WHEN TRUST MATTERS

CONFLOWS

Using wind farm control on floating wind farms

Research project outline

R. Ruisi[1], E. Bossanyi[1], M. Bastankhah[2], J. Chapman[3], R. B. Tommasini[3], M. Ogbeifun[3], G. Foster[3], P. Fleming[4]

DeepWind 2022 conference

20 January 2022

1 DNV 2 Durham University 3 MARINE POWER SYSTEMS 4 NREL Transforming ENERGY

Summary

1 *Project outline*

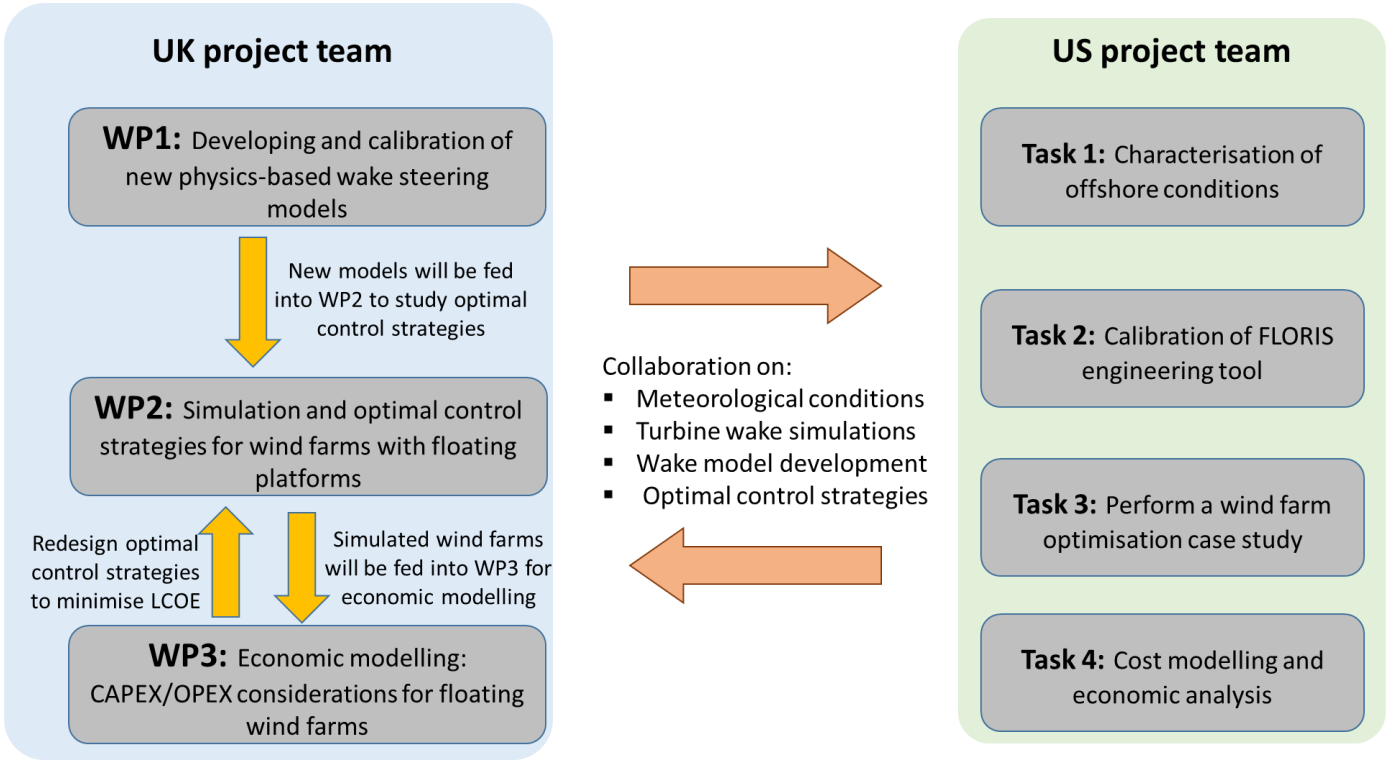
2 *Benchmark: site characteristics and floating platform*

3 *Wake modelling & wind farm control (WFC)*

4 *Next steps & conclusions*

CONFLOWS

CONtrol of FLOating wind farms using Wake Steering



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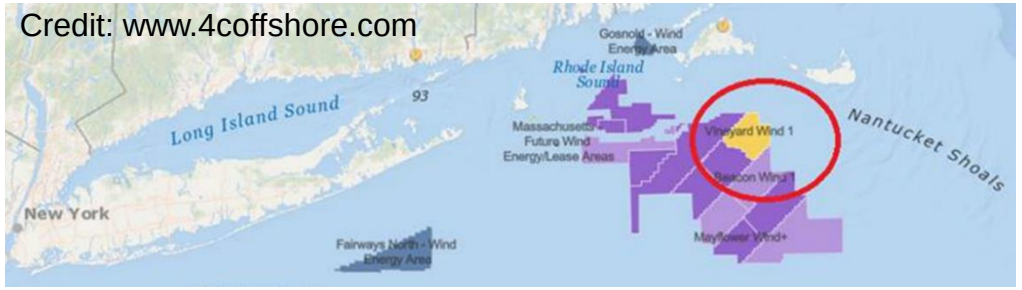
Objectives:

