Multi-Rotor-Symposium / 14.10.2025

MRS for Offshore Wind - what needs to be done?

Bernhard Stoevesandt, Lukas Vollmer, Jonas Kaczenski

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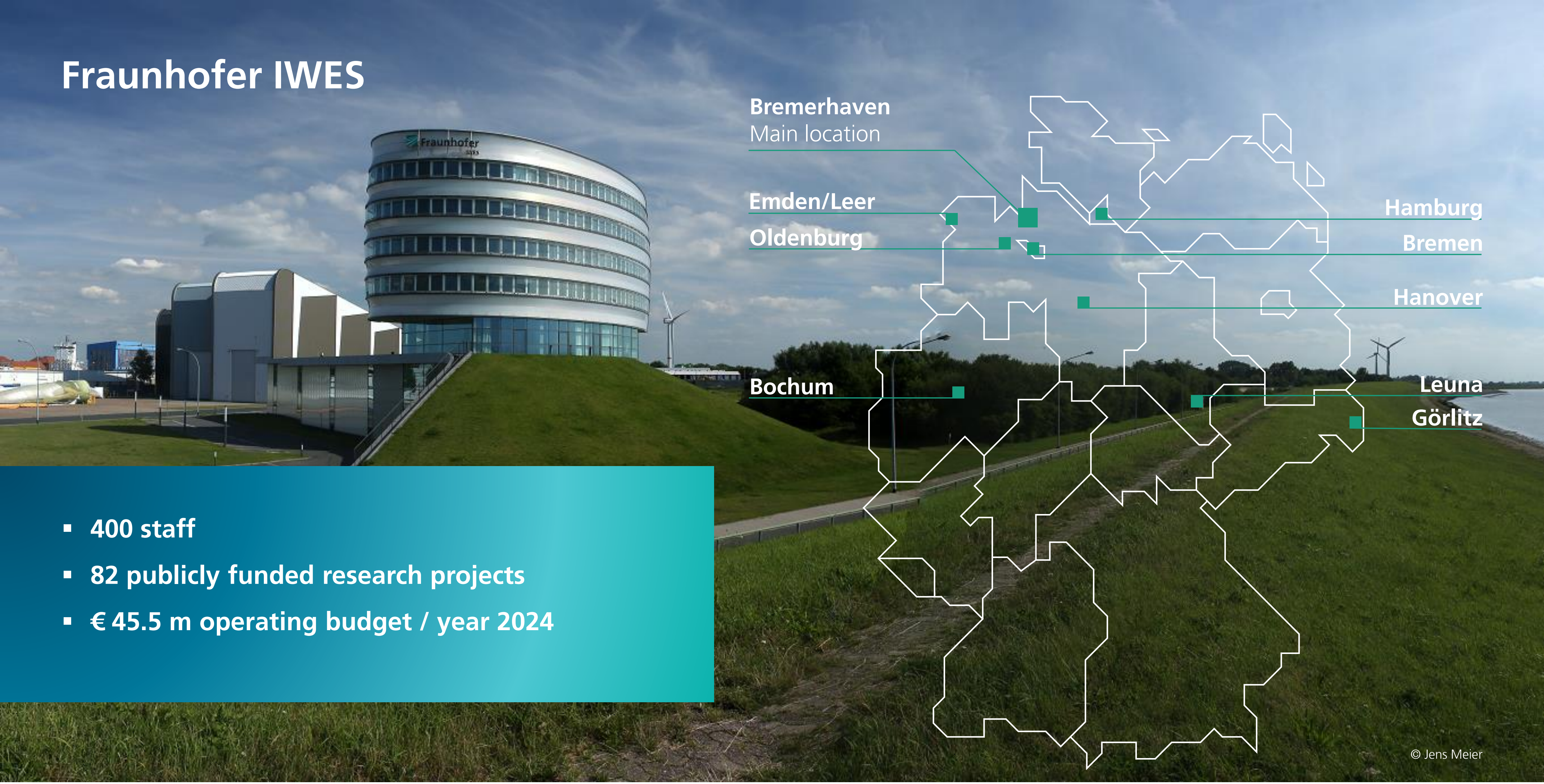

- 400 staff
- 82 publicly funded research projects
- € 45.5 m operating budget / year 2024

