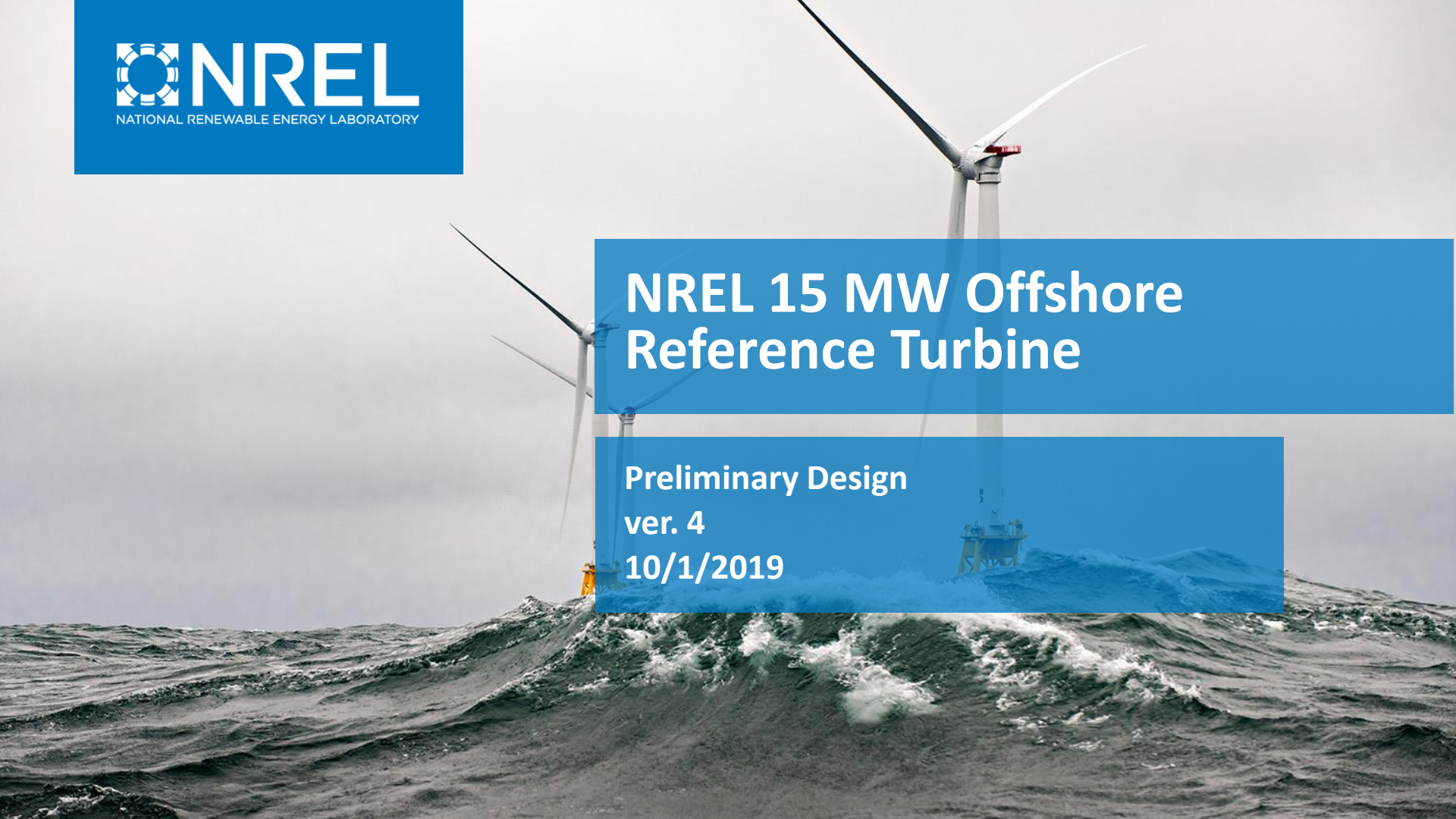


NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL 15 MW Offshore Reference Turbine

Preliminary Design
ver. 4
10/1/2019

Summary and Objectives

- **High-level turbine parameters selected**
- **NREL has completed a low-fidelity design of the rotor and blade planforms**
- **NREL has completed a low-fidelity tower and monopile design**
- **NREL has completed a low-fidelity direct drive and generator design**

- **Next steps:**
  - Release of preliminary OpenFAST model
  - Engagement with UMaine for floating substructure design
  - Engagement with DTU supporting Innwind.EU project

