U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Government Perspectives

Sandia Blade Workshop 2022

Ben Hallissy

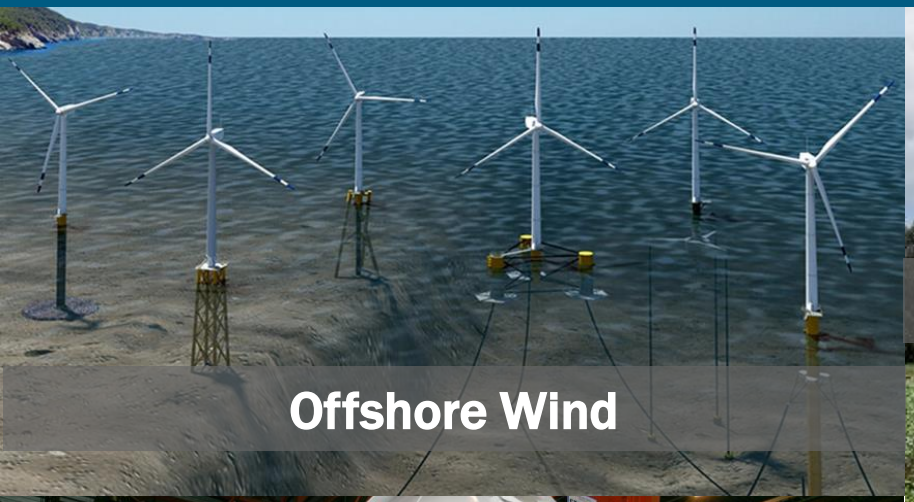
Technology Manager, Wind Energy Technologies Office (WETO)

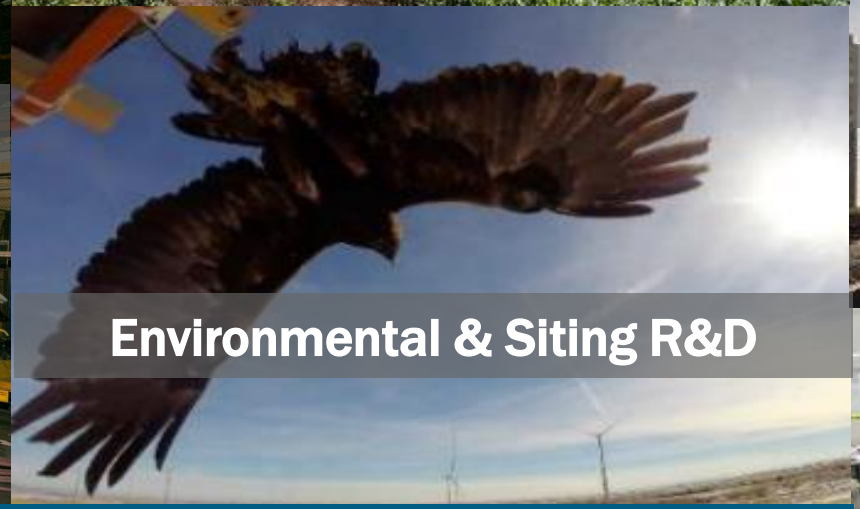
October 17th 2022

Albuquerque, NM

Wind Energy Technologies Office | What We Do

FY22 Enacted: $114M | FY23 Request: $345M



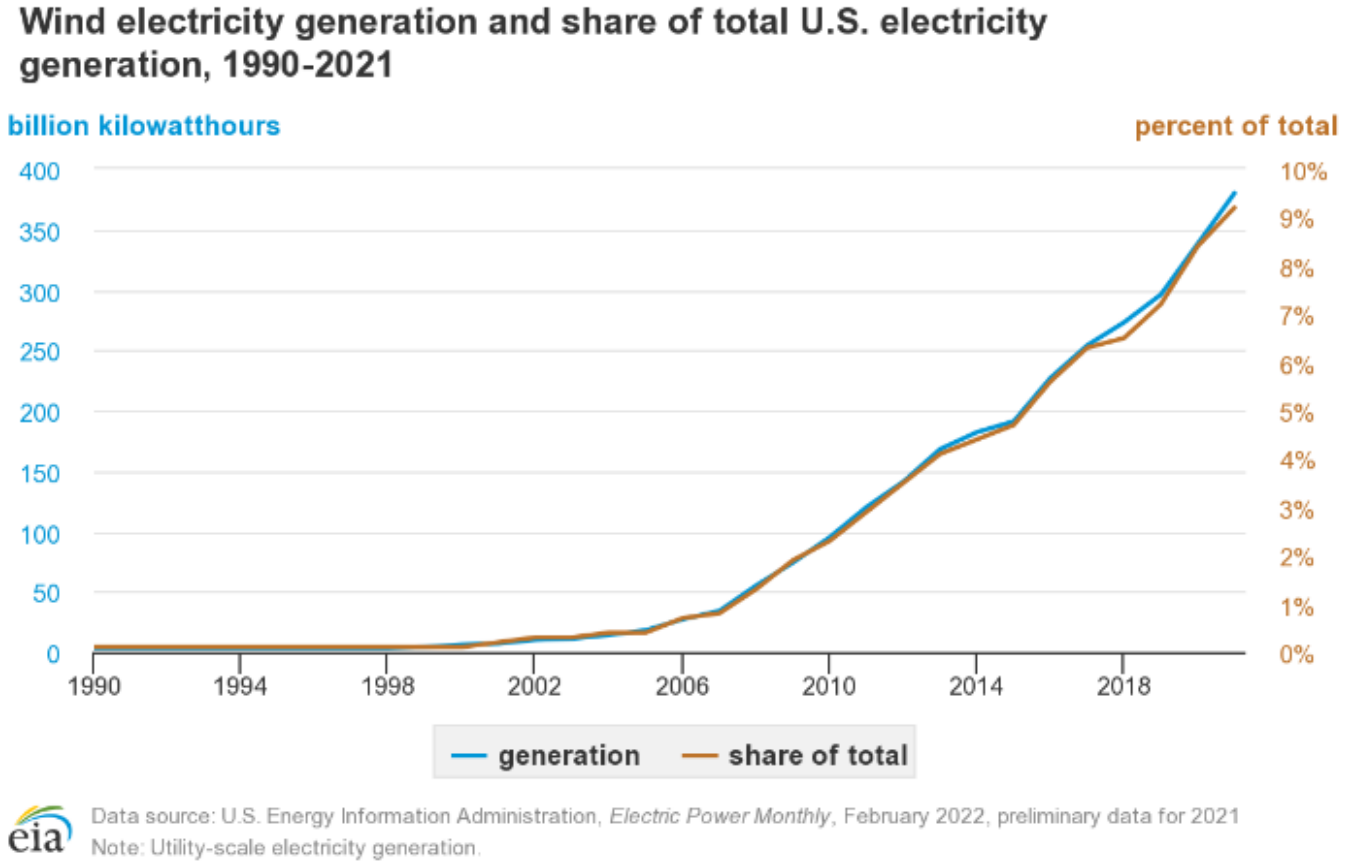


Wind is a cornerstone of achieving the Administration's goals of 100% clean electricity by 2035 and a net-zero emissions economy by 2050.