- increase confidence in the modelling and use of wake steering
- identifying challenges and advantages of using wake steering on floating offshore wind farms
- analysing economic effects of wake steering on floating platforms (*accelerate LCoE reduction*)

DNV

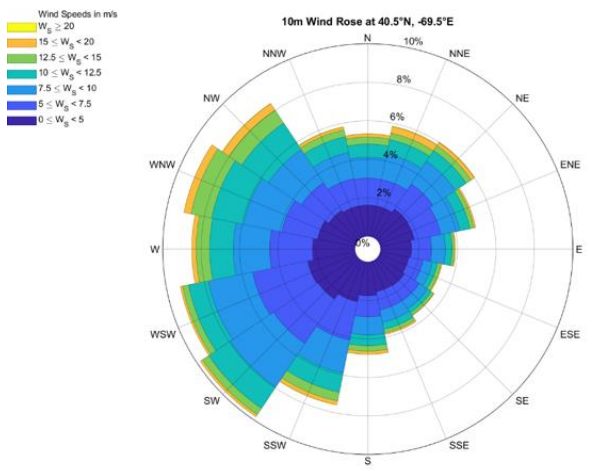
Reference Site

- WRF simulations performed at multiple sites around the US coast
- Benchmark site picked: Vineyard, N-E coast
- WRF and Metocean data used to size platform

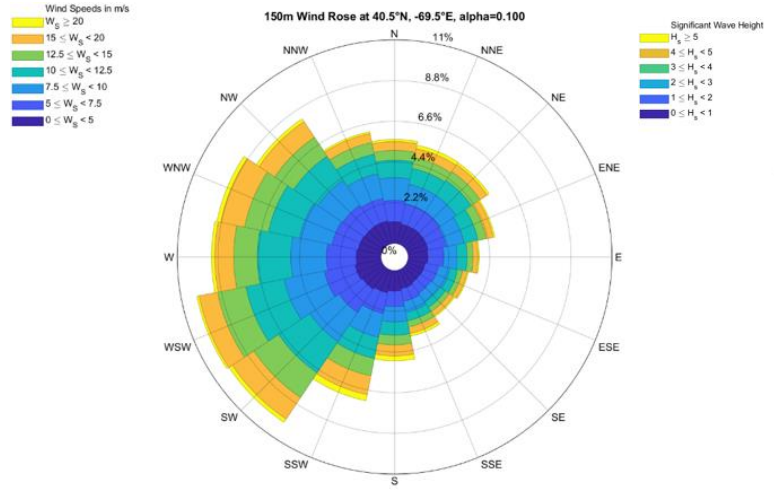


Variable	Mean	Max	Standard deviation
Hs	1.8	11.7	1.0
Tp	7.9	20.9	1.9
Tm01	6.7	14.3	1.2
100m Wind Speed	9.2	39.6	4.6

