2022 SANDIA BLADE WORKSHOP

October 17–20, 2022 | Albuquerque, NM

WHEN TRUST MATTERS

Industry Trends in Blades

One Perspective in Late 2022

Sandia Blade Workshop

Matt Malkin

19 March 2021

Design – Commercial pressure and time-to-market

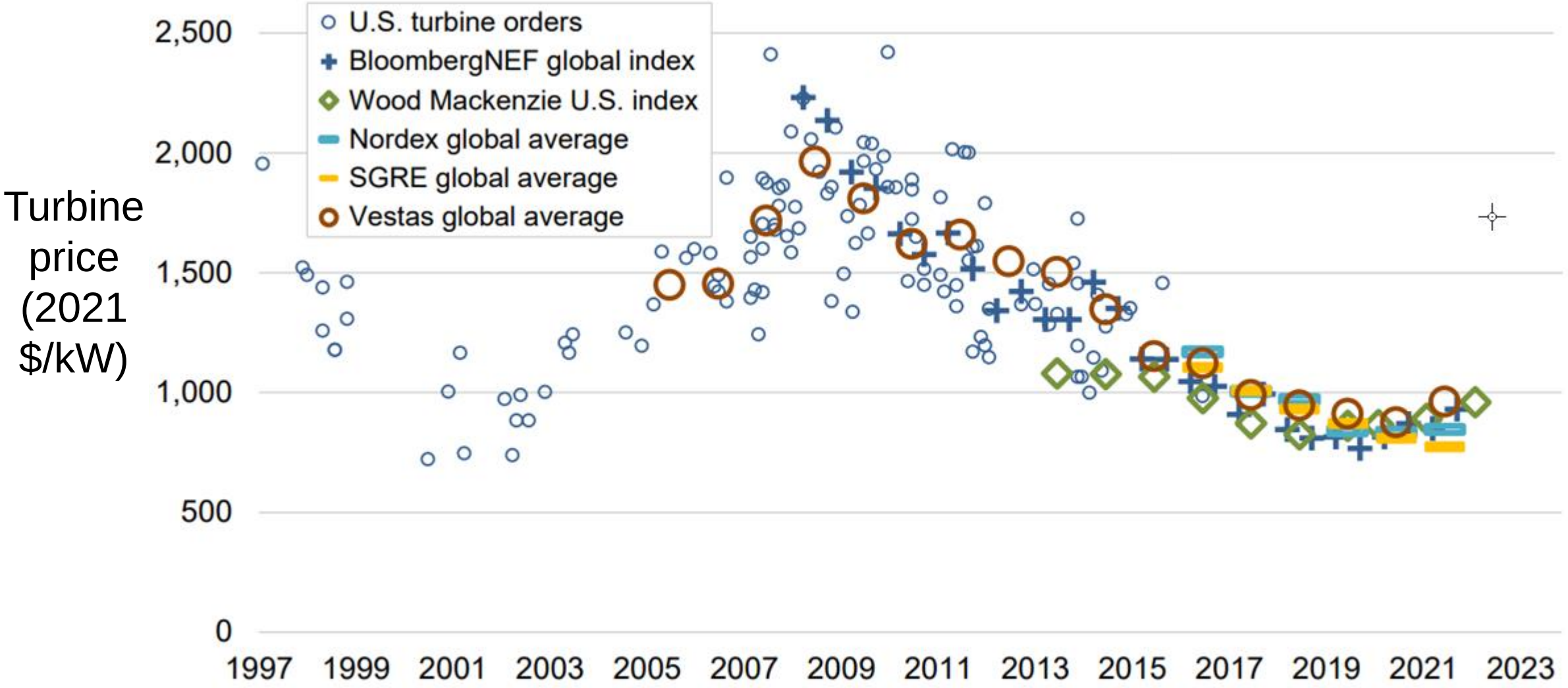
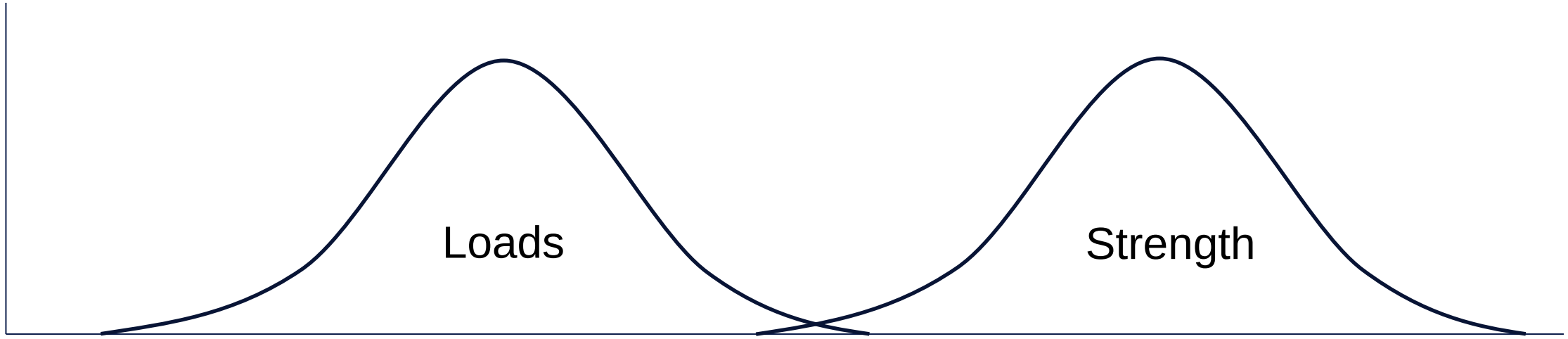
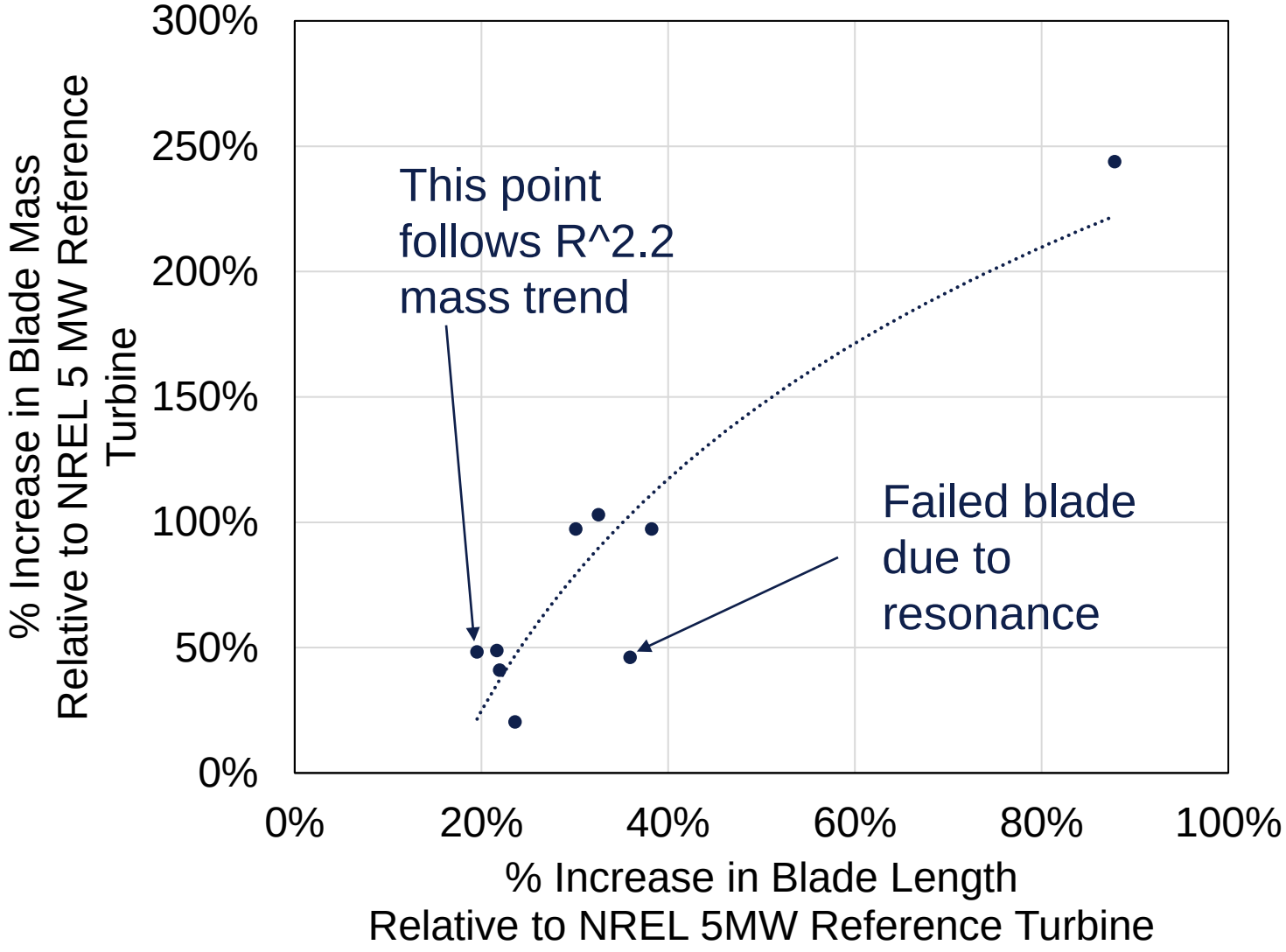