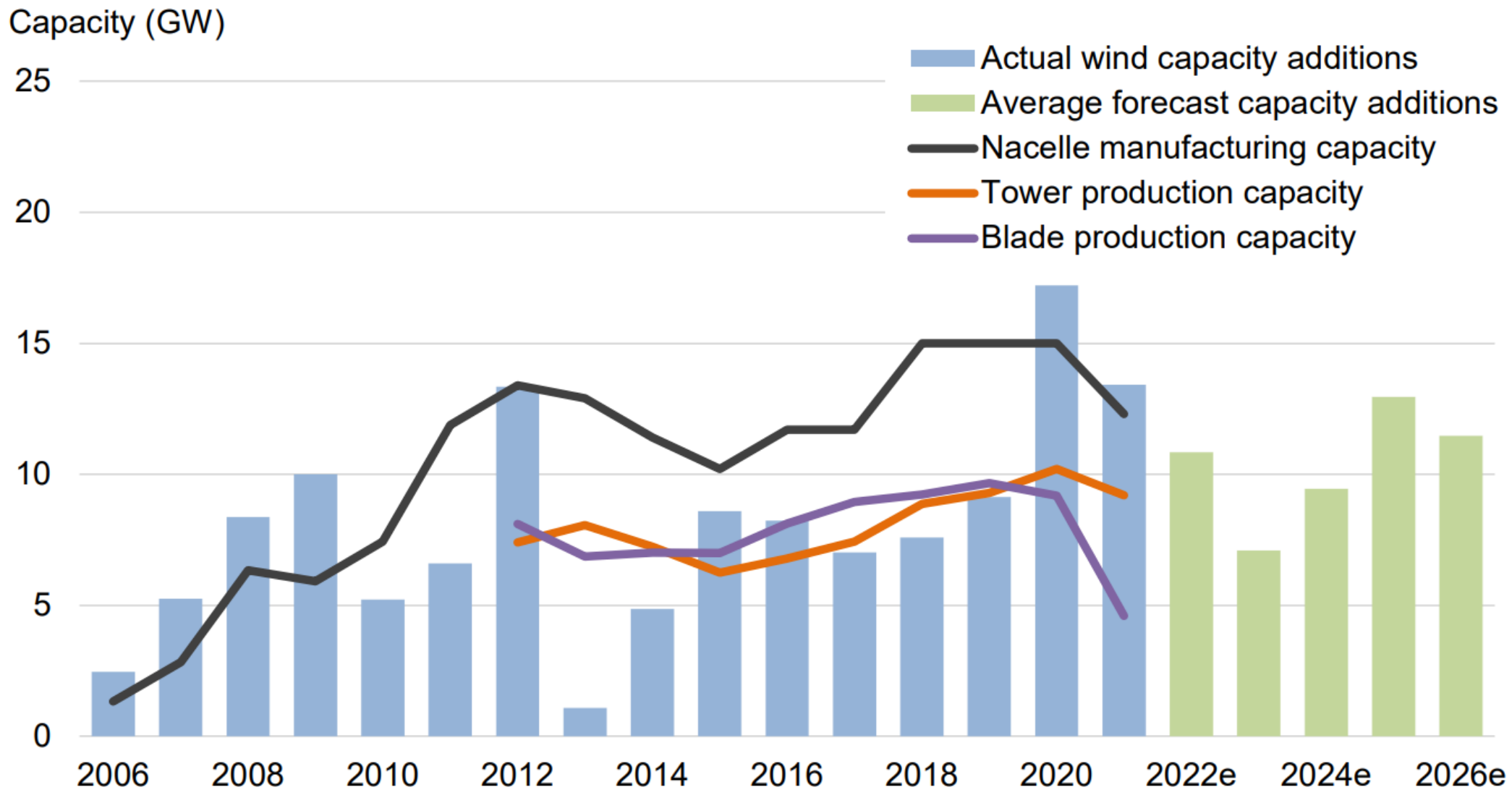
U.S. Status and Trends

U.S. Wind Market Reports

http://energy.gov/windreport



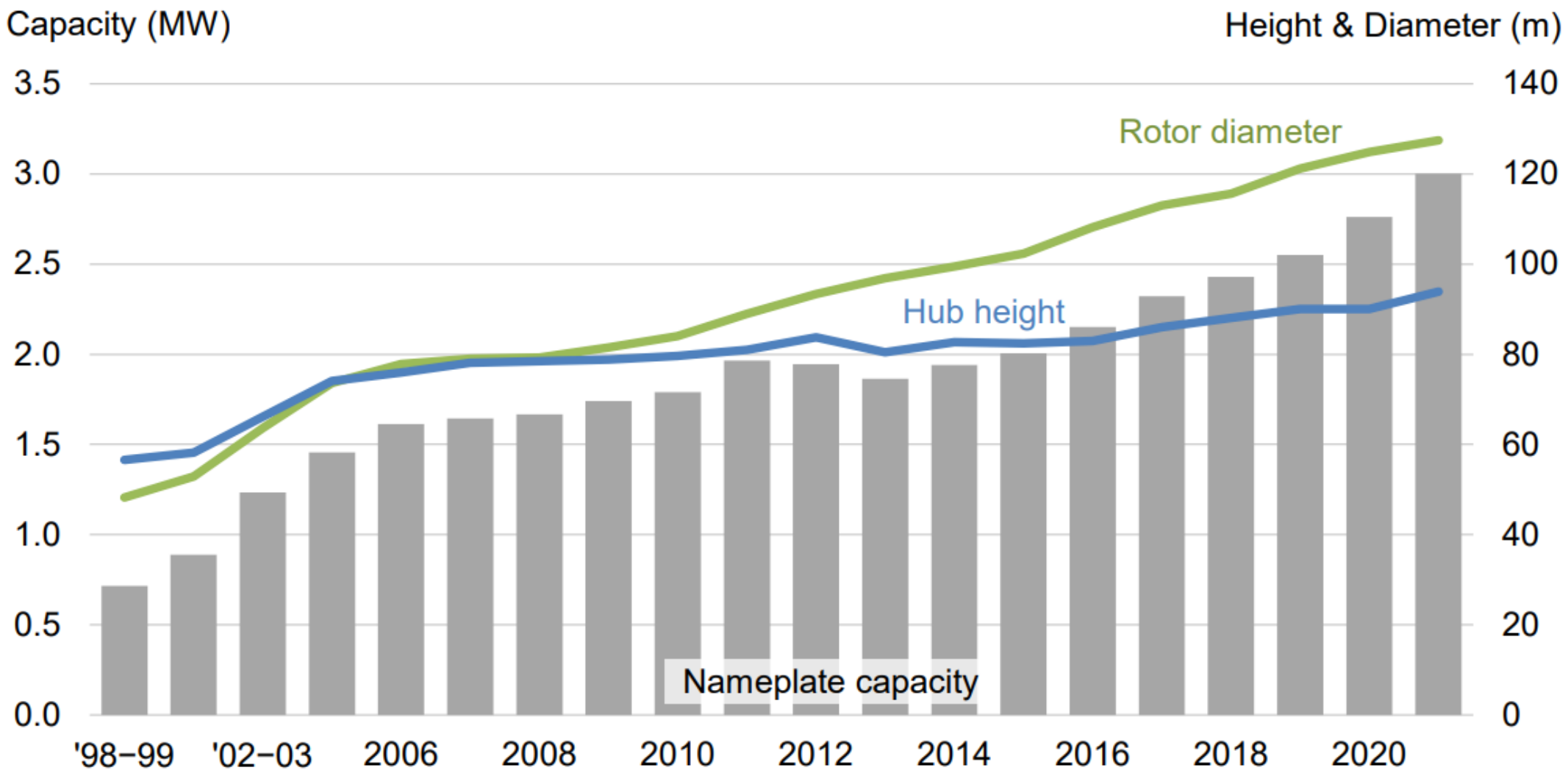
Domestic (U.S.) production and capacity



Sources: ACP, independent analyst projections, Berkeley Lab

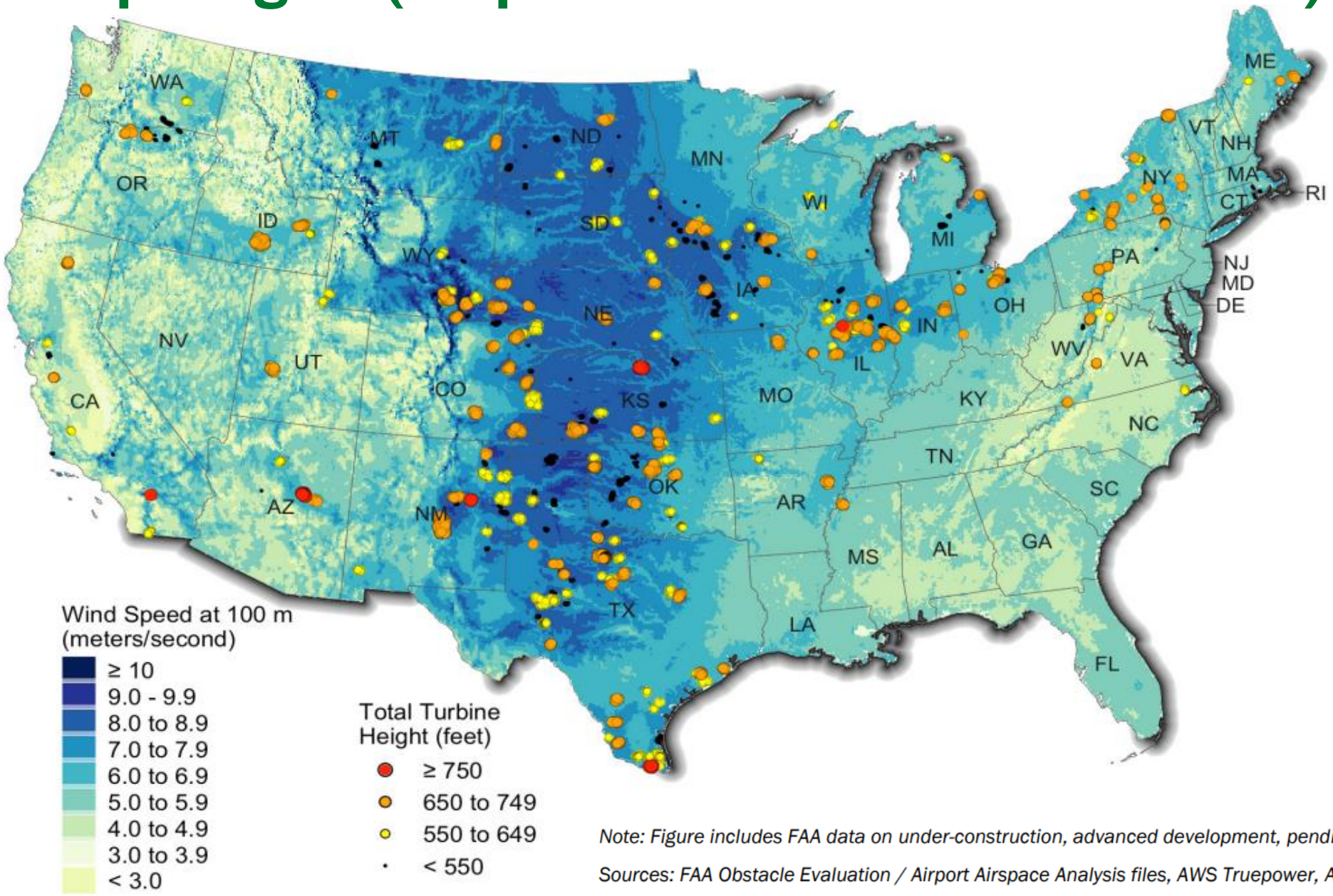
**Pre-IRA Projections*

Turbine Trends



Sources: ACP, Berkeley Lab

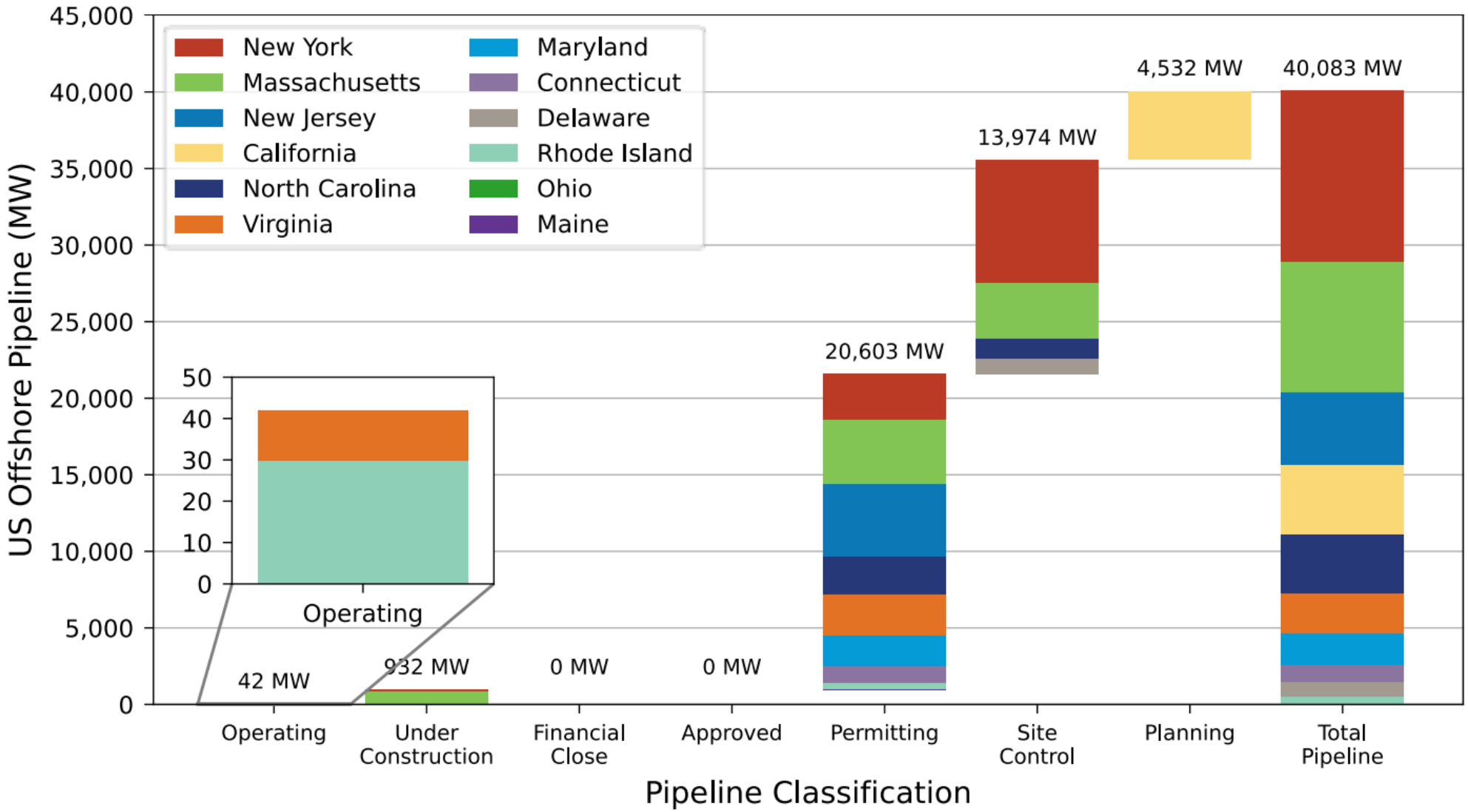
Turbine Tip Heights (Proposed and Under Construction)



Note: Figure includes FAA data on under-construction, advanced development, pending, and proposed turbines