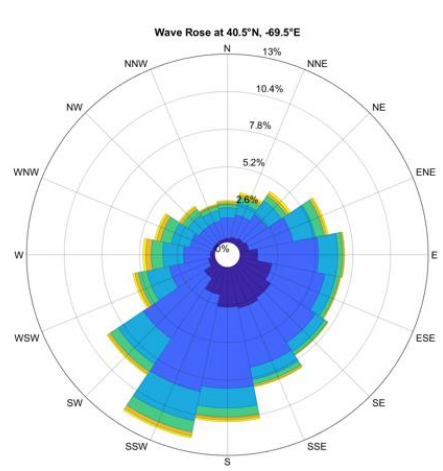
10m Wind Rose



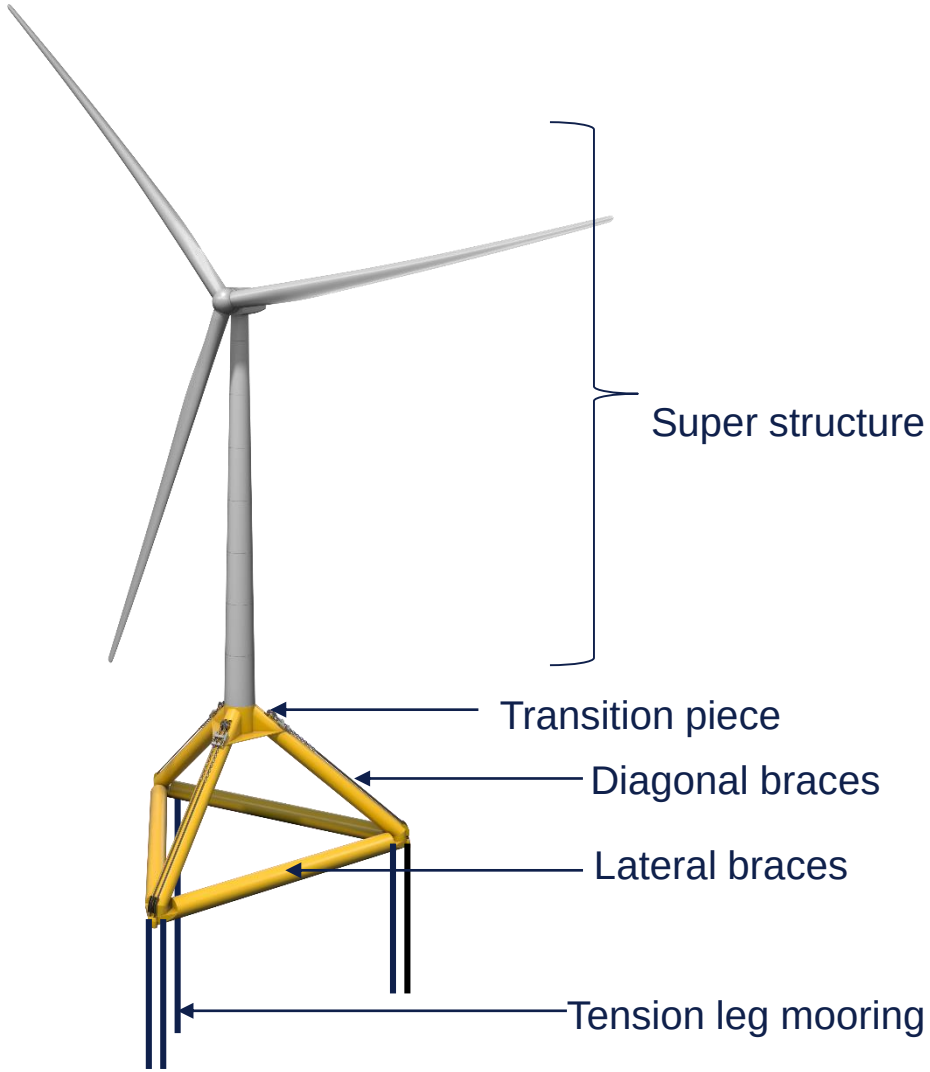
150m Wind Rose



Wave Rose



The MPS PelaFlex platform



PelaFlex Platform Configuration

(Credit: Marine Power Systems)

- Top tension platform system for hosting wind turbine system
- Truss system of connected braces for wind turbine system support
- Taut leg moorings – anchor the platform to the seabed
- Platform can be sized for a wide range of wind turbines

PelaFlex platform, (Credit: Marine Power Systems)

The MPS PelaFlex platform: motion

Preliminary testing sea & wind conditions:

H_s = 8 m

T_p = 14 s

Depth = 100m

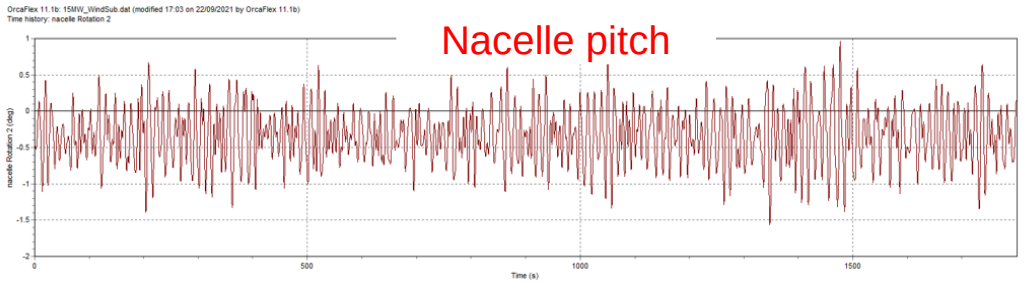
Wind speed = 8 m/s (constant profile – NPD Spectrum)