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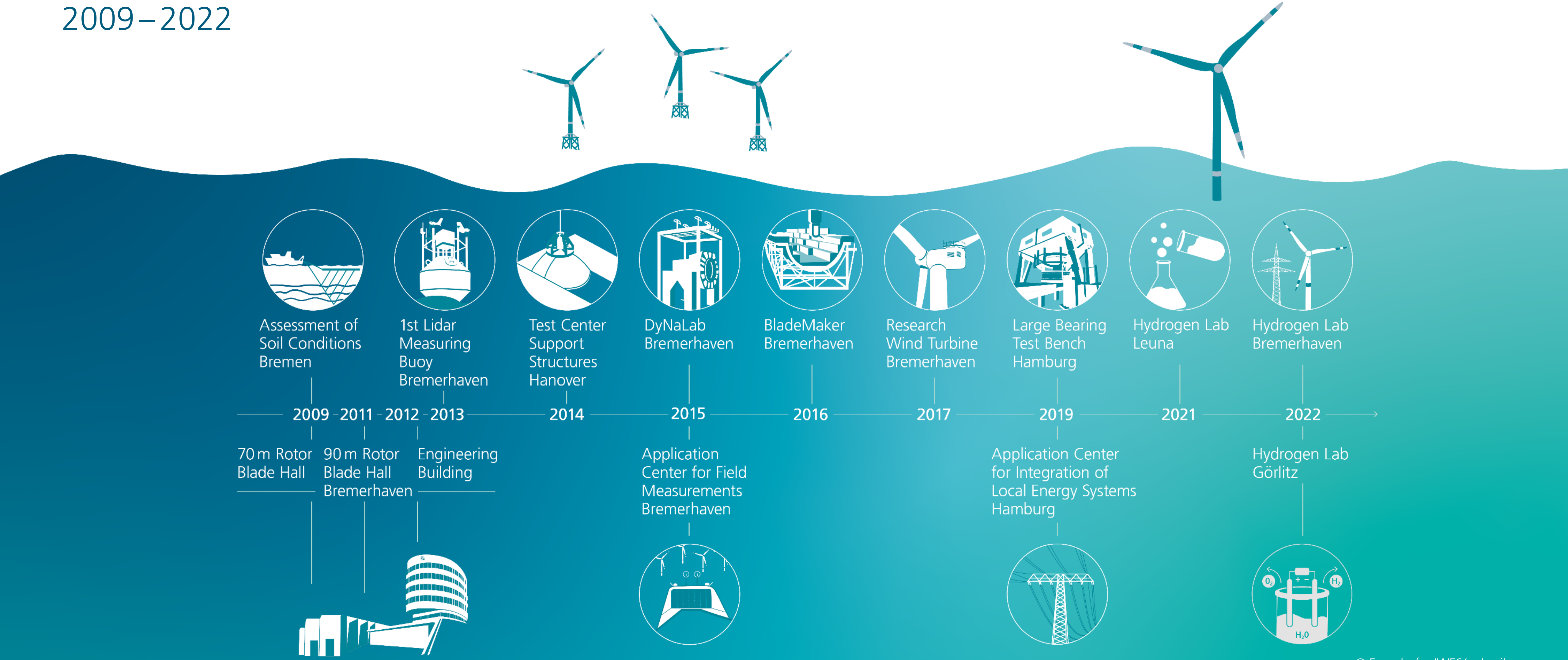
Our testing infrastructure

2009 – 2022



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Challenge the dimensions of single rotor systems

Increasing size

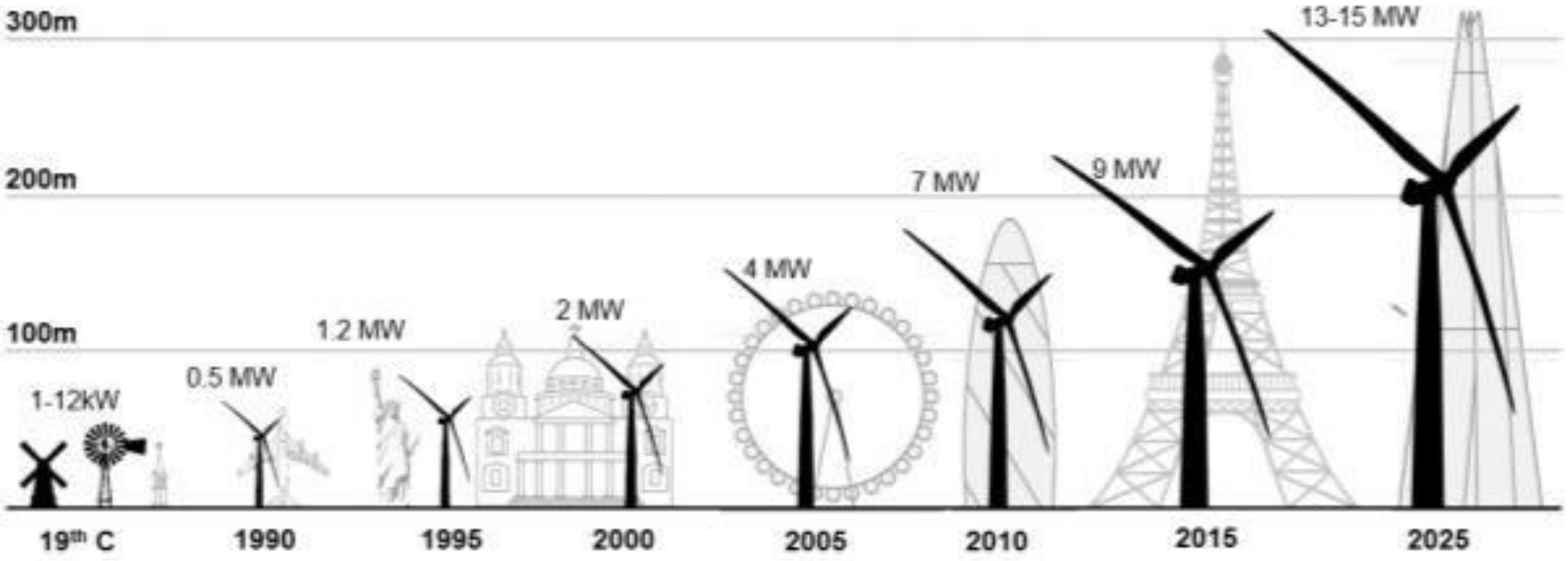
So far continuous growth

Current largest prototypes:

SGRE: 21.5 MW at 276 m rotor diameter

Dong Fang 26 MW at 310 m rotor diameter

Challenges: Rotor blade extension more and more difficult, weight leads to excessive material use



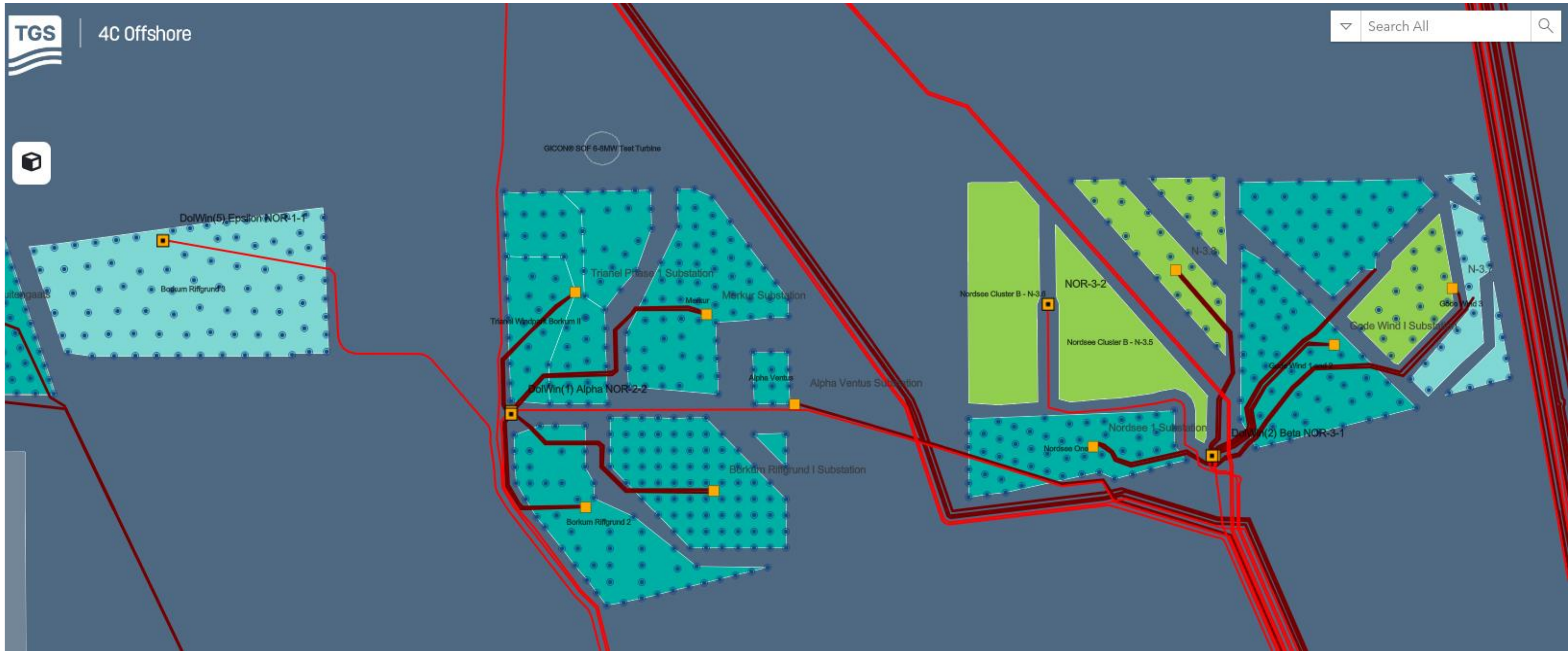
(Pisano 2019)

Why the dimensions of single rotor systems

Offshore size counts

Example DolWin Cluster (North Sea)

14 Different farms (to be) installed between 2015 and 2028 (excluding Alpha Ventus)



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Why the dimensions of single rotor systems