Chart Source: Ryan Wiser, Mark Bolinger, Ben Hoen, Dev Millstein, Joe Rand, Galen Barbose, Naïm Darghouth, Will Gorman, Seongeun Jeong, and Ben Paulos. Lawrence Berkeley National Laboratory. US DOE Land-based Wind Market Report: 2022 Edition.

Design – Structural margins



Design – Aeroelastics and resonance



Source: DNV

Manufacturing – Are processes static?

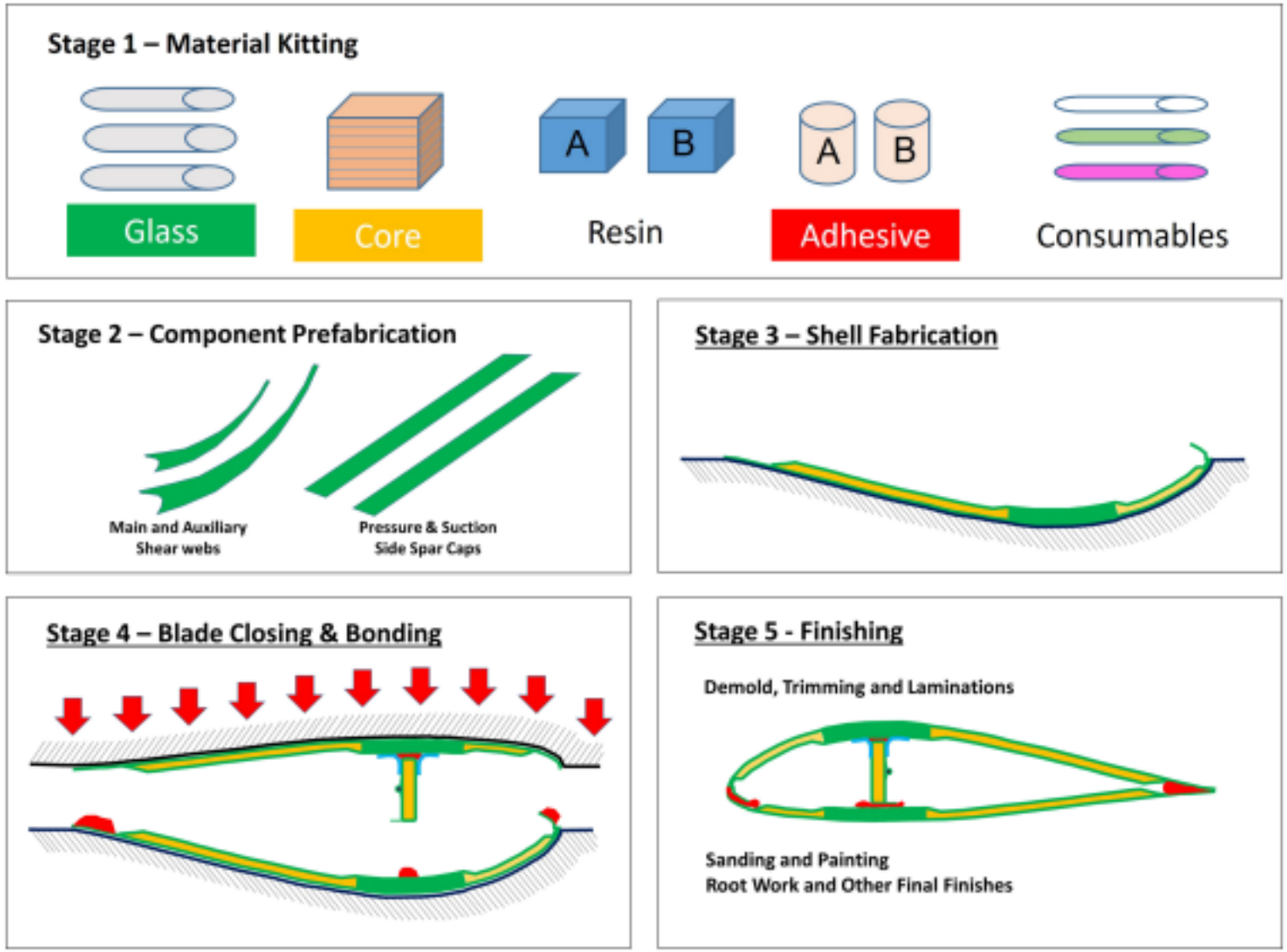


Image Source: Johnson, Stephen B., Chetan, Mayank, Griffith, D. Todd, Sherwood, James A., Development of high-fidelity design-driven wind blade manufacturing process models to investigate labor predictions in wind blade manufacture, Wind Energy, 2022;25:1313-1331.

Manufacturing – More flaws in larger blades?

- Design for Manufacturing: are design margins sufficient to cover process variability?
- Use Failure Modes and Effects Analysis in manufacturing.
- Implement adequate detection methods for manufacturing-related risks that cannot be eliminated.

Pultrusions for spar caps

Manufacturing – Novel approaches?

