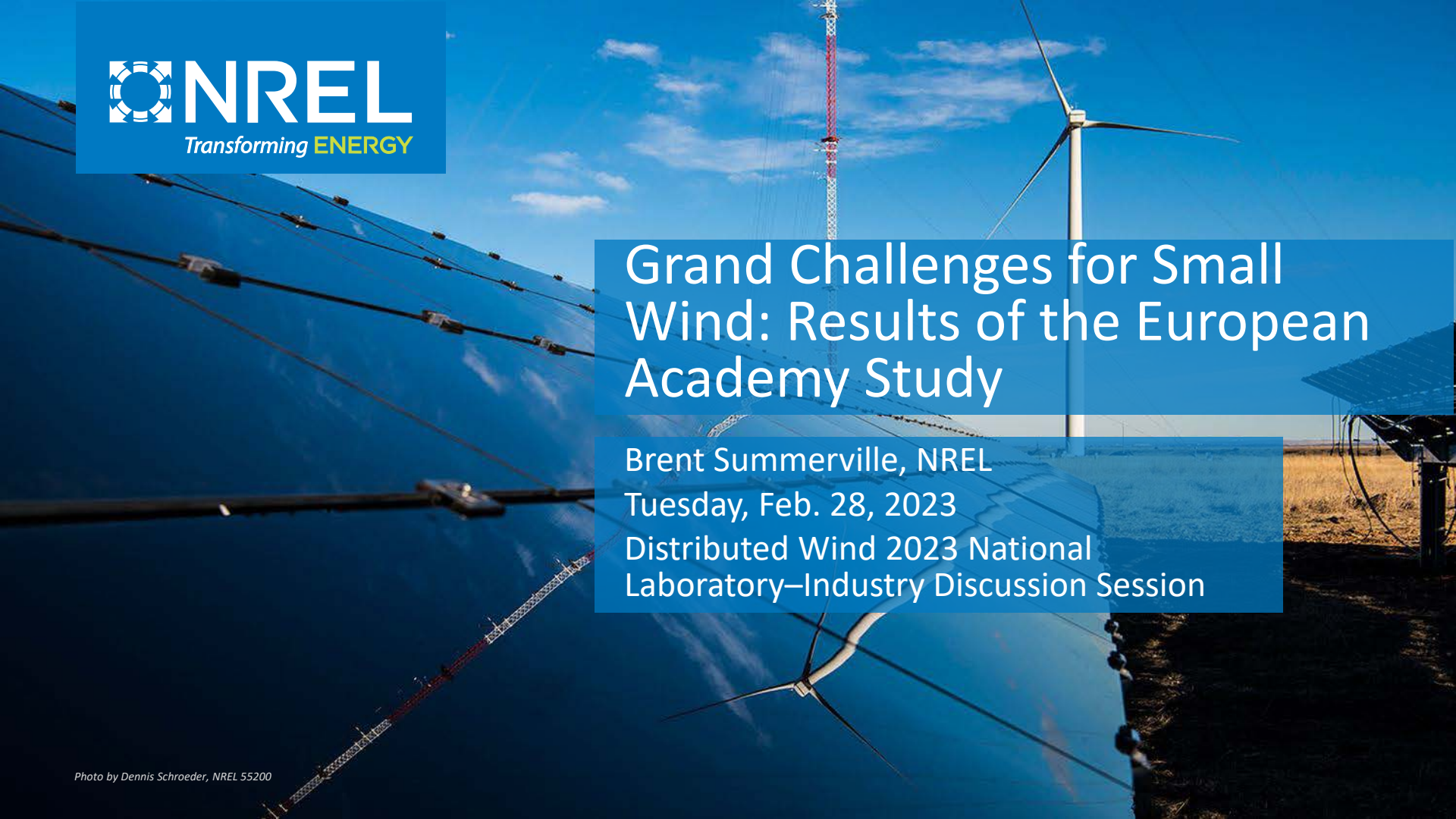

# Grand Challenges for Small Wind: Results of the European Academy Study

Brent Summerville, NREL

Tuesday, Feb. 28, 2023

Distributed Wind 2023 National Laboratory–Industry Discussion Session

*Photo by Dennis Schroeder, NREL 55200*


# Current status and grand challenges for small wind turbine technology

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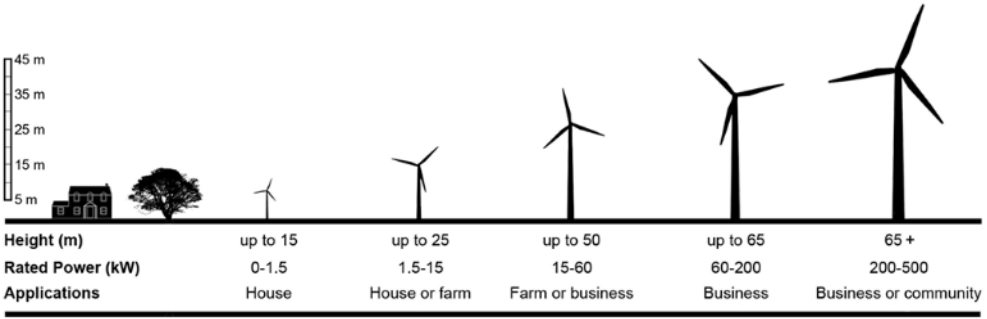
https://wes.copernicus.org/articles/7/2003/2022/wes-7-2003-2022.pdf

# What is a “small wind turbine” (SWT)?

200 $m^2$ (IEC 61400-2 ed. 3)
100 kW (Brazil)
150 kW (ACP 101-1)
500 kW (EAWE)

“Unlike the typical utility-scale, three-bladed, upwind machines, SWTs have not coalesced into a dominant archetype, with many different layouts still being offered on the market.”

*Images from GC report*




## HAWTs

horizontal-axis wind turbines

## VAWTs

vertical-axis wind turbines

## DAWTs

diffuser-augmented wind turbines

## Airborne

# 5 Grand Challenges for Small Wind Turbines

For SWTs to be widely successful, tomorrow's technology will require a new generation of turbines that are:

- Optimized for complex, low-wind-speed locations with high turbulence
