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Large Turbines on Land
NAWEA 2019

PRESENTED BY

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Panelists

Mark Bolinger

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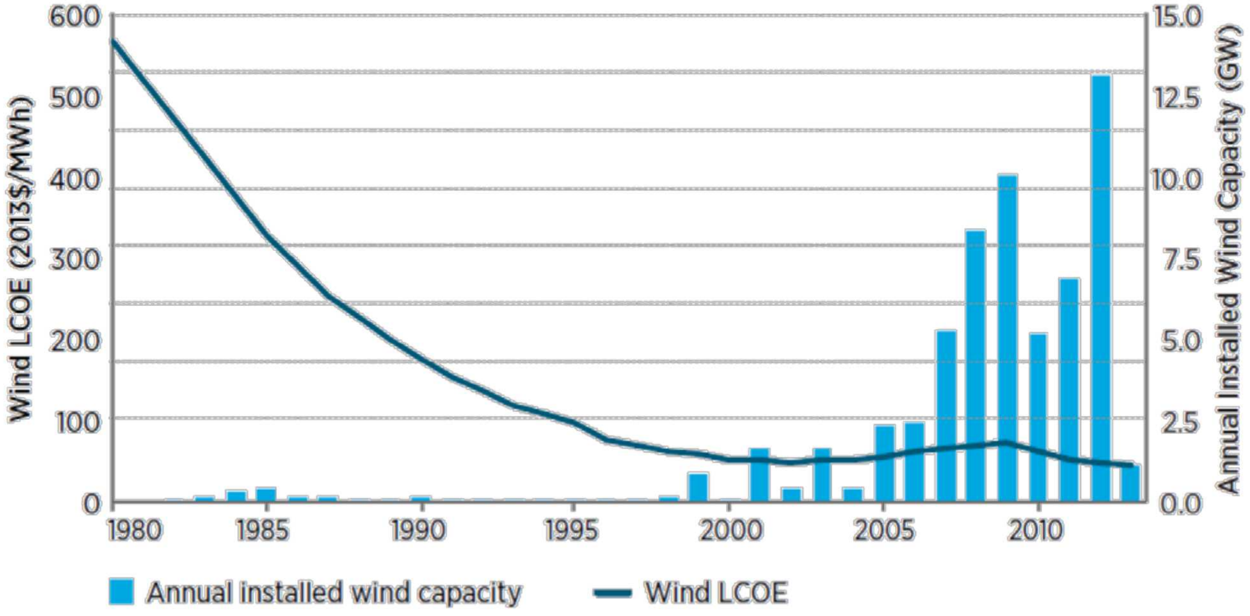
Todd Griffith