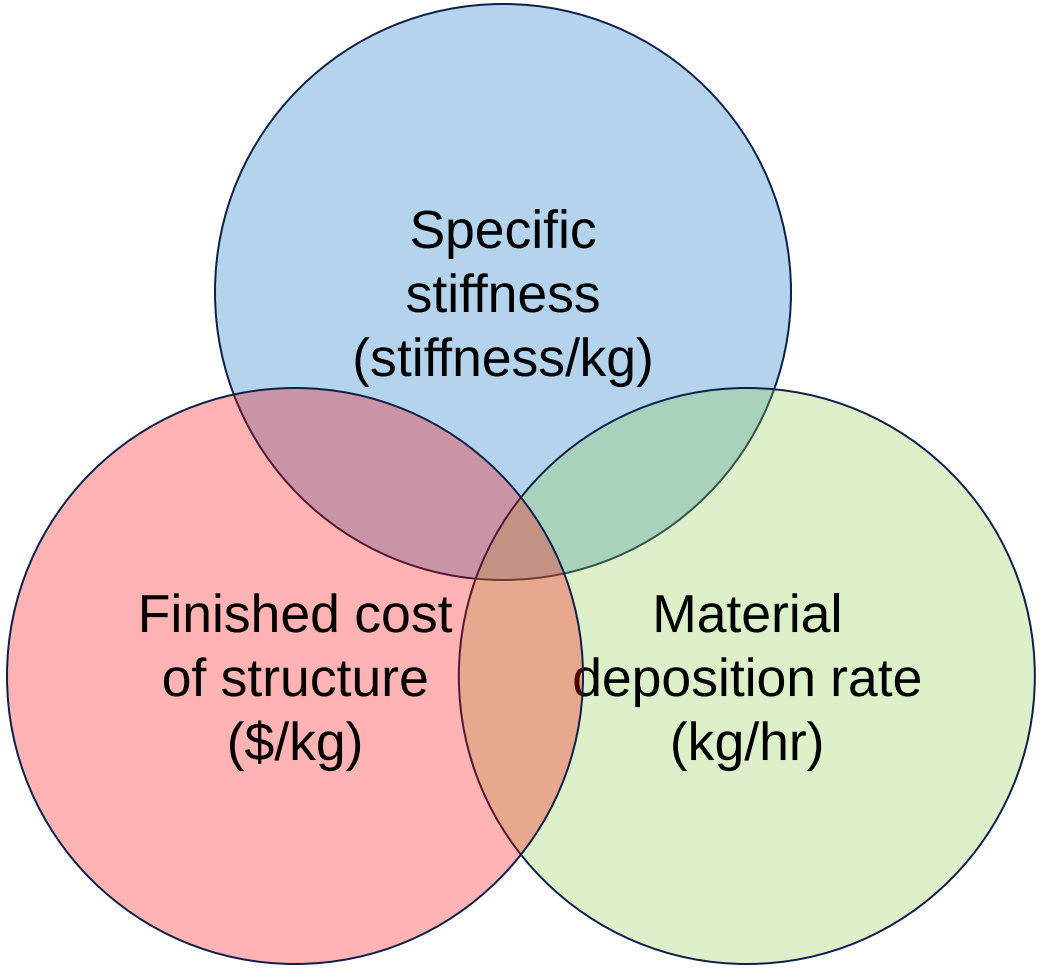
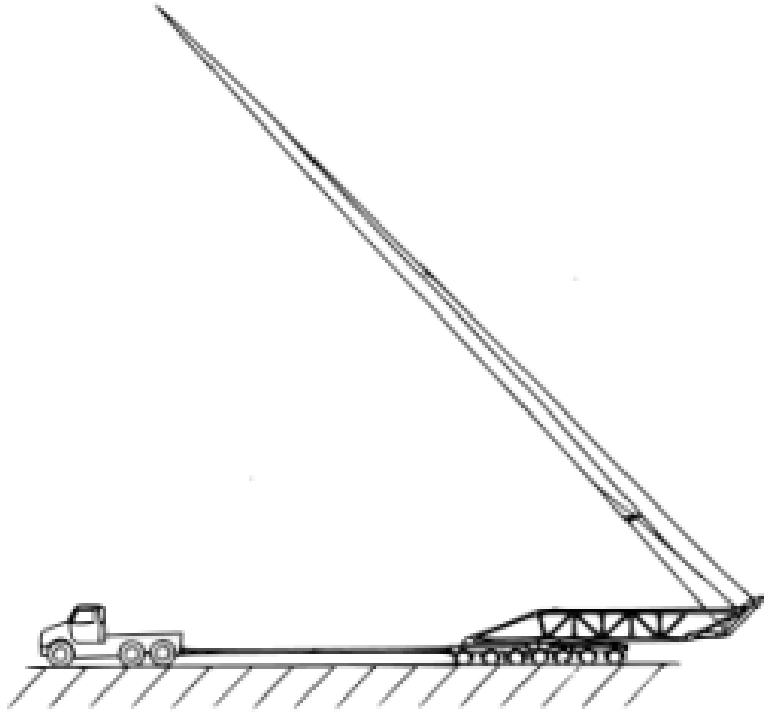
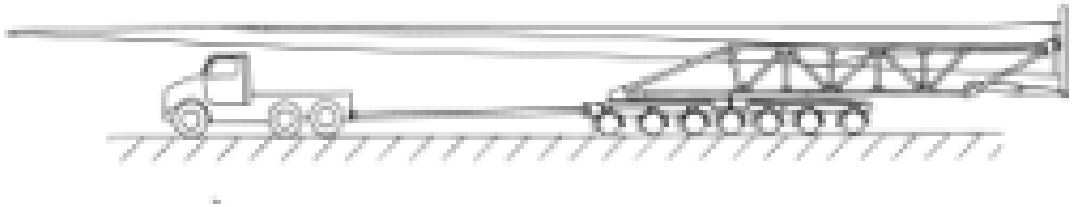