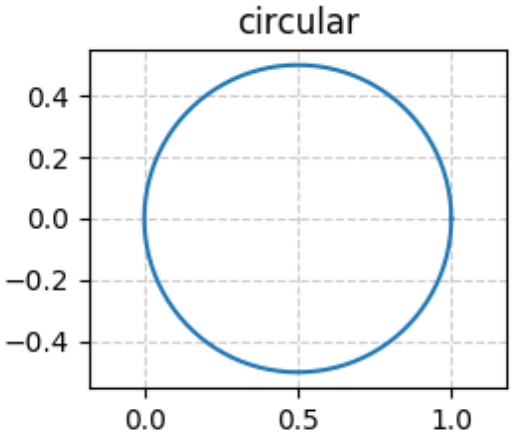
Preliminary Rotor Design

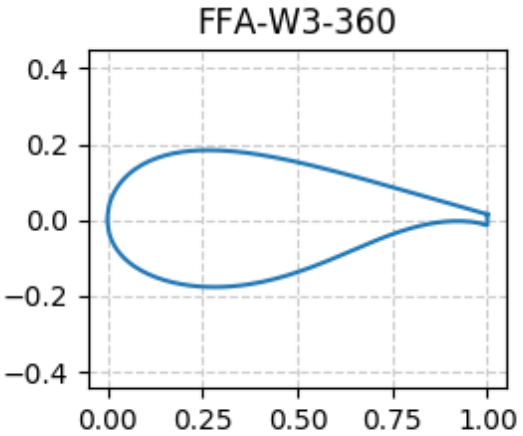
High-level rotor design specifications in context to other reference turbines

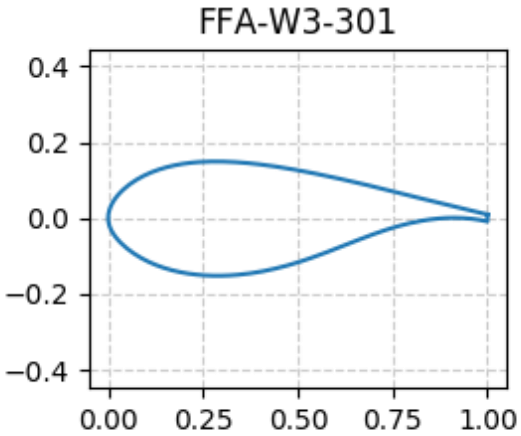
Parameter	IEA Offshore 10 MW	NREL Offshore 15 MW	INNWIND.EU 20 MW
Turbine Class	IEC Class 1A	**IEC Class I-B**	IEC Class 1C
Specific Rating	324.8 W/m^2	**332 W/m^2**	406.8 W/m^2
Rotor Diameter	198 m	**240 m**	252.2 m
TSR	10.58	**9.0**	7.86
Maximum Tip Speed	90 m/s	**95 m/s**	90 m/s
Hub Height	119 m	**150 m**	167.93 m
Cut-in Wind Speed	4 m/s	**3 m/s**	4 m/s
Cut-out Wind Speed	25 m/s	**25 m/s**	25 m/s

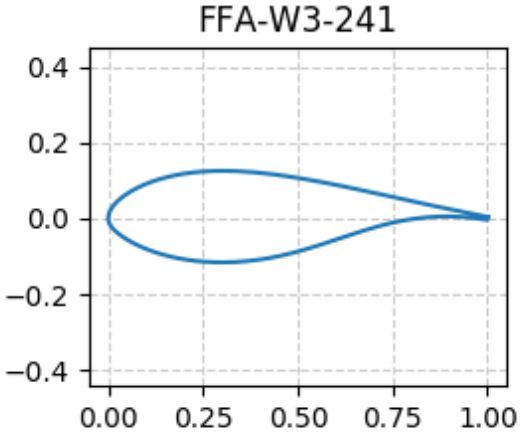
Geometric Assumptions			
Tip Prebend	4 m	Nacelle Overhang	11.3 m
Cone Angle	4˚	Vertical distance TT-to-Shaft	3.5 m
Shaft Tilt	6˚	Tower Base Diameter	10 m
Hub Diameter	6 m	Tower Top Diameter	6.3 m

