HAW HAMBURG | CC4E

University of Strathclyde Glasgow

RENEWABLE DYNAMICS

Multi-rotor wind turbines: A review of modern research efforts and challenges

Abdirahman **Sheik Hassan**, Neha **Chandarana**, Rainer **Groh**, Terence **Macquart**

Multi-Rotor System Seminar 2025 – Hamburg, DE

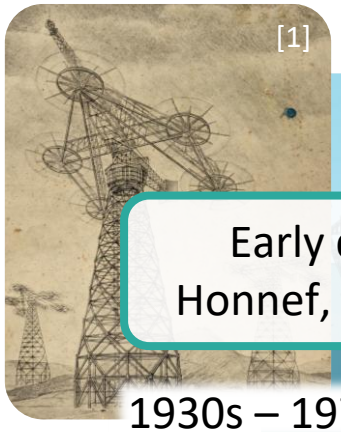
UKRI Engineering and Physical Sciences Research Council

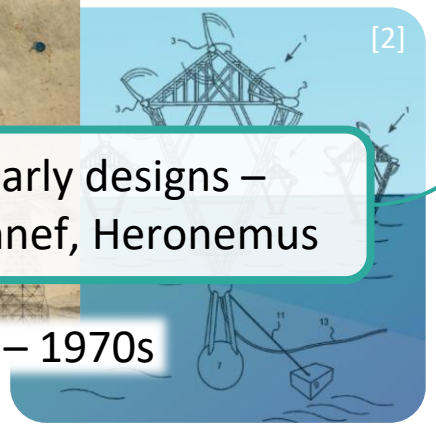
University of BRISTOL
Bristol Composites Institute

Sponsored by:
Erneuerbare Energien Hamburg
EnBW
WIND CATCHING

Multi-Rotor Wind Turbines

A History


[1]


[2]

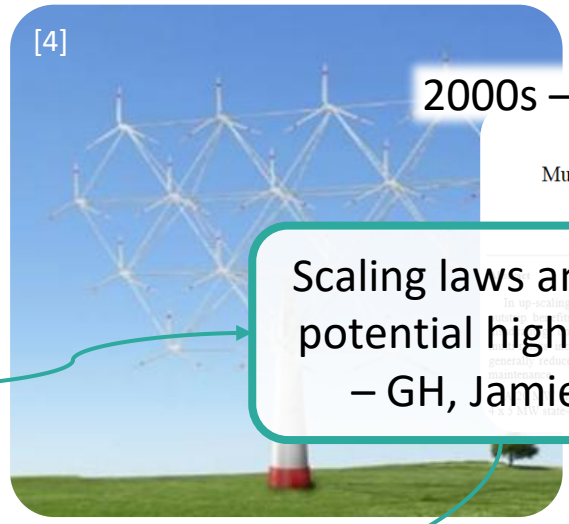
Early designs – Honnef, Heronemus

1930s – 1970s

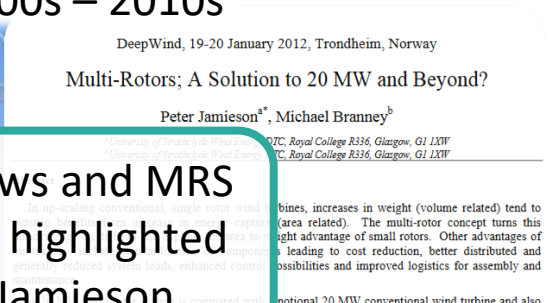

[3]

Early commercialisation
Lagerwey

1980s – 1990s


[4]

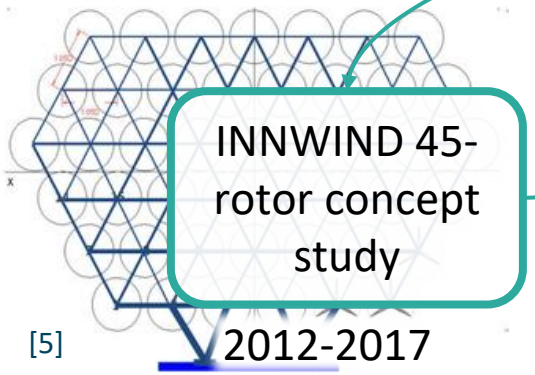
2000s – 2010s


DeepWind, 19-20 January 2012, Trondheim, Norway

Multi-Rotors; A Solution to 20 MW and Beyond?