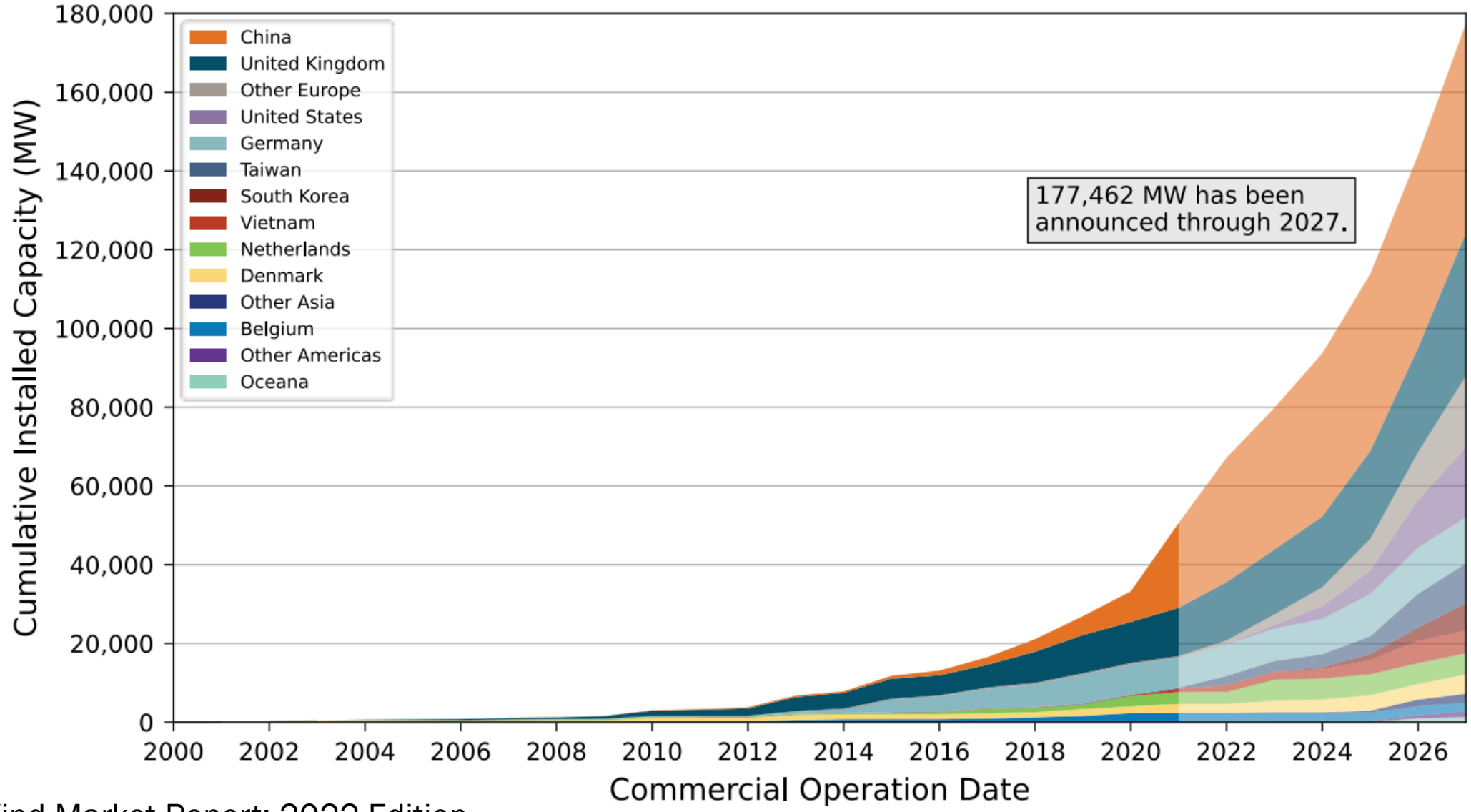
Sources: FAA Obstacle Evaluation / Airport Airspace Analysis files, AWS Truepower, ACP, Berkeley Lab

Offshore Pipeline



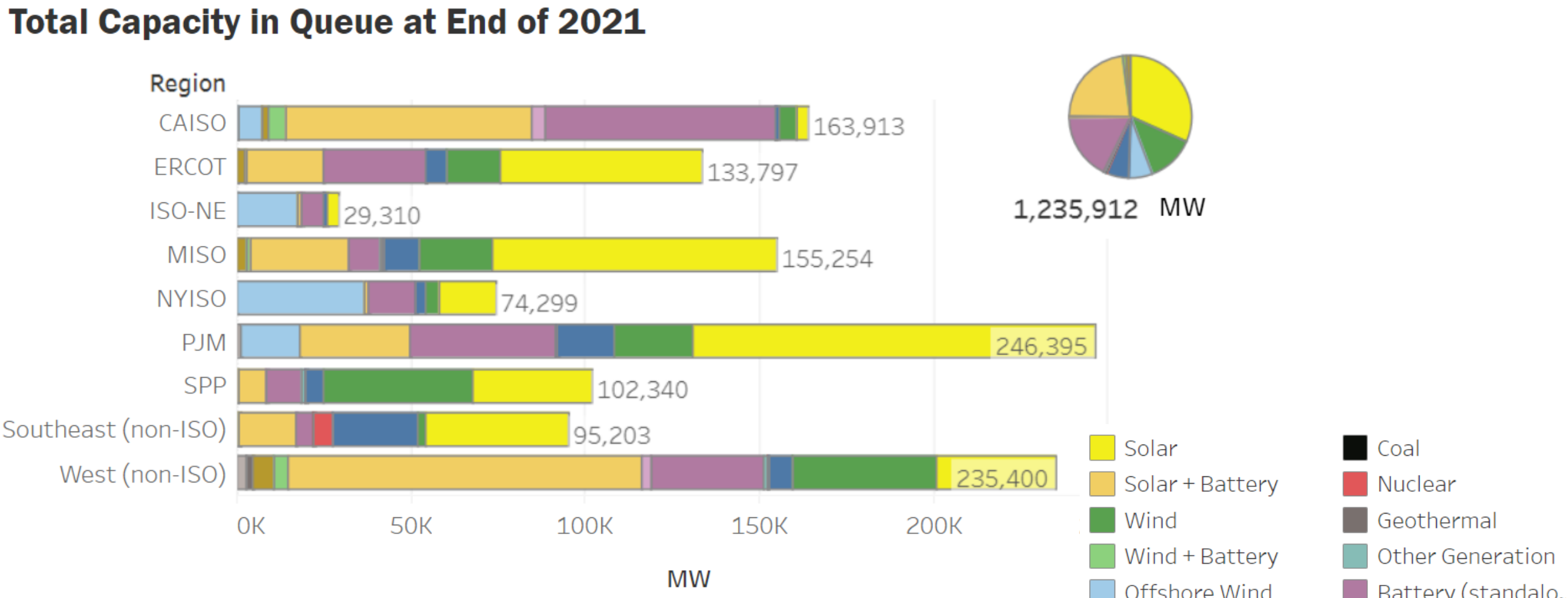
Offshore Wind Market Report: 2022 Edition

Global Offshore



Offshore Wind Market Report: 2022 Edition

Here comes solar: PV, batteries dominate interconnection queues



Interconnection queues represent all proposed generation projects that have applied to connect to transmission – NOT ALL OF THIS WILL BE BUILT

