Coastal & Offshore Modelling Symposium

COMS2026

Aerodynamic Code-To-Code Comparison via IEA 22 MW Reference Turbine

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26 Feb, 2026
Cork, Ireland

Background

COMS2026

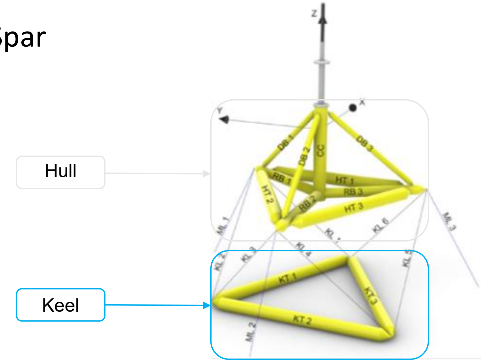
COMS 2026 COASTAL OFFSHORE MODELLING SYMPOSIUM

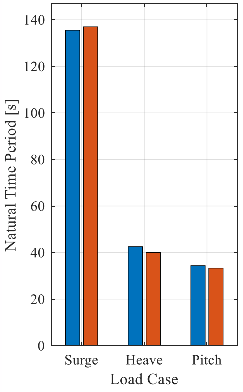
SHED Structural & Hydro-Environmental Dynamics, University College Cork

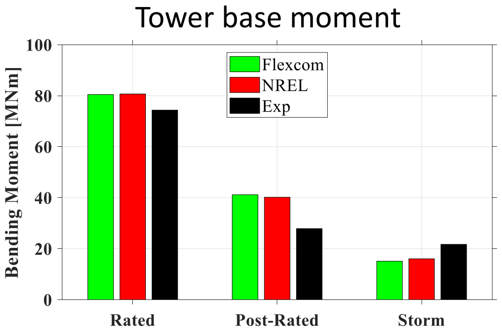
IEA OC6: Aero-hydro-elastic modelling of FOWTs

- **Offshore Code Comparison Collaboration, Continued, with Correlation, and unCertainty**
  - International research project verifying & validating modelling tools for FOW systems
  - Sponsored by IEA, coordinated by NREL

Stiesdal Tetra-Spar





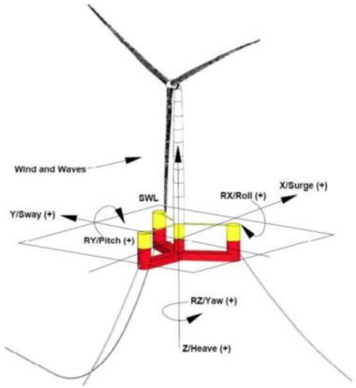


IEA International Energy Agency · NREL National Renewable Energy Laboratory · wood.

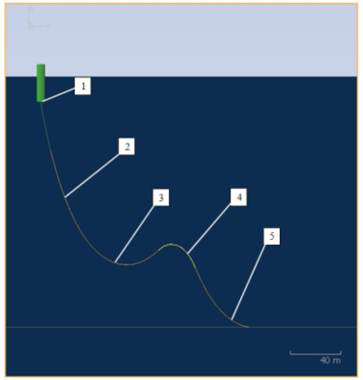
Fretting in submarine power cables

Aim: To establish a fretting wear-fatigue methodology for copper wire conductors within SPCs, with a focus on offshore renewable energy technologies

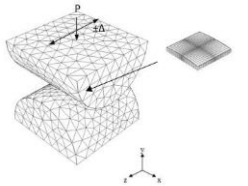
US-S Volturn FOWT



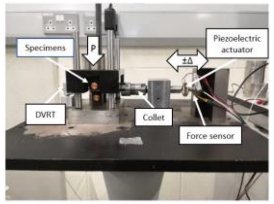
Global dynamic model



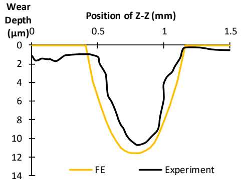
Wire contact model



Wire contact test



Wear scar

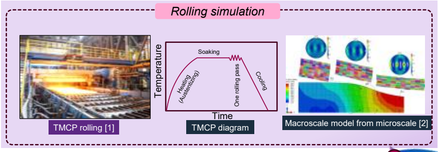


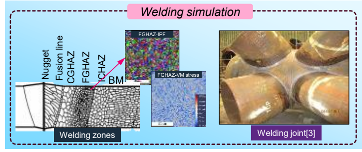
wood. · Taighde Éireann Research Ireland · MaREI Energy · Climate · Marine

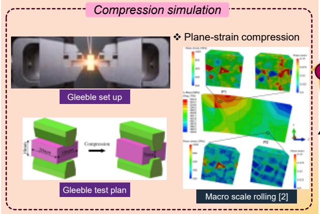
TRANSFORRM

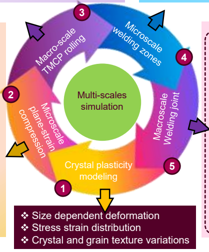
Aim: To develop multi-scale, process-structure-property-performance framework for manufacturing informed design of safe, sustainable, next-generation support structures for upscaling OWTs.

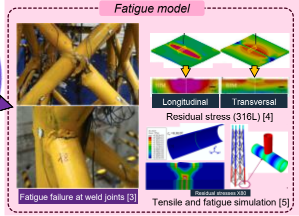
Taighde Éireann Research Ireland · seai Sustainable Energy Authority of Ireland · TRANSFORRM











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UCC University College Cork · Marine Institute Foras na Mara

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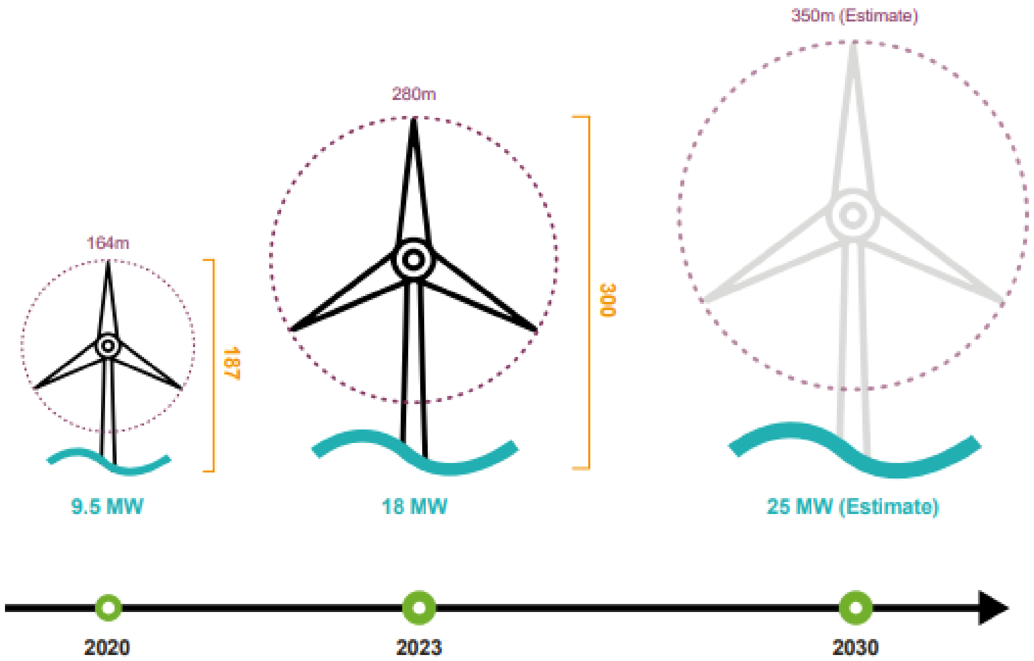
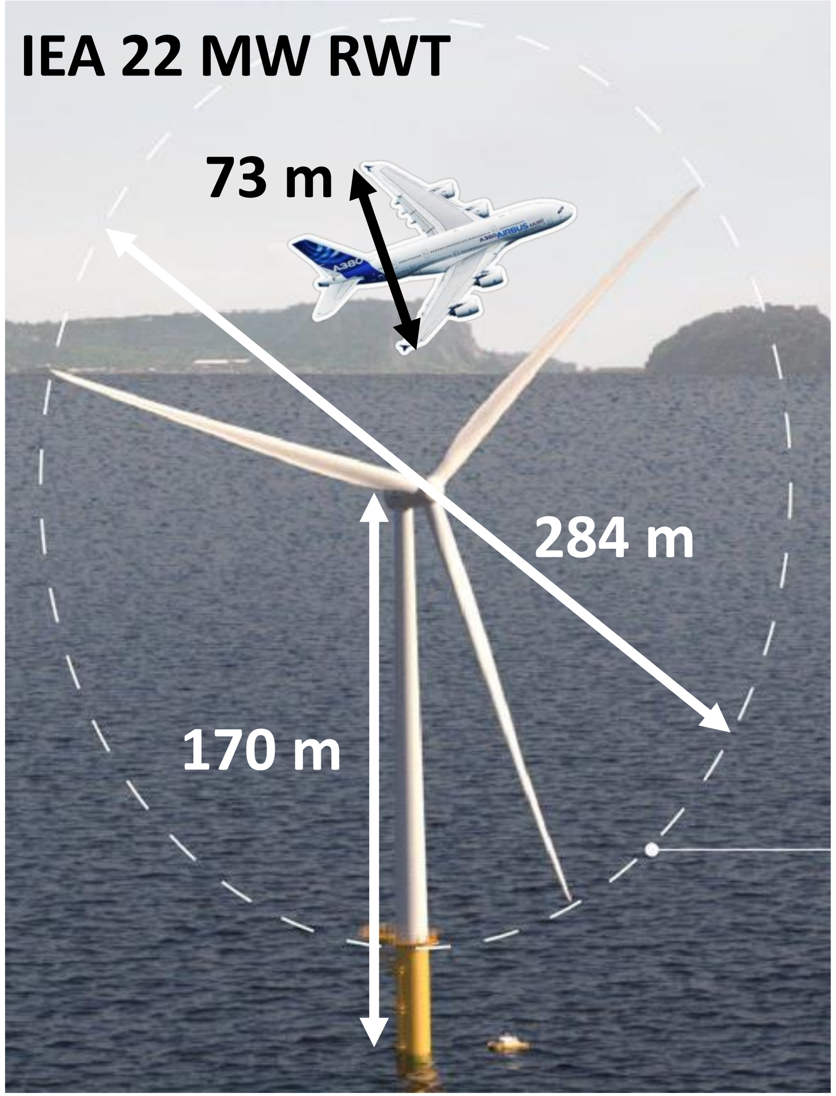
Background