Image Source: Post, B., Richardson, B., Love, L, Nolet, S., Hannan, J., Additive Manufacturing of Wind Turbine Molds, CRADA FINAL REPORT NFE-16-06051, 2017.

Transportation and handling – Where are the limits?





Operations – Lightning risk with higher tip heights

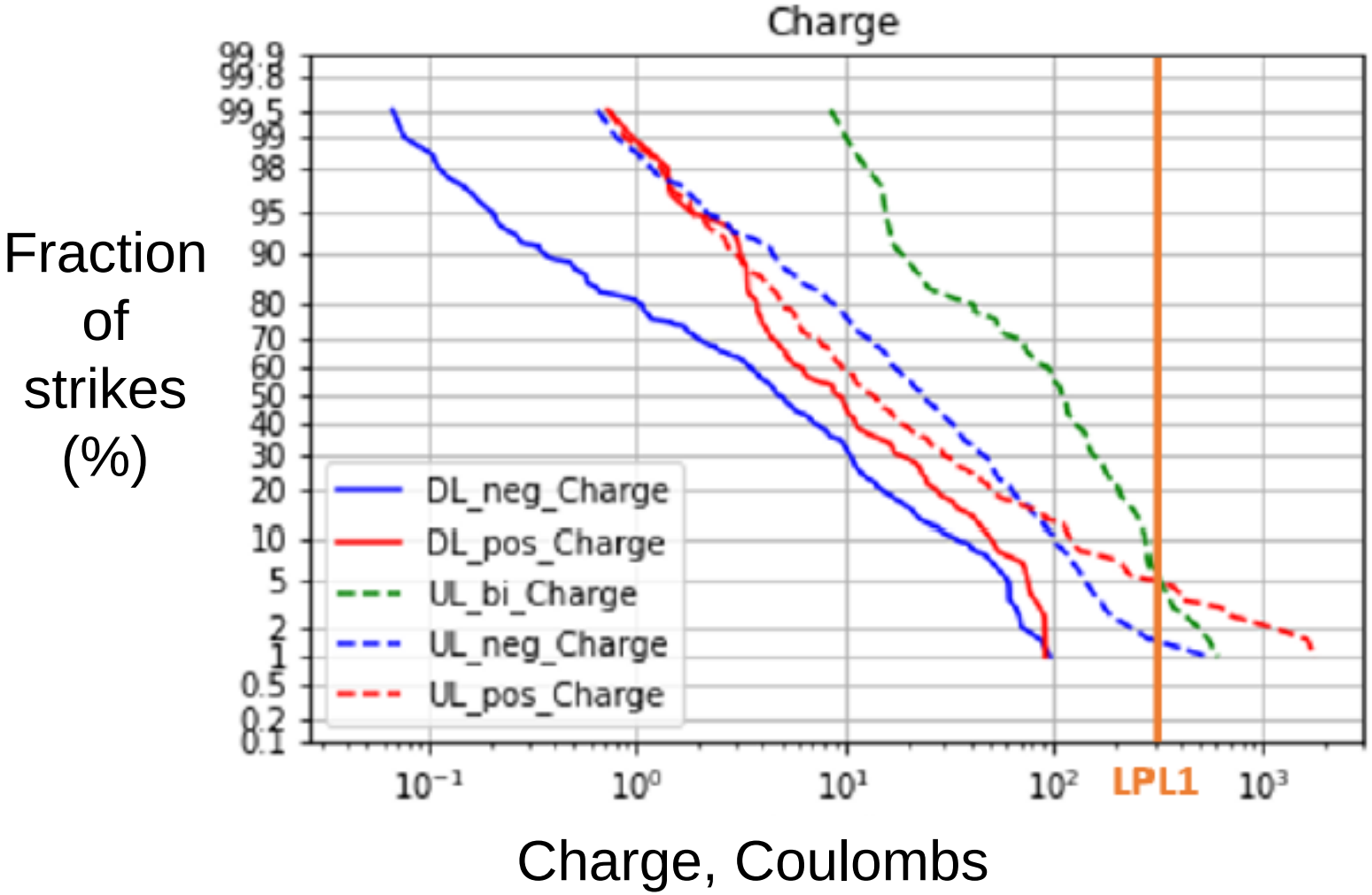
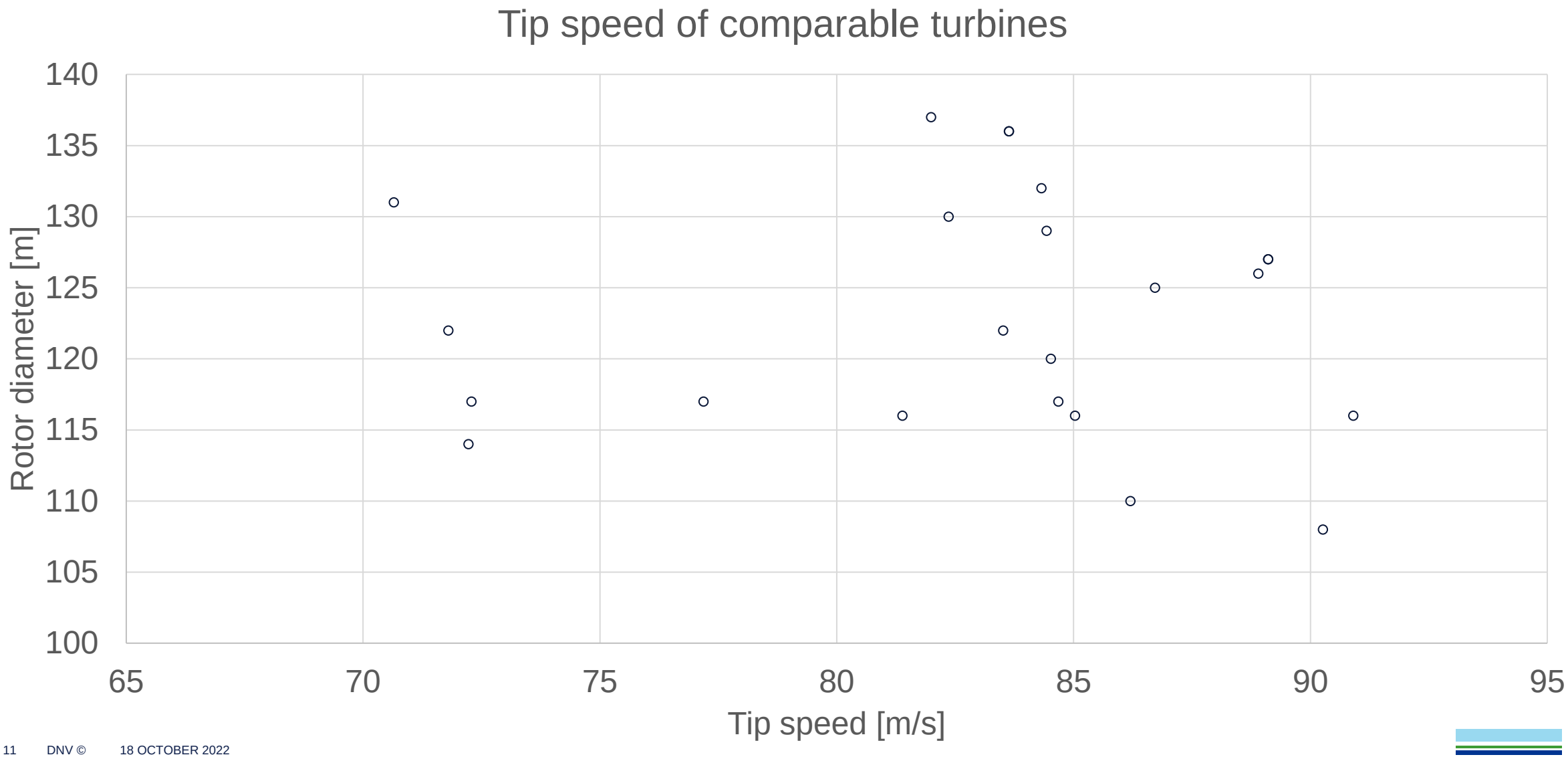


