DAMPING ANALYSIS OF A FLOATING HYBRID WIND AND OCEAN-CURRENT TURBINE

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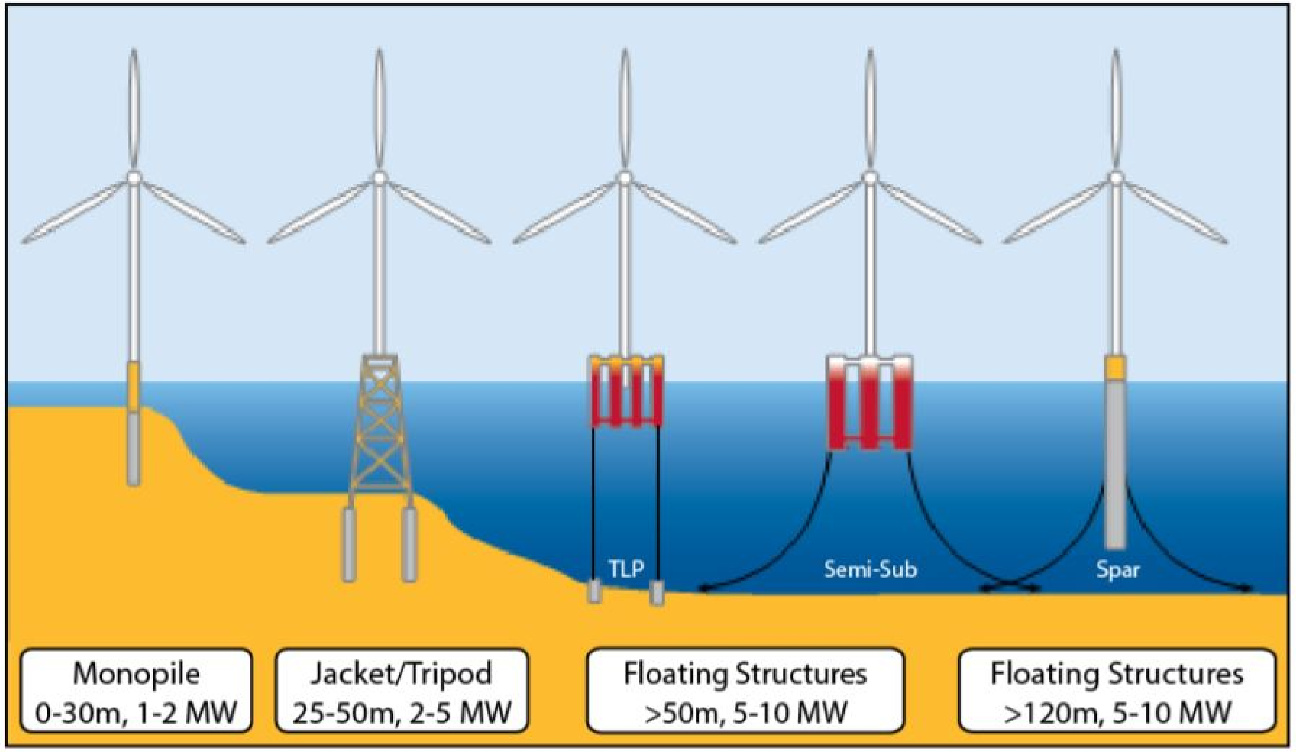
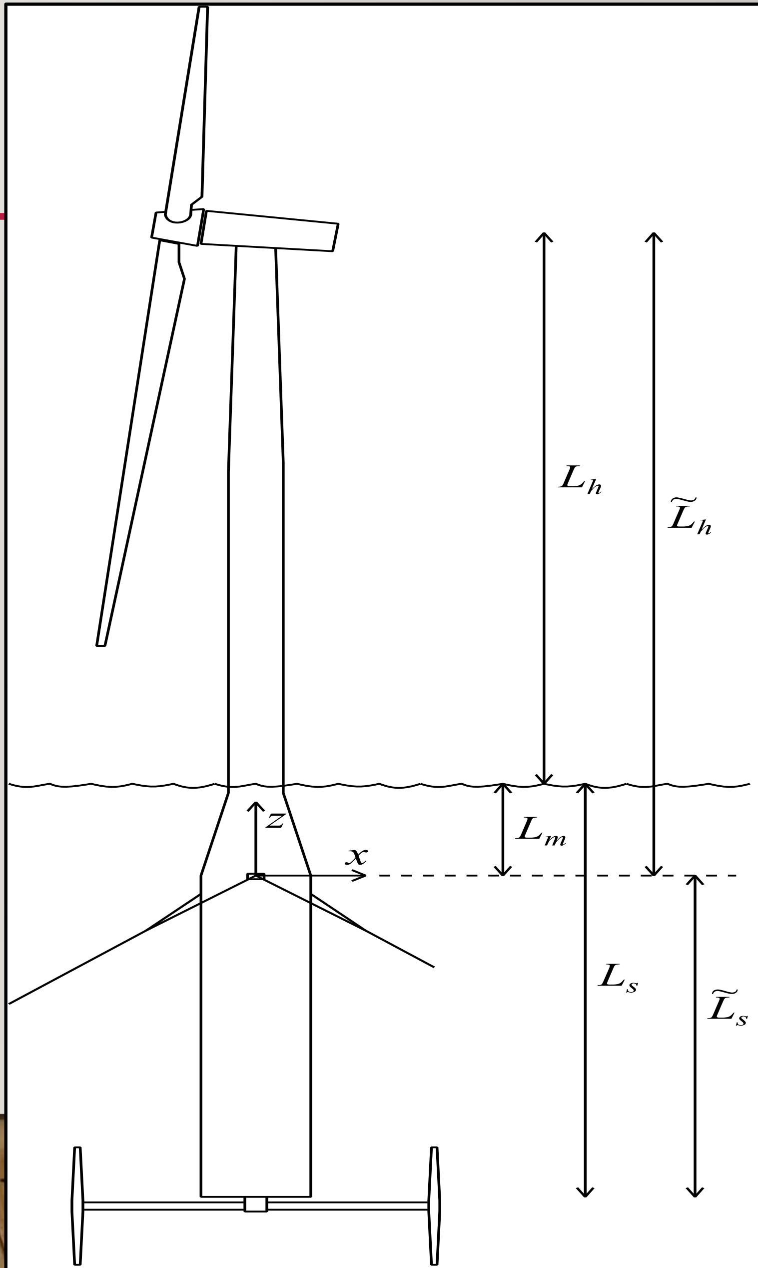
CONCEPT