Peter Jamieson[a*], Michael Branney[b]

Scaling laws and MRS potential highlighted – GH, Jamieson


[5]

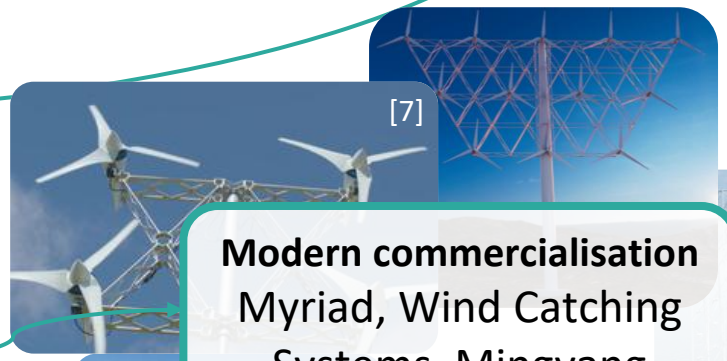
INNWIND 45-rotor concept study

2012-2017


[6]

Vestas 4-rotor demonstrator

2016


[7]


[8]

Modern commercialisation
Myriad, Wind Catching Systems, Mingyang


[9]

2020s-

Norway Grants EUR 100 Million to Deploy Multi-Turbine Windcatcher Tech

FLOATING WIND