Associate Professor of Mechanical Engineering, University of Texas at Dallas

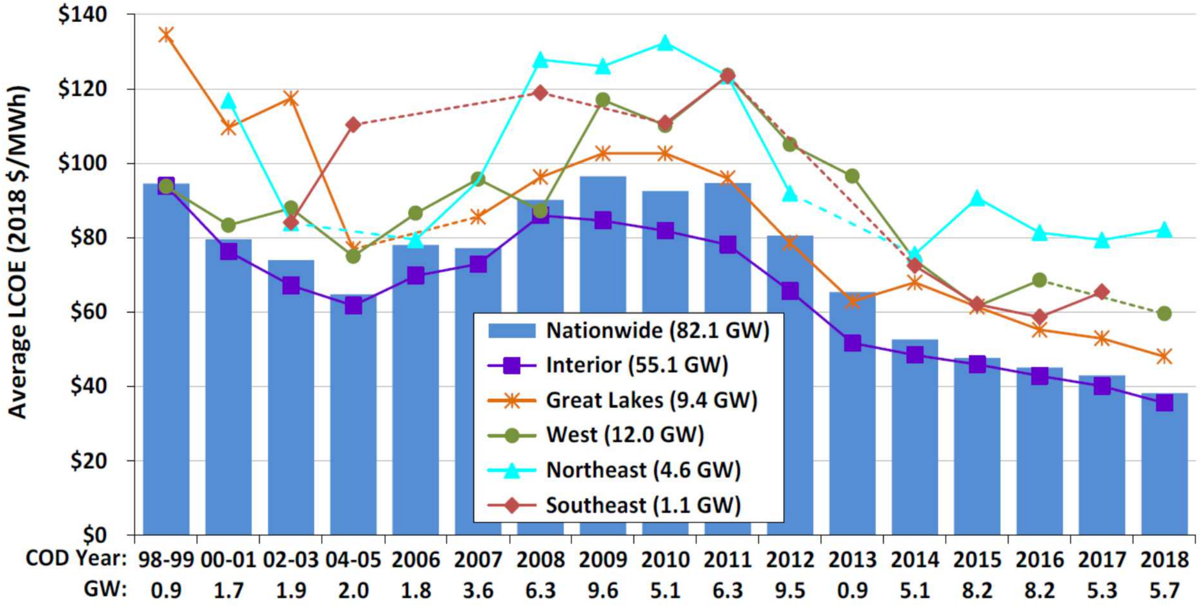
Steve Nolet

Senior Director of Innovation & Technology, TPI Composites

LCOE Trends