- Monopile
- Tripod
- TLP is fixed rigid to the surface
- Spar buoy is considered in this paper



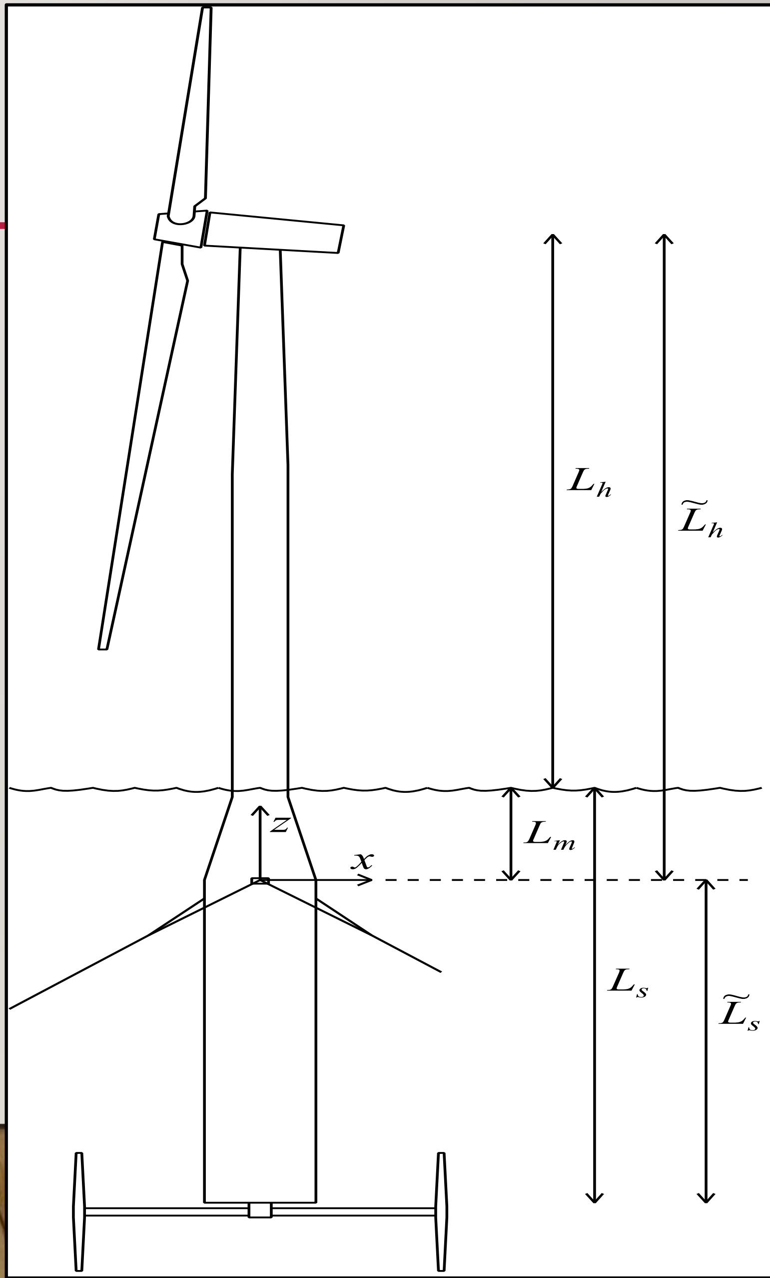
HYWIND SCOTLAND

Table 1. Dimensions and masses for the simulated structure.			
Quantity	Variable	Value	
Nacelle and rotor mass	m_n	370 tons	
Tower mass	m_t	670 tons	
Submerged tube mass	m_s	2300 tons	
Ballast mass	m_b	7700 tons	
Rotor diameter	d	156 m	
Hub height	L_h	100 m	
Submerged tube depth	L_s	78 m	
Mooring depth	L_m	15 m	
Ballast center of mass depth	L_b	70 m	



HYBRID CASE

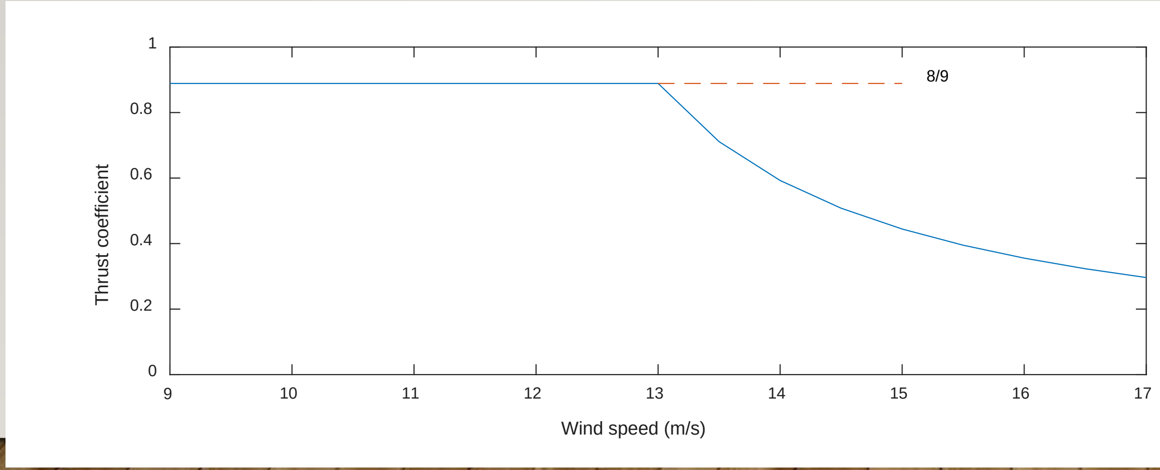
- Vertical axis ocean-current turbine attached at 78 m depth
- Swept area = 1000 m^2
- Spar buoy floating structure