- Able to successfully and reliably operate throughout their design life
- Capable of producing the power expected when they were installed.

1. Improve the **energy conversion** of modern SWTs through better design and control, especially in the case of turbulent wind
2. Become better at **predicting long-term turbine performance** with limited resource measurements and proving reliability
3. Improve the **economic viability** of small wind energy
4. Facilitate the contribution of SWTs to the energy demand and **electrical system integration**
5. Foster **engagement, social acceptance, and deployment** for global distributed wind markets.

# Small Wind Grand Challenge 1

*1. Improve the energy conversion of modern SWTs through better design and control, especially in the case of turbulent wind*

- SWTs are typically installed in areas with less energetic and more turbulent wind resources.
- Maximizing the amount of energy that can be harvested from the wind while ensuring turbine longevity and survival through infrequent high-wind events is critical.

*Project connections:*

*NREL CIP (2023) and NREL dWAM (2023)*

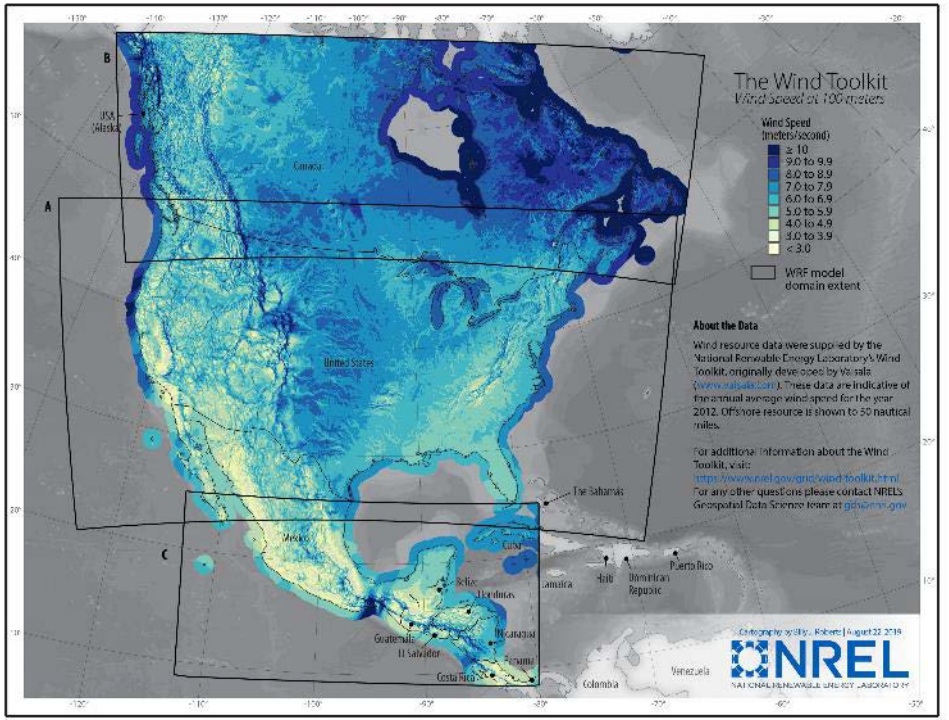
Downwind passive yaw Skystream turbine. *Photo from PNNL Distributed Wind Photo Gallery*