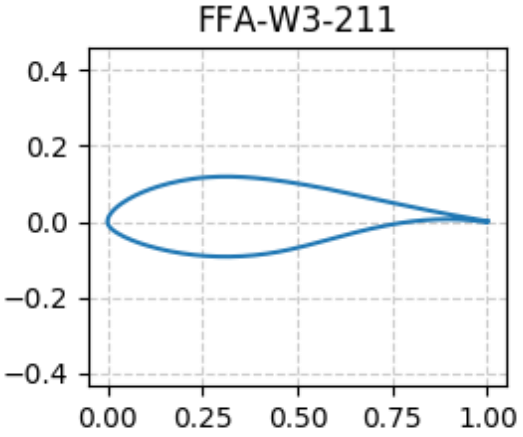
Airfoil Profiles: Chose FFA family based on other reference designs and prior work

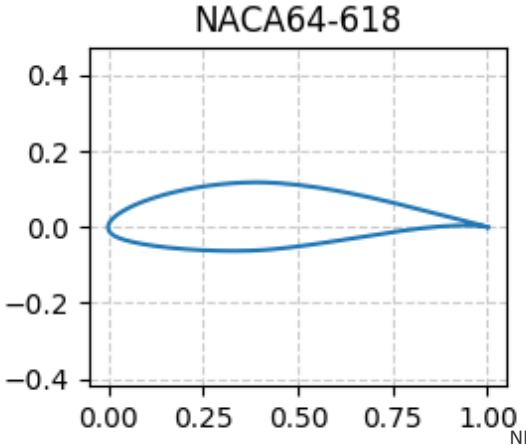


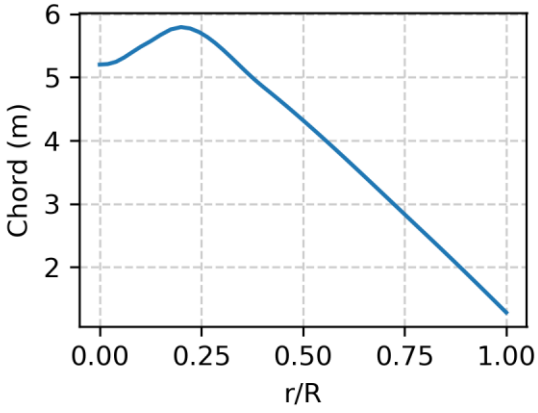


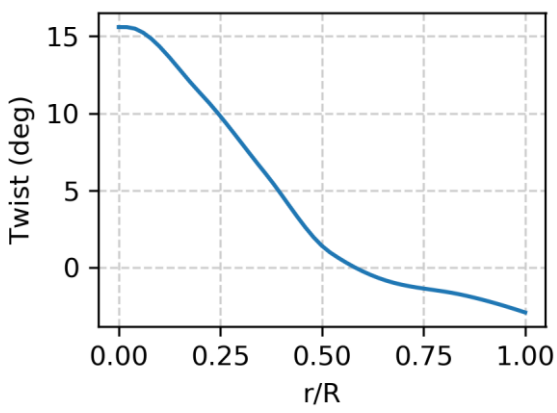


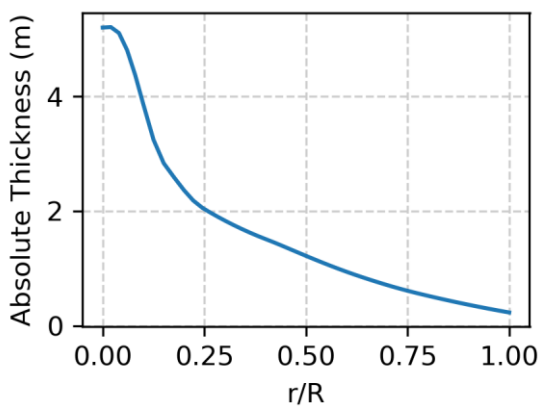