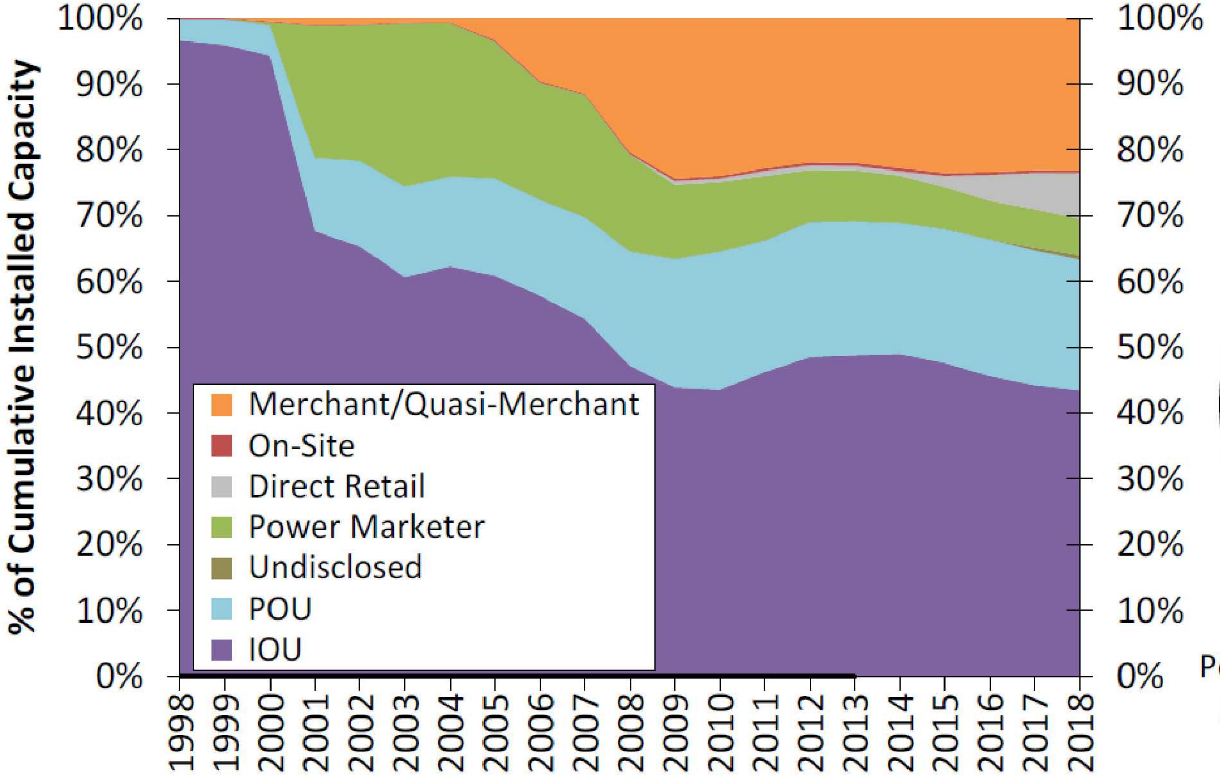


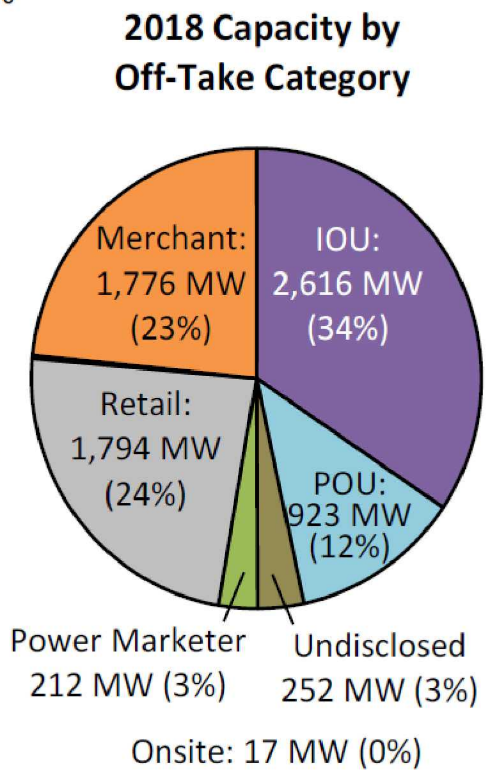
Source: DOE Wind Vision, 2015



Source: 2018 Wind Energy Technologies Market Report, Lawrence Berkeley National Laboratory