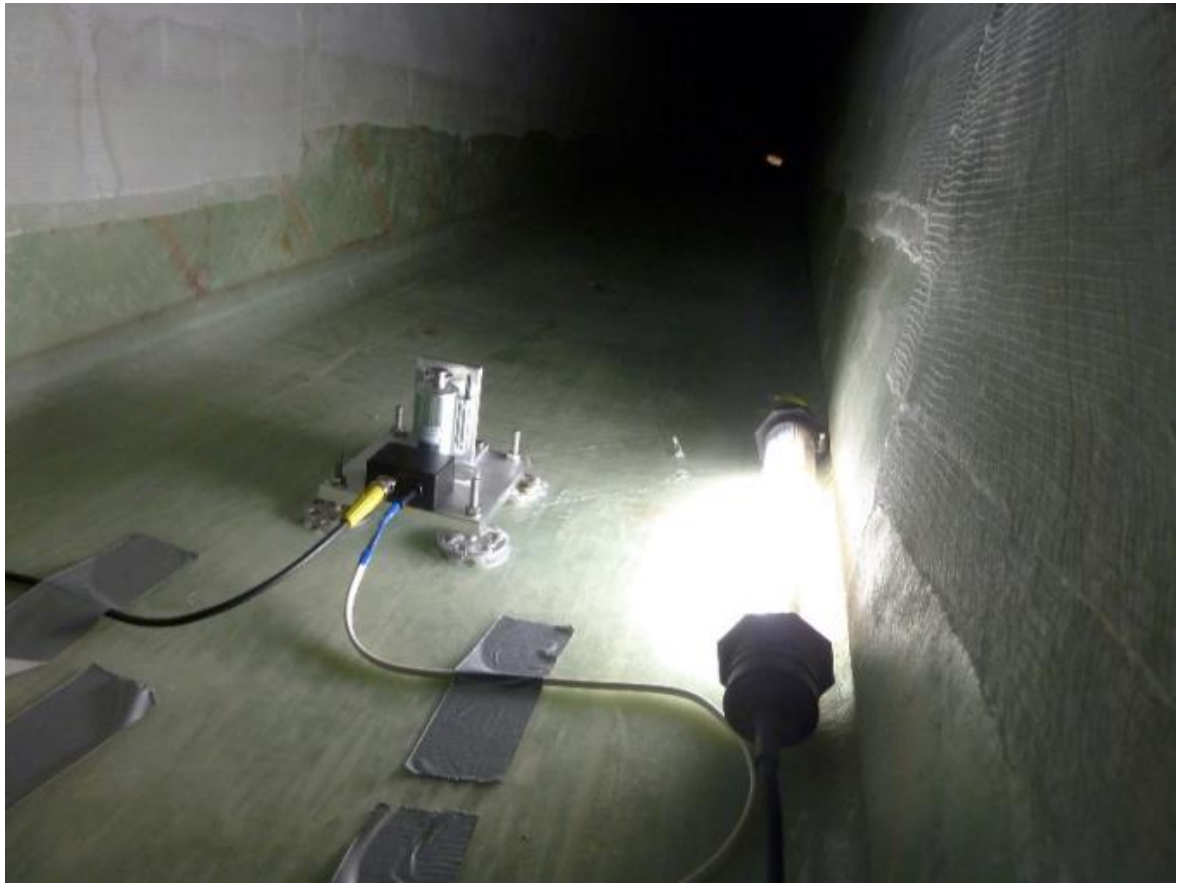
Chart source: Søren F. Madsen, Stephan Vogel, Javier Lopez, Lisa Carloni, Wind turbine blade LPS design process revisited – leveraging on latest knowledge from actual lightning measurements in wind turbines, PolyTech, 2022.