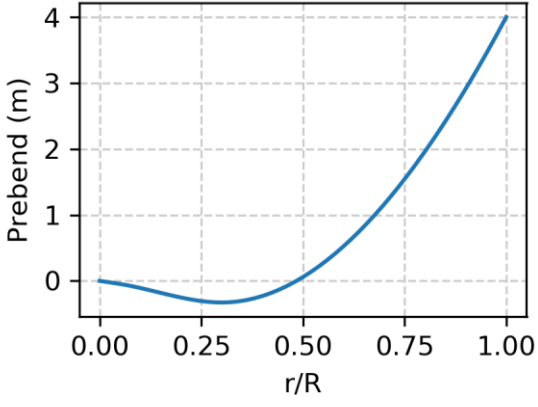


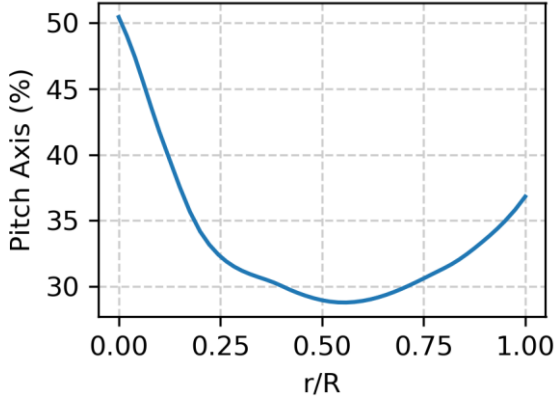


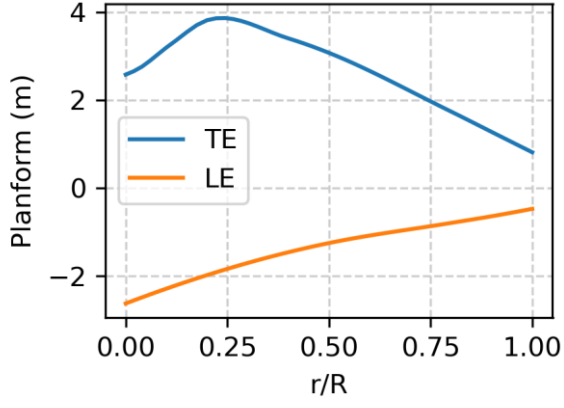

Chord (m)
r/R


Twist (deg)
r/R

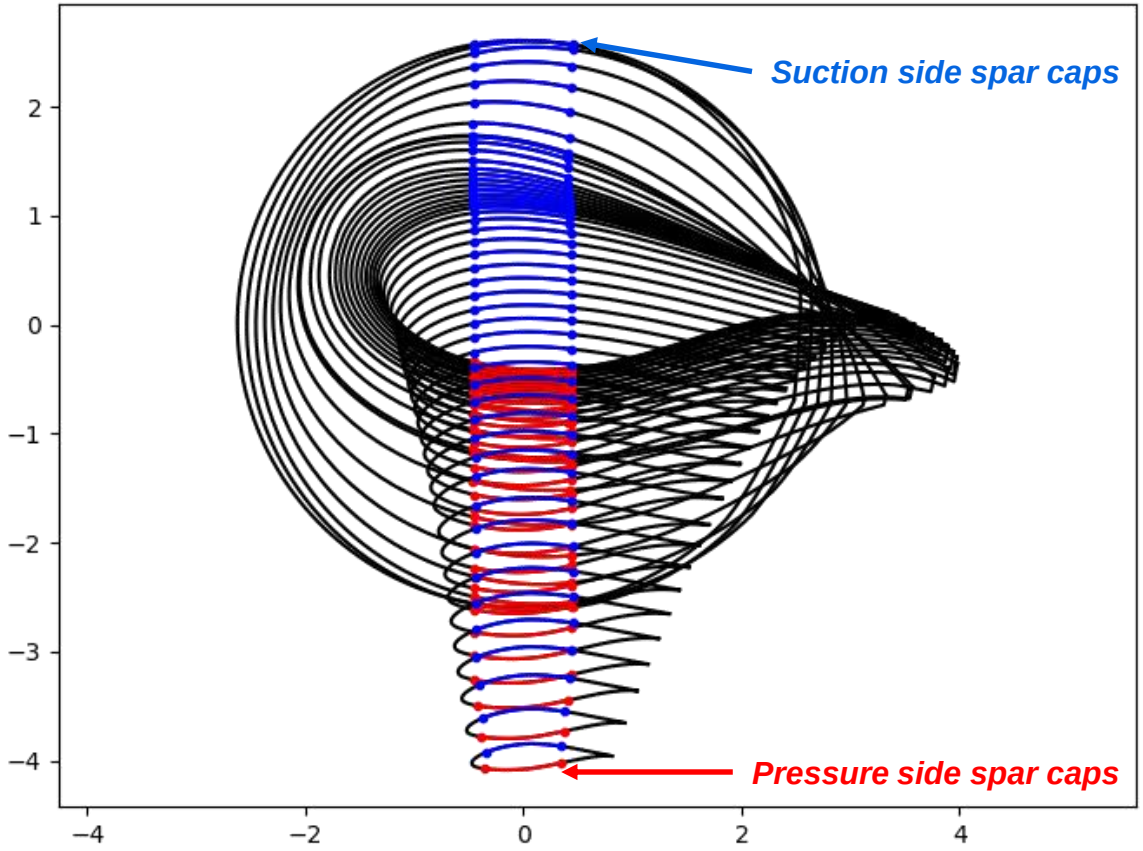

Absolute Thickness (m)
r/R


Prebend (m)
r/R

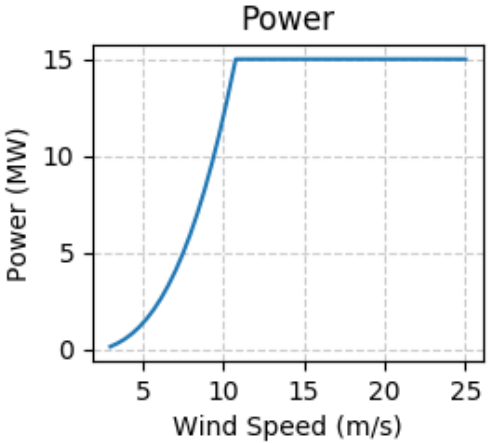