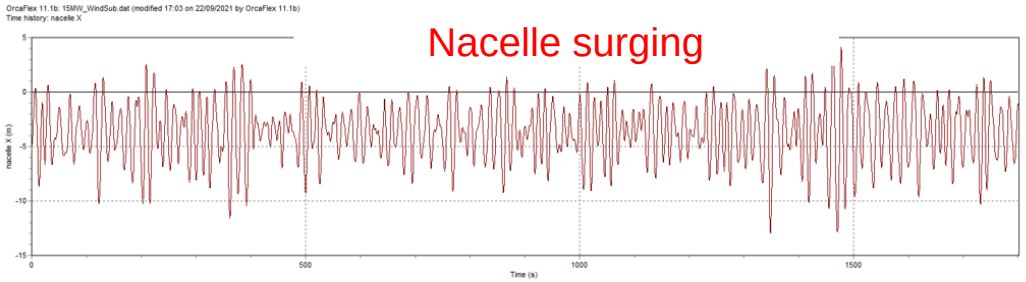
Wind and wave aligned with turbine axis

Hosted Wind Turbine: **NREL 15 MW**

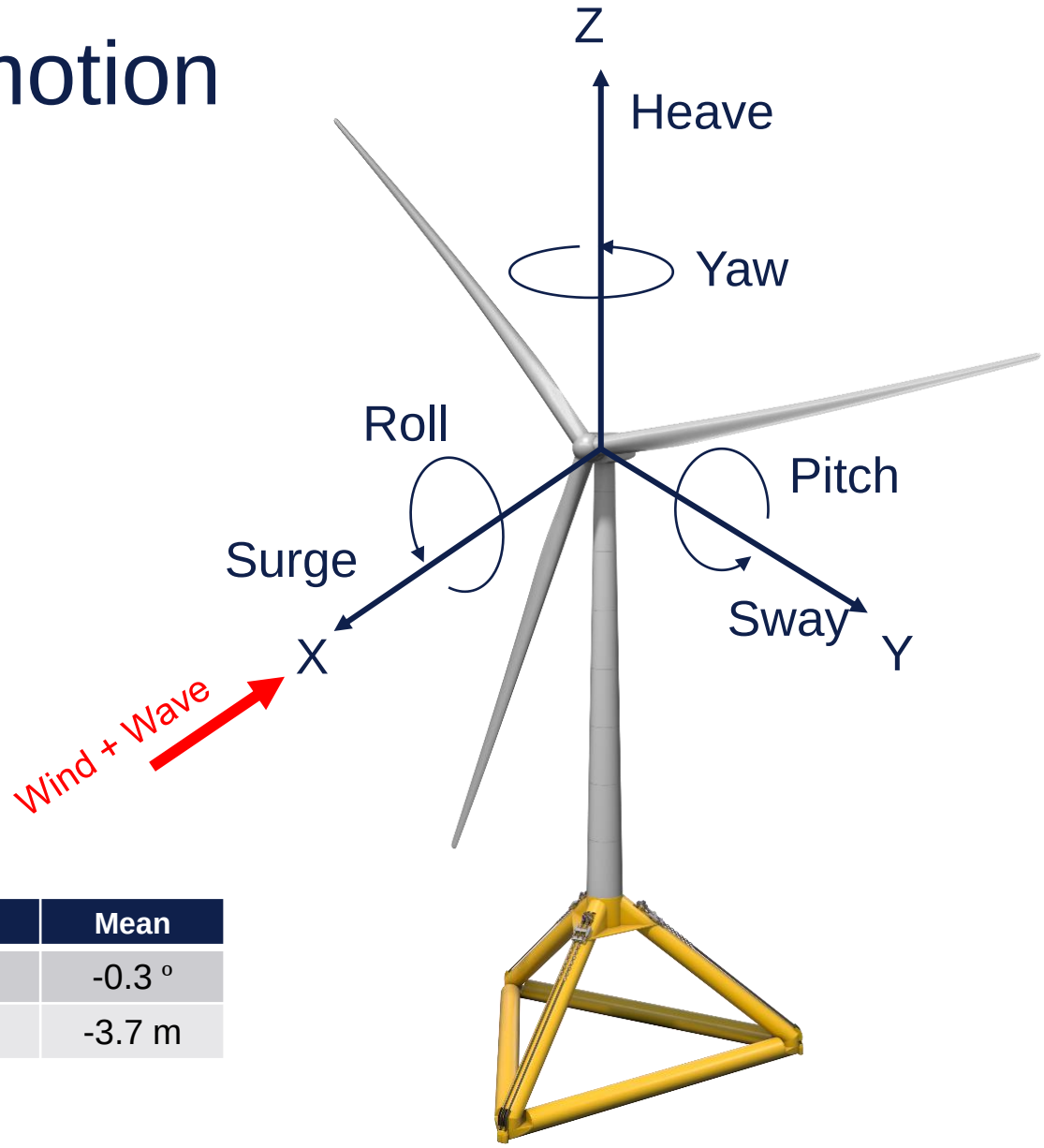
Hub height: 145 m

Diameter: 240 m





Orcaflex results	Mean
Nacelle pitch	-0.3 °
Nacelle surge	-3.7 m

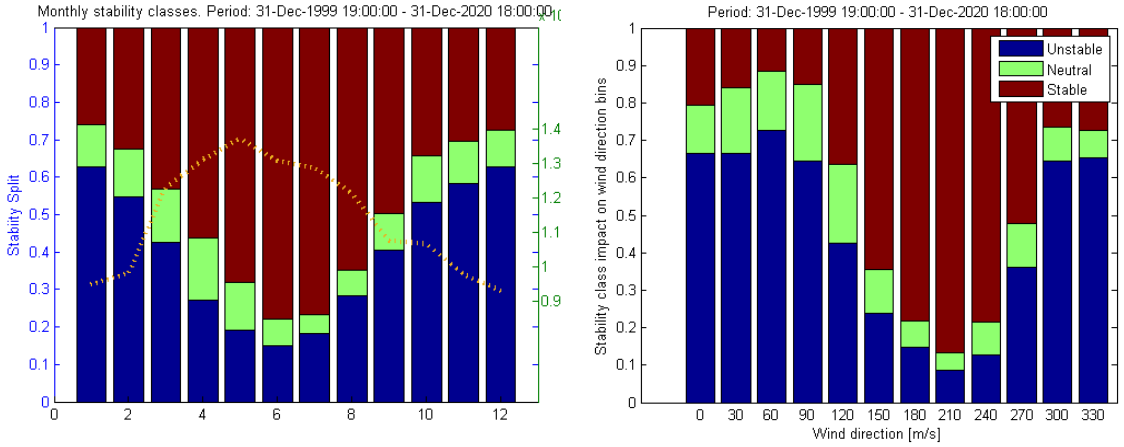


Engineering wake models

- Literature review on floating-turbine wakes
  - Wake dynamics, wake steering, atmospheric conditions

- Improve models: LES simulations, focusing on the effect of veer (and atm. stability) on normal and yawed operations.