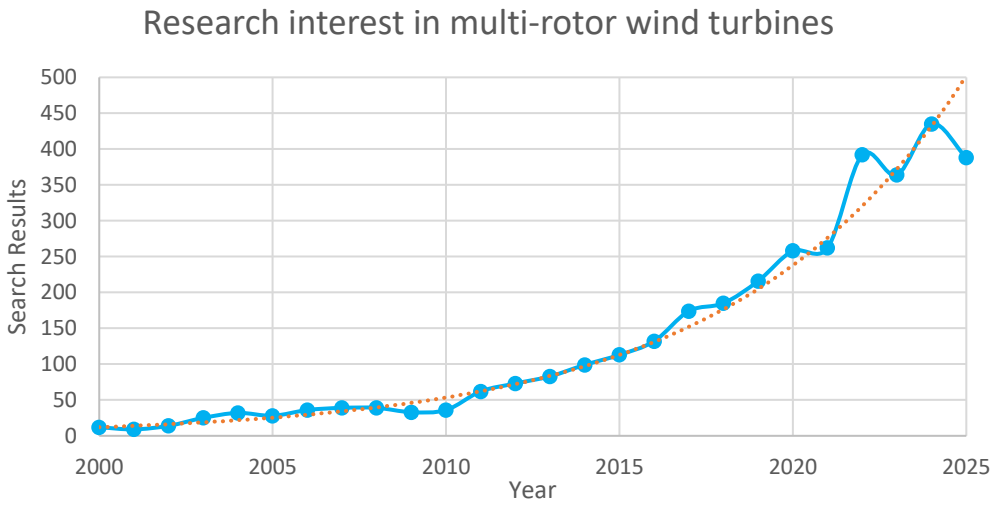
January 28, 2025, by Adrijana Buljan

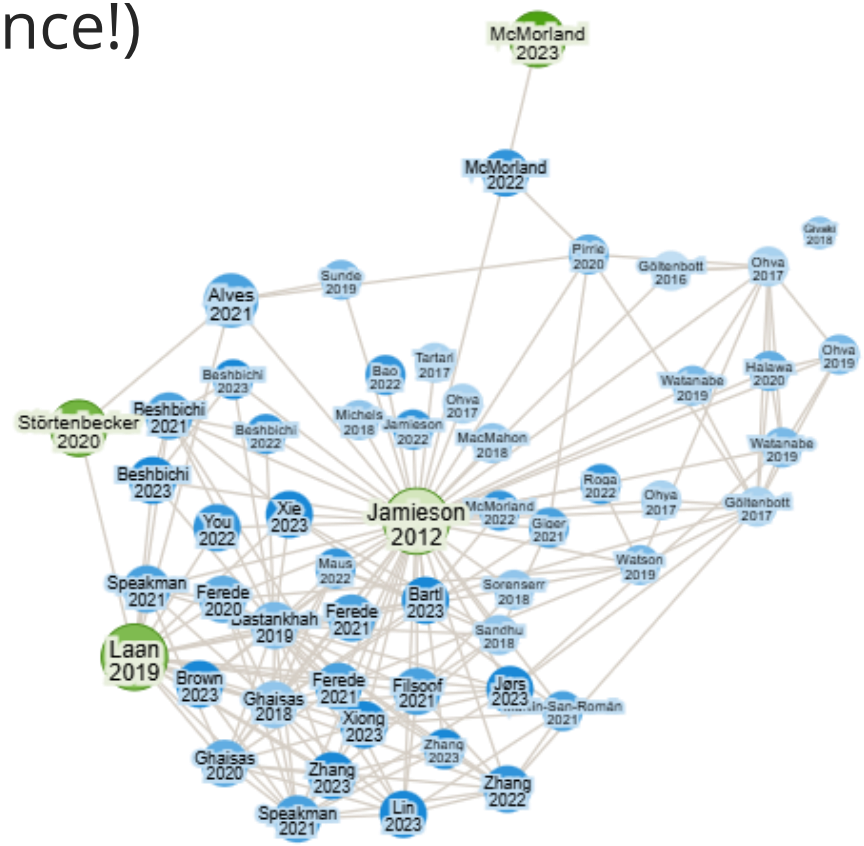
Today

Motivation

Why a review?

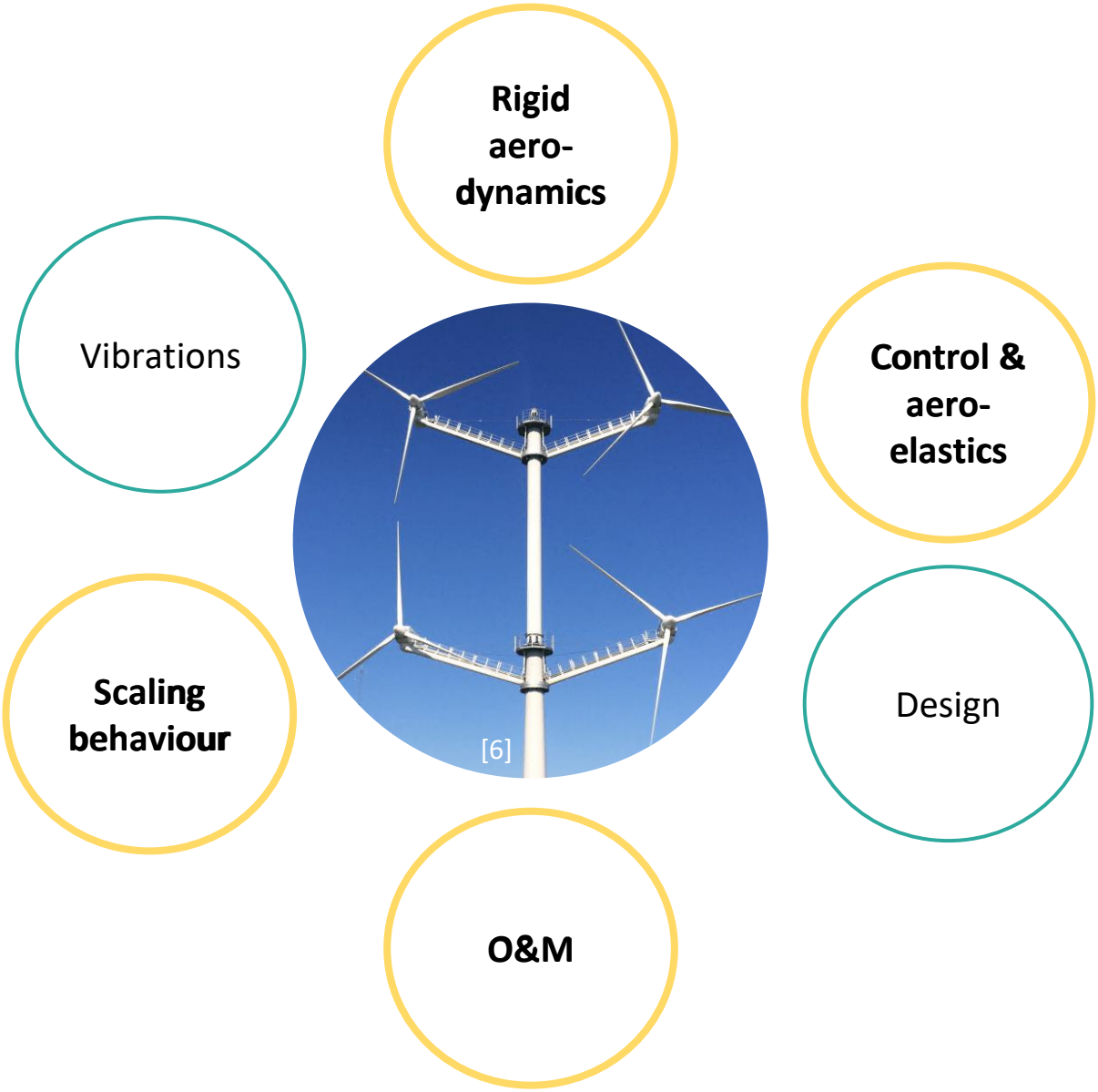
- Growing interest in the multi-rotor concept from academia and industry
- Body of research growing (see: this conference!)
- Gaps to target
  - Point of reference for multi-rotor community
  - “Launchpad” – ideas for future research