Pitch Axis (%)
r/R

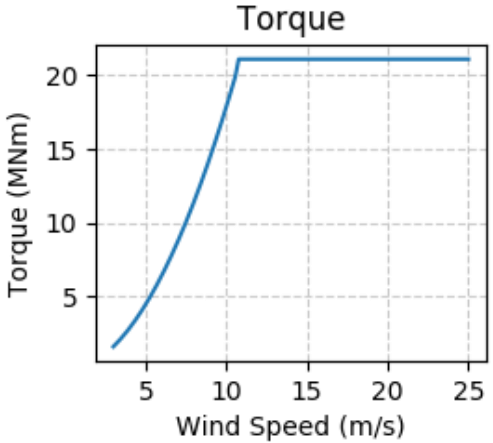

Planform (m)
TE
LE
r/R

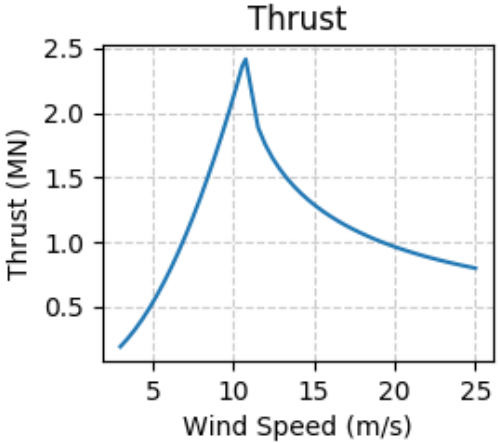
Lofted Shape

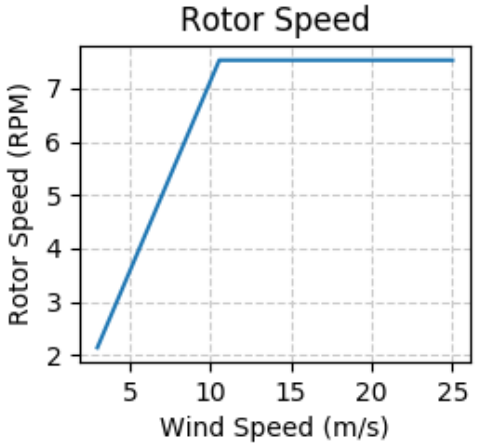


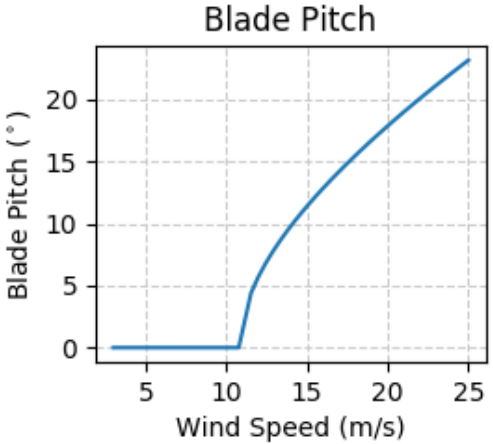
Optimized Rotor: Performance as a function of wind speed