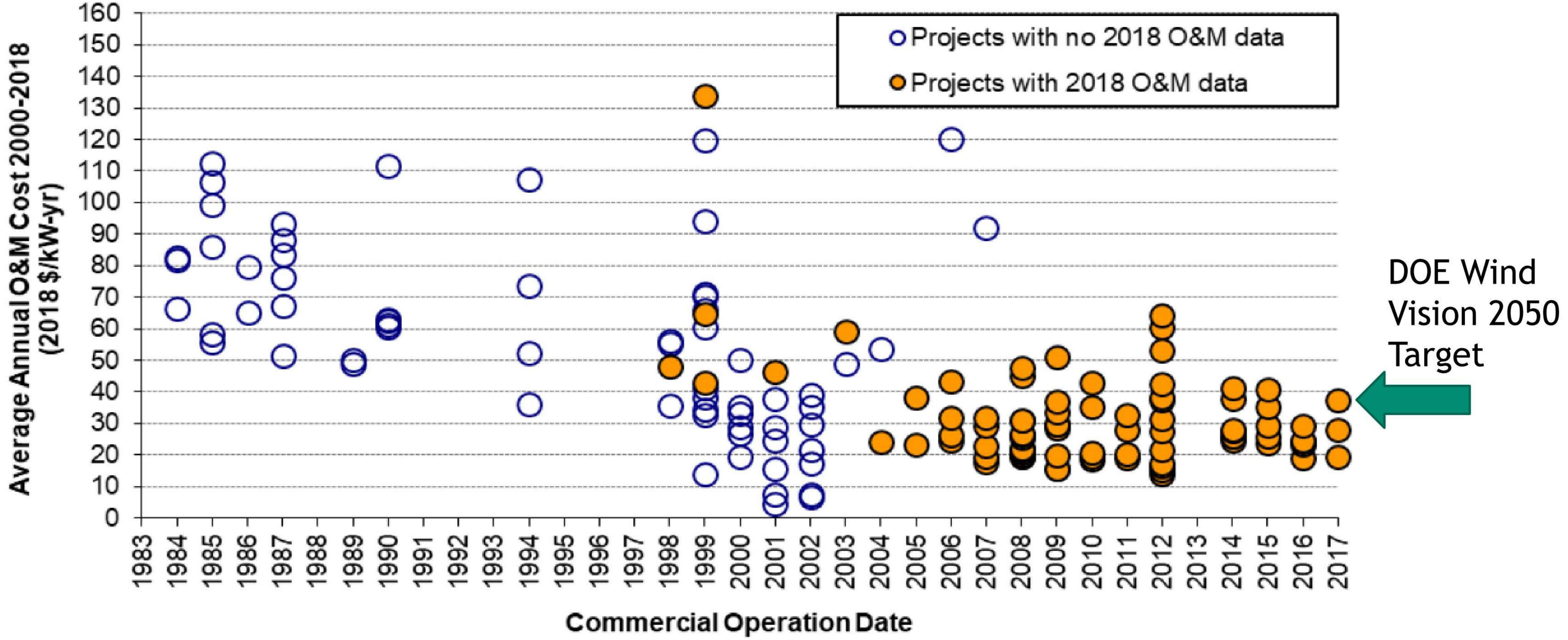
Market Trends





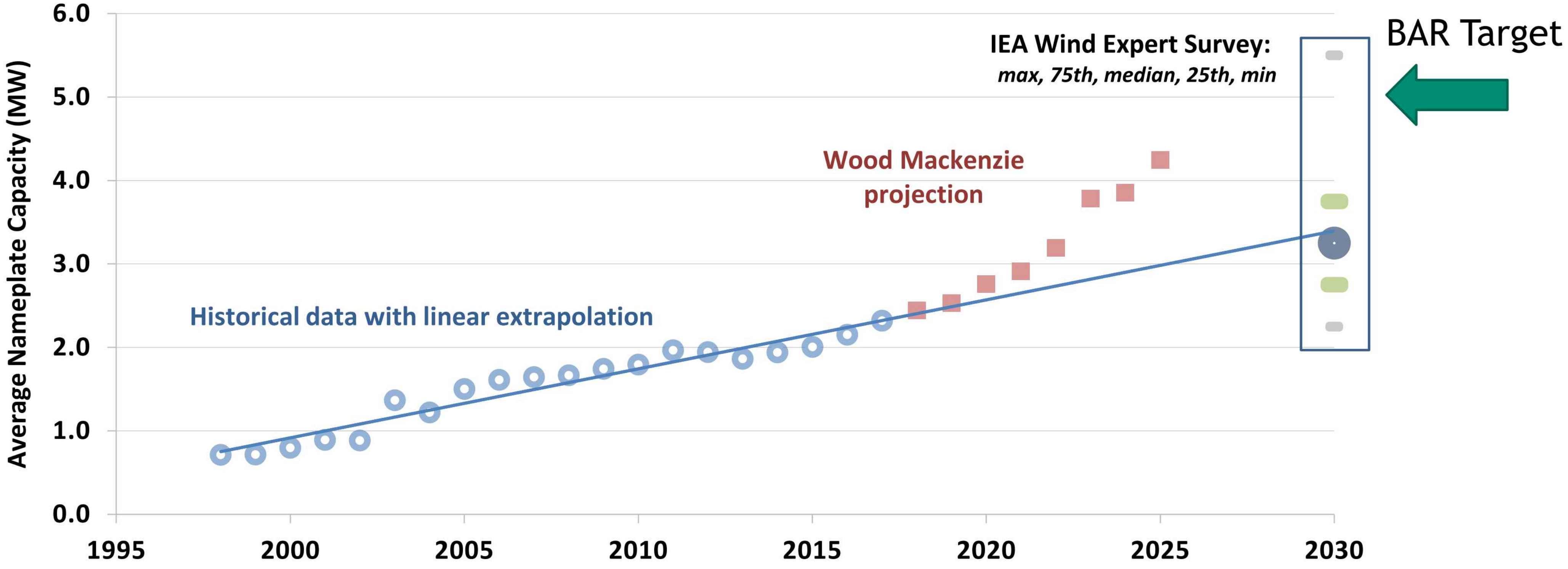
Source: 2018 Wind Energy Technologies Market Report, Lawrence Berkeley National Laboratory