U.S. Policy Update

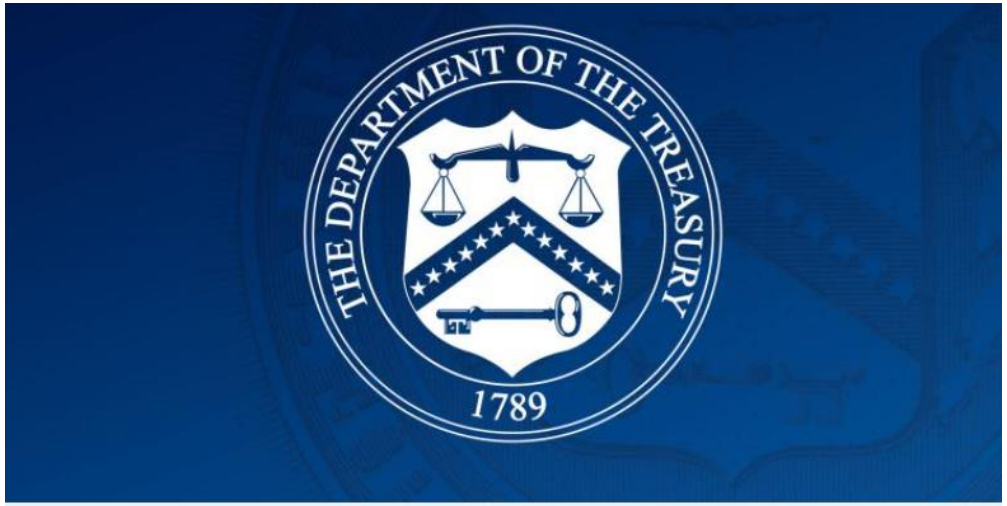
- **Bipartisan Infrastructure Law (BIL)**
  - $60M to WETO for all authorizations
  - $40M to WETO for recycling R&D (EA2020)

- **Inflation Reduction Act (IRA)**
  - PTC extension for wind 2023-2024
  - PTC becomes tech-neutral 2025-2032 or until CO_2 targets met (can also choose ITC)
  - Introduces advanced manufacturing tax credits
  - $100M for OSW transmission planning

Advanced Manufacturing Production Tax Credits

Blade	2c/watt
Nacelle assembly	5c/watt
Tower	3c/watt
Offshore wind foundation	Fixed 2c/watt and floating 4c/watt
Offshore wind vessel	10% of sales price

Source: ACP

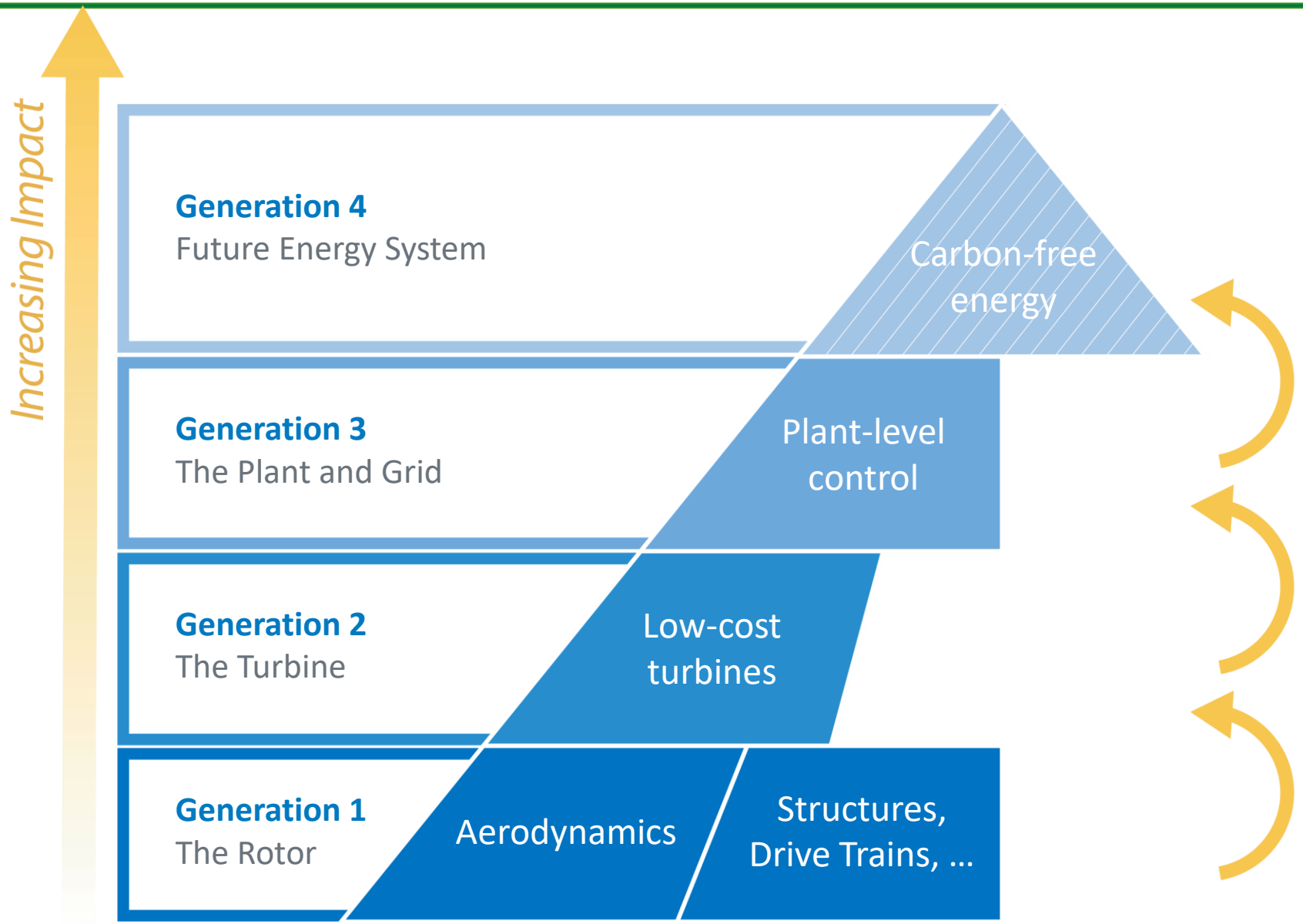


Treasury Seeks Public Input on Implementing the Inflation Reduction Act's Clean Energy Tax Incentives

What we don’t know

And some ways we’re trying to help

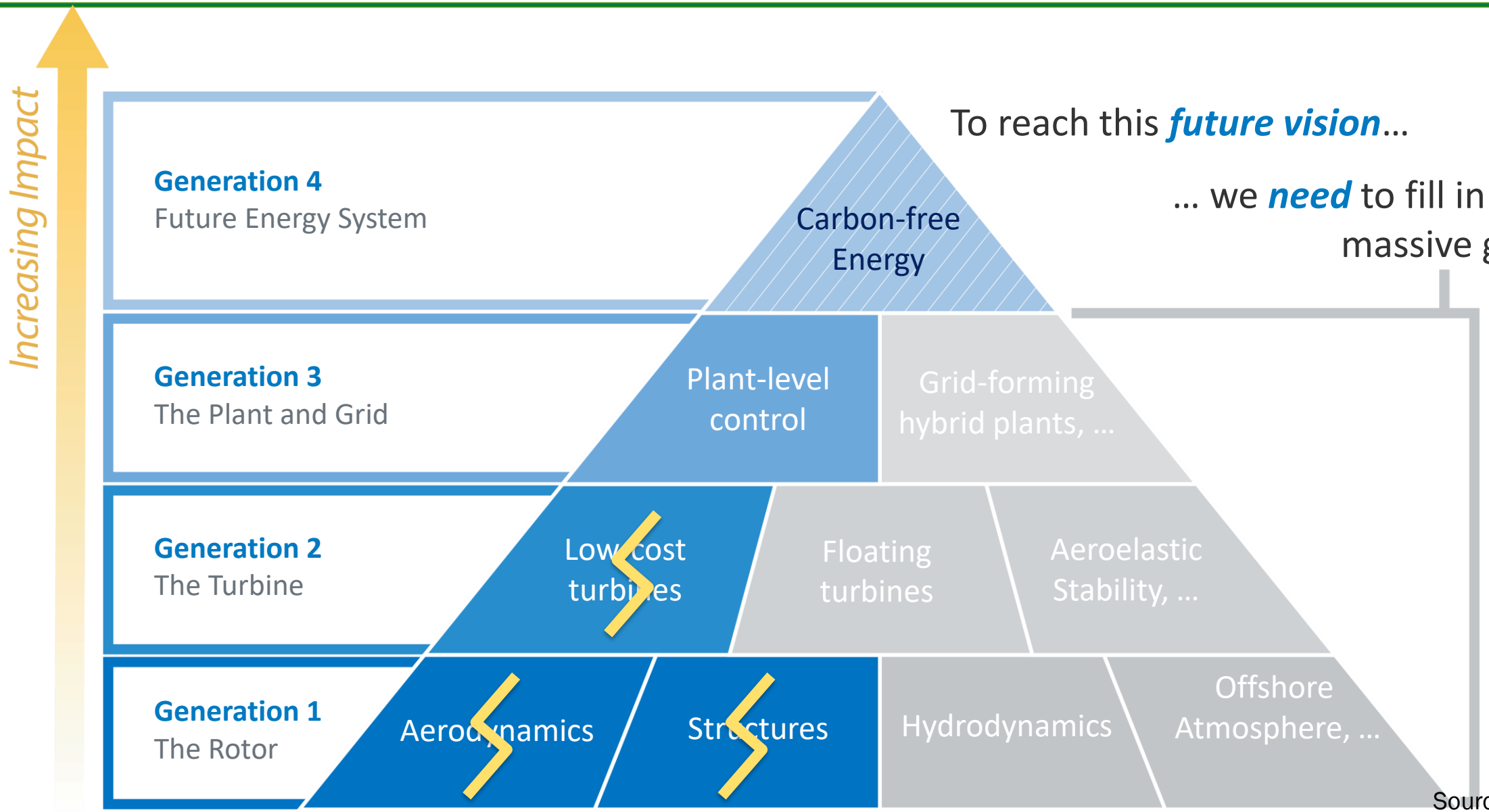
Each Generation Requires a Shift in Focus



While scope has grown, resources have been stretched, and the fundamental science has not kept up with the demands

Source: Paul Veers

Fill in the gaps



To reach this ***future vision***…

… we ***need*** to fill in this massive gap!