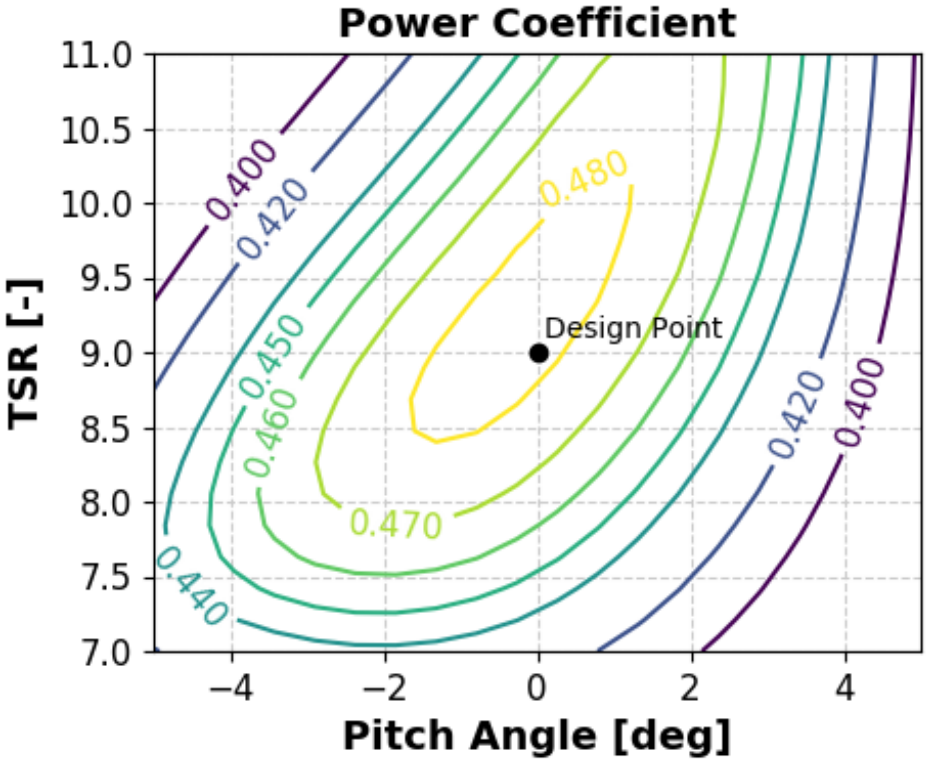


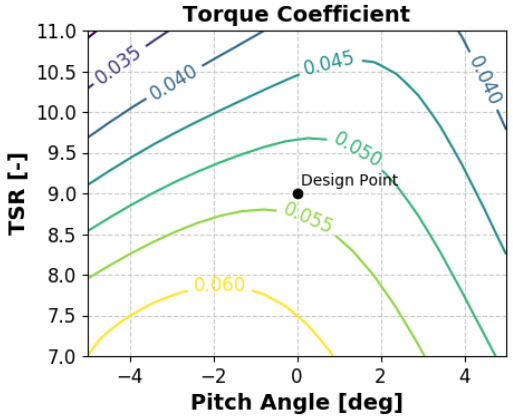


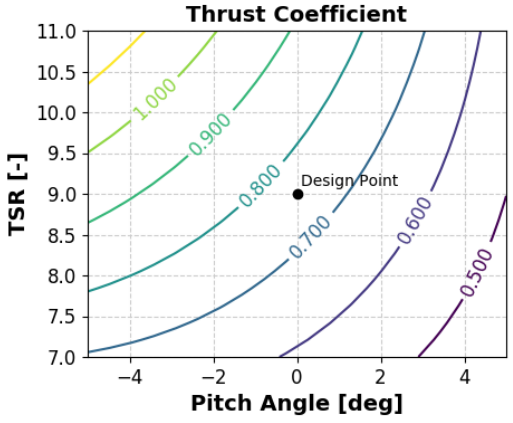


Parameter	Value
Max chord	5.85 m
Aero C_P	0.482
Rated wind speed	10.77 m/s
Rated rotor speed	7.54 rpm
AEP	76.96 GWh
Blade mass	70.1 ton