Influence of atmospheric stability @ Reference site

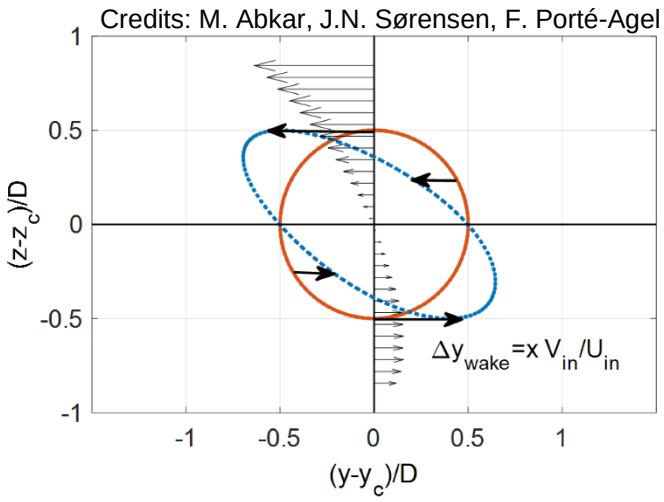


stable → *less mixing*, *greater wake deficits*

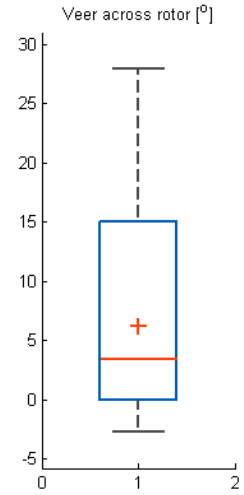
unstable → *more mixing*, *smaller wake deficits*

Engineering wake models

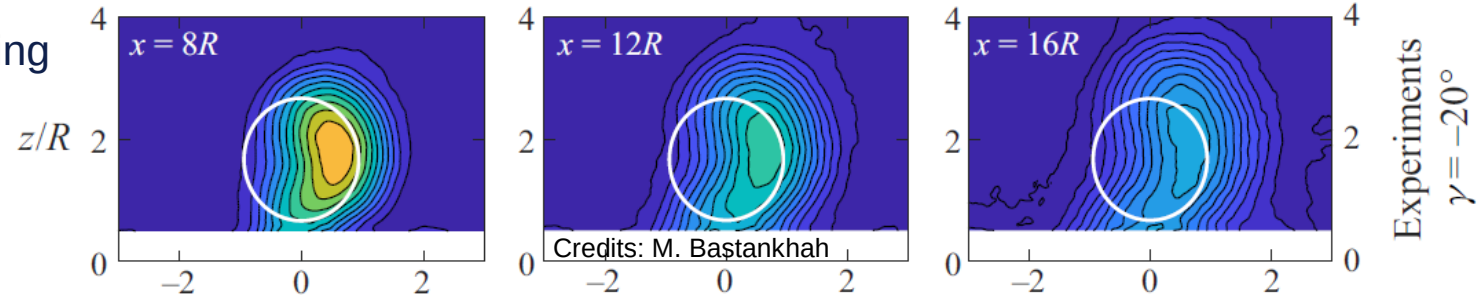
- Importance of veer increases with increase in rotor size



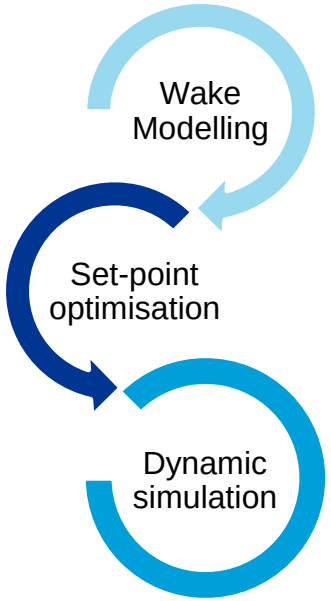
WRF @
Reference site



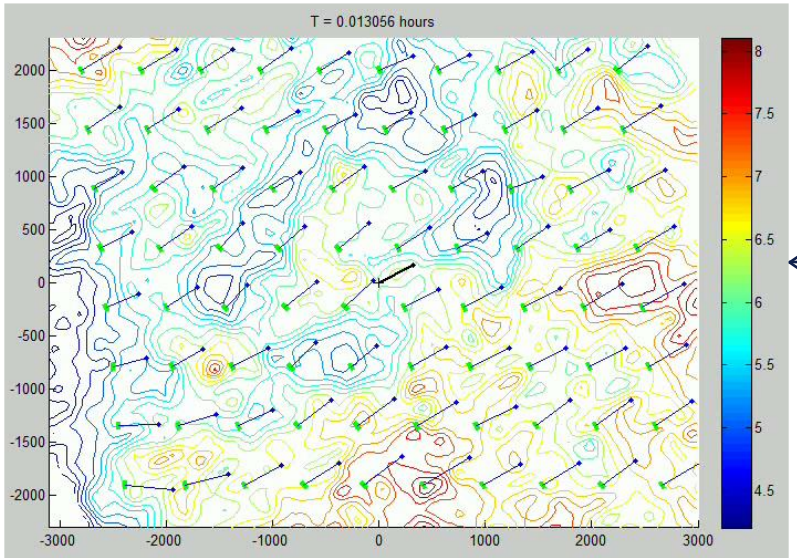
- Veer affects curl-shaped wake when wake steering (impact on power and WFC effectiveness)