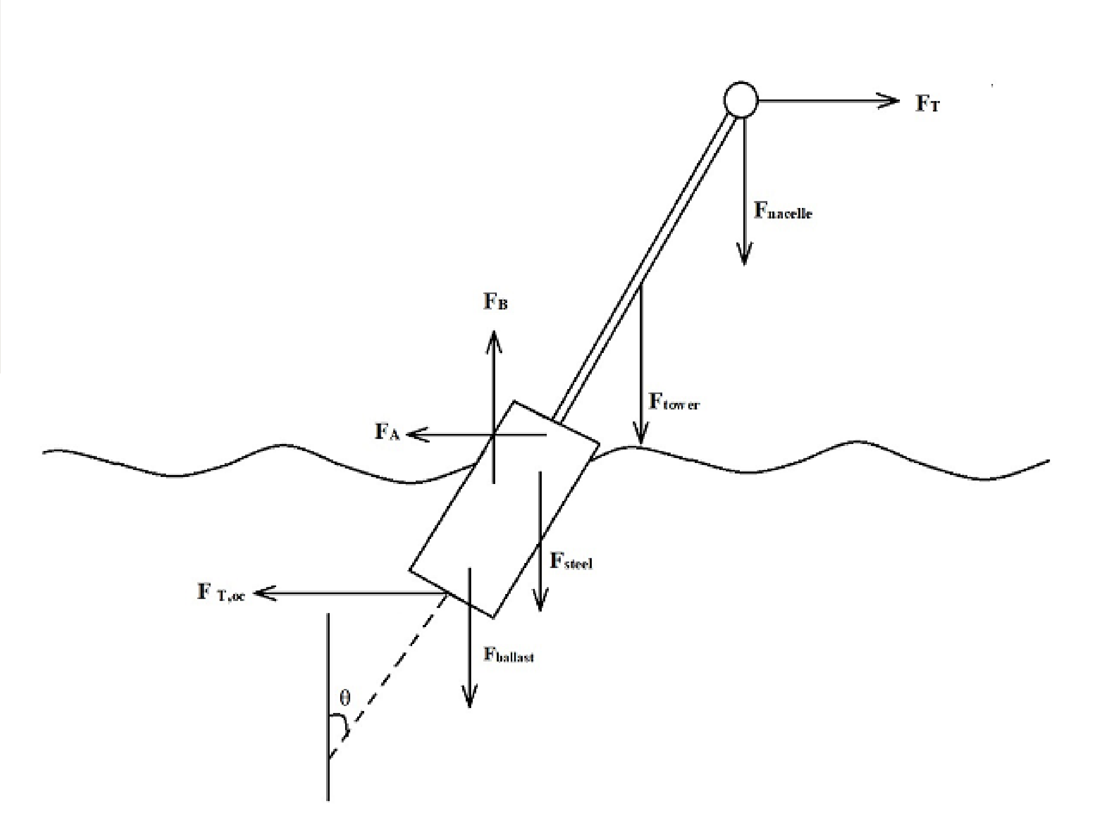


HYBRID CASE

- *Wind speed is taken in x direction and ocean current is allowed in* $0°, 90°180°$
- *Thrust force:*