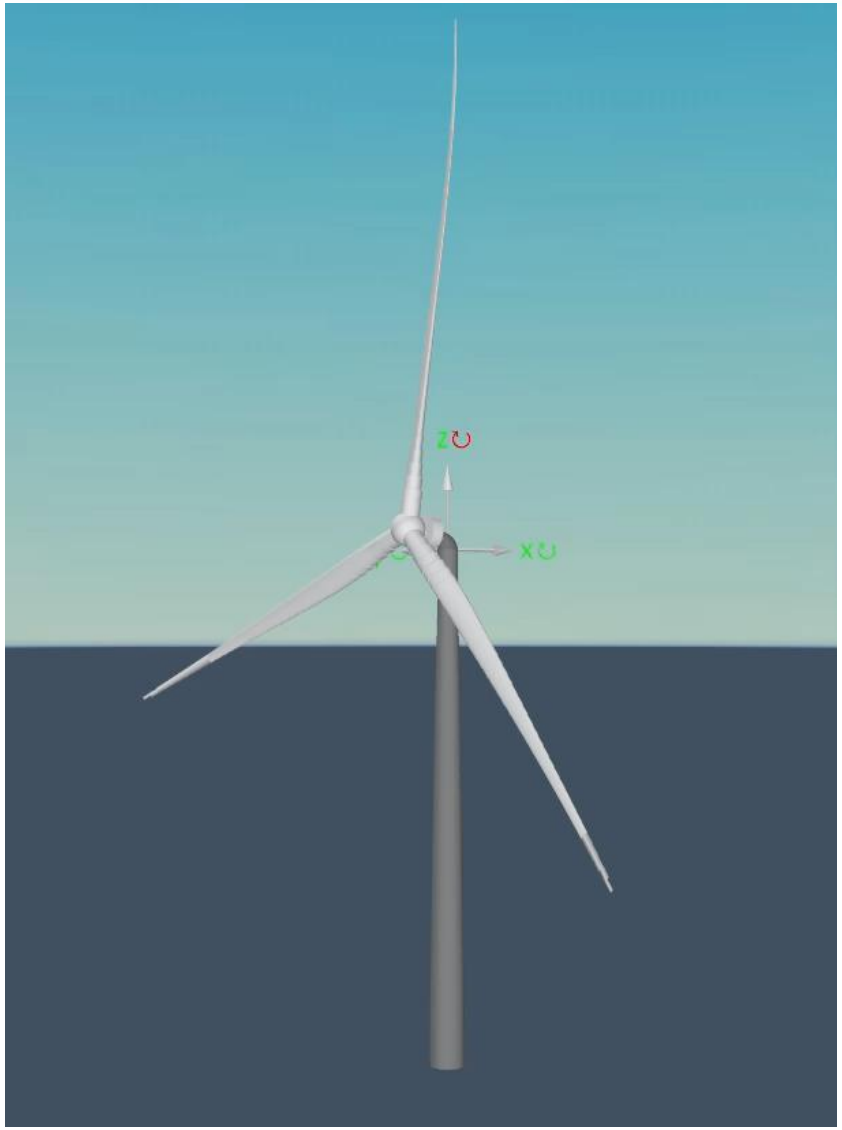


- Increasing blade flexibility introduces modelling challenges
- RWT's are used for evaluation of current modelling tools



Overview

Aeroelastic Tool	OpenFAST (NREL)	OrcaFlex (Orcina)	Flexcom (Wood)
Origins	Wind Energy, Open-source	Oil & Gas, Commercial	Oil & Gas, Commercial
Aerodynamics	Blade Element Momentum	Blade Element Momentum	As per OpenFAST
Structural Dynamics	GEBT	Finite Element	Finite Element
Control	Equivalent customisable DLL's		



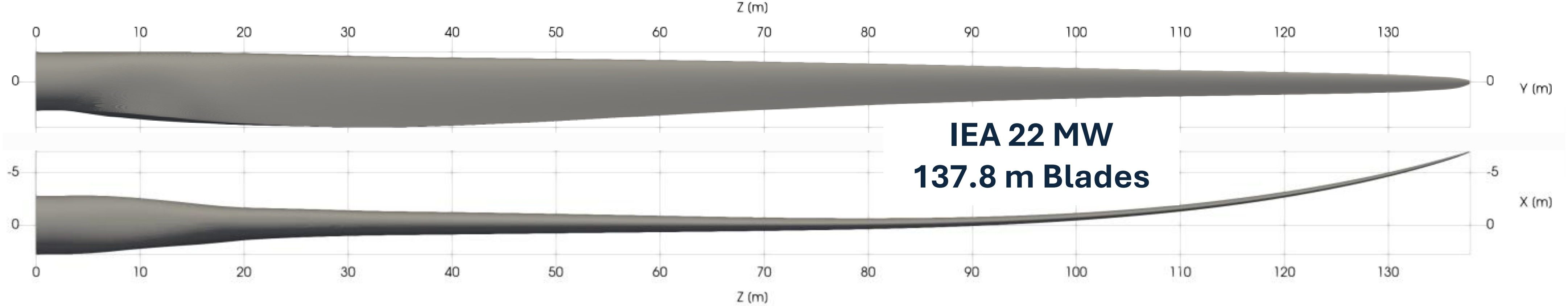
Code-to-Code Comparison focused on aeroelastic response

- Fixed tower base, no hydrodynamics

Key Objectives are to Provide:

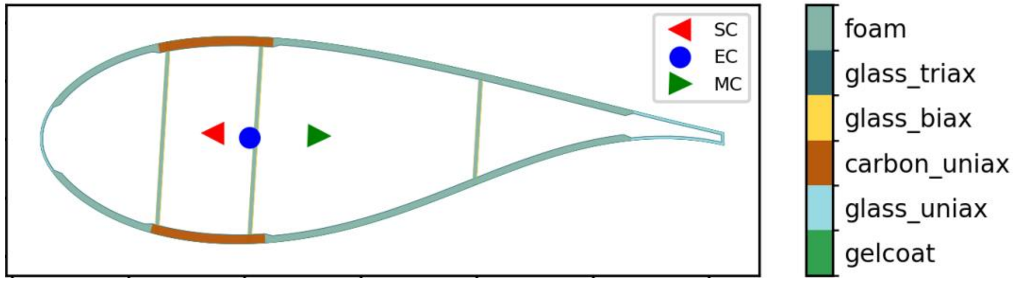
- Verification and validation data
- Open access models

