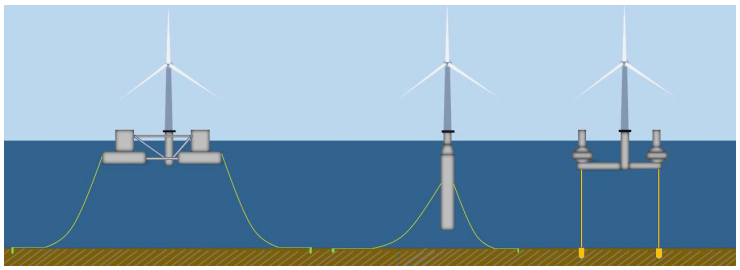
EERA DeepWind'2019, 16-18 January, 2019, Trondheim, Norway

Conceptual Design of a 12 MW Floating Offshore Wind Turbine in the Ulsan Offshore Area, Korea

Pham Thanh Dam*, Hyunkyoung Shin†
School of Naval Architecture and Ocean Engineering, University of Ulsan, Korea

Introduction

- Korean Government announce a plan "Renewable Energy 3020" to rise 48.7 GW new renewable energy by 2030. The target includes 13 GW offshore wind. Ulsan City plans to develop a 200 MW demonstration wind farm project (phase 1) and 1 GW wind farm (phase 2) in Ulsan offshore area, Korea.
- University of Ulsan introduced a 12 MW wind turbine concept, this is a gearless wind turbine and uses super-conducting generator to reduce the wind turbine top mass.
- To investigate a feasible concept for supporting the 12 MW wind turbine in 150 m water depth in the Ulsan Offshore area, three concepts of platform are designed and analyzed. These are semi-submersible, spar and TLP.



Three concepts of 12 MW floating offshore wind turbine

12 MW Wind Turbine and Floater Concepts

- Semisubmersible concept is stabilized by the water plane area of column separation which provide large roll and pitch stiffness.
- Spar concept length is limited by water depth. Concrete is used to distribute the center of mass lower than center of buoyancy.
- TLP is stabilized by high tension of the tendon system.
- Semi-submersible and spar are moored by catenary mooring systems

12 MW wind turbine specifications		Value
Rated power of wind turbine		12-MW
Rotor orientation		Upwind, 3 blades
Control		Variable Speed, Collective Pitch
Rotor diameter	[m]	195.2
Hub height	[m]	120.25
Rated wind speed	[m/s]	11.2
Rated rotor speed	[rpm]	8.25 (gearless)
Hub mass	[kg]	169,440
Hub inertia about shaft	[kg·m2]	829,590
Nacelle mass (target)	[kg]	400,000

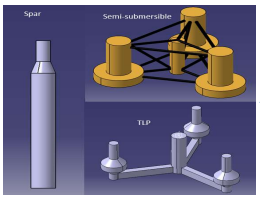
Platform properties	Unit	Semi-sub.	Spar	TLP
Depth to platform base below	m	27	120	36
Elevation to platform top	m	10	10	10
Platform mass, including ballast	ton	28,975	23,028	10,265
Platform center of mass	m	-20.15	-96.14	-28.00
Platform roll inertia	ton*m^2	1.96E+07	1.00E+07	1.08E+07
Platform pitch inertia	ton*m^2	1.96E+07	1.00E+07	1.08E+07
Platform yaw inertia	ton*m^2	3.55E+07	8.50E+05	3.52E+07

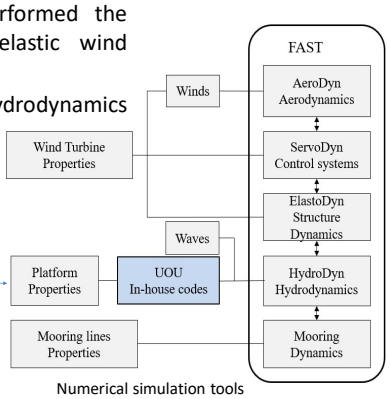
Mooring line properties	Unit	Semi	Spar	TLP
Number of mooring lines	-	3	3	3
Mooring type	-	Studless chain	Studless chain	Tendon
Mooring nominal diameter	m	0.142	0.142	1.04
Mooring line weight in water	N/m	3708.8	3708.8	0
Axial stiffness (EA)	MN	1815	1815	22290
Unstretched mooring length	m	950	750	113.95

Numerical Simulation

Numerical simulations were performed the fully coupled aero-hydro-servo-elastic wind turbine by NREL FAST V8

UOU in-house codes calculated hydrodynamics coefficients





Numerical simulation tools

Environmental Condition in the Ulsan Offshore Area

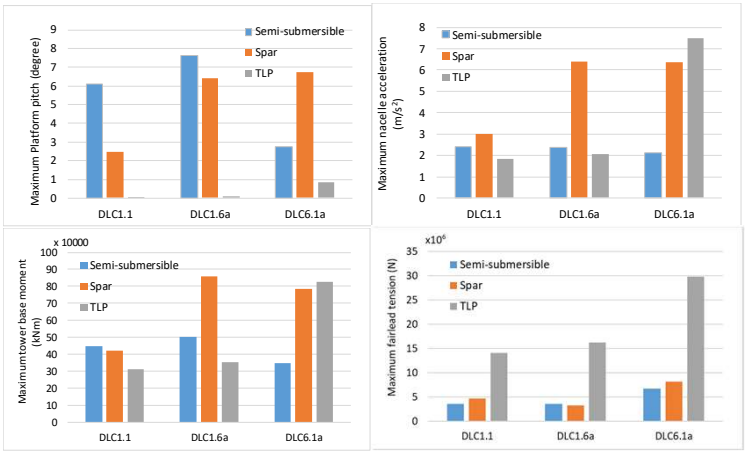
Reference location of Ulsan offshore area

Three design load cases were selected to analyze the ultimate loads and fatigue loads based on the environmental condition of Ulsan offshore area

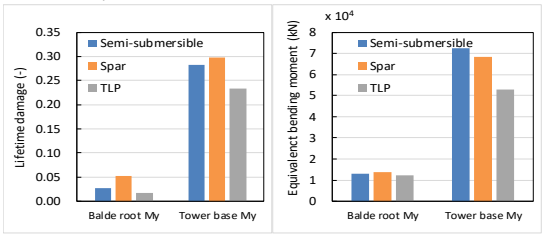
Design load cases

Item	Wind	Waves	Current	WT status
DLC 1.1	NTM 4 - 24 m/s	NSS	NCM	Operation
DLC 1.6a	NTM 10-24 m/s	SSS Hs 10 m, Tp 13 s	NCM	Operation
DLC 6.1a	EWM 41.3 m/s	ESS Hs 12.49 m, Tp 15.46 s	ECM 0.93 m/s	Parked

Numerical Simulation Results



Maximum responses and loads



Fatigue damage of 20 years operation

Conclusions

- TLP concept is preferable in operation condition, however in extreme condition at high speed of current, the nacelle acceleration and tower bending moment are higher than other concepts
- In general, semi-submersible concept is suitable design
- Further investigation about installation, transportation is needed

ACKNOWLEDGEMENT
This research was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea Government (MOTIE) (No. 20184030202280 & No. R18XA03).

울산대학교 UNIVERSITY OF ULSAN
E-mail
* Author : phtdam@gmail.com
† Corresponding author : hkshin@ulsan.ac.kr

산업통상자원부 MINISTRY OF TRADE, INDUSTRY & ENERGY MOTIE
KETEP 한국에너지기술평가원 KOREA INSTITUTE OF ENERGY TECHNOLOGY EVALUATION AND PLANNING