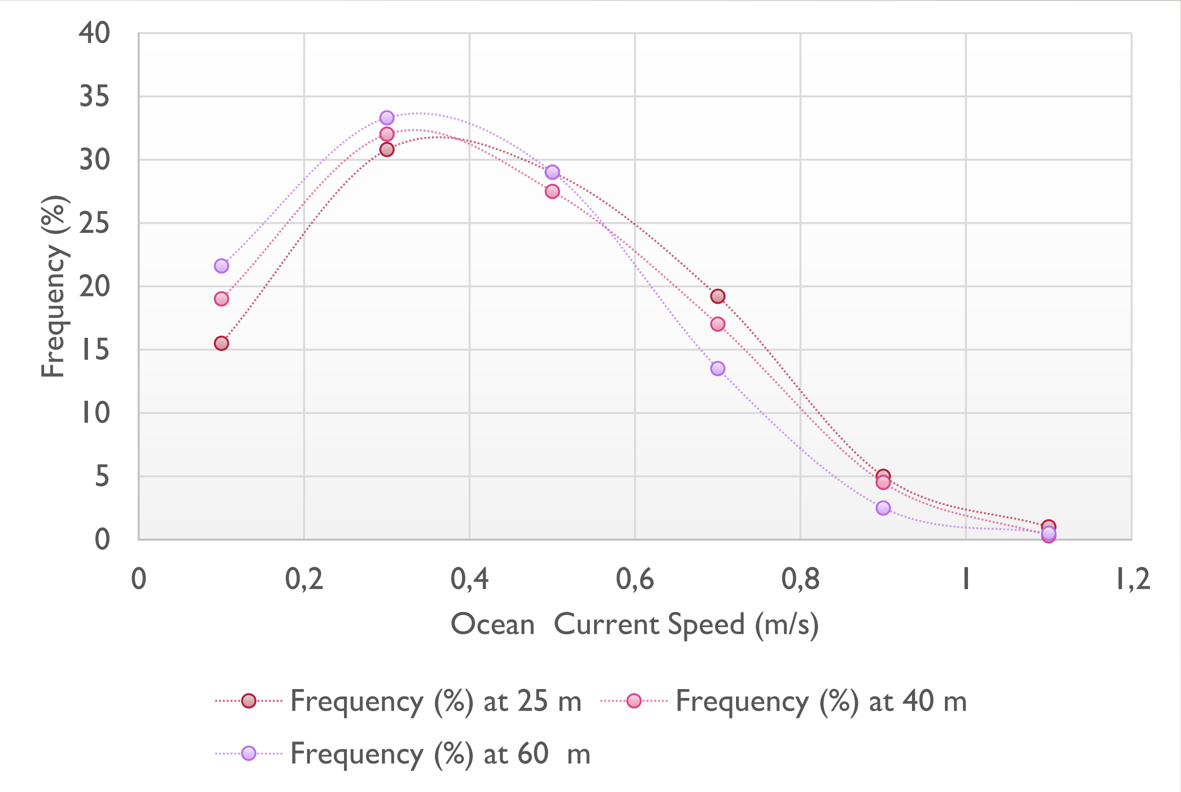
$$F_t = \frac{1}{2} C_t A \rho v^2$$





OCEAN DATA

- Ocean current data are taken from 25 m, 40 m, and 60 m
- 60-m distribution assumed at 78 m depth
- Swept area 1000 m^2, $C_p = 0.35$
- Average production: ~20 kW (0.18 GWh/yr)
- Ocean current turbine is simulated at 0.4 m/s.