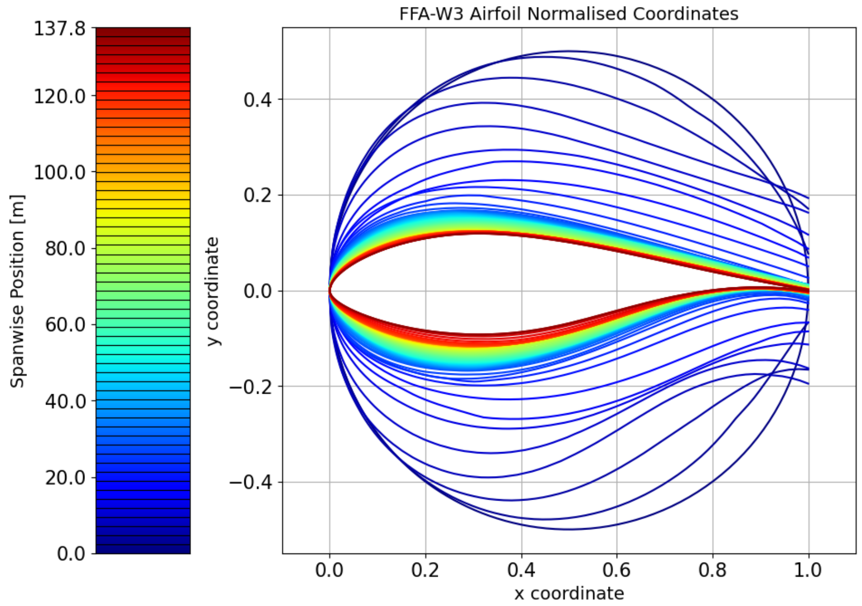
IEA 22MW RWT



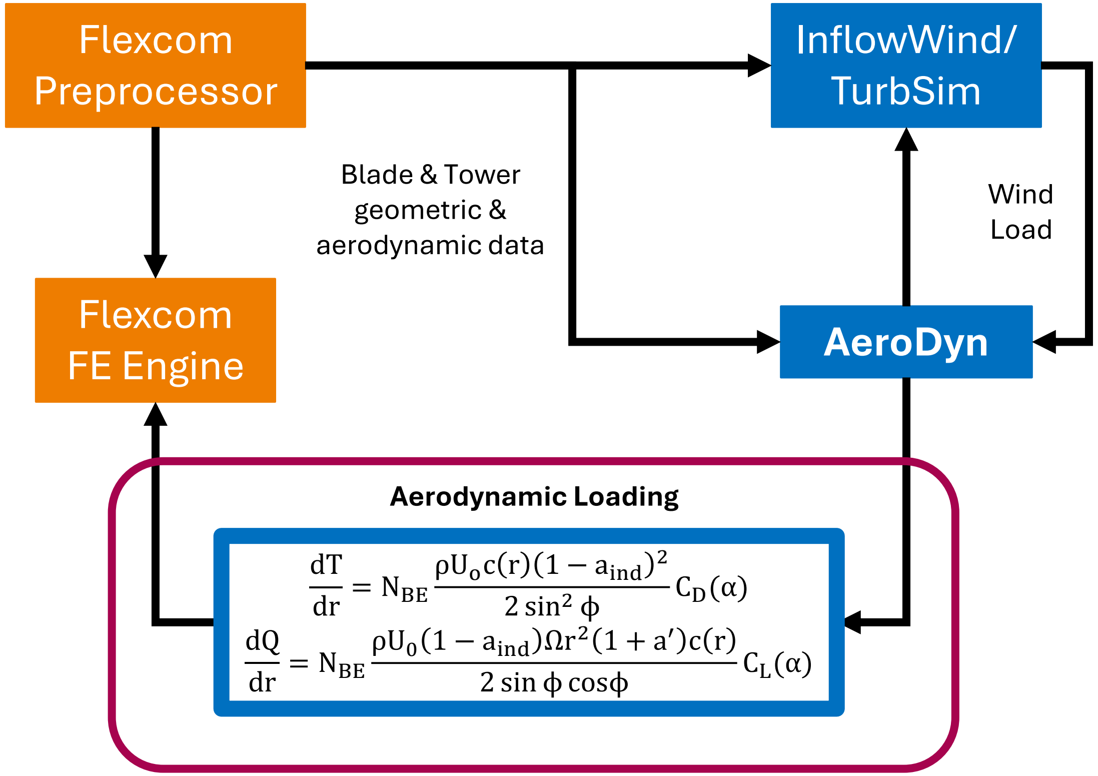
Developed by NREL & DTU as a realistic representation of next-generation, ultra-large WT's to be installed in the next 5 years:

- Advanced, up-winded class 1-B WT with a direct-drivetrain
- Variable speed, collective pitch control strategy
- Wind Speed Range: 3-25 m/s
  (Rated - 11.5 m/s | 7.061 rpm)



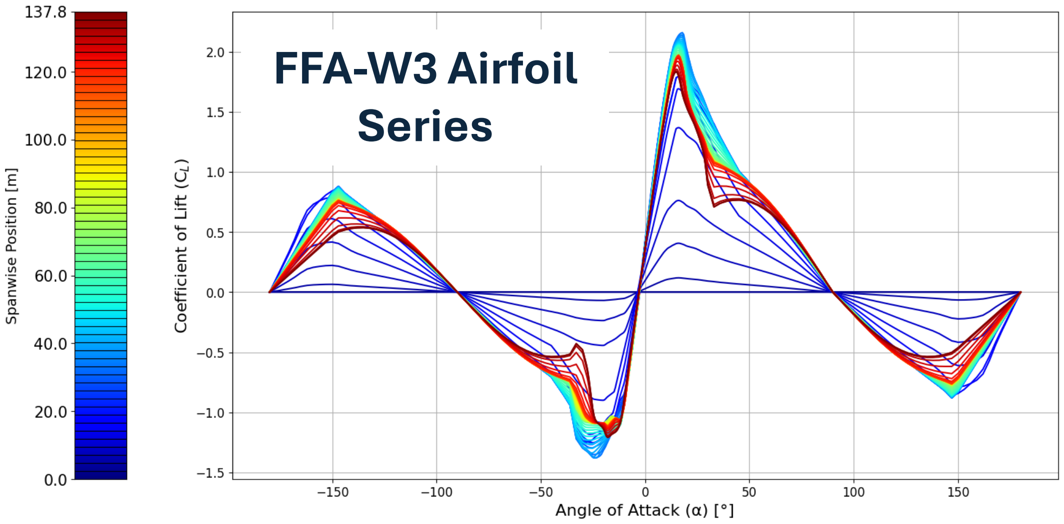


Aerodynamics



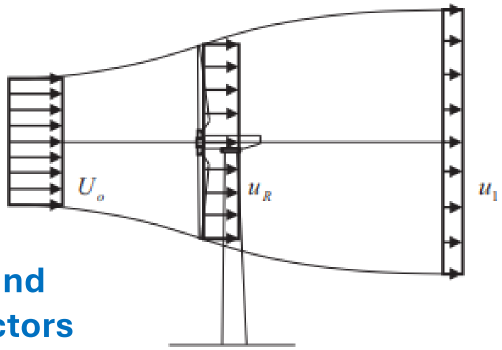
$$\frac{dT}{dr} = N_{BE}\frac{\rho U_o c(r)(1-a_{ind})^2}{2\sin^2\phi}C_D(\alpha)$$

$$\frac{dQ}{dr} = N_{BE}\frac{\rho U_0(1-a_{ind})\Omega r^2(1+a')c(r)}{2\sin\phi\cos\phi}C_L(\alpha)$$



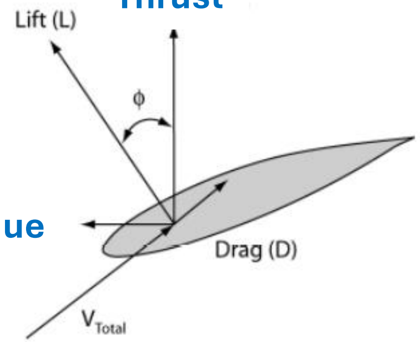
AeroDyn BEM Algorithm

Momentum Theory:



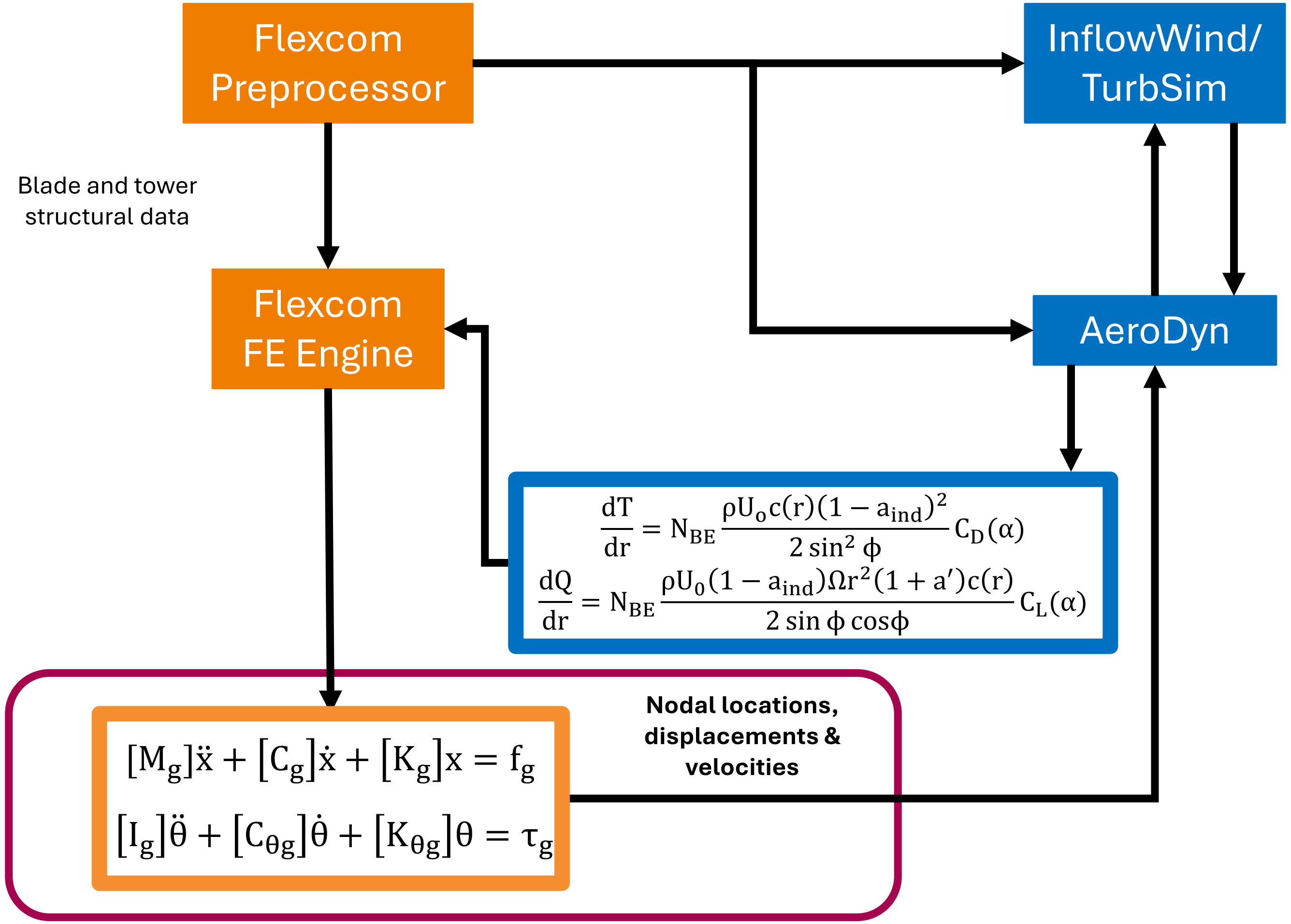
Axial Flow and Induction Factors

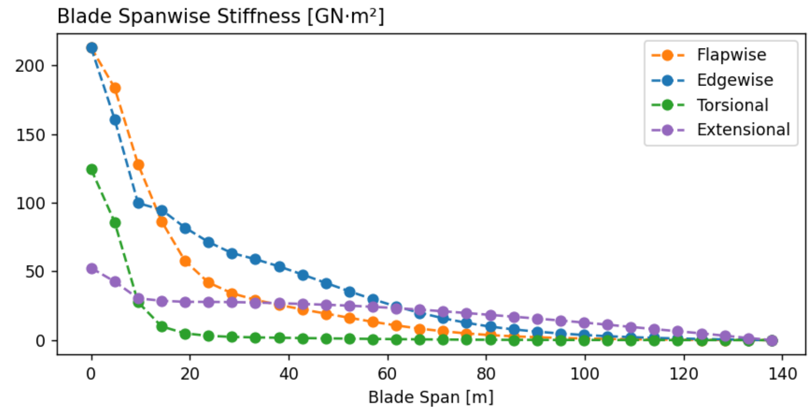
Blade Element Theory:



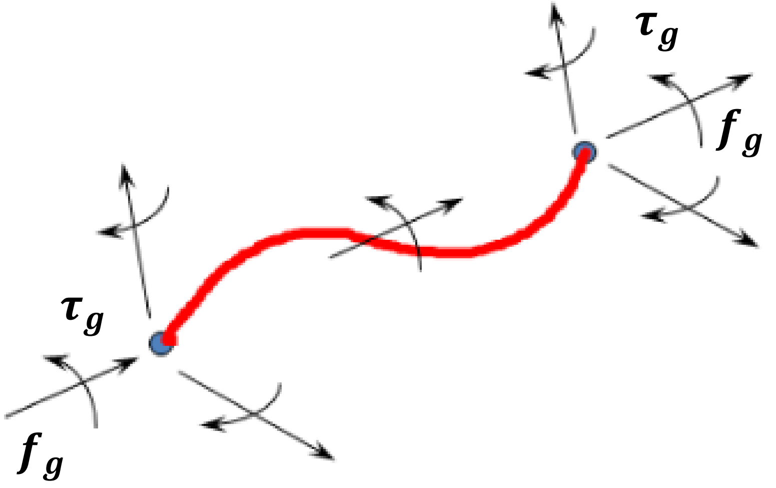
Corrections Include: Tip & Hub Loss (Prandtl)