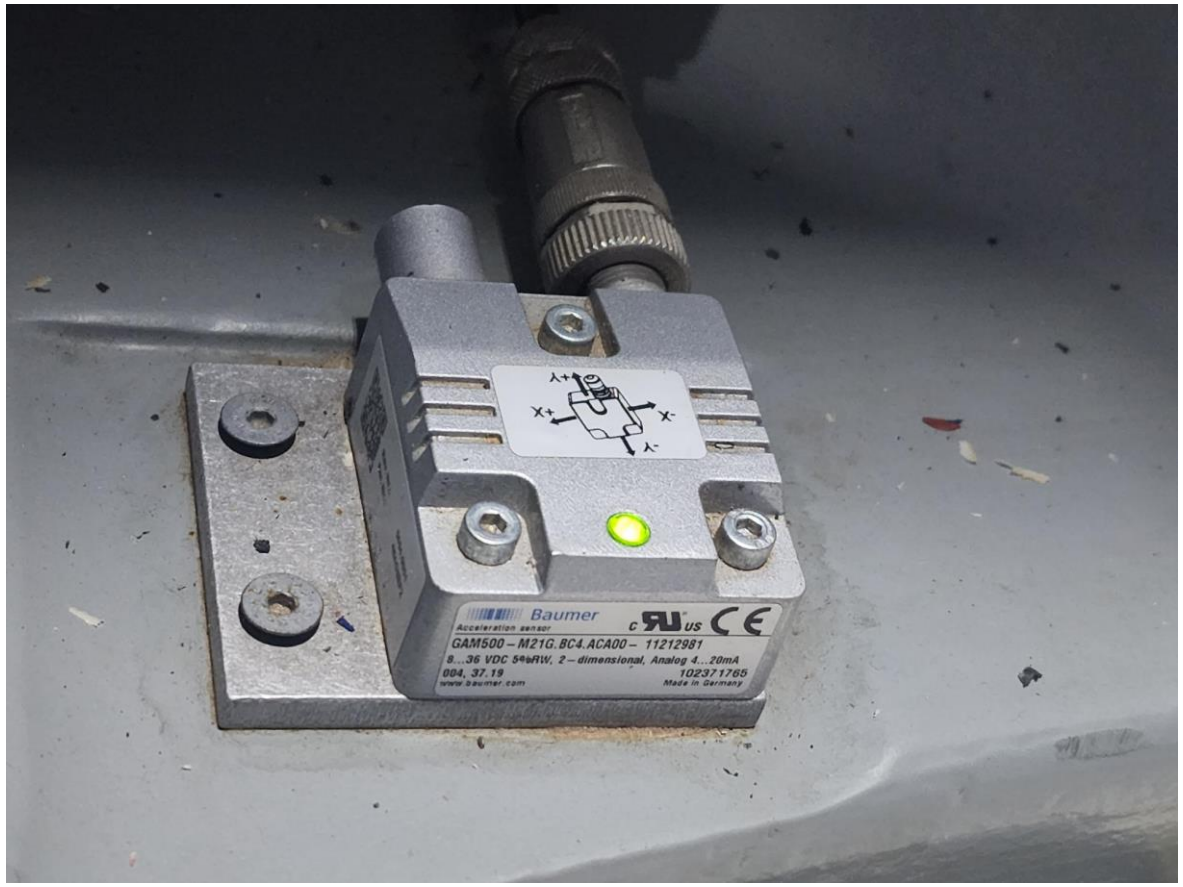
Image source: Montanyà, J., van der Veldde, O., Williams E. R., *Lightning Discharges Produced by Wind Turbines*, Journal of Geophysical Research, Vol. 119, Issue 3, 2014.