Areas of study

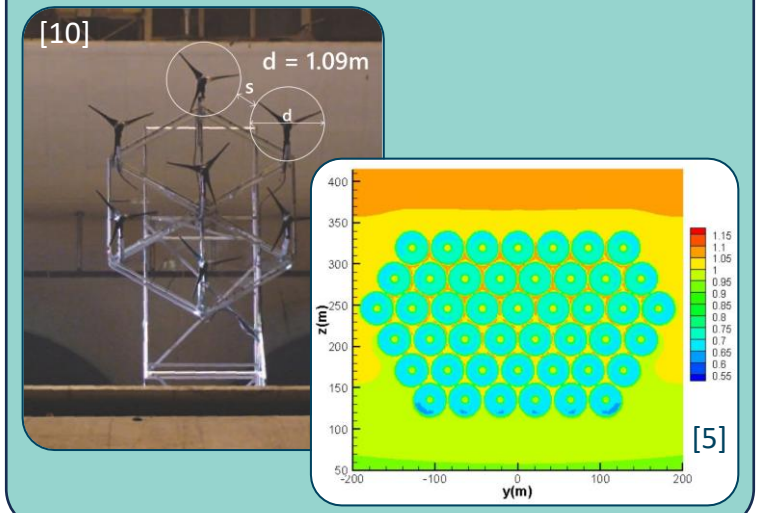
- Scope considered:
  - Co-planar, single support structure
  - Offshore and onshore
  - Experimental and numerical simulations
- Aims of review:
  - Collating research in different areas
  - Highlighting under-researched areas



Rigid Aerodynamics

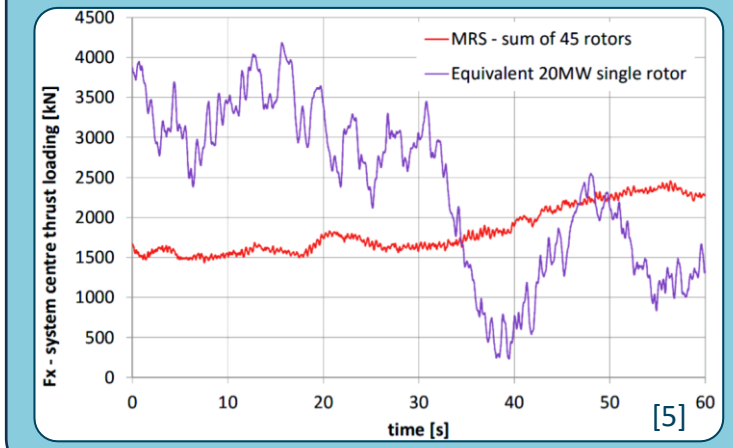
Effect of Rotor Interaction

- Power gains from blockage and flow acceleration (1-8%)
- Backed up by measurement and CFD
- Effect on loads (?) Data availability (?)