Structural Dynamics



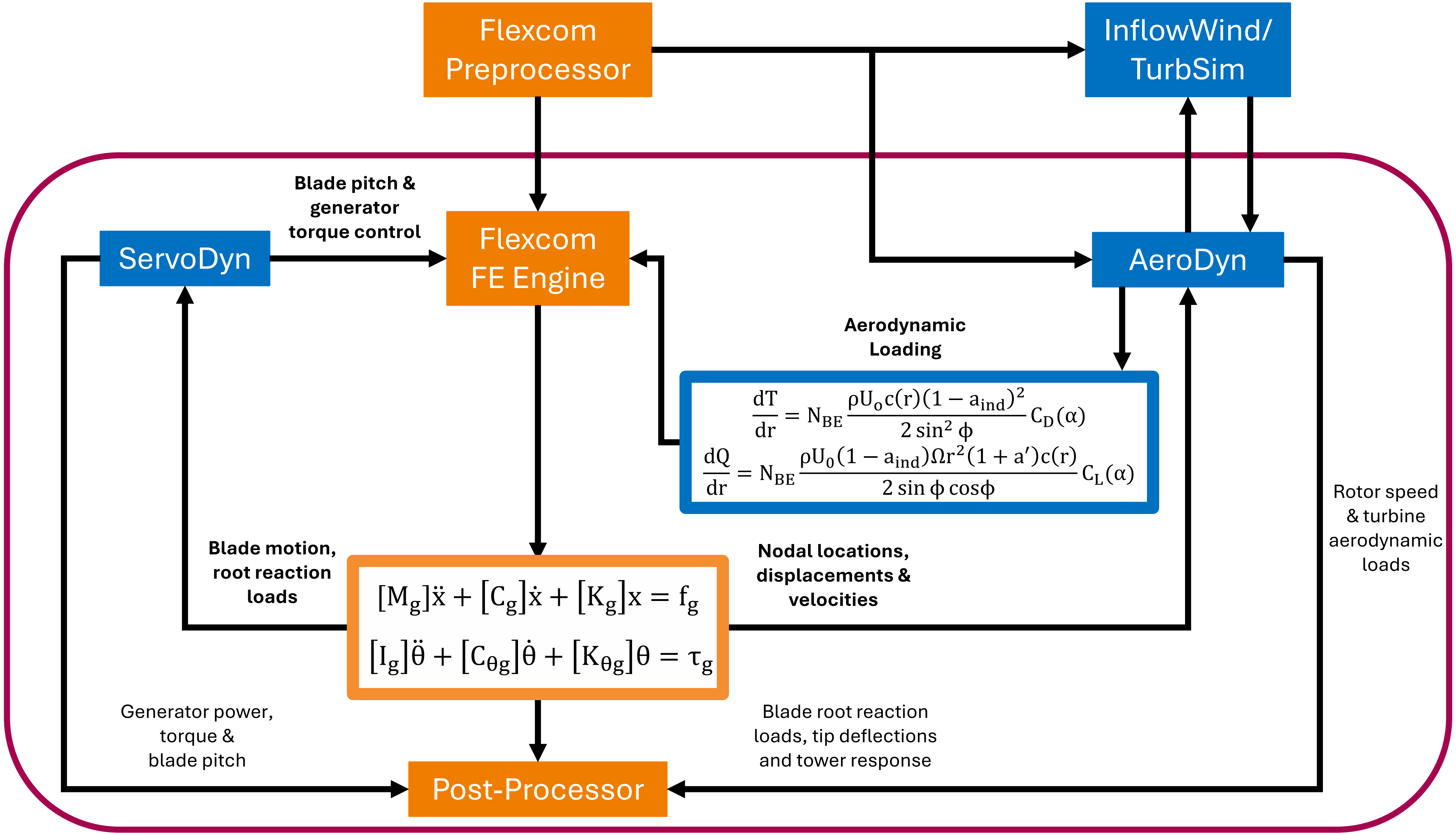


Flexcom FE Formulation



14-DOF Hybrid Finite Element

Aero-Servo-Elastic Framework



OPENFAST NREL

Flexcom

Ollscoil na Gaillimhe University of Galway

Load cases

Steady Wind

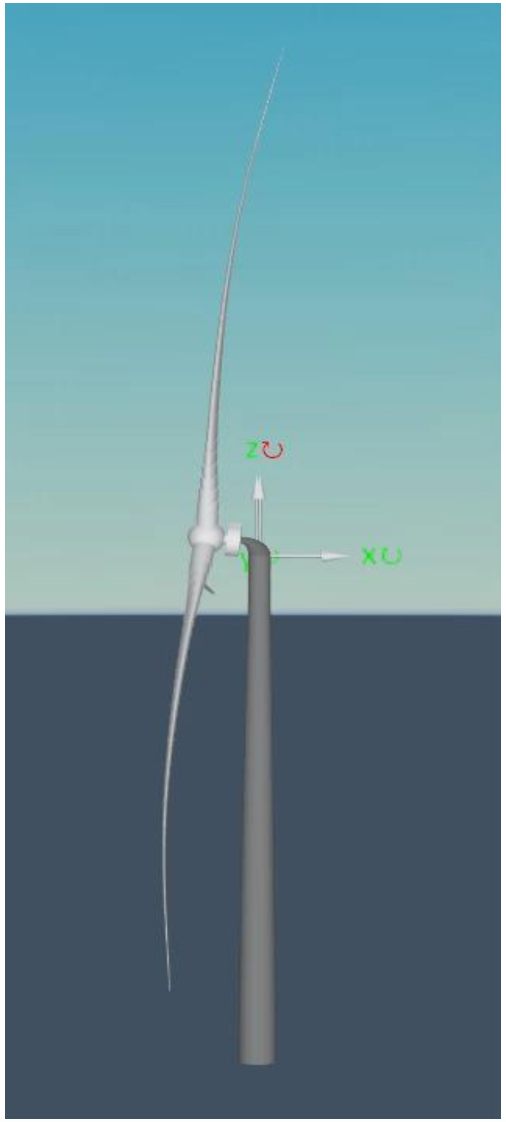
- Range of constant wind speeds considered (3m/s-25 m/s)
- Rotor is aligned with incoming wind

Stepped Wind

- Time varying wind load
- Starts at 4 m/s, raised by 1 m/s every 40s, up to 25m/s
- 30° Skew angle

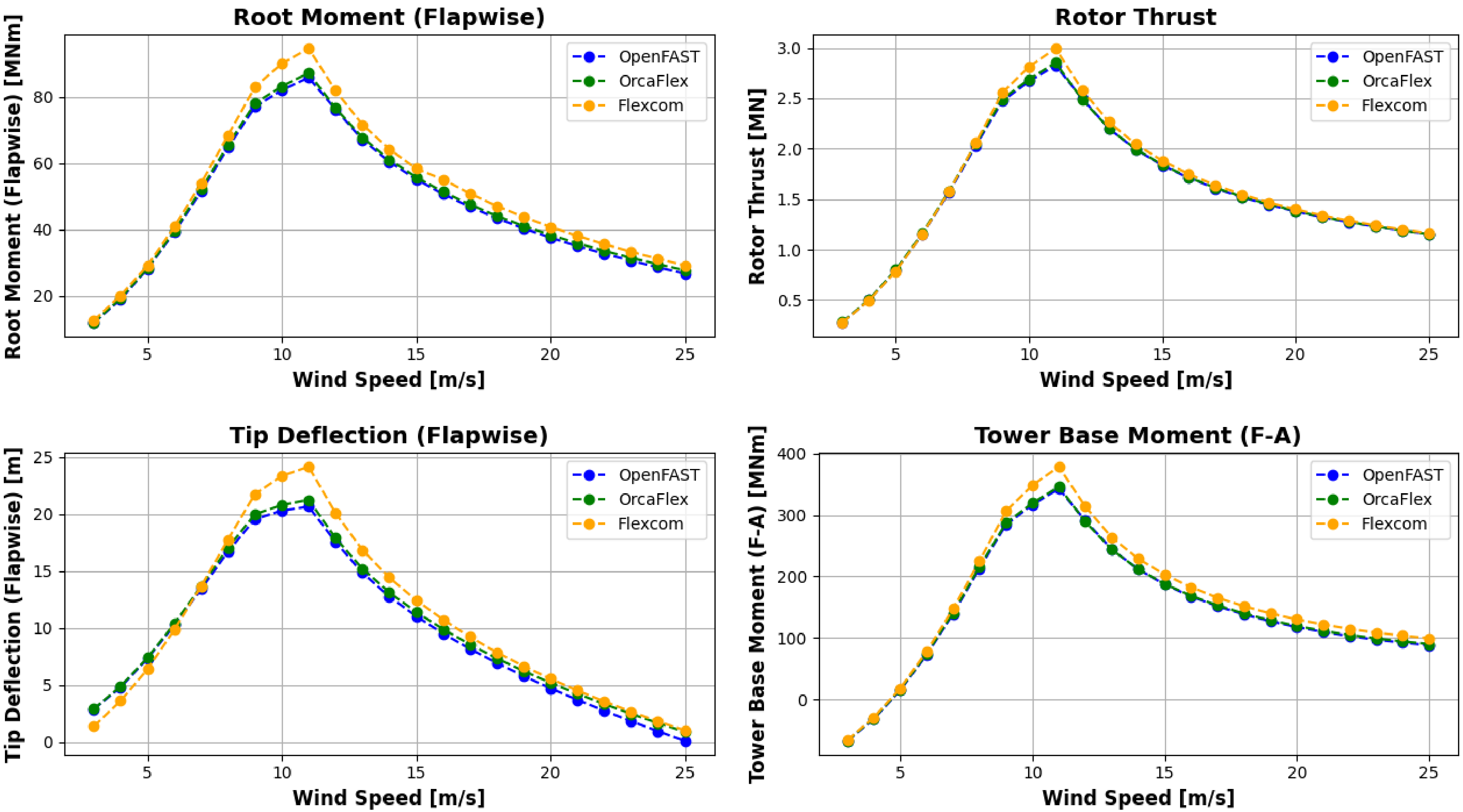
Turbulent Wind

- Full-field wind turbulence (IEC standard extreme)
- Range of mean wind speeds considered (3m/s-25m/s)