Optimisation & simulation process



LongSim



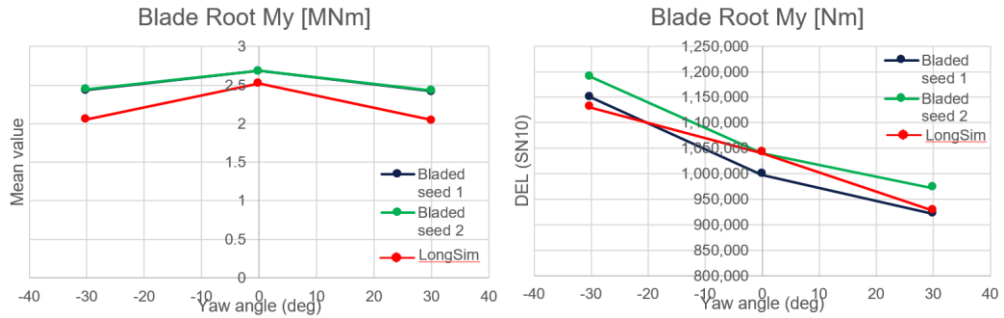
Waked wind characteristics of all turbines

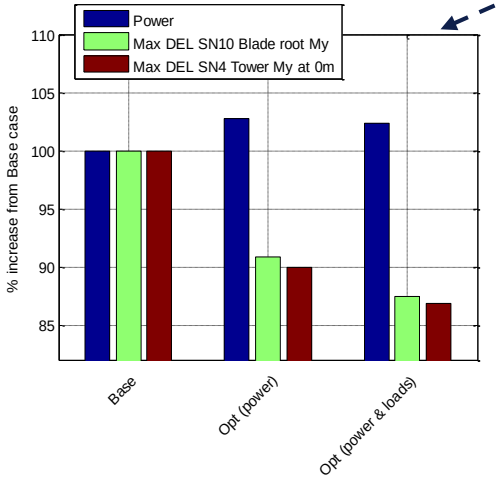
Wake steering setpoints

Loads estimation (surrogate loads model)

OrcaFlex

To analyse *Loads* and *Response* to waked and yawed conditions





Conclusions & Next steps

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- ✓ *International collaboration started (June 2021 – March 2023)*
- ✓ *WRF simulations finalised at multiple sites and final reference site chosen*
- ✓ *Metocean conditions assessed and floating platform being sized*
- ✓ *LES simulations with strong veer conditions performed*
- ✓ *Literature review on turbine wakes in floating wind farms carried out*

>

1. *Model veer effects on deflected wakes starting from LES simulations*
2. *Finalise design of floating system; test turbine controller prior to wake steering optimisation*
3. *Perform simulations on a reference turbine layout and optimise wake steering strategy*
4. *Above results fed into offshore platform simulations to capture loads and response in (waked) normal and yawed operational conditions*
5. *Assess advantages and disadvantages of using WFC in a floating wind farm, deducing impact on LCoE*

Acknowledgements

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The National Offshore Wind Research and Development Consortium, established in 2018, is a not-for-profit public-private partnership focused on advancing offshore wind technology in the United States through high impact research projects and cost-effective and responsible development to maximize economic benefits. Funding for the Consortium comes from the U.S. Department of Energy and the New York State Energy Research and Development Authority (NYSERDA), with each providing $20.5 million, as well as contributions from the Commonwealths of Virginia and Massachusetts and the States of Maryland and Maine, bringing total investment to approximately $47 million. For more information, please visit nationaloffshorewind.org.

Thanks for your attention!
Questions?