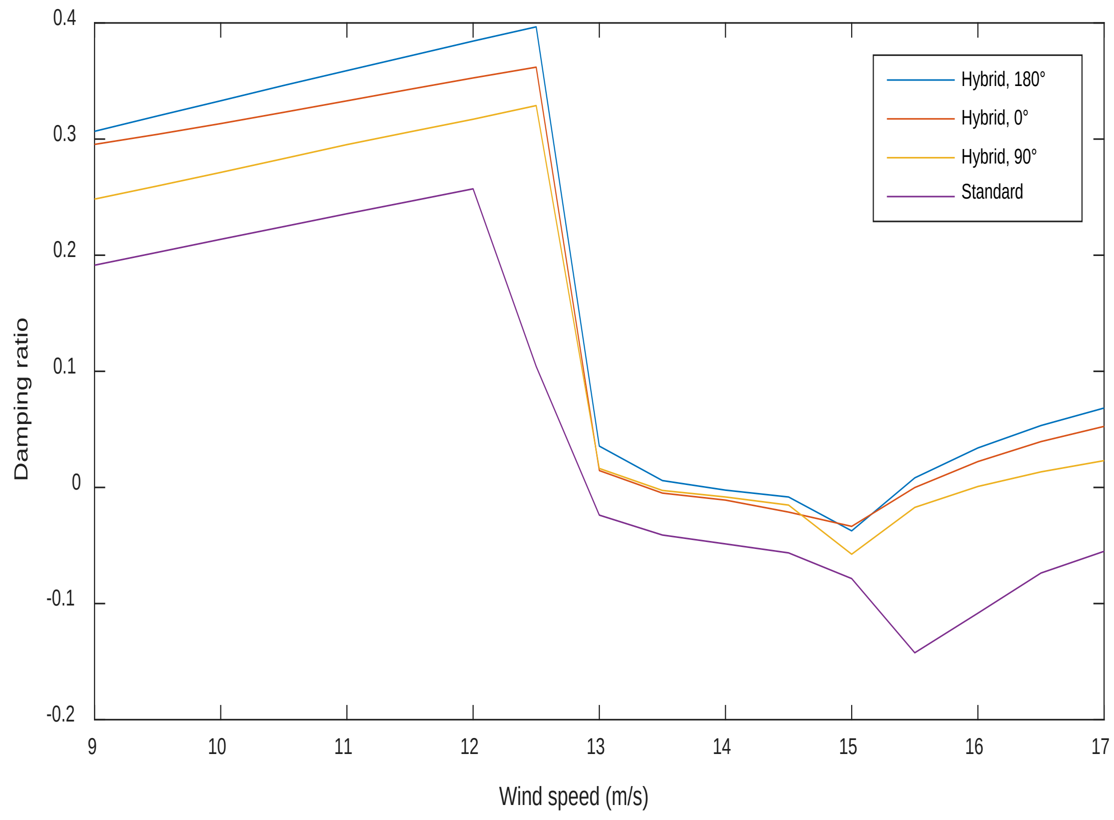


DYNAMIC CASE

- Damping Ratio
- The tower is allowed to oscillate from 3°
- Ocean current turbine is receiving ocean-current speeds up to roughly 1 m/s.