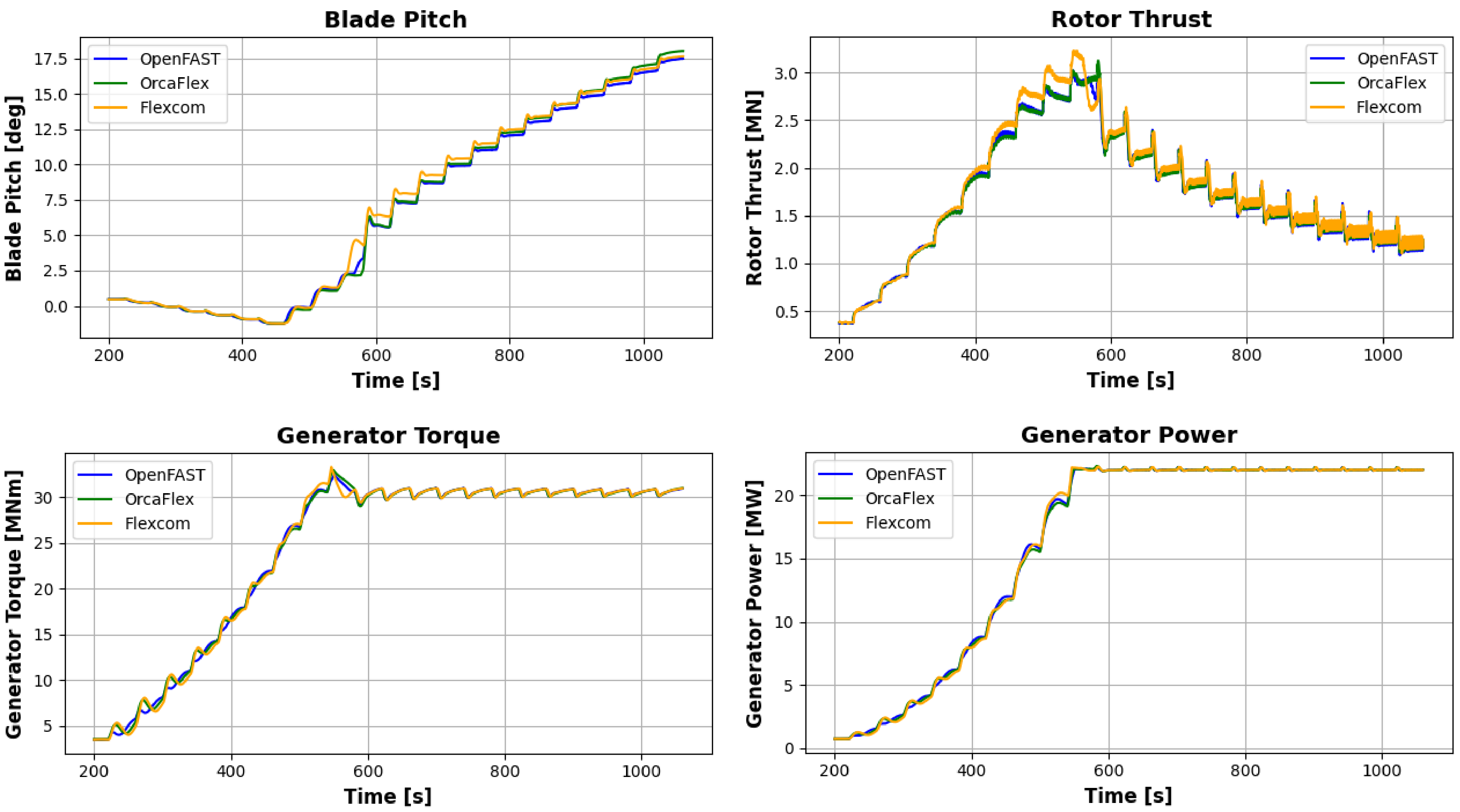
Steady Wind (mean values)

Time invariant characterisation of steady state response



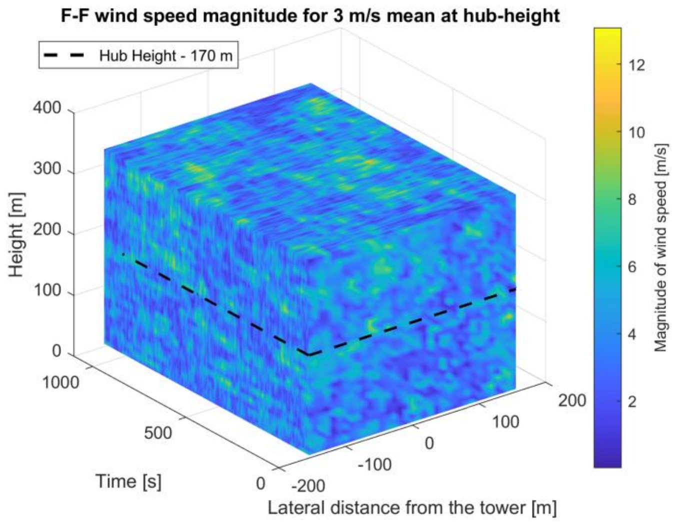
Stepped Wind (time histories)

Time and directional dependent wind load response

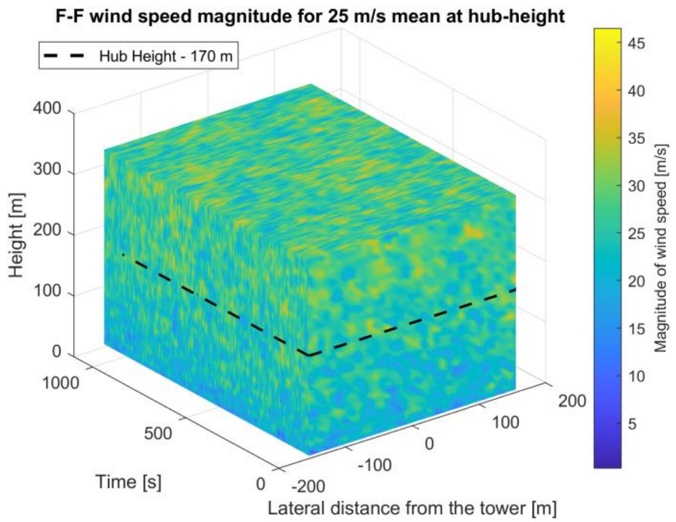


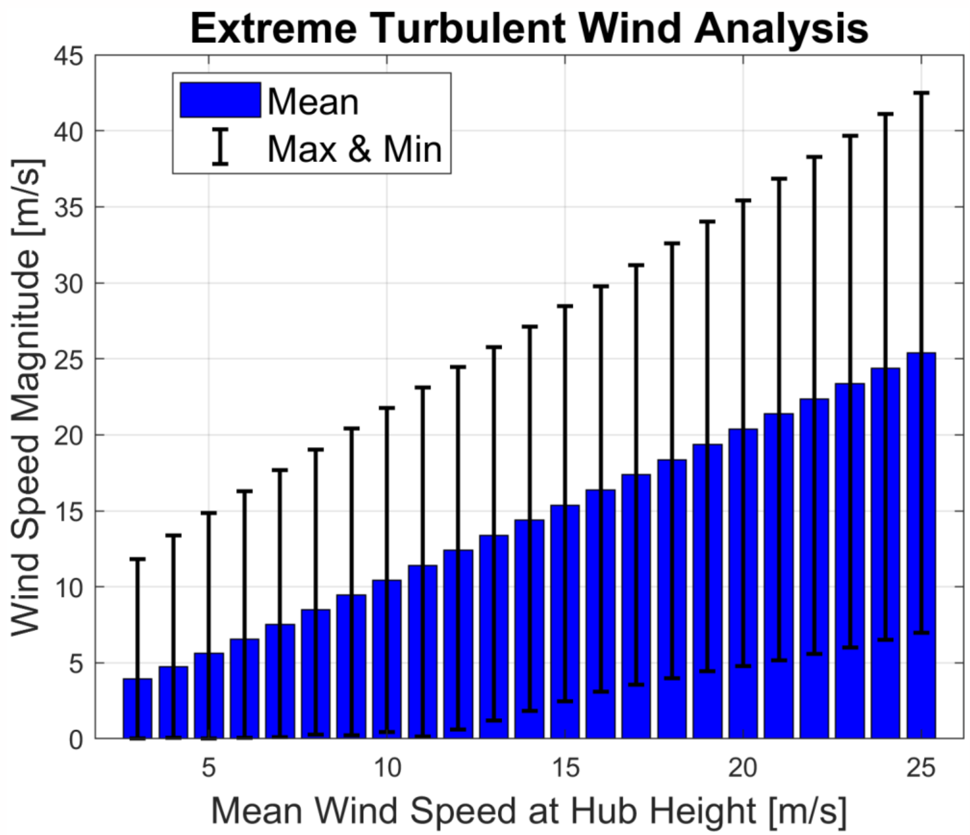
Turbulent Wind

Cut-in speed



Cut-out speed





Realistic power production cases in IEC extreme turbulent conditions

Full operational range statistics

Turbulent Wind (time histories)