Operations – Leading edge erosion



Operations – Sensors for damage detection





Source: D Tcherniak and L L Mølgaard, Vibration-based SHM System: Application to Wind Turbine Blades, J. Phys.: Conf. Ser. 628 012072, 2015.

Source: DNV

Operations – Maturing blade management programs

Source: Skyspecs website, accessed October 2022.

Source: Aerones website, accessed October 2022.

Source: Jomitek website, accessed October 2022.

Data management,
Risk-based inspection,
Use of decision theory for repairs,
Tie operations and procurement with contracts…
and much more!

End of life and decommissioning

- Long initial blade and turbine design life
- Interest in life extension of projects
- Blade recycling
  - Recent ACP work
  - IEA task force
  - OEM efforts, built in from the start

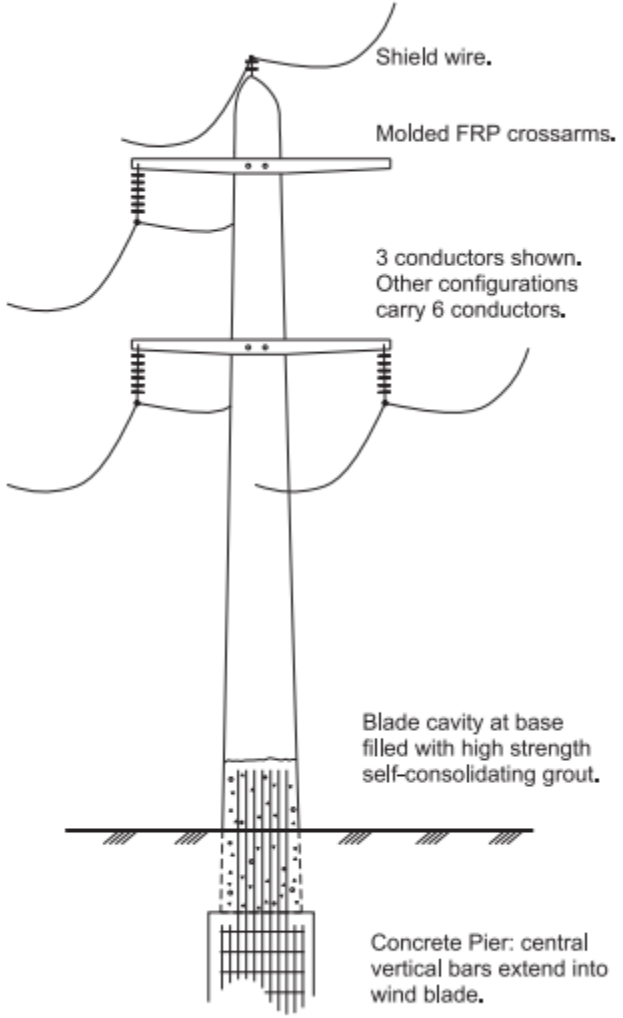


Fig. 4. BladePole concept proposal.

Drawing source: Alshannaq, Ammar A., Bank, Lawrence C., Scott, David W., Gentry, T. Russell, *Structural analysis of a Wind Turbine Blade Repurposed as an Electrical Transmission Pole*, Journal of Composite Construction, 2021.

The Guardian

Wind turbine blades could be recycled into gummy bears, scientists say

Researchers design composite resin for blades that can be broken down to make new products including sweets

DNV

Connecting the trends

- As an industry we should be continuously improving: we have experience, better tools
- The opportunity space for improvement is still tremendous
- Include robust design and high manufacturing quality in standards: IEC61400-5, DNV-ST-0376
- Drive positive change with commercial pressure: Contractual requirements that emphasize quality
- Maximize and optimize use of operational data; tie contracts to the data
- Plan for the full blade life cycle from the beginning

Image source: Vestas website, accessed October 2022.

Thank you!

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