Source: Paul Veers

Pace of progress

Photo by The Oregonian

ABC News 9 via Twitter

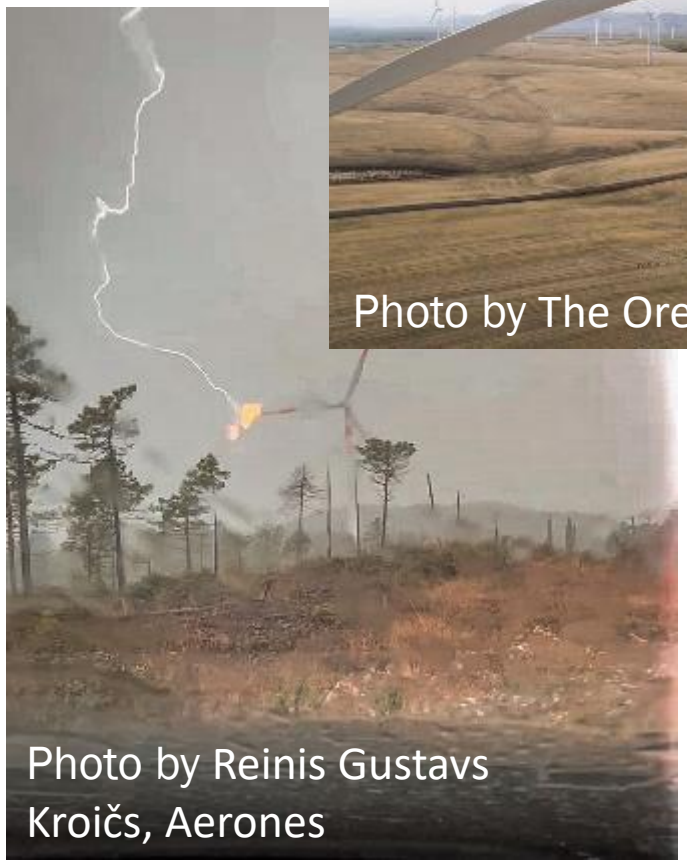


Photo by Reinis Gustavs Kroičs, Aerones

Video by Brent Havins

What's happening out there?

- Range of scales:
  - Spatial: 1e-5m to >1km
  - Temporal: 1μs +
- System dynamics
  - Aeroelastically active
  - Inflow variability across the rotor
- Cost pressures
  - Rapid design cycles
  - Turbine scaling

Design tools are reaching the limits of applicability

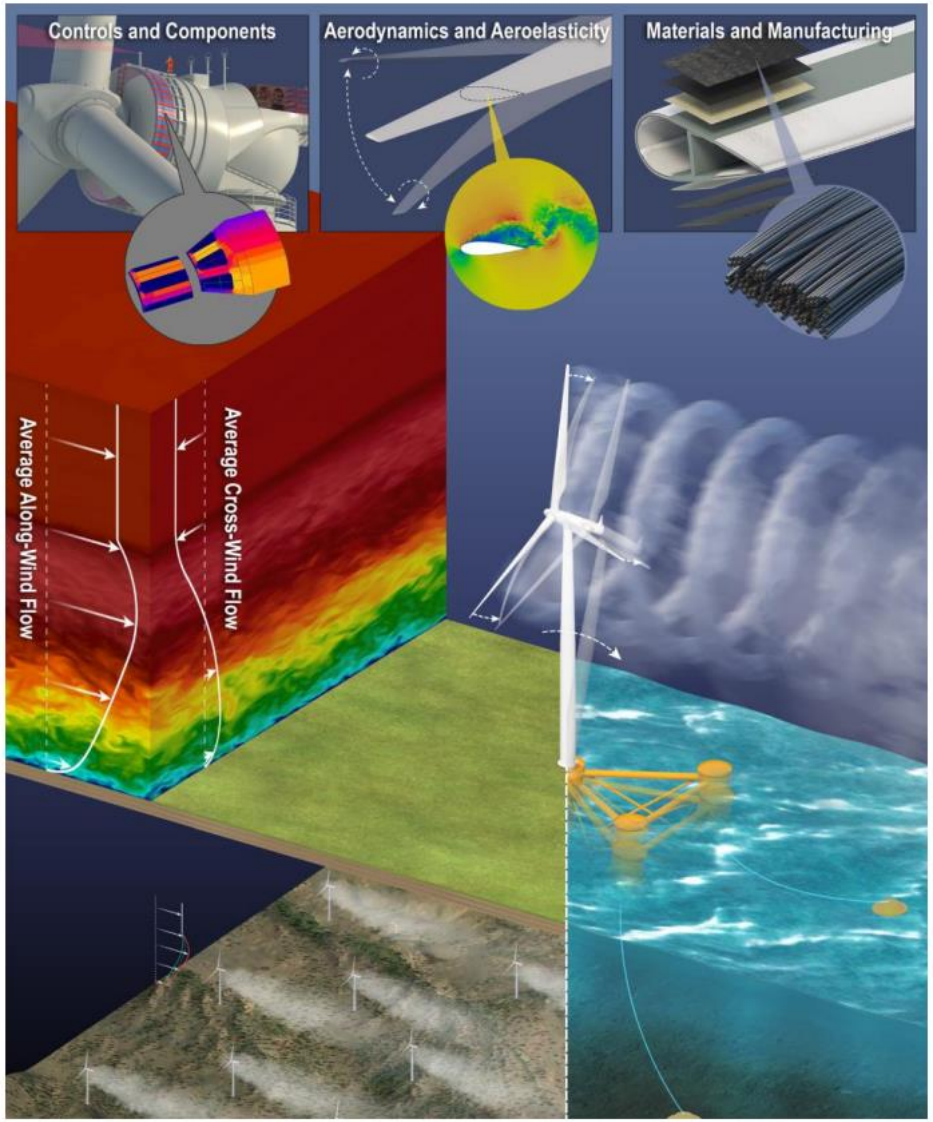
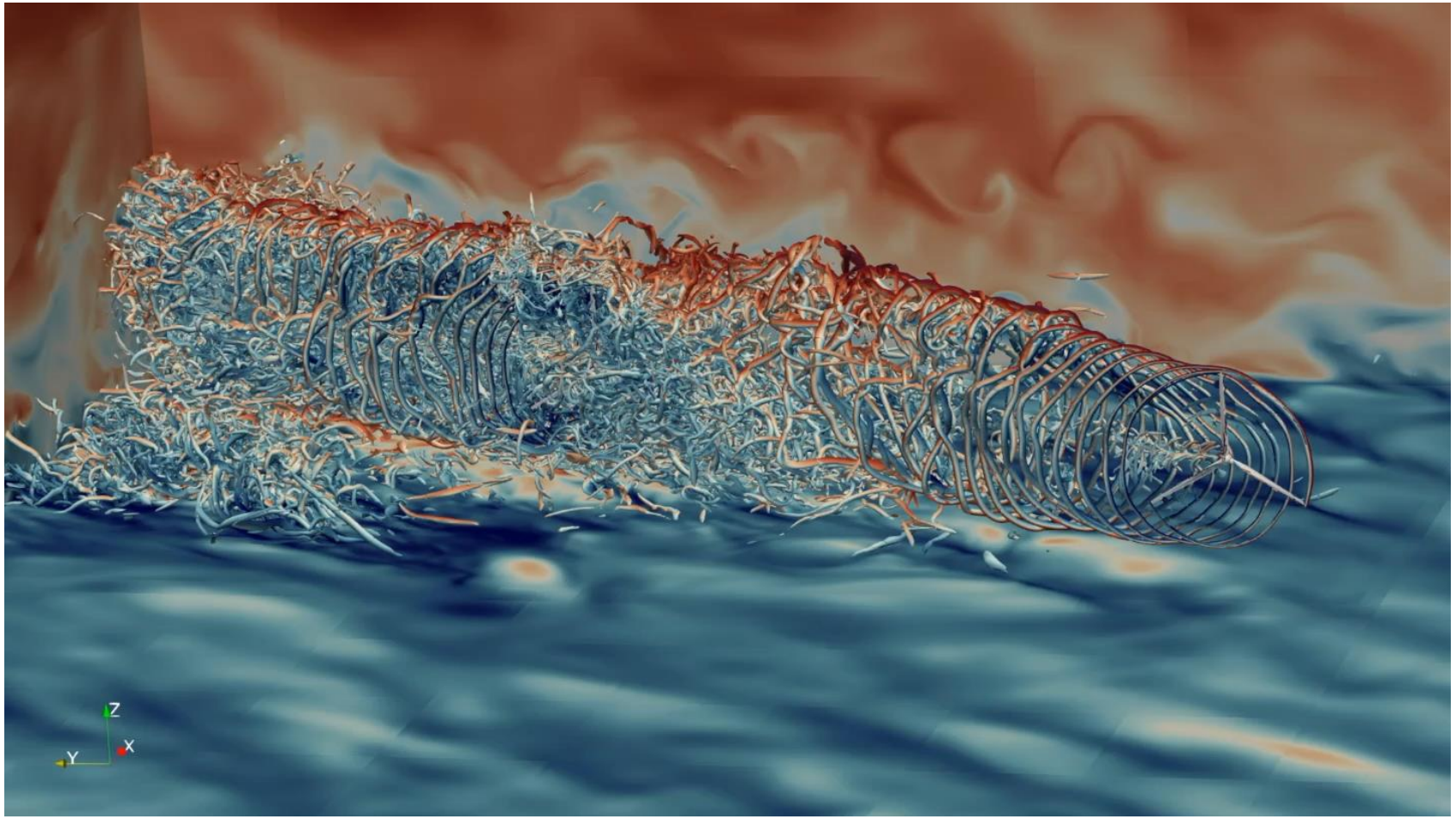