Offshore size counts

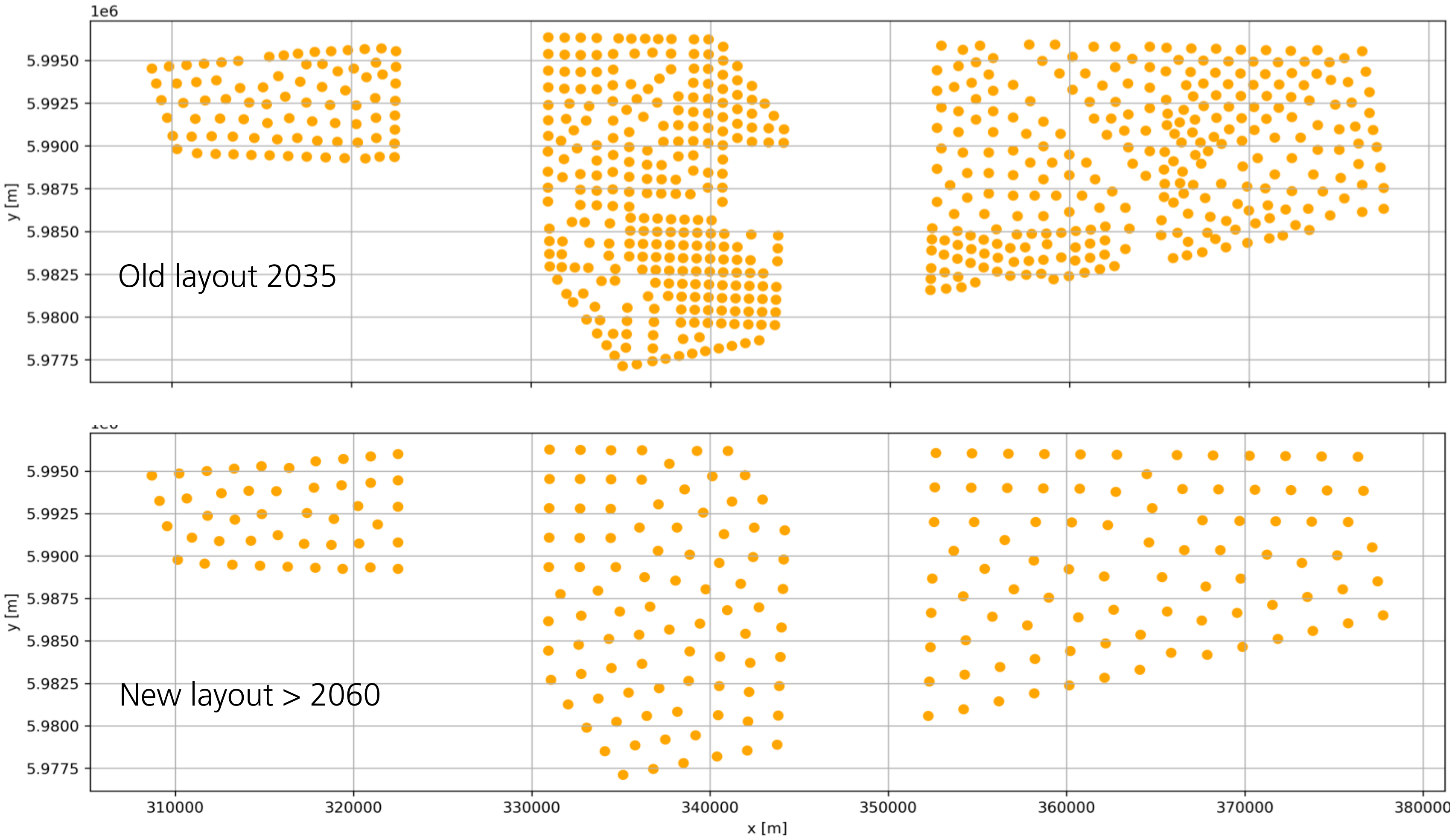
Example DolWin Cluster (North Sea)

14 Different farms (to be) installed between 2015 and 2028 (excluding Alpha Ventus)

1. Old layout
   - N-1 = 83 * 11 MW Turbines
   - N-2 = 272 * many sizes
   - N-3 = 278 * many sizes

2. New layout:
   - N-1 = 45 * 22MW Turbines Distance = 5.34 D
   - N-2 = 91 * 22 MW Turbines Distance = 5.96 D
   - N-3 = 91 * 22 MW Turbines Distance = 7D

Used Wake-Modell: Turbopark



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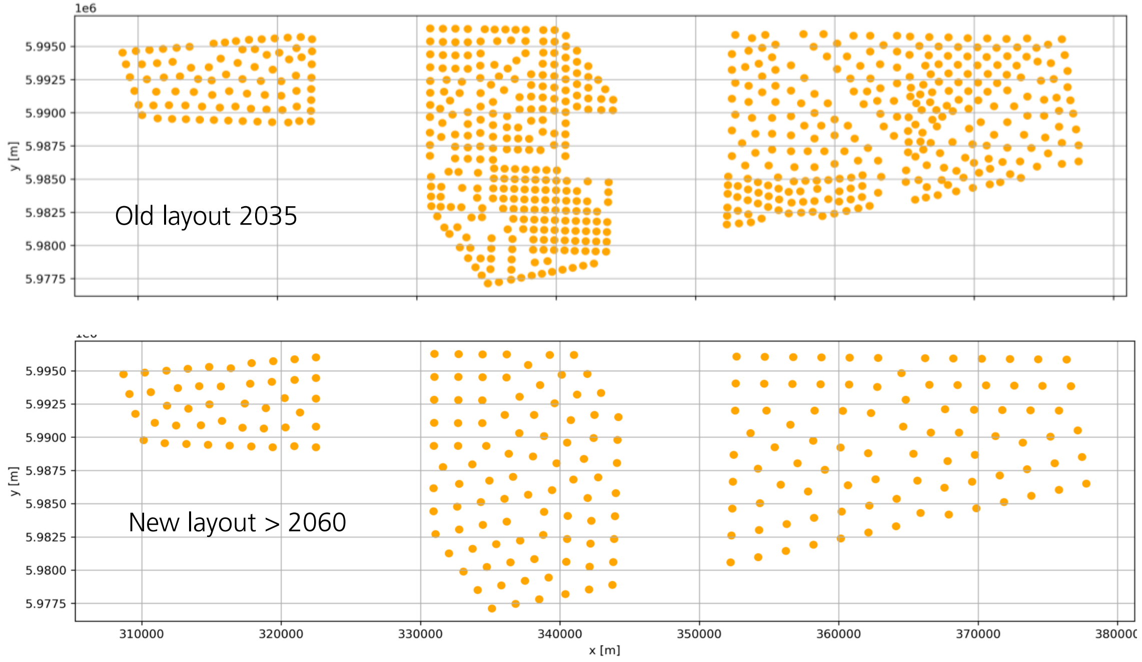