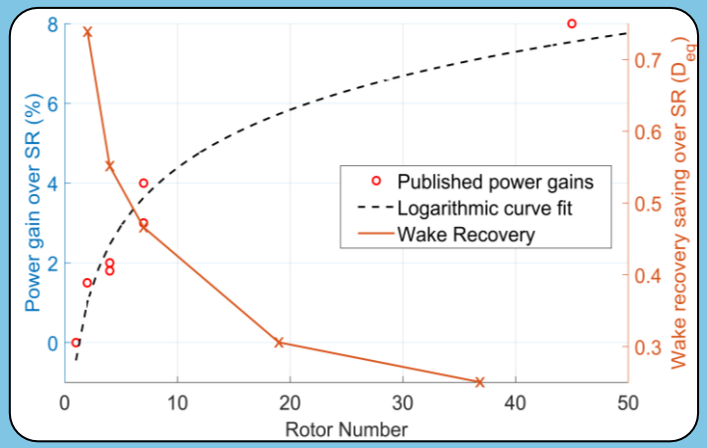
Thrust/Load Averaging

- Incoherent wind > reduced peak system thrust
- Improved reliability and fatigue (?)



Improved Wake Recovery

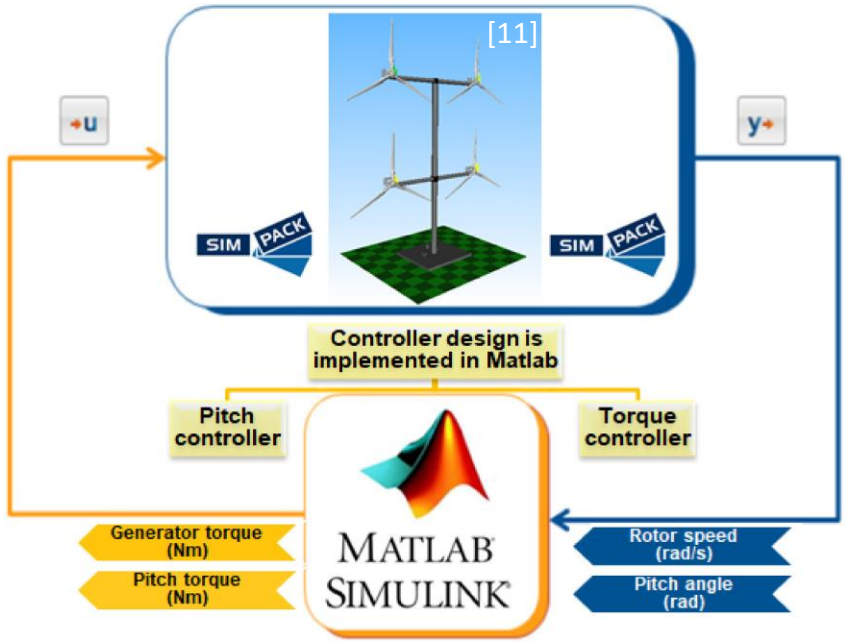
- Reduced wake recovery distance
- Varies with rotor number and spacing
- Long-term AEP gains (?)

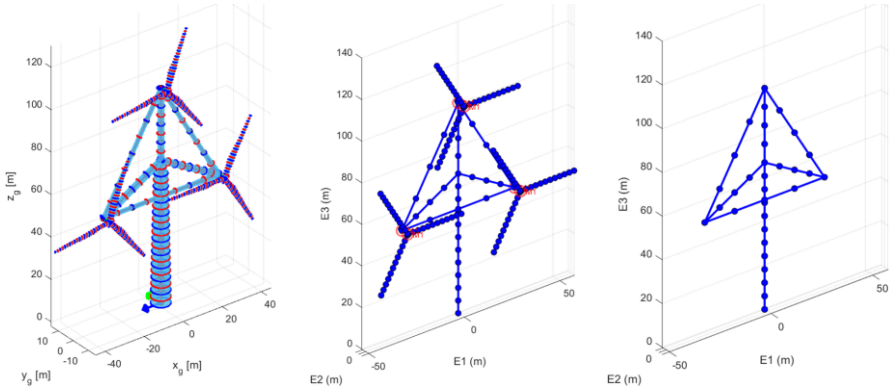


[10] D Ransom, JJ Moore, and M Heronemus-Pate. "Performance of wind turbines in a closely spaced array". In: Renewable Energy World 2.3(2010), pp. 32–36.