O&M Cost Trends



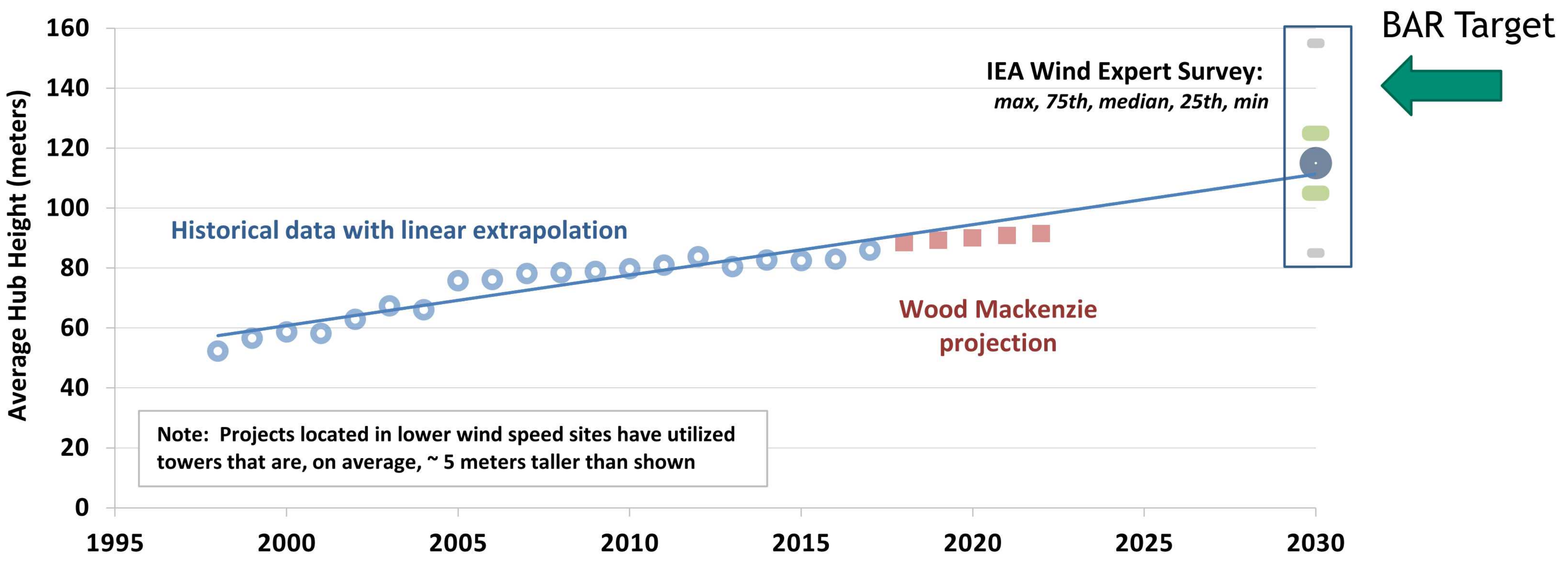
Source: 2018 Wind Energy Technologies Market Report, Lawrence Berkeley National Laboratory

Land-Based Turbine Trends: Capacity



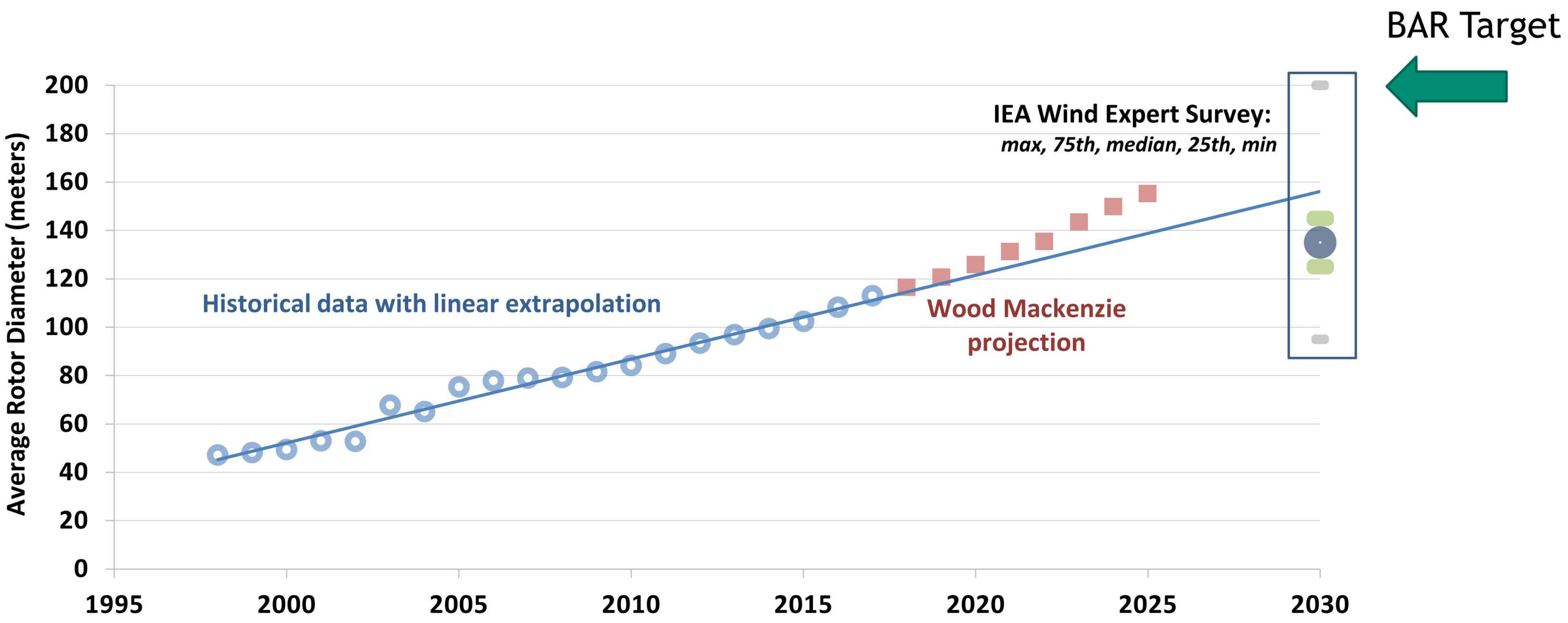
Source: Lawrence Berkeley National Laboratory, U.S. DOE Big Adaptive Rotor project, 2018