		Current capacity	now GW/N	GW/N with 22MW
	Nordsee One	332,1		
	Nordseecluster B (N-3.5)	420		
	Nordseecluster B (N-3.6)	480		
N-3	Nordseecluster A (N-3.7)	225	2,718	2
	Nordseecluster A (N-3.8)	435		
	Gode Wind 1	332,1		
	Gode Wind 2	252		
	Gode Wind 3	241,8		
	Trianel Windpark Borkum I	200		
	Trianel Windpark Borkum II	203		
N-2	Borkum Riffgrund 1	312	1,621	2
	Borkum Riffgrund 2	450		
	Merkur Offshore	396		
N-1	Borkum Riffgrund 3	913	0,913	1
		Total (GW)	5,192	5

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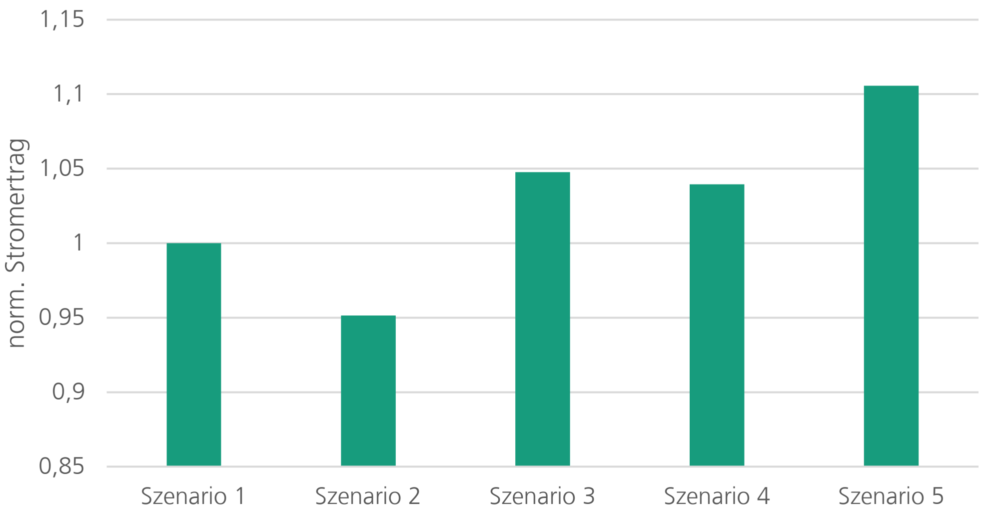
Why the dimensions of single rotor systems

Offshore size counts

Energy yield (2040 to 2066)



- More energy yield in the same wind conditions with larger turbines even though installed capacity is lower
- Less costs due to O&M with larger turbines, since less turbines to be maintained
- Reason for yield: larger rotor area toward higher altitudes

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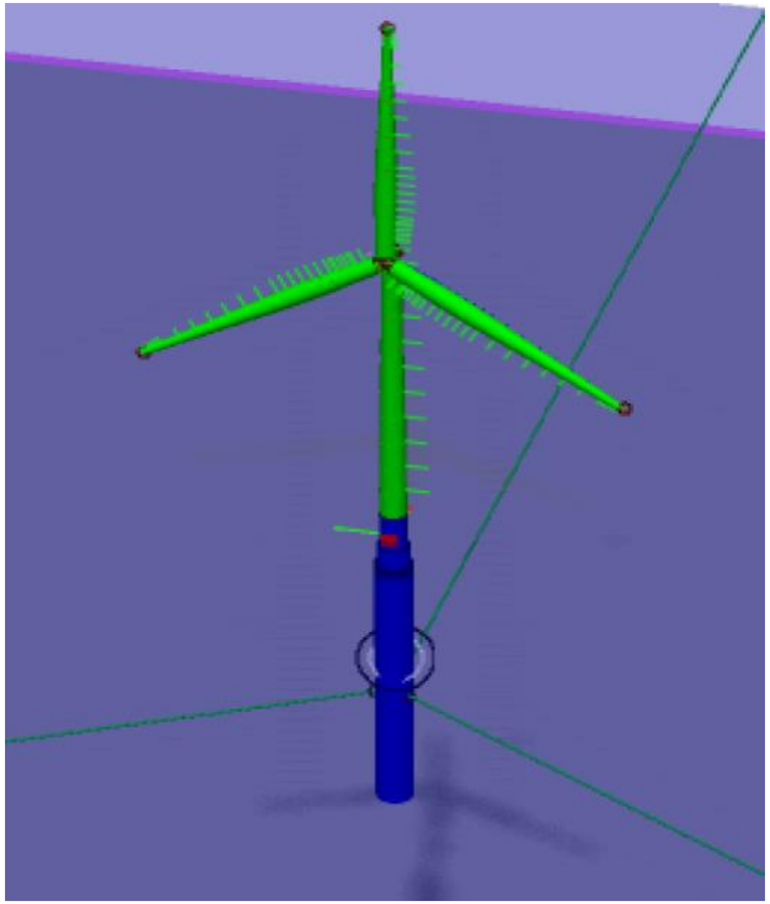
Why multi-rotor system are attractive offshore

Floating systems

- CAPEX costs of floating systems are currently extremely high
- If floating is to come, yield of single turbines need to be high
- Wind energy is globally under strong competition – so wind energy at whatever costs will not fly
- Thus we need even larger systems to make floating competative
- MRS is more easily scaleable than single rotor system