Control & Aeroelasticity

- More moving parts, more interconnectivity
  - ⇒ Greater complexity in modelling & control
- Research ruling out instabilities or critical modes
- Control studies to reduce tower movement
- Modelling simplifications? Benchmarking?

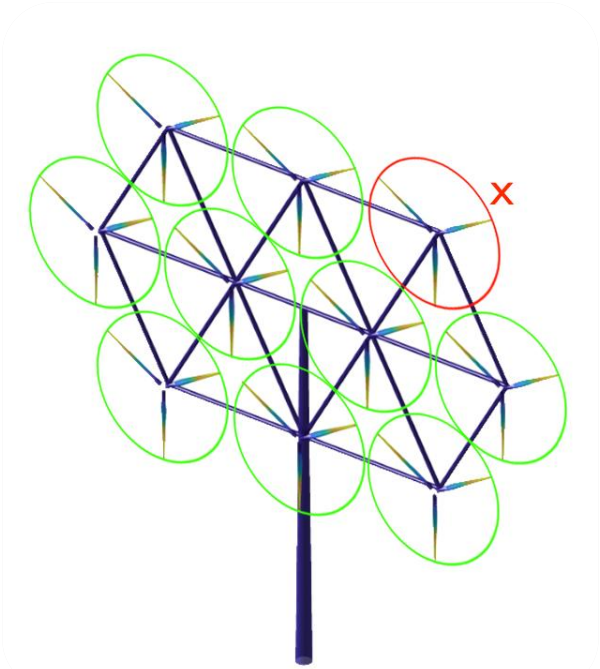


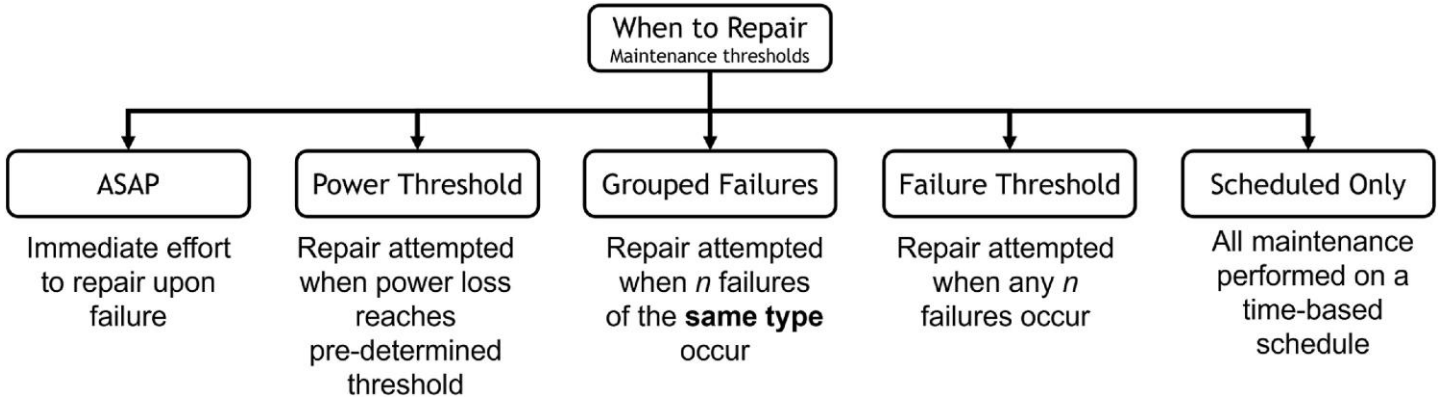


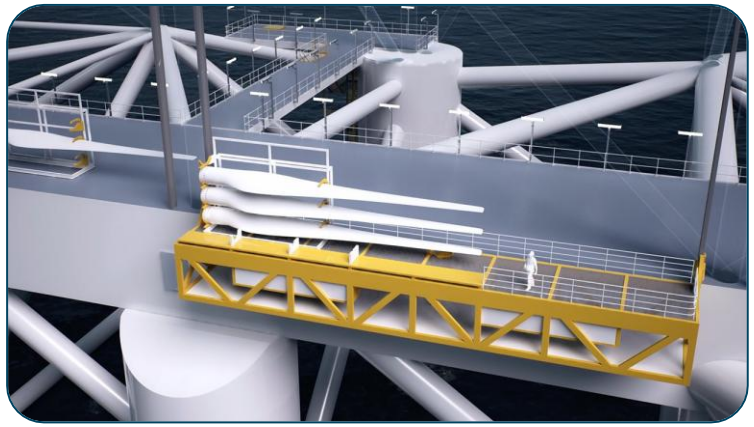
[11] Ferede, E., & Gandhi, F. (2022). Aeroelastic load analysis of a co-rotating quad-rotor wind turbine. Wind Energy, 25(3), 450–467. https://doi.org/10.1002/we.2681