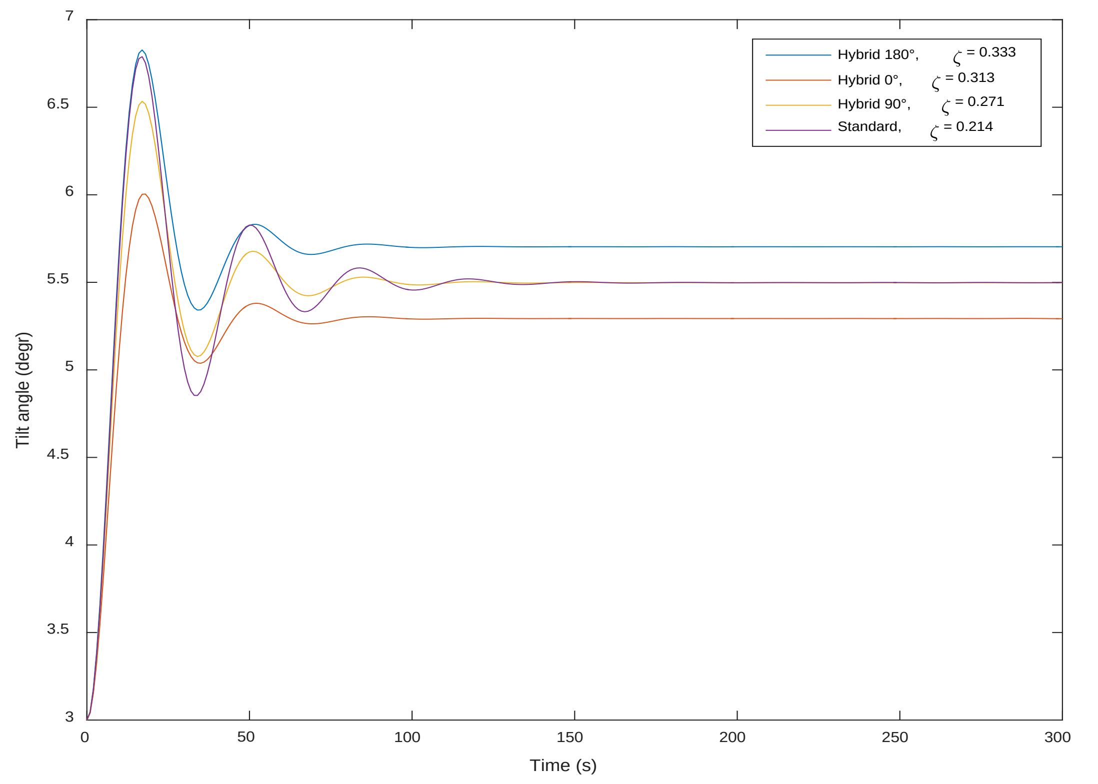
RESULT

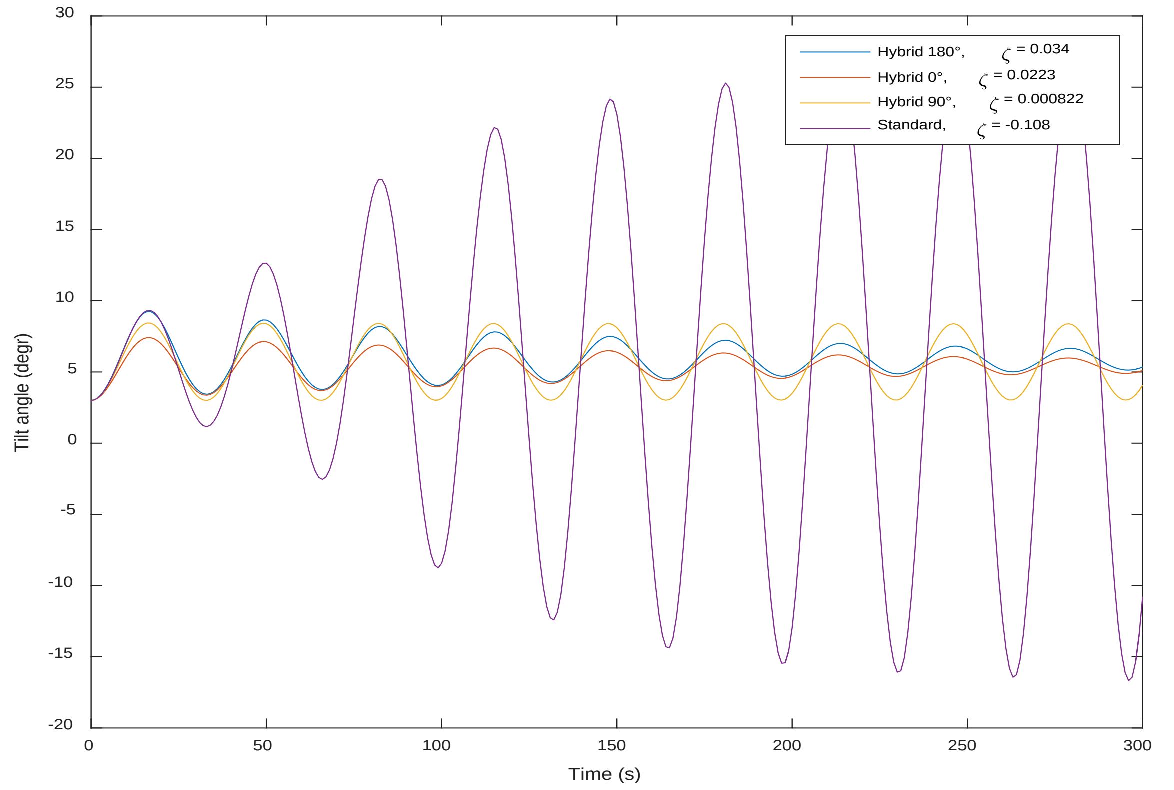
- Std case- Negative damping after rated speed
- Hybrid case improves damping mostly in parallel and antiparallel direction
- Increasing the swept area of ocean current turbine positive damping can be achieved.



RESULT

- Hybrid case is well damped at less than 90 sec below rated wind speed
- Negative damping is introduced in standard case after rated wind speed





8. CONCLUSION & FUTURE REFERENCE

- The damping is improved to a greater amount using with the submerged turbine.
- Increasing the swept area of ocean current turbine positive damping can be achieved.
- Further dynamic analysis and 3d simulations to be conducted.

THANK YOU