(Islam 2016)

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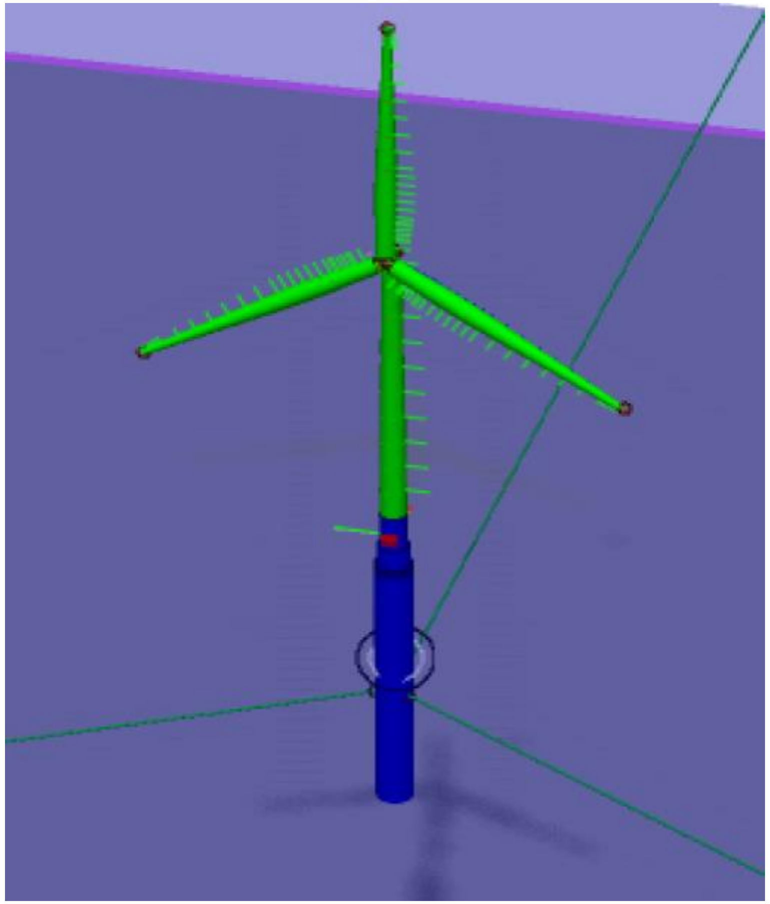
If they really work in a competitive manner



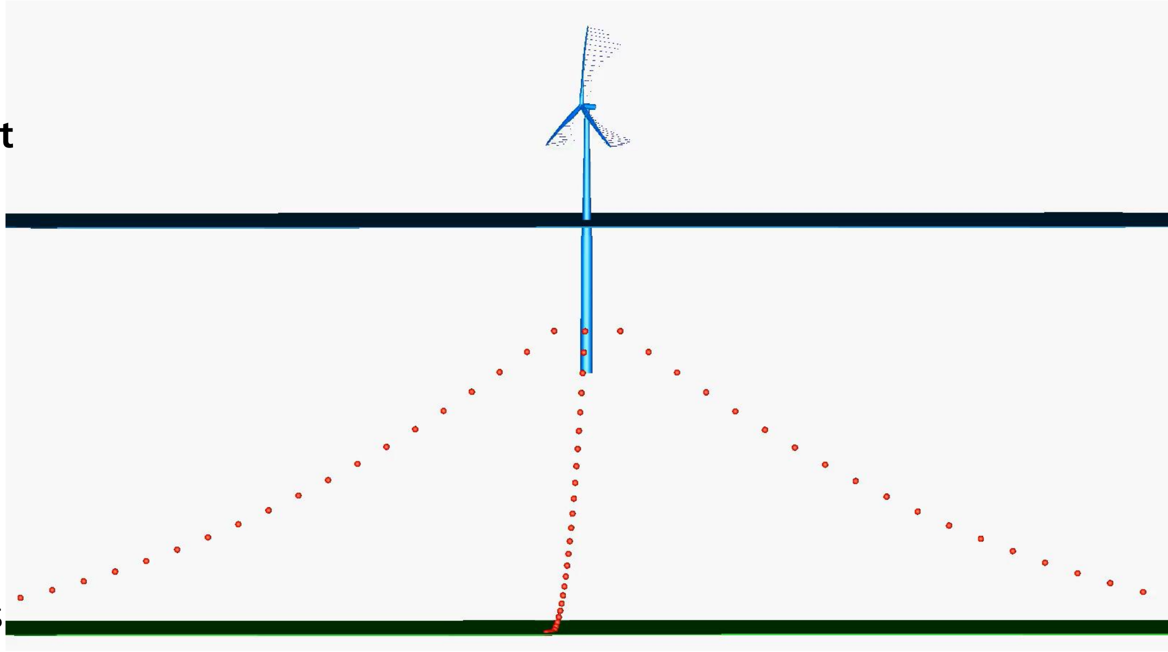
(Islam 2016)

Why isn’t everybody doing it?