Operations, Maintenance & Reliability

- Built-in redundancy
  - Reduction in lost revenue
  - Potential for maintenance scheduling (?)
- On-site maintenance?
  - Leverage support structure as maintenance scaffold
- Failure rate for complex structure?



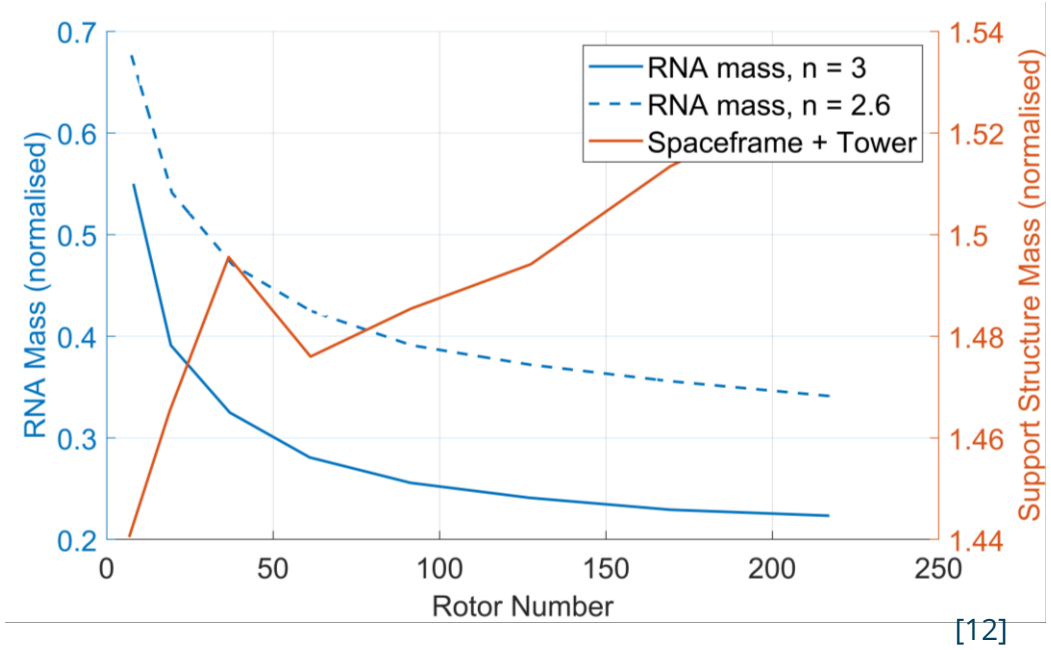




[1] McMorland, J.et. al. (2022). A review of operations and maintenance modelling with considerations for novel wind turbine concepts. In *Renewable and Sustainable Energy Reviews*
[2] Wind Catching Systems. (n.d.). Retrieved October 24, 2023, from https://www.windcatching.com/