renzo.ruisi@dnv.com / ervin.bossanyi@dnv.com

www.dnv.com

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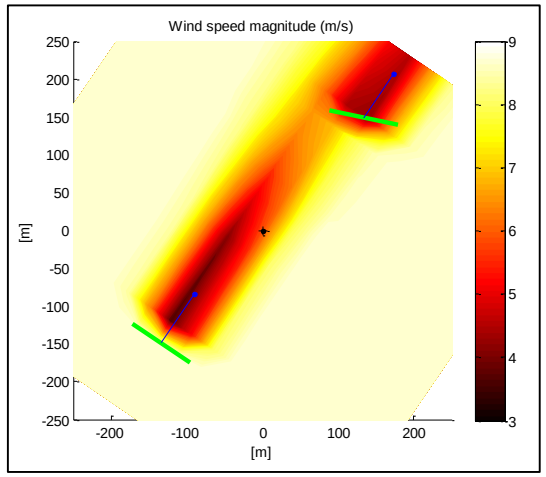
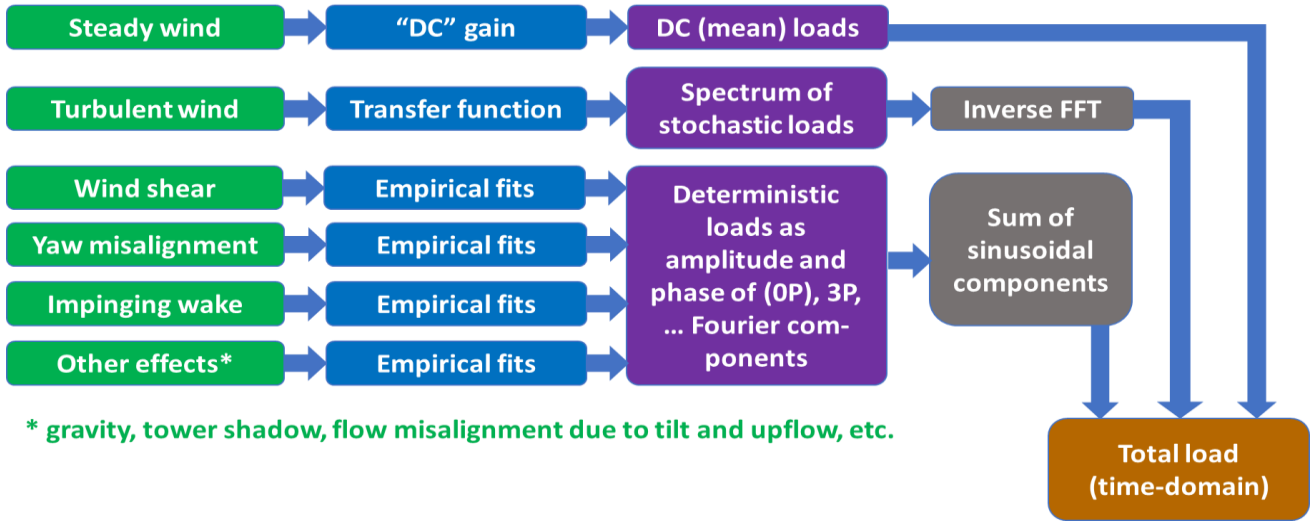
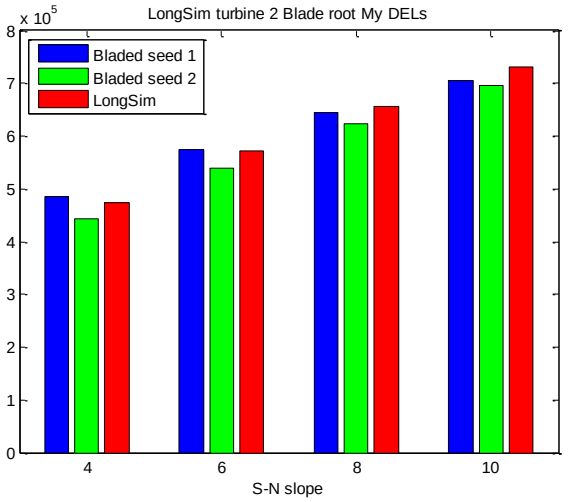
(Extra slides) LongSim: surrogate loads model