Land-Based Turbine Trends: Hub Height



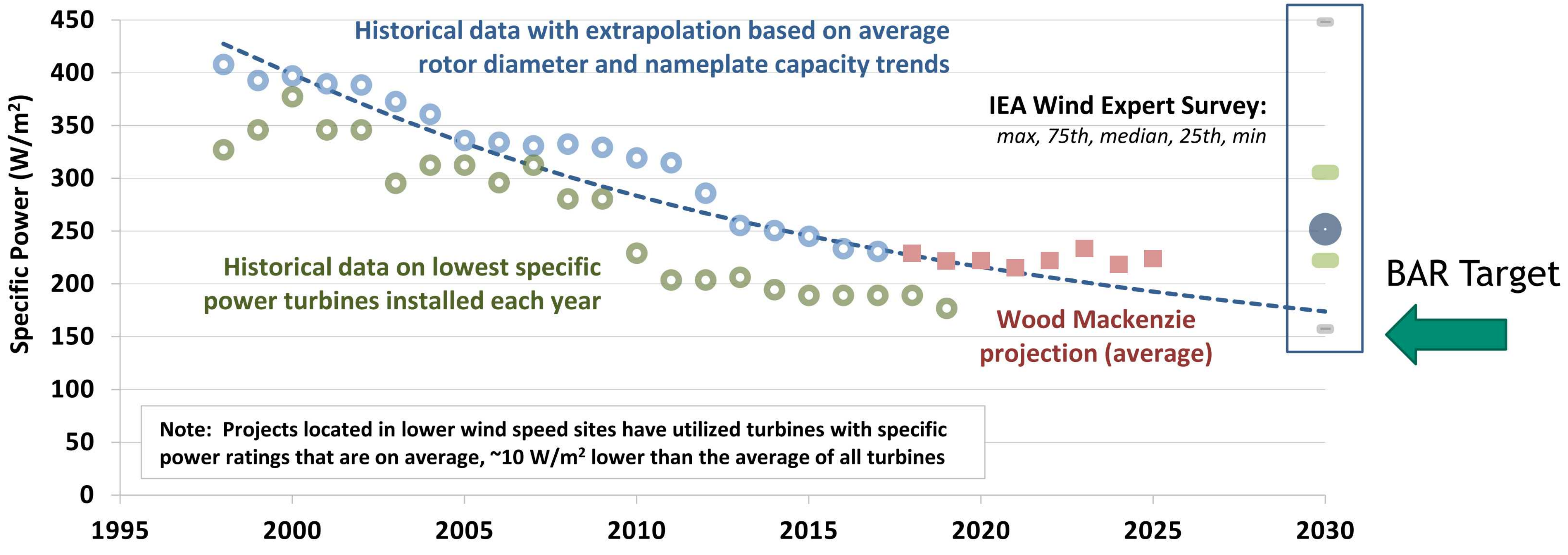
Source: Lawrence Berkeley National Laboratory, U.S. DOE Big Adaptive Rotor project, 2018