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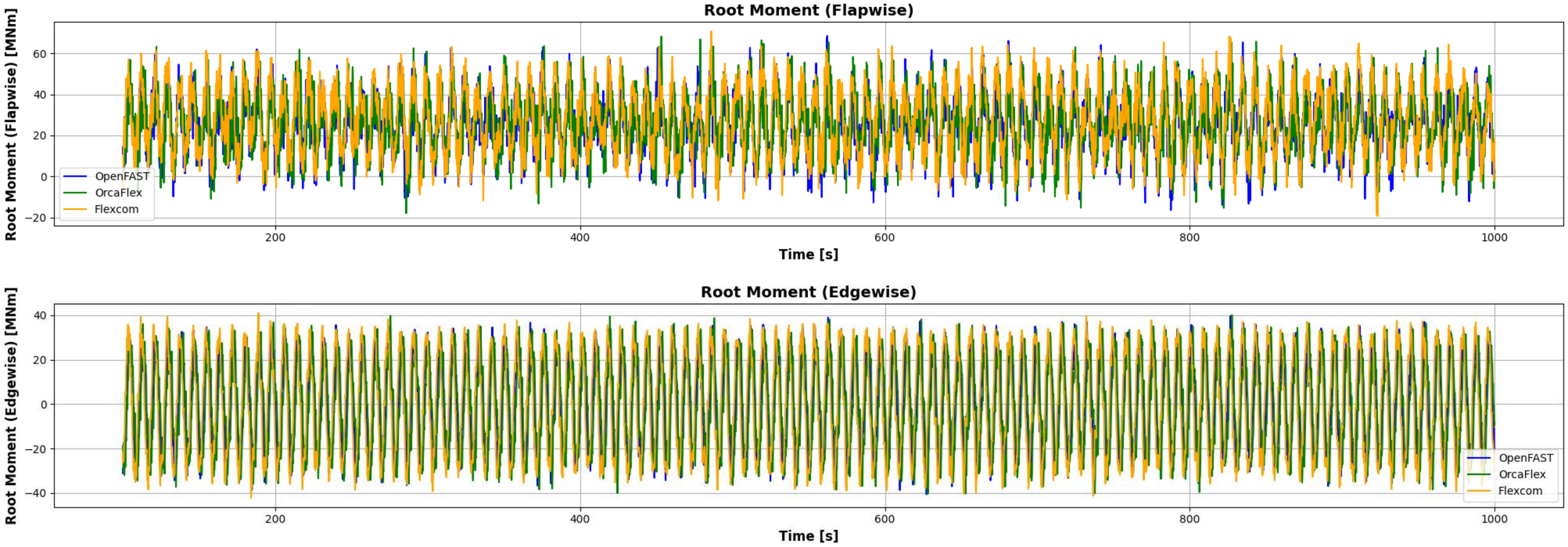
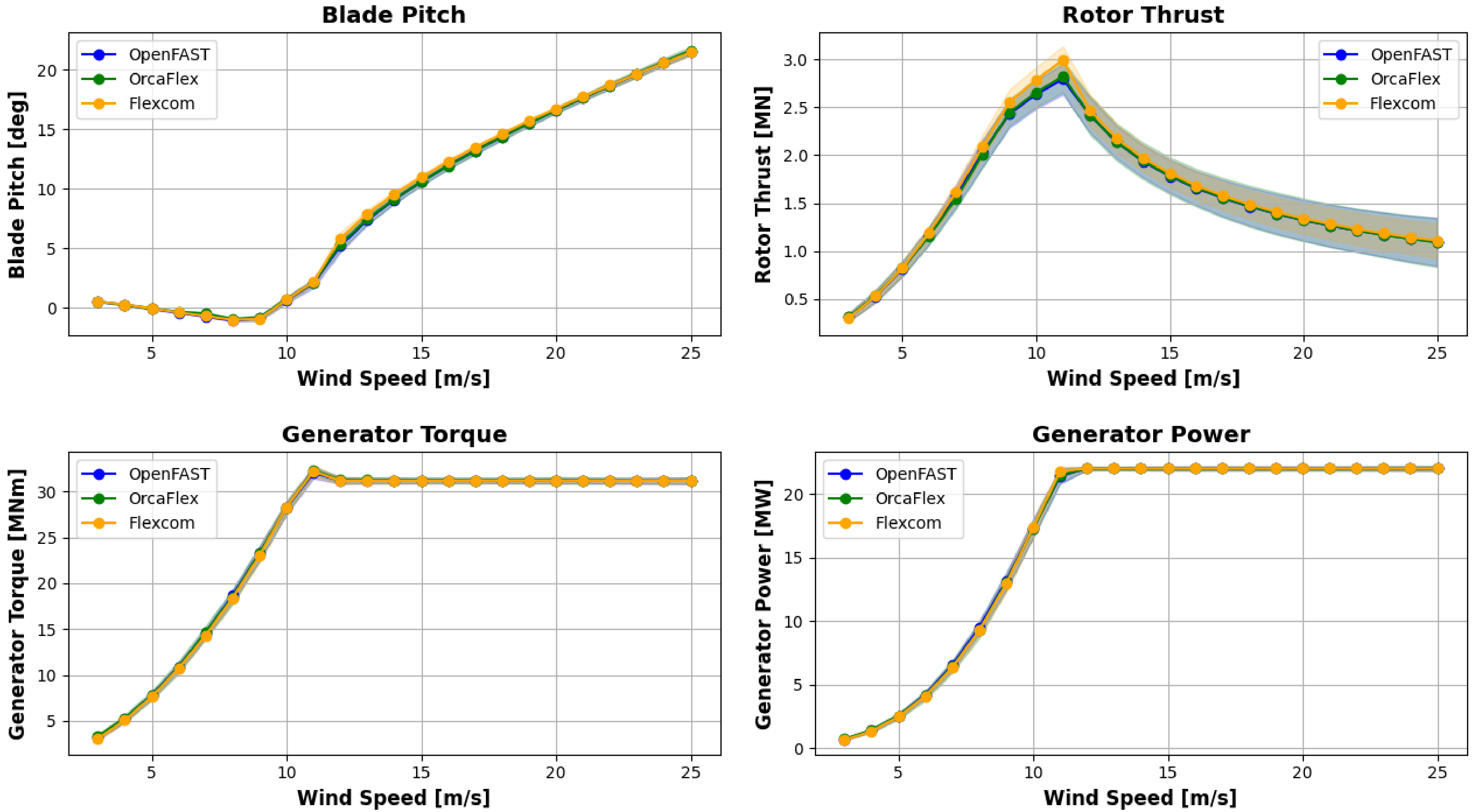
Realistic power production cases in IEC Extreme Turbulent Conditions



Turbulent Wind (mean, st. dev.)