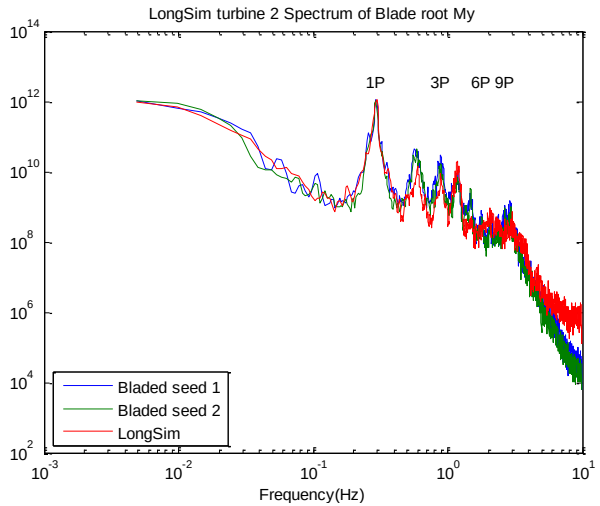
Comparison to Bladed





Blade root bending moment: spectra and DEL's

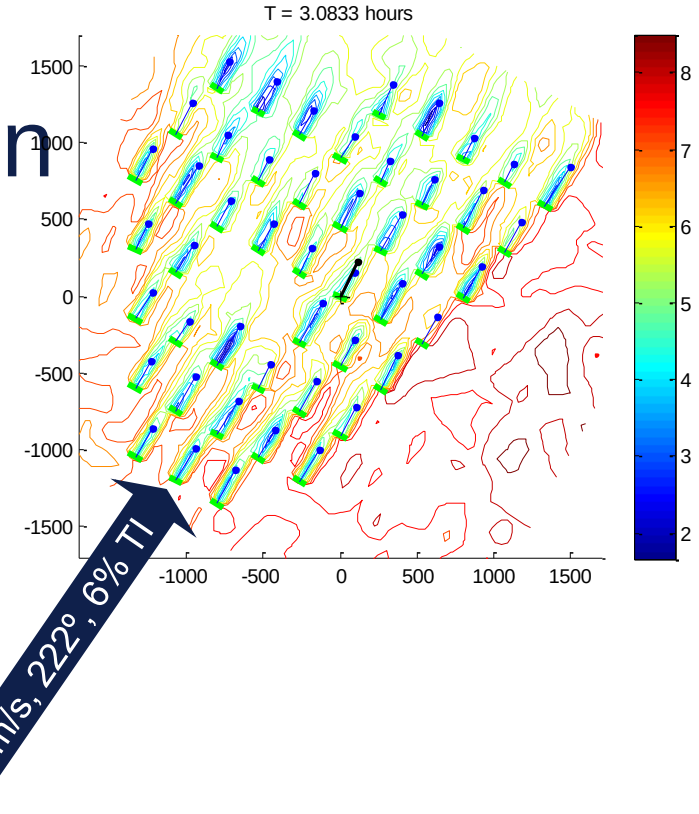




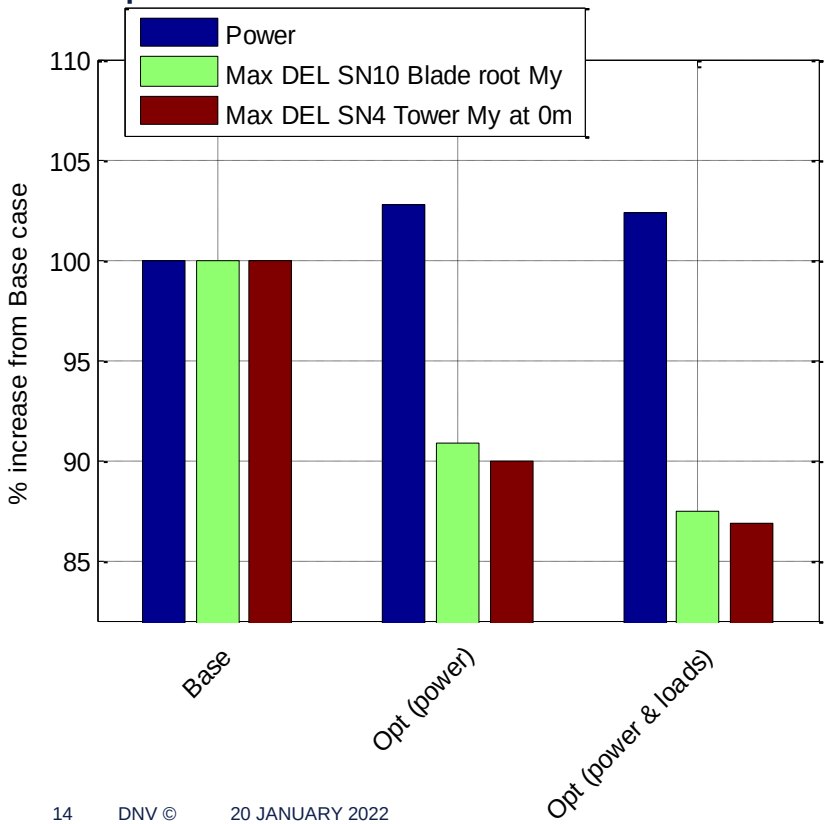
(Extra slides) LongSim: WFC optimisation

Lillgrund offshore wind farm – Steady state optimisation
48 turbines, Siemens 2.3 MW, very close spacing

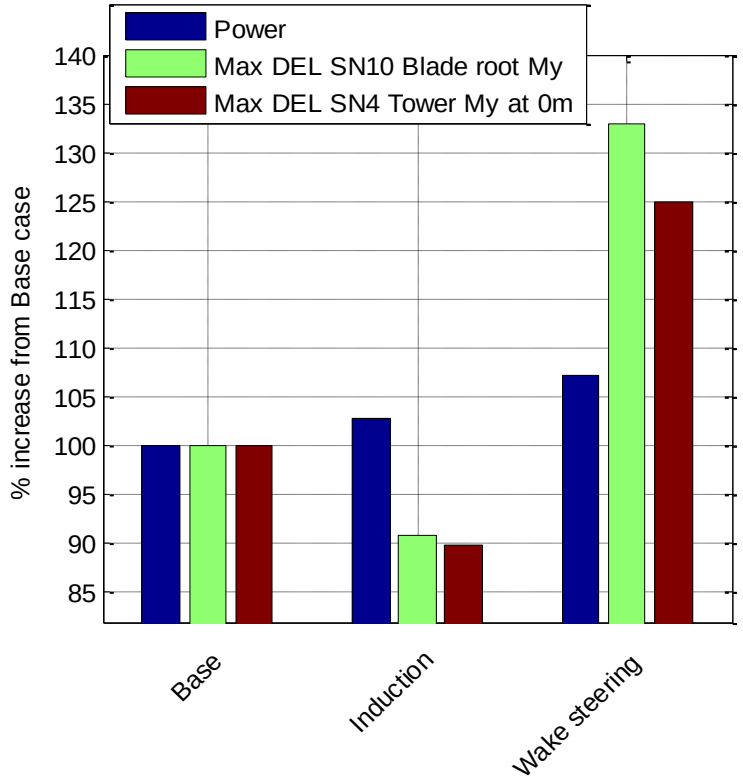
TotalControl



Optimisation with and without loads



Induction control vs wake steering



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