$C_P - \lambda$ Surfaces

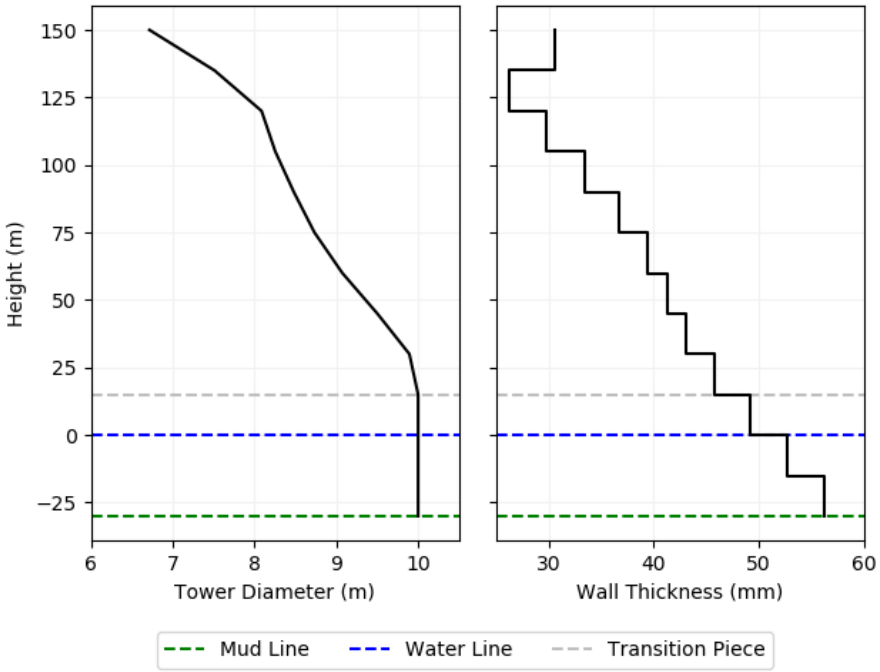






Preliminary Tower and Monopile Design

Tower and Monopile Design



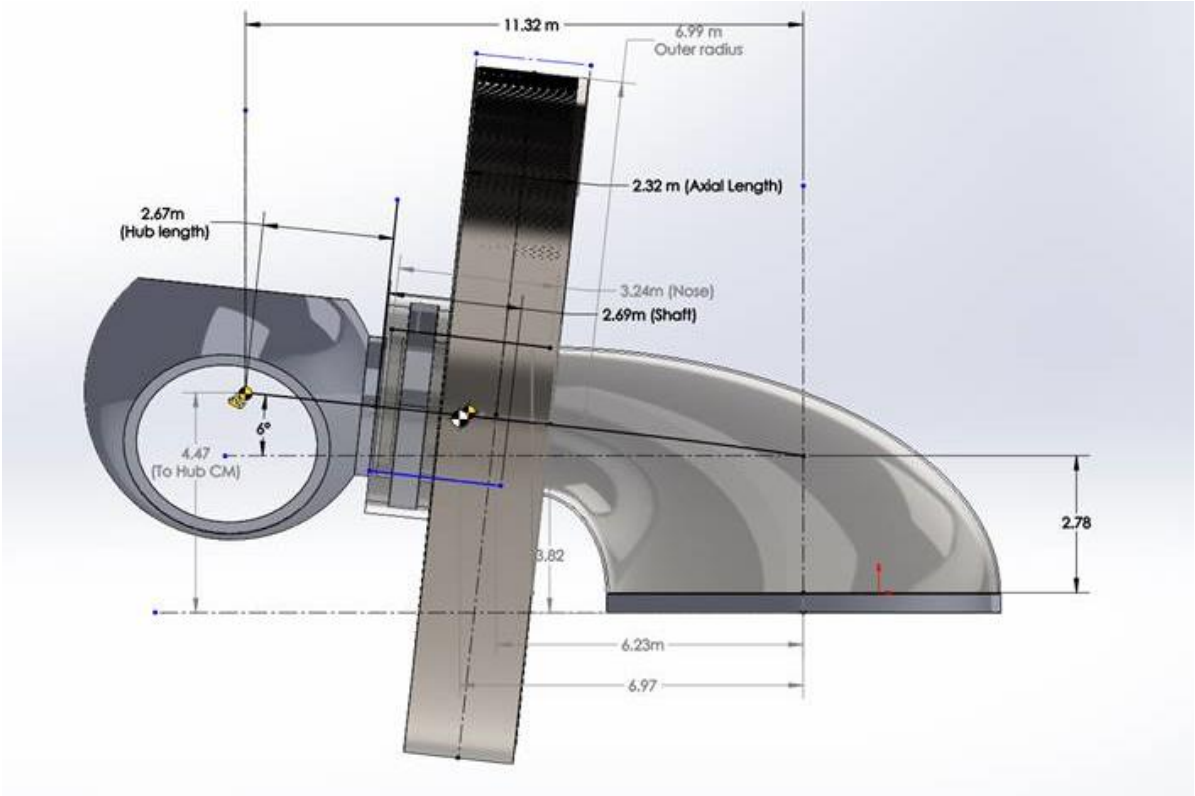
Parameter	Value
Water Depth	30 m
Transition Piece Height	15 m
Hub Height	150 m
RNA Mass	1,250 ton
Monopile Max Diameter	10 m
Tower Mass	1,130 ton
Monopile Mass	185 ton

