Design tip-speed ratio	-	9 0	.//.
Minimum rotor speed	rpm	5	.//.
Maximum rotor speed	rpm	7.56	.//.
Maximum tip speed	m/s	95	.//.
Rotor diameter	m	240	.//.
Airfoil series	-	FFA-W3	.//.
Hub height	m	150	.//.
Hub diameter	m	7.94	
Hub overhang	m	11.35	
Rotor precone angle	deg	-4	
Blade prebend	m	4	
Blade mass	t	65	66.5
Drivetrain	-	Direct drive	Medium Speed
Shaft tilt angle	deg	6	
Rotor nacelle assembly mass	t	1,017	1,073

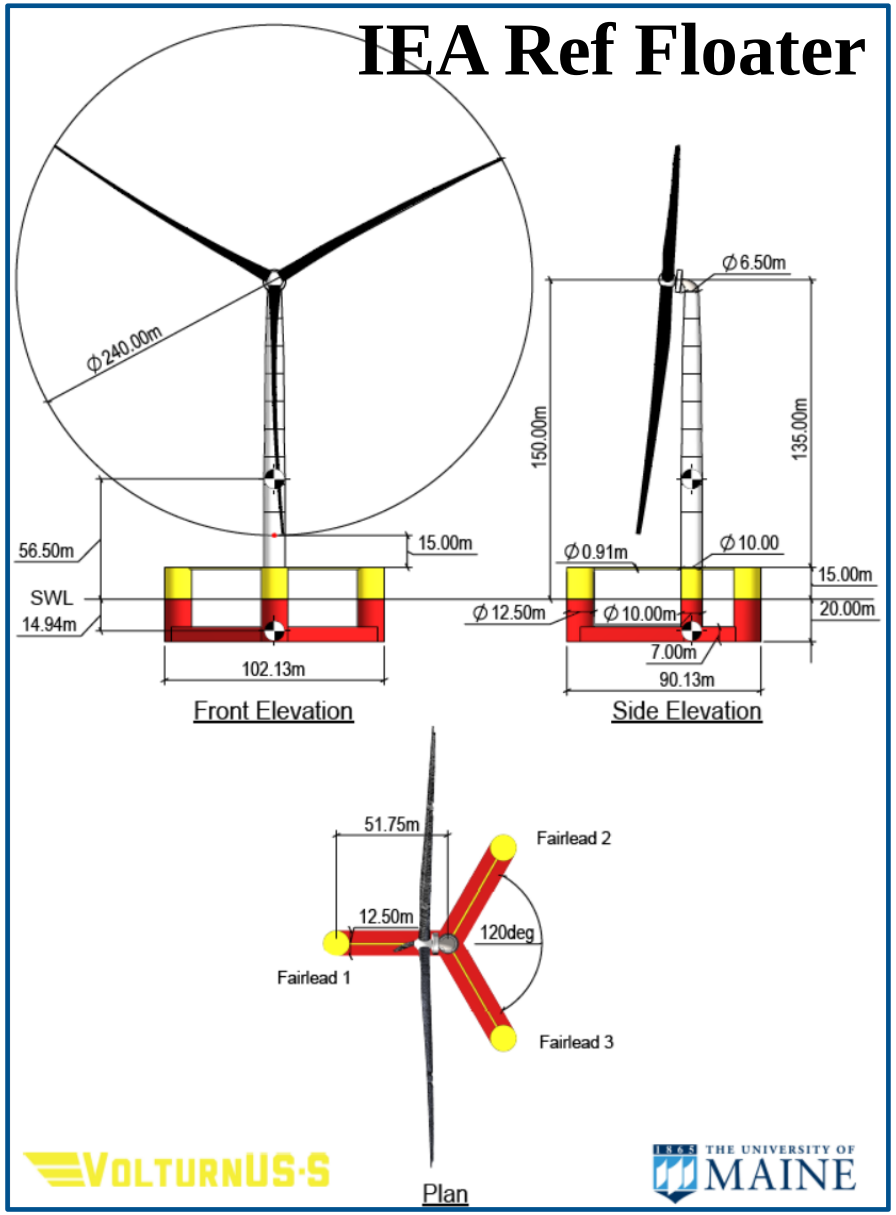


Offshore Support Structures

Monopile Version (30m w.d.)		IEA 15-MW Turbine	Innwind.EU
Parameter	**Units**	**Value**	
Transition piece height	m	15	
Monopile length (from t.p. to seabed)	m	45	
Monopile embedment depth	m	45	
Monopile base diameter	m	10	
Tower mass	t	860	
Monopile mass	t	1,318	
Jacket Version (50m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**		**Value**
Transition piece height	m		15
Jachet length (from t.p. to seabed)	m		65
Piles embedment depth	m		
Jacket base diameter	m		
Tower mass	t		1,043
Jacket overall mass (incl. tp and piles)	t		2,700
Semisubmersible Floater (200m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**	**Value**	
Excursion1 (Length, Width, Height)	m	90.1, 102.1, 290.0	
Freeboard	m	15	
Draft	m	20	
Total System Mass (incl. ballast)	t	20,093	
Hull Steel Mass	t	3914	
Platform Mass (incl. ballast)	t	17,839	
Tower Mass	t	1,263	
RNA Mass	t	991	
Water Depth	m	200	
Mooring System	-	Three-line chain catenary	

Reference Floater

Semisubmersible Platform Properties		
Parameter	**Units**	**Value**
Hull Displacement	m3	20206
Hull Steel Mass	t	3914
Tower Interface Mass	t	100
Ballast Mass (Fixed/Fluid)	t	2,540/11,300
Draft	m	20
Freeboard	m	15
Vertical Center of Gravity from SWL	m	-15
Vertical Center of Buoyancy from SWL	m	-14
Mooring System Properties		
Parameter	**Units**	**Value**
Mooring System Type	-	Chain Catenary
Line Type	-	R3 Studless Mooring Chain
Line Breaking Strength	kN	22,286
Number of Lines	-	3
Anchor Depth	m	200
Fairlead Depth	m	14
Anchor Radial Spacing	m	837.6
Fairlead Radial Spacing	m	58
Nominal Chain Diameter	mm	185
Dry Line Linear Density	kg/m	685
Extensional Stiffness	MN	3270