What it needs from the farm developers view

Many open questions in research. However, not all open questions are equally relevant to the point of: Will this be built or not. So, what is needed:

- **Complete knowledge of structural integrity of the MRS under all relevant circumstances**
  - Is already a difficult task for regular single rotor systems
  - In the end, the turbine needs to be certified according to IEC 61400-1-4 or similar standard (DiBT, …)
  - This means, the numerical turbine model has to show the capability to withstand numerous load cases all specified in the standard
  - Not all of these load cases can be easily done with regular model-based load calculations
  - Load cases might be more complex for MRS since rotor-rotor interactions in the specific situations might cause further issues
  - Afterall the concept needs remain inexpensive enough stay attractive



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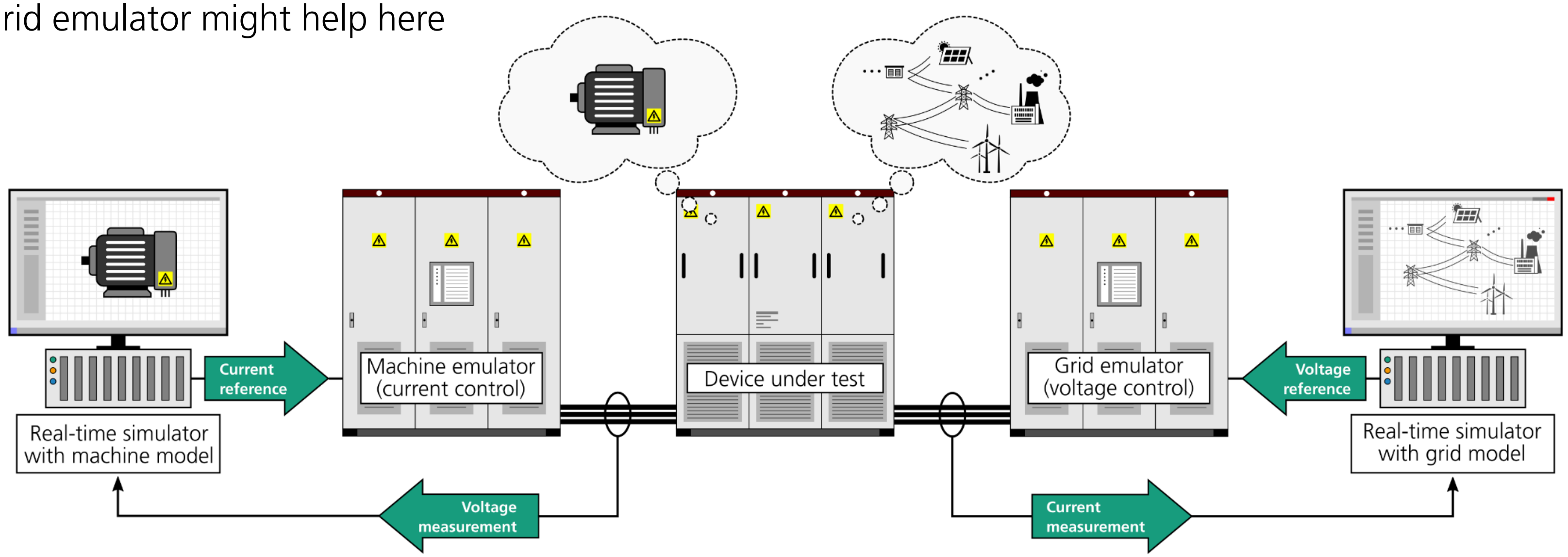
- Complete knowledge of structural integrity of the MRS under all relevant circumstances
- **Grid compliance of the complete system**
  - The whole system is to be positively interacting with the connecting grid
  - Even under bad grid conditions, in the future it might be mandatory, that the system rather stabilizes than destabilizes the grid
  - The electrical interaction of the single rotors thus must be synchronized in a way to fulfill this criterion
  - This has implications on the load of the system – thus the life-time and structural integrity
  - Tests e.g. in a grid emulator might help here



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- Complete knowledge of structural integrity of the MRS under all relevant circumstances
- Grid compliance of the complete system
- **A realistic O&M strategy**
  - Instead of one rotor, there might be several rotors, with possible damages or failures
  - Having to multiply the amount of mission to the turbine by the amount of rotors is not an option
  - It needs a concept on how to exchange all parts with possible major degradation everywhere in the whole system
  - Good HSM to ensure optimal downtime times, while staff on the system is not endangered