Image credit Besiki Kazaishvili, NREL

High fidelity modeling as a bridge



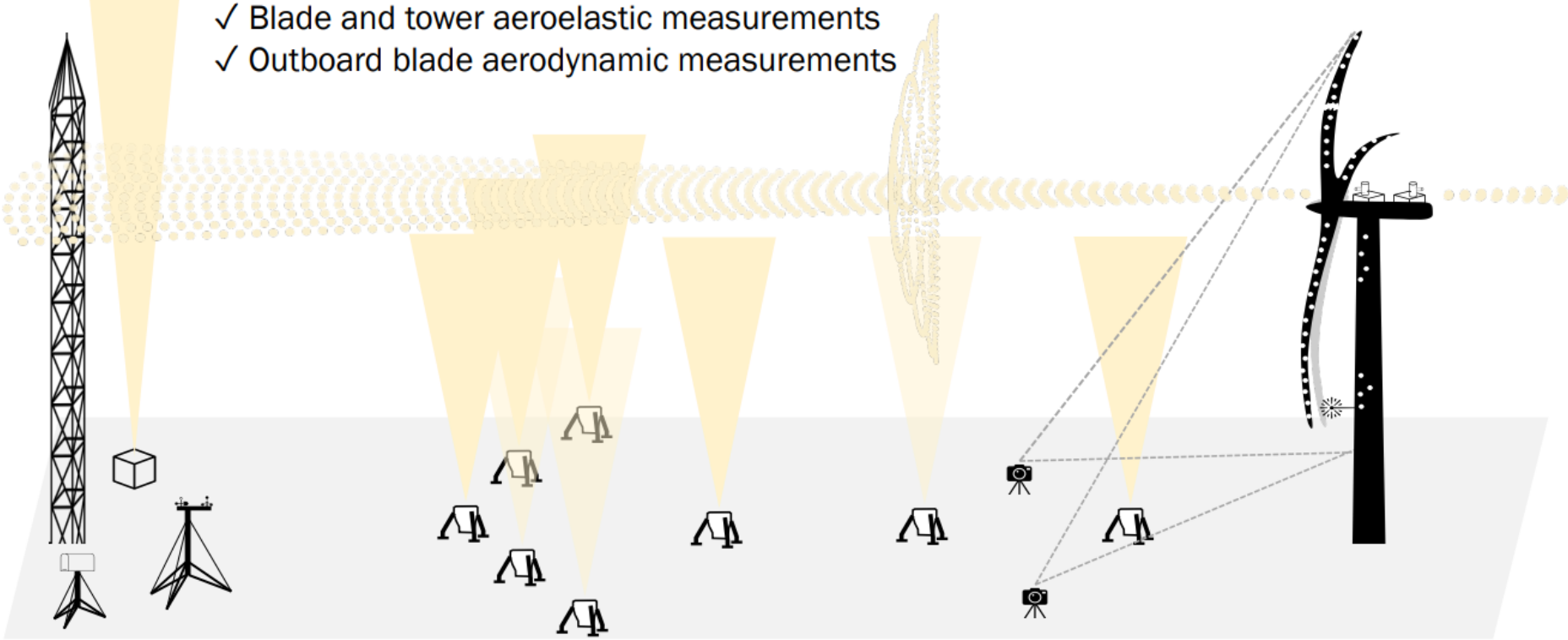
ExaWind simulation of two NREL 5-MW turbines in turbulent atmospheric flow.

Image credit: Brazell, Brunhart-Lupo, Henry de Frahan, Rood, Sharma, Vijayakumar, et al.

Validation and Verification

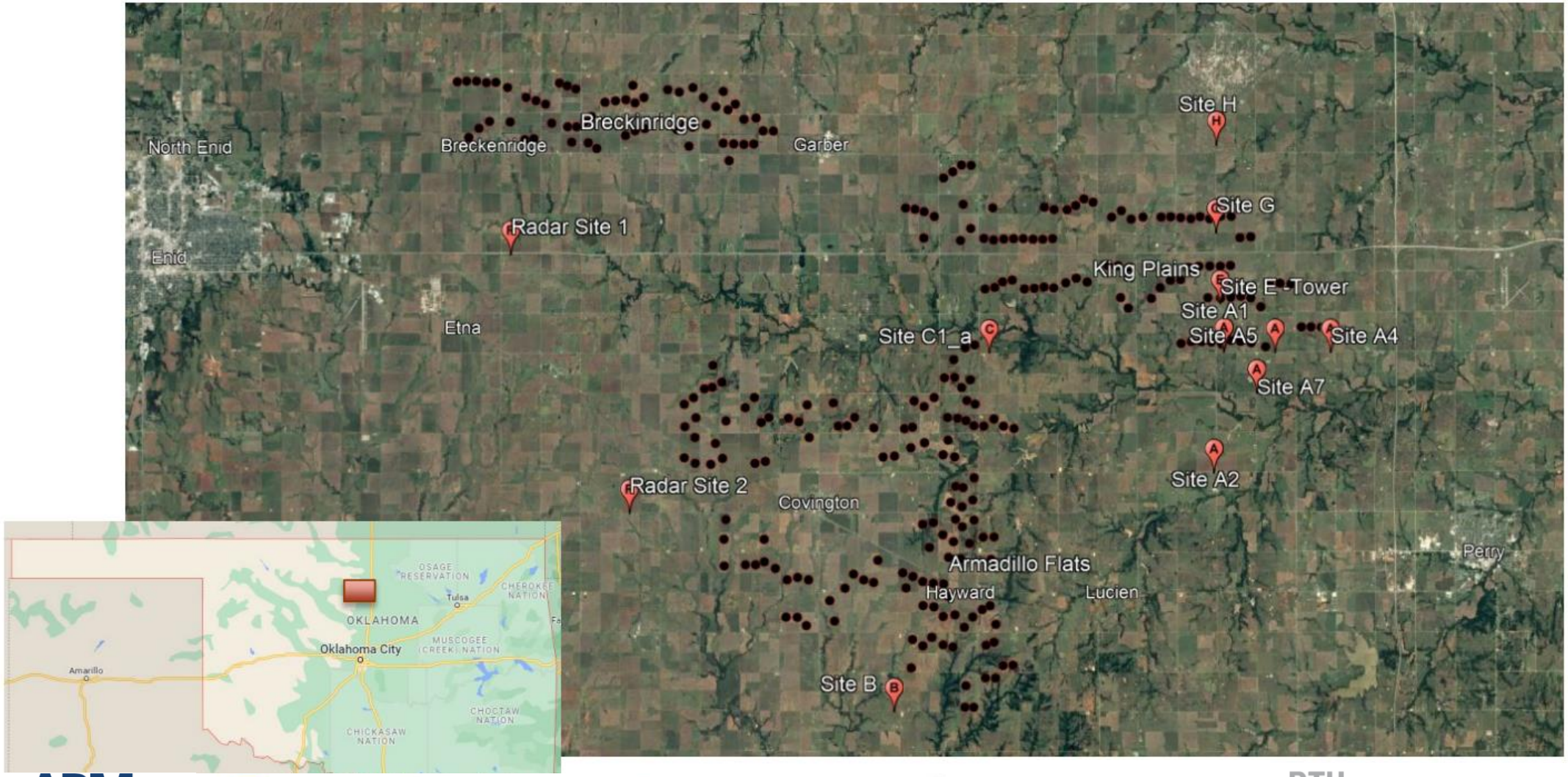
Rotor Aerodynamics Aeroelastics and Wake

✓ 19 in situ wind sensors
✓ 12 remote sensing wind sensors (1 dedicated to the wake)
✓ Turbulence flux measurements near the surface and across the rotor
✓ Temperature and humidity profilers
✓ Blade and tower aeroelastic measurements
✓ Outboard blade aerodynamic measurements



Validation and Verification

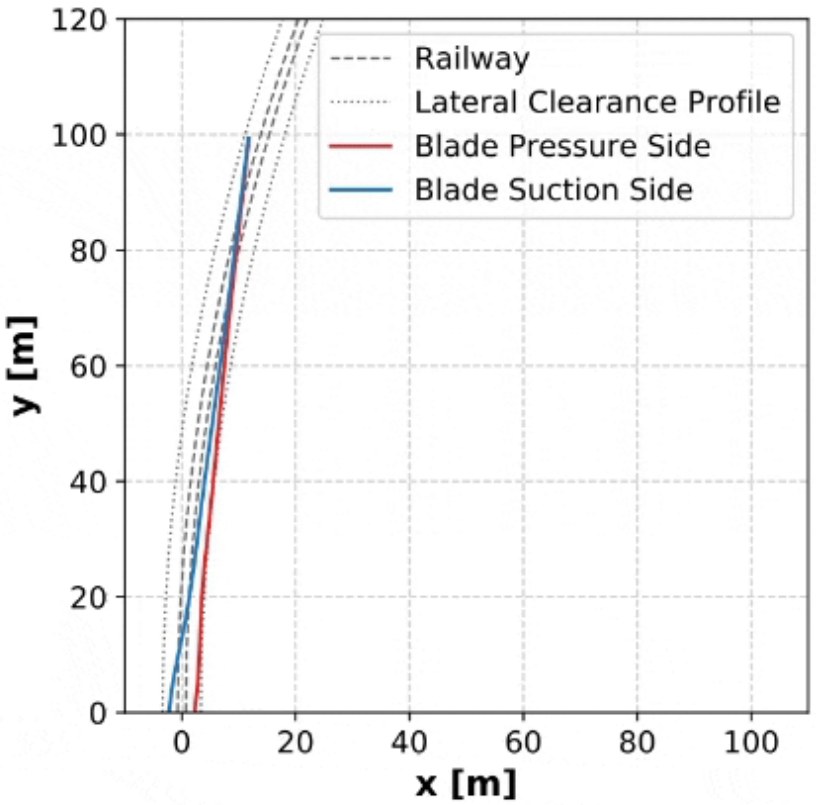
American WAke ExperimeNt (AWAKEN)



Next-gen Rotors (and Plants)

- Low specific power rotors – taller, likely more flexible
- Novel transport techniques
- Dispatchable power – wind-based hybrids
- Severe weather (Lightning, Tropical Cyclones)
- O&M Considerations
  - Long life turbines (Durability and damage tolerance)
  - Think of the techs (stay ashore and on the ground)
  - Share data and failure modes