Line Unstretched Length	m	850
Fairlead Pretension	kN	2,437
Fairlead Angle from SWL	°	56.4



Staging needs (turbine's dry part)

Nacelle-hub Assembly Dimensions & Weight		
Length	m	19
Width	m	13
Height	m	13
Weight	t	821
Surface Area	m2	245
Surface pressure	t/m2	3.35

Blade box dimensions & Weight		
Length	m	117
Width	m	6
Height	m	7
Weight	t	65
Surface Area	m2	675
Surface pressure	t/m2	0.10

Tower box dimensions & Weight		
No of sub-elements per tower	-	10
Length	m	13
Width	m	10
Height	m	10
Weight (mean value)	t	126
Surface Area	m2	130.00
Surface pressure	t/m2	1

Harbour needs

Staging

NET STAGING NEEDS	m2
Per 15MW Turbine	3,570
3 Blades	2,025
Nacelle-hub	245
Tower	1,300
300MW Wind Farm (20 WTG)	71,408
Net to gross factor	3.5
300MW Wind Farm GROSS	250,000

Soil bearing capacity

- The **highest** value of **surface pressure** estimated for the RWT is **3.35t/m2** for the **nacelle-hub assembly**, weighting **821 t**.
- We anticipate that the weight load will be undertaken by the ¼ of the projected area, leading to a **soil bearing capacity** of 4*3.35 ~ **13.5 t/m2**.
- The soil bearing capacity of the areas where the blades and the tower substructures will be stored can be less.
- **Cranes** will be needed for the assembly of the dry parts of the turbines. The heaviest single component to be lift-up is again the nacelle-hub assembly. It is anticipated that the **soil bearing capacity under the crane-base** area must be of the order of **35 t/m2**.

Draft

- Assuming that the **floater will be transferred with tag boats** having the turbine assembled on top and its fixed ballast in place, the **total system mass will be 8,700 t**.
- The **draft of the fully assembled** and moored turbine is **20m** where **the total system mass**, including the water ballast is **20,000 t**. It is reasonable to assume that during its transfer the **unballasted system** will have a **draft ~ 10m**.
- Adding a **2m margin** to that, we come to a **minimum harbour depth of 12m**.
- Evidently, this minimum draft requirement refers to the considered floating platform.

THANK YOU

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