Land-Based Turbine Trends: Rotor Size



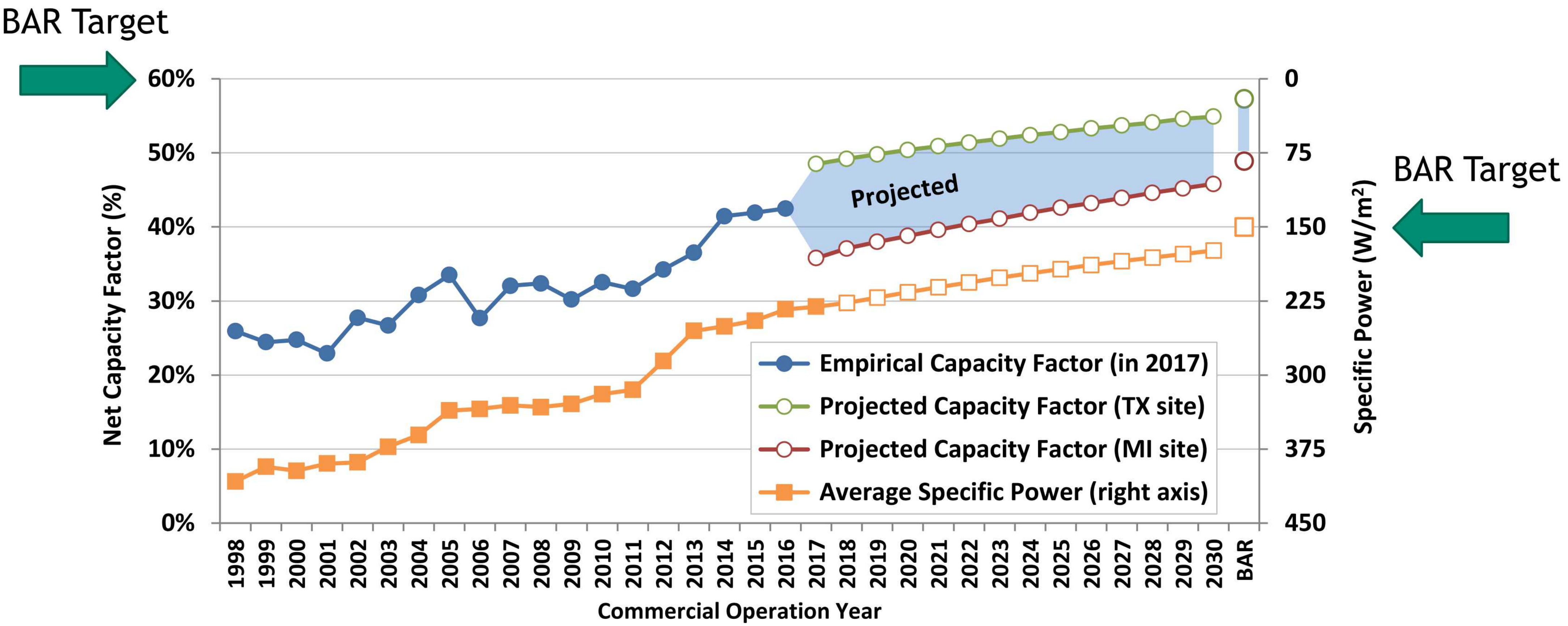
Source: Lawrence Berkeley National Laboratory, U.S. DOE Big Adaptive Rotor project, 2018