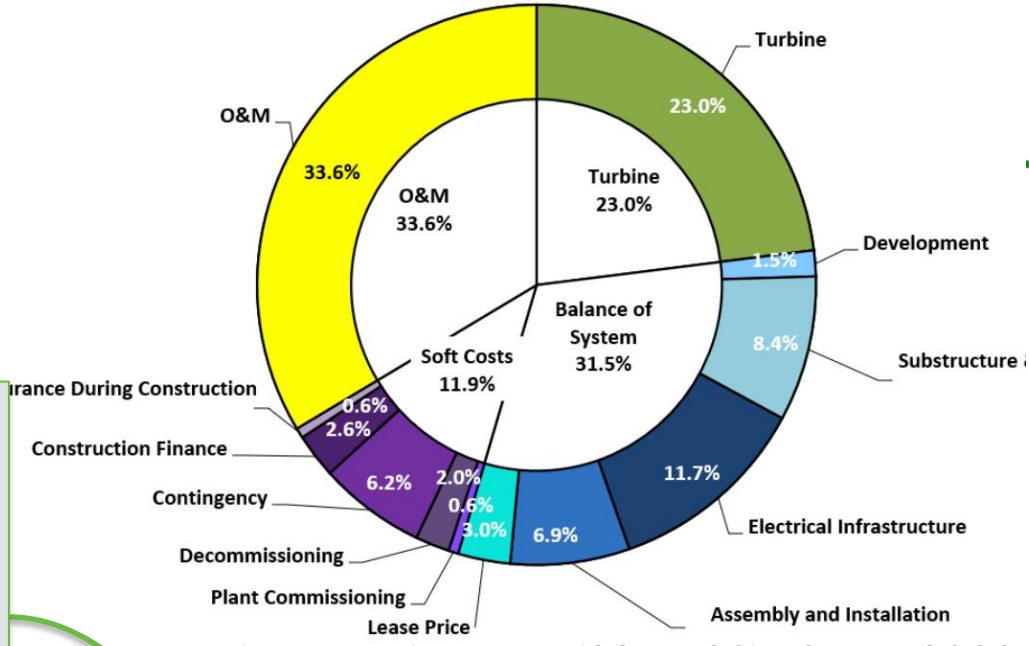
Rail transportable 100m blade



Birds-eye view of blade and tracks

Offshore O&M

R&D Prioritization Analysis	Blades	Generator/ Nacelle	Structure/ Foundation	Electrical
Failure Mode Analysis and Mitigation	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities
Monitoring, Sensing, and Inspection	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities
Maintenance Execution	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities	State of the Practice State of the Art Priority Emerging Technologies Challenges Needed Research Activities



Fixed-bottom OSW LCOE, Stehly 2020

Use Case Definition

- Digitalization
- Autonomy
- Logistics

- State of the Practice
- State of the Art
- Priority
- Emerging Technologies
- Challenges
- Needed Research Activities

Example: Leading Edge Erosion

- Why/when does it occur,
- How can we sense/inspect
- Prevention or repair technologies

Recycling and Circular Economy

- The wind industry can do even more to support the nation's decarbonization goals by being a leader in developing a circular industry, marked by sustainable material life cycle management and reduced negative impacts on communities and the environment.
- WETO is conducting a Wind Technology Recycling program, defined by the Energy Act of 2020, in order to improve the reuse and recycling of wind materials.
- A multi-lab team (NREL, ORNL, SNL) has kicked the program off with a stakeholder focused assessment of recycling in the wind industry that will inform R&D investments in this area through FY25 and beyond.
- Program targets:
  - Economically self-sustaining recycling options for all wind materials by 2030
  - Accelerate industry targets to eliminate waste
  - Reduced lifecycle carbon emissions from production, use, and decommissioning of wind materials

Source: Bloomberg

Learn more:
Thursday 10/20
1300-1500

Summary

- Reaching the limits of design tool appropriateness. “Cracks in the foundation”
- High-fidelity, multi-physics modeling (when well validated!) can close the loop between fleet experience and design
- Still a lot we don’t know.
- O&M is key. ~30% LCOE. Capacity doesn’t matter if it isn’t producing.

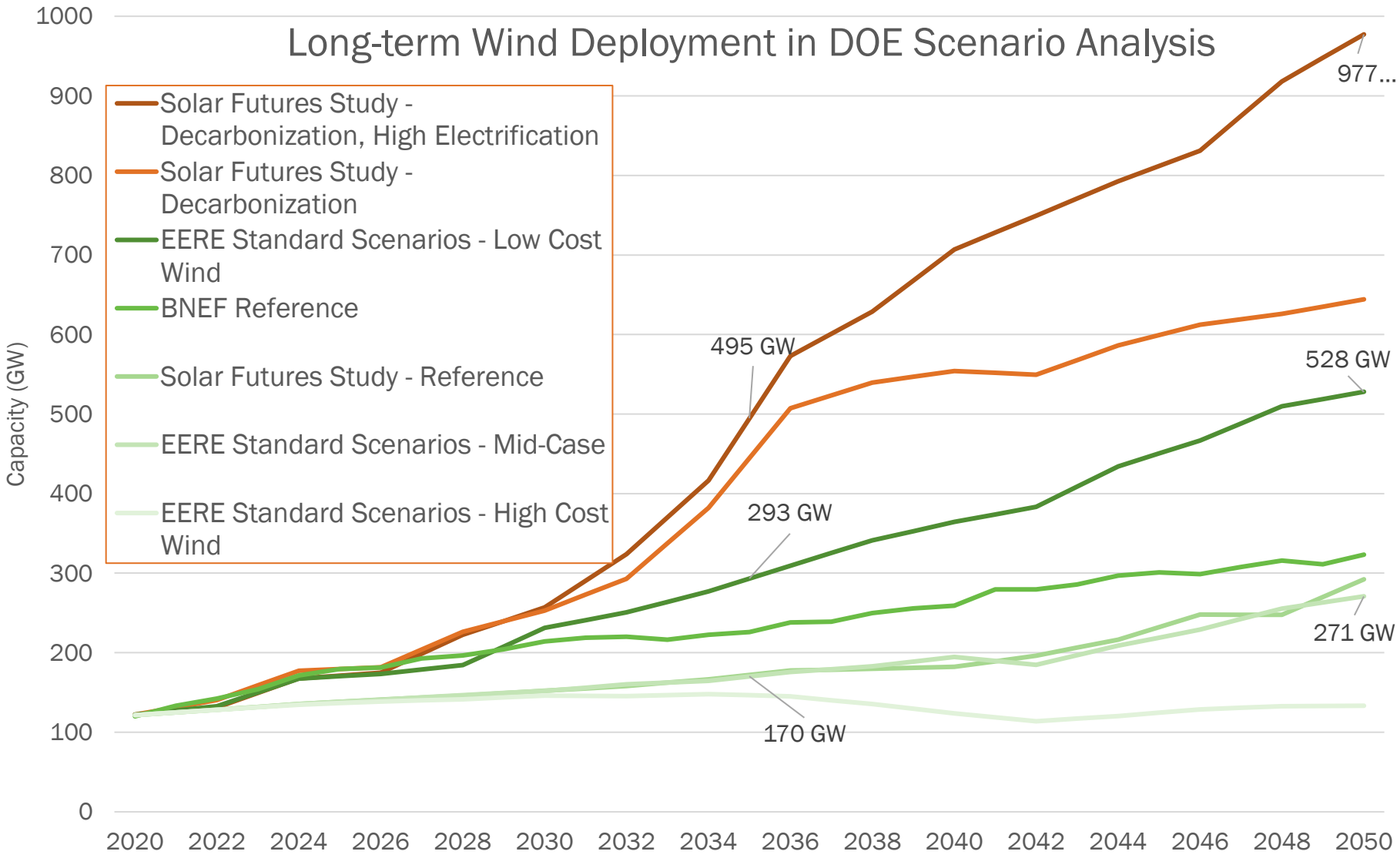
Grand Challenges in the Design, Manufacture, and Operation of Future Wind Turbine Systems

Paul Veers[1], Carlo Bottasso[2], Lance Manuel[3], Jonathan Naughton[4], Lucy Pao[5], Joshua Paquette[6], Amy Robertson[1], Michael Robinson[1], Shreyas Ananthan[7], Athanasios Barlas[8], Alessandro Bianchini[9], Henrik Bredmose[8], Sergio González Horcas[8], Jonathan Keller[1], Helge Aagaard Madsen[8], James Manwell[10], Patrick Moriarty[1], Stephen Nolet[11], and Jennifer Rinker[8]
https://doi.org/10.5194/wes-2022-32

The path toward 100% clean power

Likely bumpy

2035: Up to ~300 GW wind if no policy; 500+ GW to meet climate goals



- **Achieving a carbon-free grid by 2035 could require:**
  - **60-80% wind + solar (up from ~10% now)**
  - **> 500 GW wind**
  - **Average install rates of 35 GW/year, peak > 50 GW/yr**
  - **Significant expansion into new areas**
- **Achieving a net-zero carbon economy by 2050 could require more than 1 TW wind**
- **Cost reductions alone could drive up to ~300 GW wind by 2035**
- **But…extremely high uncertainty**