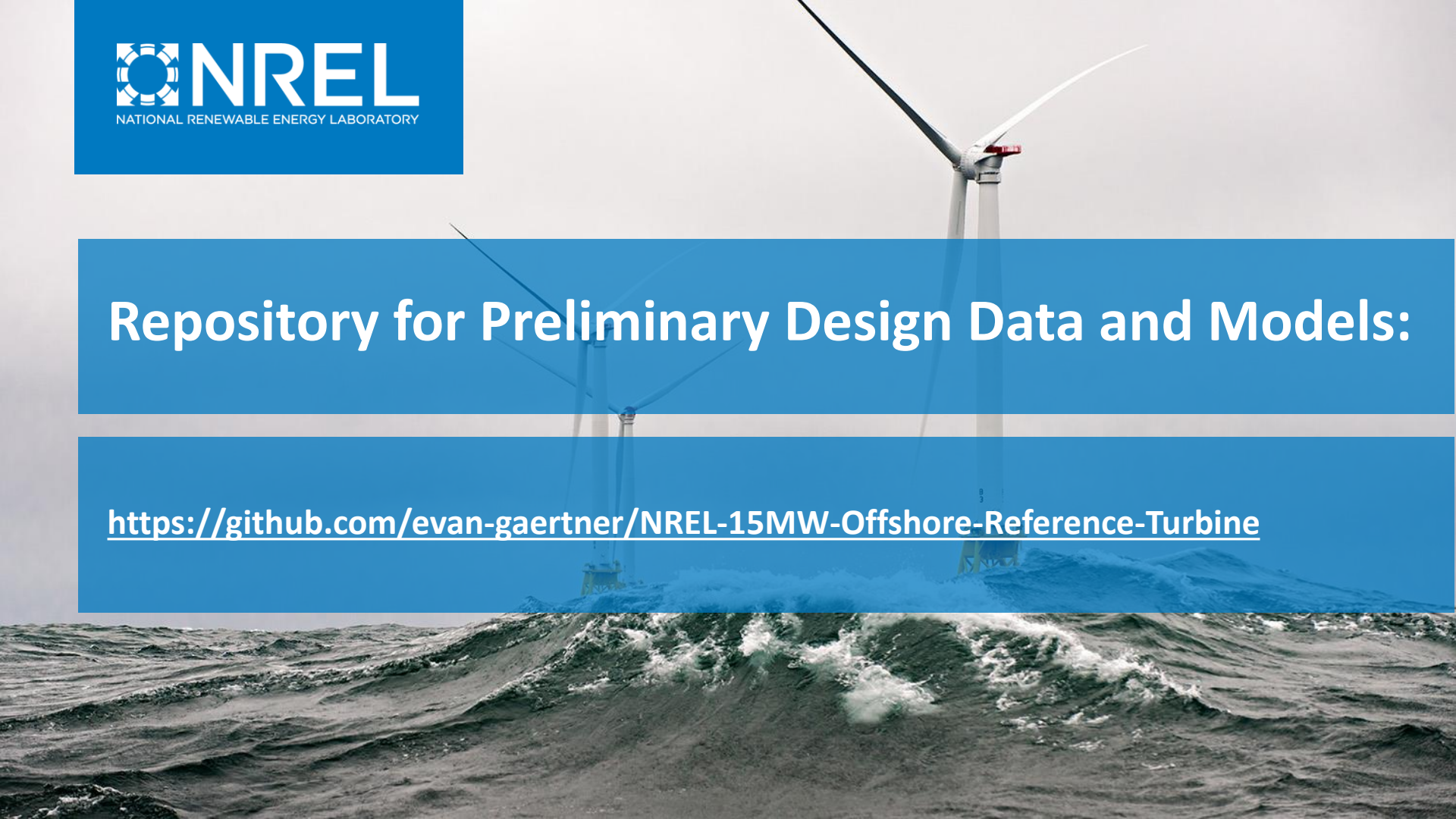
Preliminary Drivetrain Specifications

Generator Configuration

Generator Specifications	
Location	Upwind
Rated torque	20.5 MNm
Tangential stress	85 kN/m^2*
Peak air gap flux density	0.8-1.05 Tesla
Specific current loading	60kA/m
Type of cooling	Liquid cooled

CAD Model of Generator, Bedplate, and Hub





Repository for Preliminary Design Data and Models:

https://github.com/evan-gaertner/NREL-15MW-Offshore-Reference-Turbine