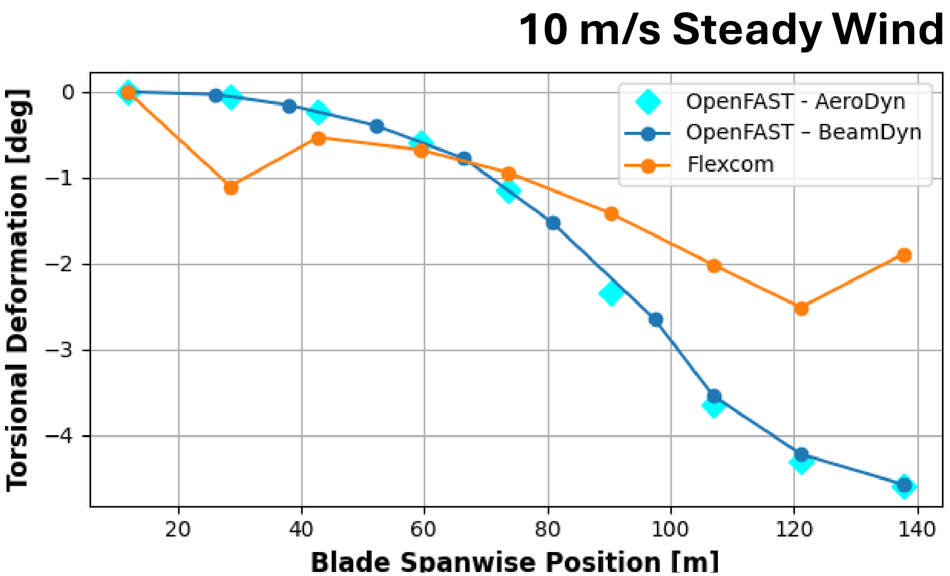
Discussion – Blade Twist

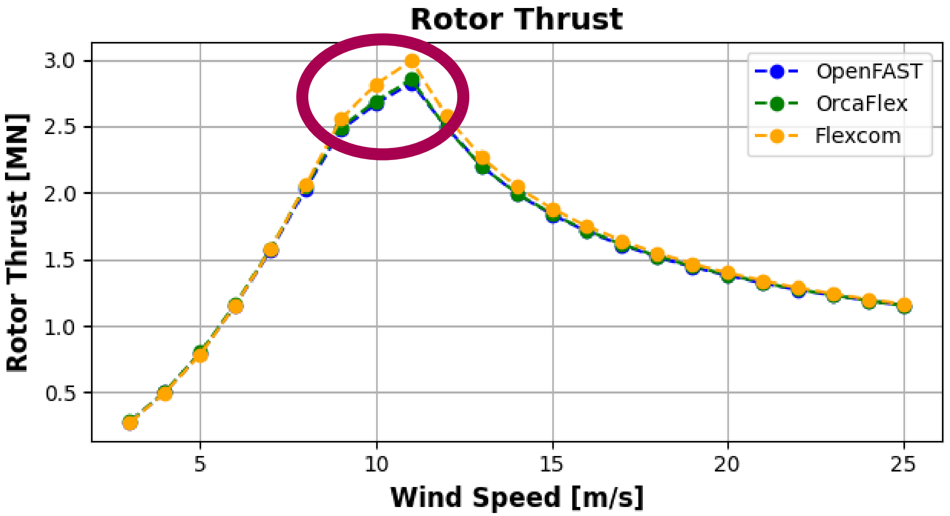
Flexcom model ignores offset between structural centre and aerodynamic centre

- Twisting moment induced by spatial offset is neglected
- Underprediction of blade torsional deformation
- Likely cause of Flexcom's overprediction of rotor thrust. To be addressed in the future

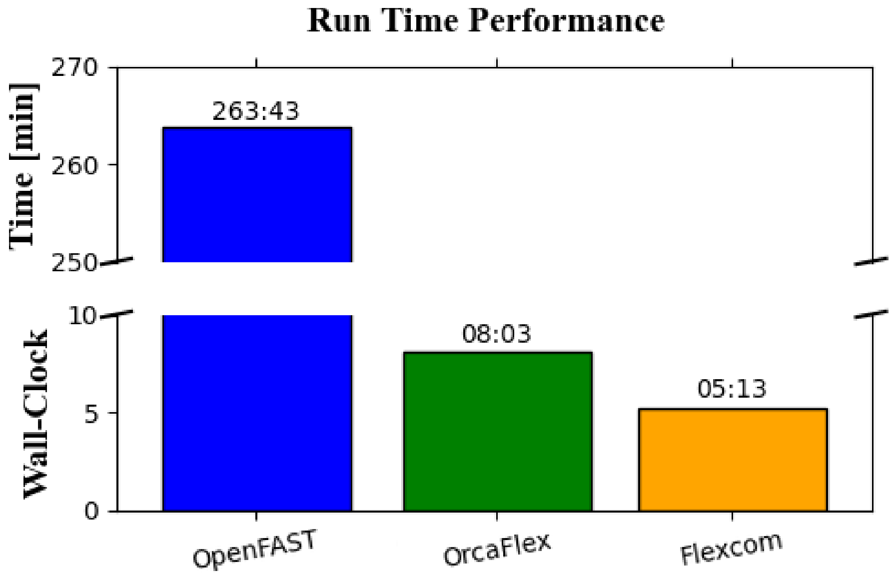
Good agreement overall

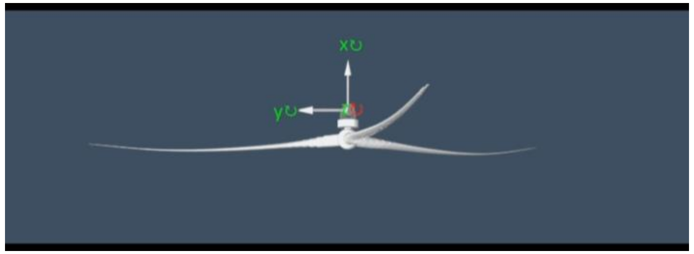
- Structural twist due to physical shape correct
- Rigid body twist due to control system correct
- Local AoA close to theoretical value





Run Times (stepped wind)



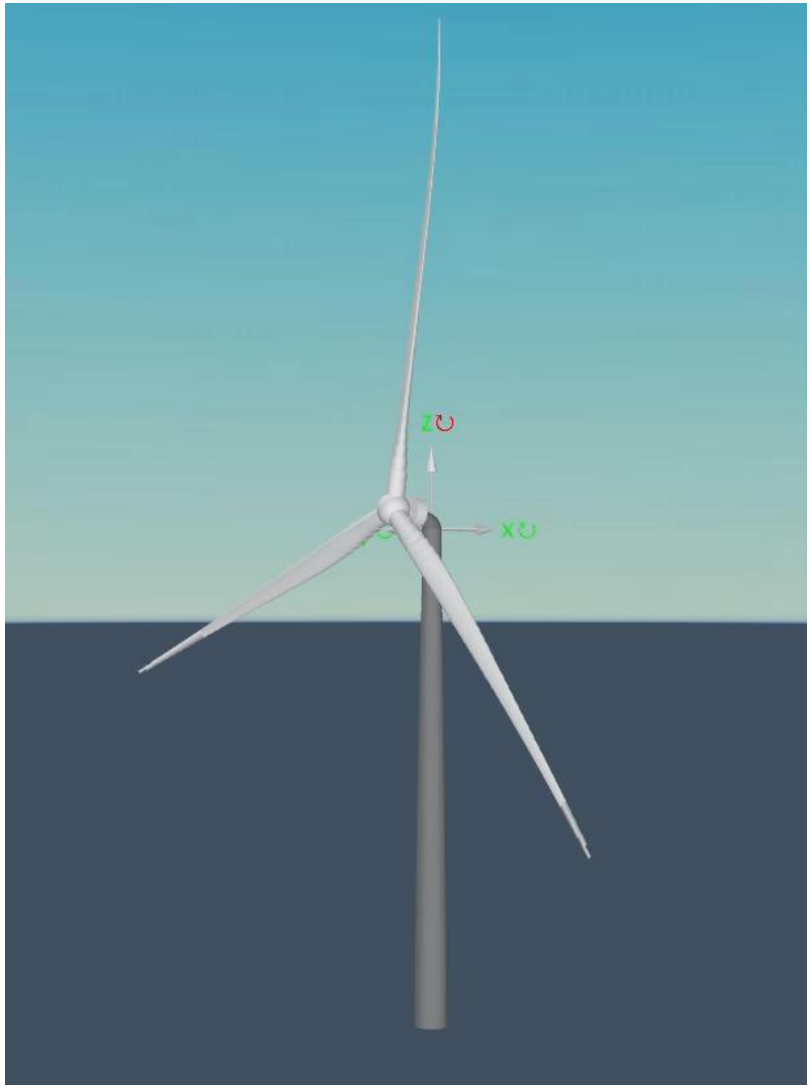


Solver	OpenFAST	OrcaFlex	Flexcom
No. of Structural Elements per Blade	58	37	58
Solution Time Step (s)	0.001 *	0.05	0.05

* NREL are developing coupling enhancements to improve performance

Conclusion

- Credible code-to-code validation via the IEA 22 MW RWT
- First peer-reviewed benchmarking of OrcaFlex & Flexcom for a 22 MW WT*
- Close agreement is achieved for key performance metrics
- Open access models have many future applications including:
  - Fully coupled floating system
  - Fatigue or storm analysis



*B Britton, O Conway, A Connolly, SB Leen, "Aerodynamic Code-to-Code Comparison via IEA 22 MW Reference Turbine" Proc ASME 2025 International Offshore Wind Technical Conference (IOWTC2025), Toulon, September 2025 vol 89282, pp V001T01A008, https://doi.org/10.1115/IOWTC2025-164262

Acknowledgements

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MaREI

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Sustainable Energy Authority of Ireland