Solar Futures Study, EERE Standard Scenarios, Bloomberg

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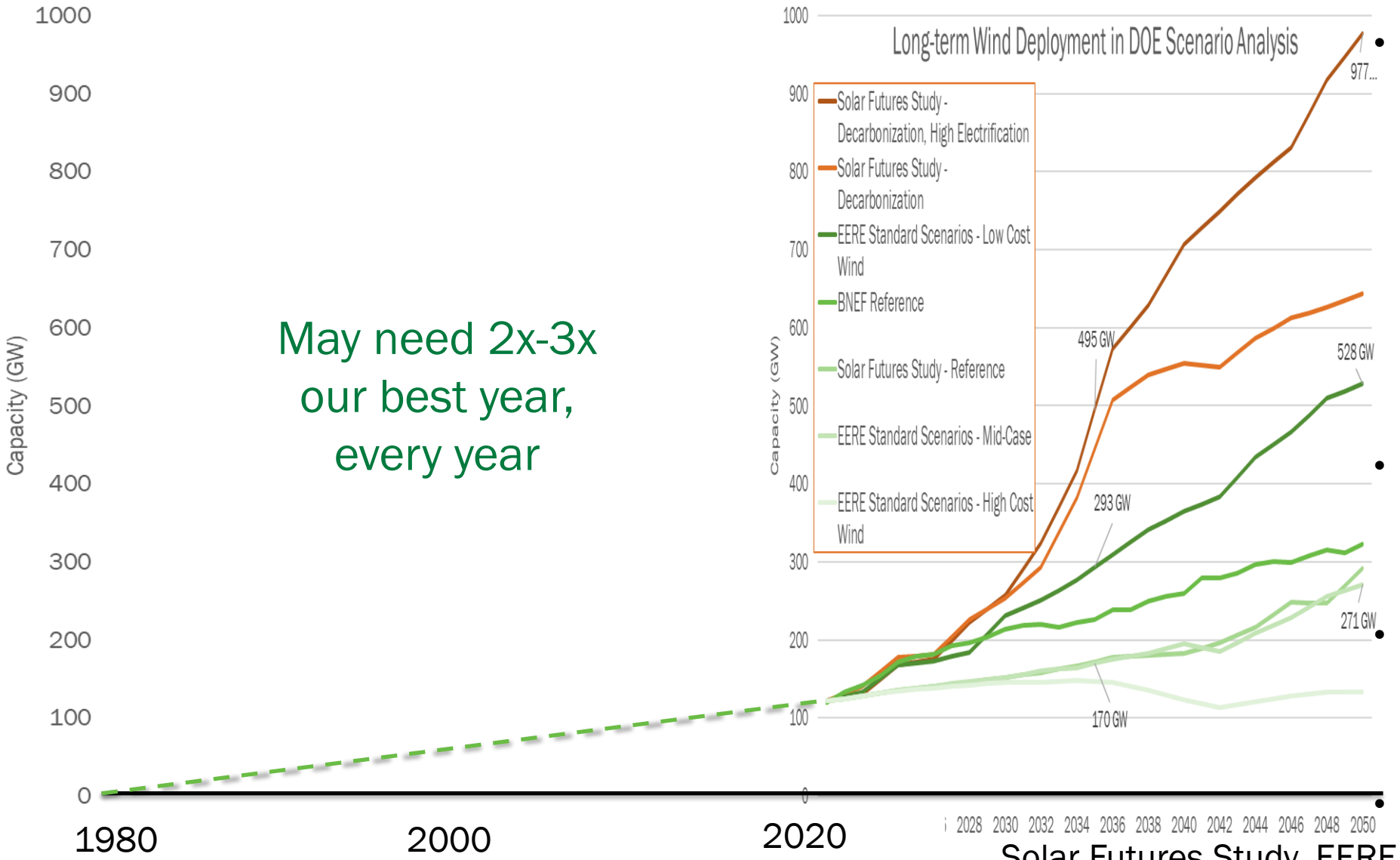

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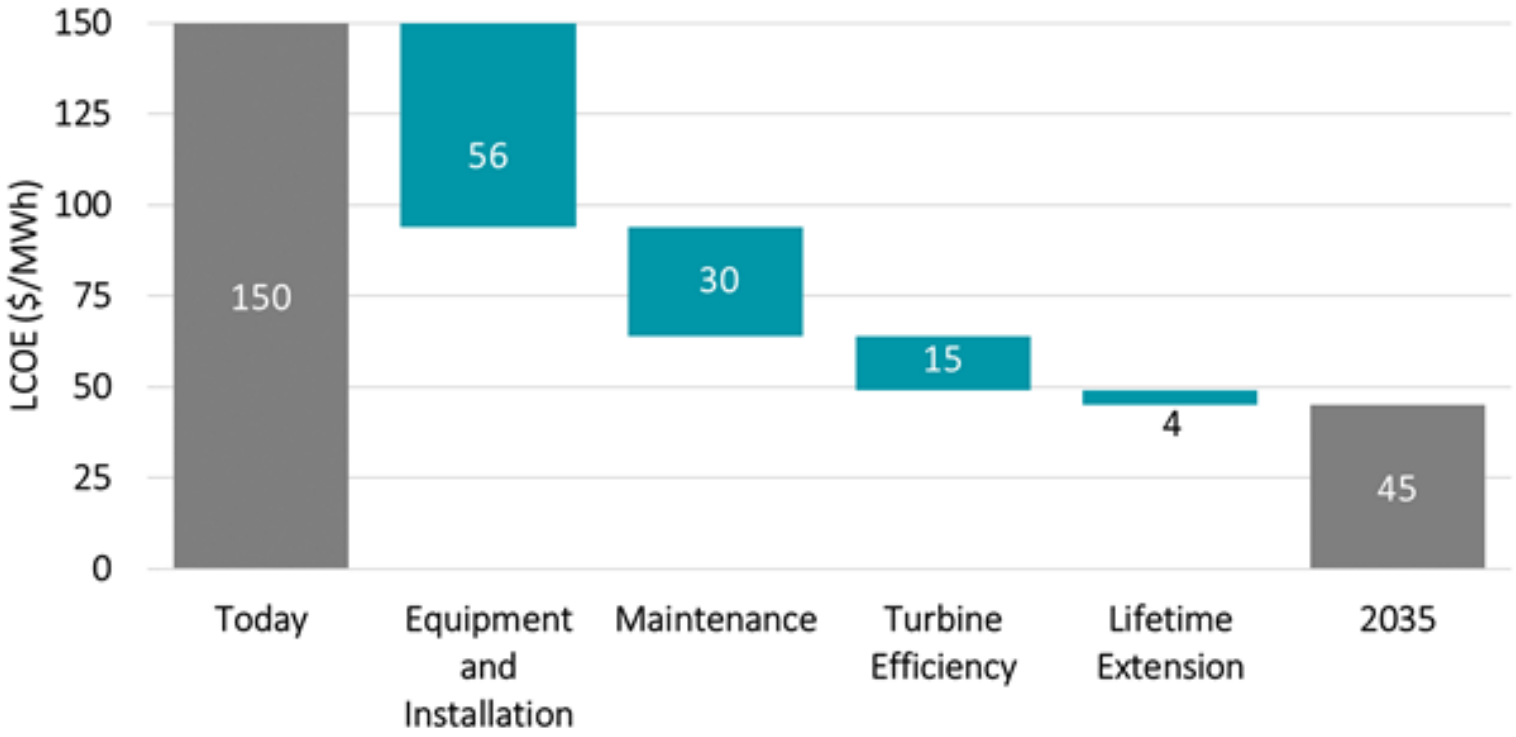
Lowering Costs for Floating Offshore Wind

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

Floating Offshore Wind™

>70% Reduction

2035



Federal Partners

Raw Material Supply

- The Energy Act of 2020 directs WETO and SETO to deliver a: “comprehensive physical property database of materials for use in [wind and solar] energy technologies, which shall identify the type, **quantity, country of origin, source, significant uses, projected availability, and physical properties of materials used in [wind and solar] energy technologies**”
- Soon to be published: Renewable Energy Material Property Database ((REMPD)) looked at two scenarios, ~10GW (nominal) and ~46GW (decarbonization+electrification)
- Under high-deployment scenario (46GW wind/yr) U.S. demand could consume significant fractions of the current global production of rare-earth elements and carbon fiber

DOE as a partner

- Broad expertise, but not uniformly deep – we rely on national lab researchers and *this community*
- Significant congressional direction, appropriations are not discretionary
- Public peer review every 2 years (report from 2021 available).
- Frequently weighing tradeoffs between breadth and impact of investment
- Significant funding announcements (~1-2/yr, usually multiple topics each)
- Lab Direct, SBIR, Technology Commercialization Fund

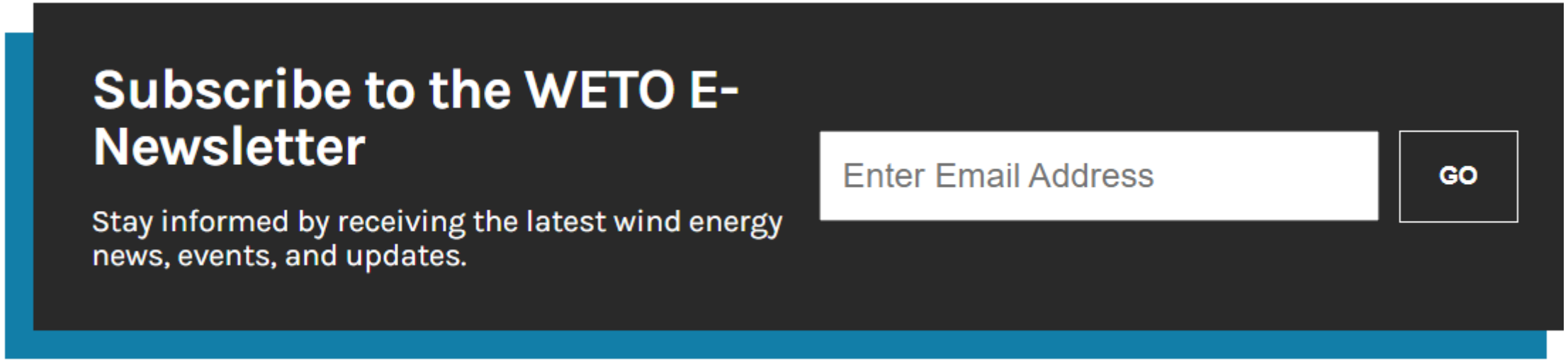
SBIR · STTR
America's Seed Fund™
POWERED BY SBA

Technology Commercialization Fund | U.S. DEPARTMENT OF ENERGY | OFFICE OF Technology Transitions

Notice of Intent to Issue FY23 Appropriated Technology Commercialization Fund | Department of Energy

Stay Up to date

- Monthly “Catch the Wind” newsletters
- Semi-annual R&D round ups – just published the fall edition this week



Wind Energy Technologies Office | Department of Energy

Takeaways

- **U.S. market status and trends**
  - Gloomy near-term, glorious post 2024
- **What we don't know**
  - Many grand challenges remain, from the "*workings of the global weather system to the minutiae of materials science*". We aren't "done" with any discipline.
- **Collaboration and the way toward 100% clean power**
  - Success at deployment (50GW/yr) hinges on interconnection and transmission, navigating myriad supply chain constraints
  - DOE is a partner in the journey

Wind Energy Technologies Office – Here in NM

Nate McKenzie

Ben Murray

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