Land-Based Turbine Trends: Specific Power



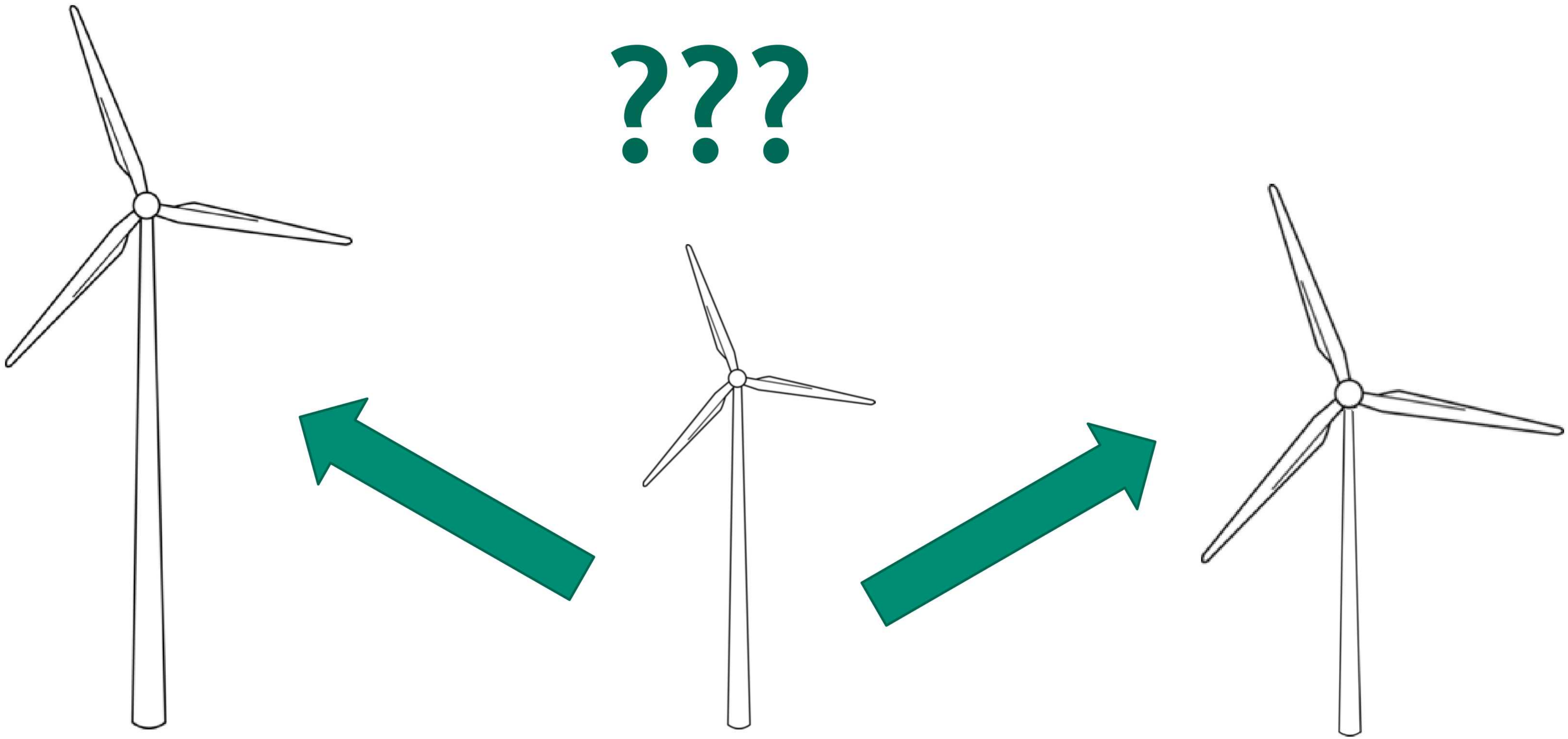
Source: Lawrence Berkeley National Laboratory, U.S. DOE Big Adaptive Rotor project, 2018

Land-Based Turbine Trends: Capacity Factor



Source: Lawrence Berkeley National Laboratory, U.S. DOE Big Adaptive Rotor project

Future Turbines



High Capacity

High Capacity Factor

Rotor Scaling

Better Materials

Thick Airfoils

Load Distribution

Control Displacement

$$m = (k)(\frac{\rho}{E})(\frac{R^2}{t^2})(\frac{R}{\delta})(M_{\text{root}})$$ ← Control Loads

$$M_{\text{root}} = C_M \frac{1}{2} \rho U_r^2 \pi R^3$$

held constant	spar mass scaling
load shape, material, slenderness, δ, S_P	R^4
load shape, material, slenderness, $\frac{\delta}{R}$, S_P	R^3
load shape, material, slenderness, δ	$R^{2.67}$
load shape, material, slenderness, $\frac{\delta}{R}$	$R^{1.67}$

Source: Sandia National Laboratories, 2019 Wind Energy Science Conference

DOE Big Adaptive Rotor Project

Objectives

- Investigate value of low specific power turbines
- Evaluate innovative rotor technologies
- Understand logistics challenges for large on-shore blades
- Design 5MW turbine with 206m rotor with 60% capacity factor in Class III, low wind speed site
- Identify enabling technology for the next generation of high capacity factor wind turbine rotors

Impact

- Enable high capacity factor wind rotors to maintain grid resilience in high renewable penetration future
- Open up large areas of the U.S. for potential wind development
- Reduce all-inclusive LCOE for wind
- Push turbine innovations towards commercialization

Rotor Innovations

From top left to bottom right: NASA/DOE, Rosenberg and Sharma, EB 28 Glider, Vestas, GE, UVA, UCLA, Enercon, DTU (RISO) , NREL, Sandia/UC-Davis, GE (Blade Dynamics)

Source: “Investigation of Innovative Rotor Concepts for the Big Adaptive Rotor Project”, U.S. DOE Big Adaptive Rotor project, NREL Technical Report, May 2019

Logistics Challenges

Source: General Electric

Logistics Challenges

Source: “R&D Pathways for Supersized Wind Turbine Blades”, U.S. DOE U.S. DOE Big Adaptive Rotor project, DNV-GL/LBNL