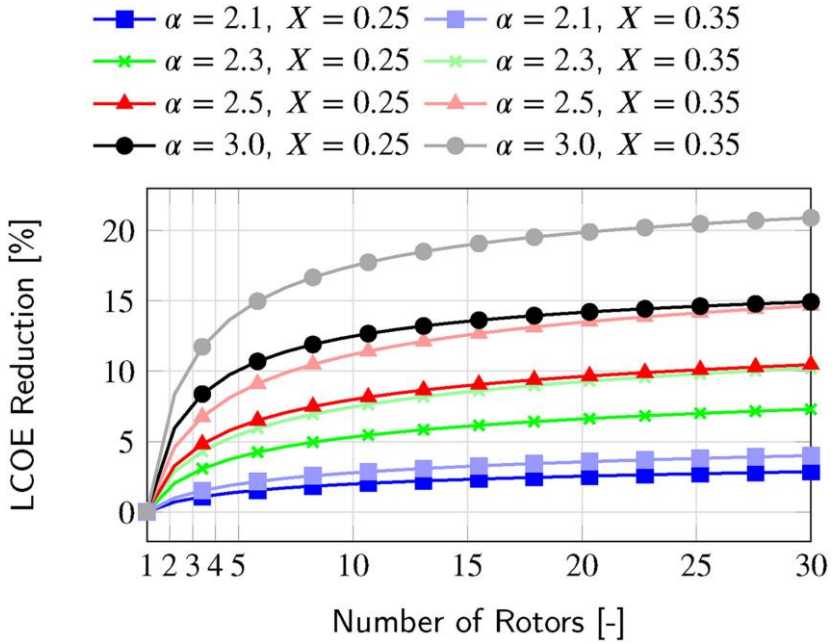
Trends in Multi-Rotor Scaling

- Sources of LCoE savings
  - Structural – square-cube law, support structure
  - Aerodynamic – rotor interaction, wake recovery



[12]

$$\Delta\mathrm{LCOE} = 0.73X\left(1 - n\left(\frac{1}{\sqrt{n}}\right)^{\alpha}\right)$$



[12] Data adapted from Störtenbecker, S. et al, Journal of Physics: Conference Series (2020)

Gaps & Limitations

What's left to address?

- System-wide savings
  - Best and worst case LCoE gains?
  - Quality of data?
- High uncertainty, sensitive to assumptions

	Performance Factors	Impact on LCoE [%]	Confidence (0–5)
AEP	Power gain from 2 to 7 rotor blockage	-[0, 3]	3
	Power gain from 7 to 40 rotor blockage	-[2, 8]	1
	Farm-level AEP gain from wake saving	-[0, 2]	3
	Faster turbulence response	?	
CAPEX	Reduced cost for 2 to 7 RNAs	-[0, 16]	3
	Reduced cost for 7 to 40 RNAs	-[2, 22]	1
	Increased support structure mass	+[5, 0.3]	2
	Larger production volume	?	
OPEX	Reduced cost of downtime	?	
	On-platform repair equipment	?	
	Reduced vessel size/personnel requirements	?	
	Greater volume of failure	?	
TOTAL		[+5, -30]	

Priority - reduce uncertainty through:

- **Multi-disciplinary detailed design**
- **Publicly available test data**

Goal: Improve our understanding of the ceiling of benefit on LCoE offered by the multi-rotor concept

HAW HAMBURG | CC4E

University of Strathclyde Glasgow

RENEWABLE DYNAMICS

Image credits:
[1] Timaru Herald, Volume CXXXVII, Issue 19461, 8 April 1933, Page 16
[2] The Life and Work of Bill Heronemus, Wind Engineering Pioneer. URL: https://www.umass.edu/windenergy/about/history/heronemus.
[3] Lagerwey - Vom Multirotor zur getriebelosen Großturbine mit Kletterkran. (n.d.). Retrieved September 23, 2025, from https://www.erneuerbareenergien.de
[4] Jamieson, P., & Branney, M. (2012). Multi-rotors; a solution to 20 MW and beyond? Energy Procedia, 24, 52–59. https://doi.org/10.1016/j.egypro.2012.06.086
[5] Jamieson, P. et. al. (2017). Deliverable 1 . 3 3 Innovative Turbine Concepts - Multi- Multi - Rotor System August 2015. August 2015, 1–197.
[6] van der Laan, M. P. et. al (2019). Power curve and wake analyses of the vestas multi-rotor demonstrator. Wind Energy Science, 4(2), 251–271. https://doi.org/10.5194/wes-4-251-2019
[7] Myriad - Home. URL: https://www.myriadwind.com/.
[8] Wind Catching Systems. (n.d.). Retrieved September 23, 2025, from https://www.windcatching.com/
[9] Mingyang Smart Energy. Retrieved October 2nd, 2025, from https://en.myse.com.cn/

Thank you.

Contact:
a.sh.2019@bristol.ac.uk

Read the paper here →

UKRI Engineering and Physical Sciences Research Council

University of BRISTOL
Bristol Composites Institute

Sponsored by:
Erneuerbare Energien Hamburg
EnBW
WIND CATCHING