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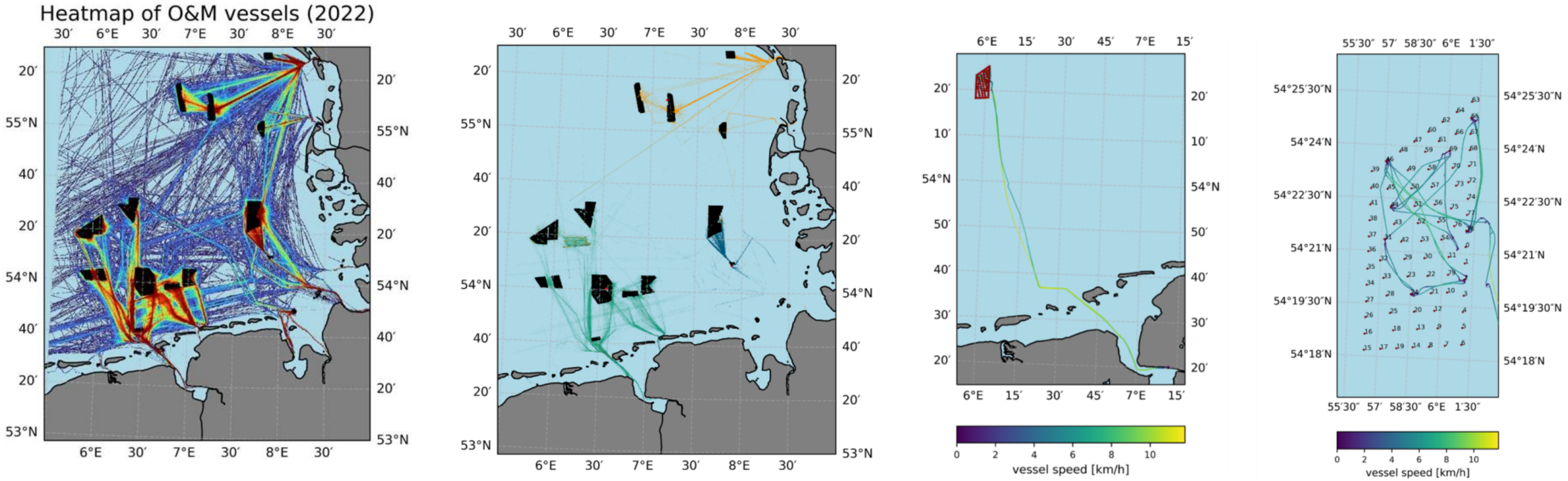
- Complete knowledge of structural integrity of the MRS under all relevant circumstances
- Grid compliance of the complete system
- A realistic O&M strategy
- **Low O&M costs**
  - It needs a persuading concept to reduce O&M missions
  - reduce the times of a mission,
  - reduce yield losses due to down-times in a way, that the expected O&M costs do not exceed the gains of the systems due to the possibly larger capacity



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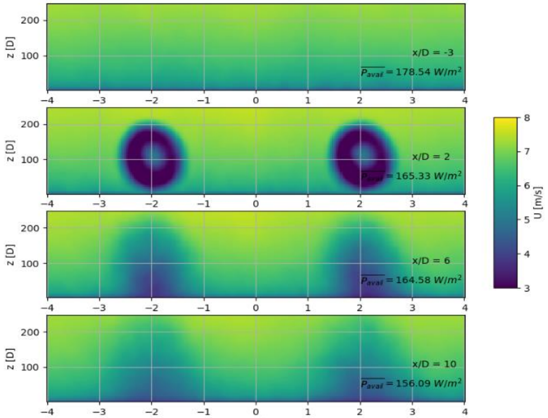
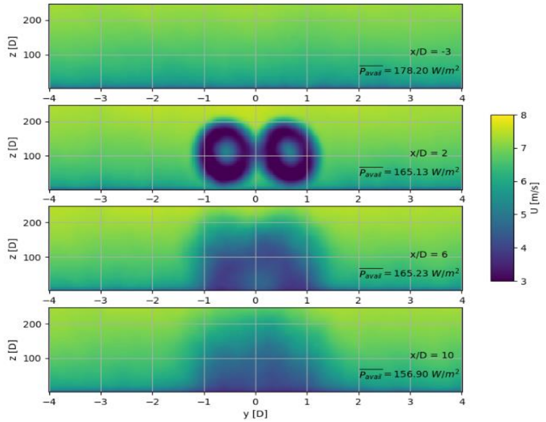
- Grid compliance of the complete system
- A realistic O&M strategy
- Low O&M costs
- **Realistic wind farm planning tools**
  - Companies don't buy single turbine (or MRS), they buy wind farms
  - For an optimal wind farm planning you need the wind field within the wind farm – all wake effects
  - However, wakes of MRS interact with another leading to different wake behaviors than with single rotor systems
  - For wind farm planning fast and easy to use, yet realistic models for wakes are needed for yield assessments
  - How the wakes of the single rotors interact may depend on the dimensions on geometry of the MRS





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- A realistic O&M strategy
- Low O&M costs
- Realistic wind farm planning tools
- **Tools to plan life-times and operational strategies**
  - Due to several reasons (volatile electricity prices, curtailments, O&M) the operation of the wind farm might not target maximum yield at all times
  - For wind farm operators it might be more profitable to directly control the performance of the wind farm
  - To do so, they need to be able to calculate the remaining life-time of the MRS in a realistic manner
  - Since they will not get the design load model of the turbine, good surrogate models are needed, which can mimic the original model under the past and future conditions

Conclusion

Many steps to success – or failure of the concept

- **There are several reasons why MRS may be the answer for (floating-) offshore developments in the future**
- **First steps are made in the direction already with single concepts (e.g. double-rotor)**
- **Some critical points are still open to be shown for large scale MRS to out-compete single rotor systems:**
  - **Complete knowledge of structural integrity of the MRS under all relevant circumstances**
  - **Grid compliance of the complete system**
  - **A realistic O&M strategy**
  - **Low O&M costs**
- **Other issues still need to be addressed for the commercialization**
  - **Realistic wind farm planning tools**
  - **Tools to plan life-times and operational strategies**
- **It is not impossible – but also it remains open if it really works**
- **Otherwise MRS remain like VAWT or skyborn WE a nice idea – yet to be realized some day**

Thanks a lot for your attention!

Contact

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Literature

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- Islam, M. T. (2016). Design, Numerical Modelling and Analysis of a Semi-submersible Floater Supporting the DTU 10MW Wind Turbine (Master's thesis, NTNU).

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