# Small Wind Grand Challenge 2

*2. Become better at predicting long-term turbine performance with limited resource measurements and proving reliability*

Long-term performance prediction is built on:

- Turbine performance characteristics
- Combined with accurate wind resource estimation, and
- Any changes due to local obstacles over the life of the project.




NREL WIND Toolkit wind resource map. *Image from NREL, https://www.nrel.gov/grid/wind-toolkit.html*

*Project connections:*

NREL TAP (2023) and in this session, *Novel Approaches for Wind Resource Validation* – Lindsay Sheridan, PNNL

# Small Wind Grand Challenge 3

## *3. Improve the economic viability of small wind energy*

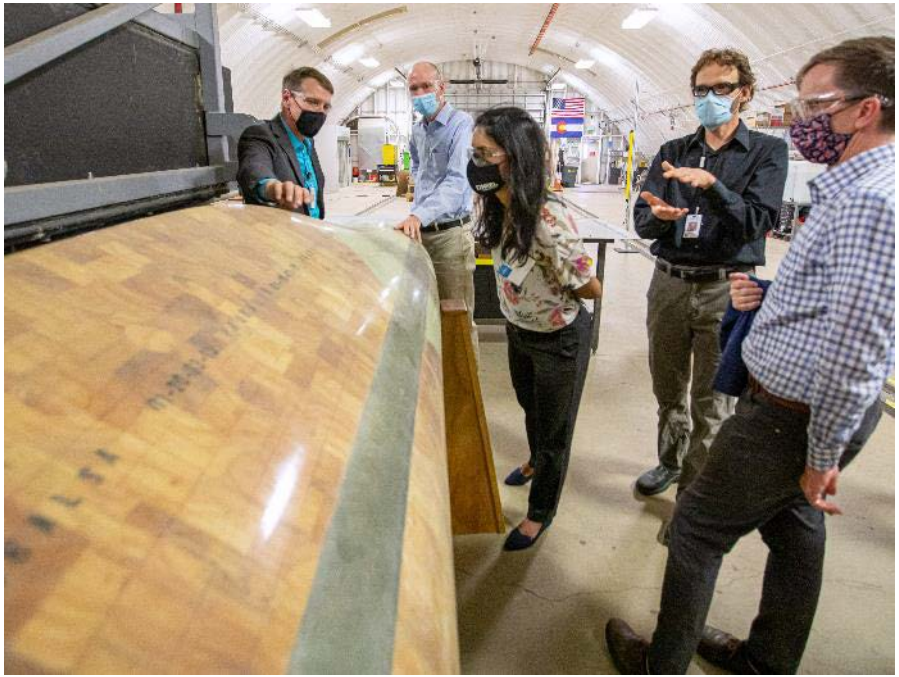
Cost reductions can come from…

- Design optimization
- New materials and manufacturing techniques
- Standardized solutions across multiple turbine models (e.g., inverters)
- Incentivizing production economies of scale
- Improvements in installation techniques

…while ensuring successful operation over the turbine's designed life

*Project connections:*

NREL CIP (2023) and in this session, *Advancing Distributed Wind Energy Valuation*– Sarah Barrows, PNNL, and *Technologies Enabling Manufacturing Scale Up* – Peter Wang, ORNL



Composites Manufacturing Education and Technology (CoMET) facility at the National Renewable Energy Laboratory Flatirons Campus. *Photo by NREL 65371*

# Small Wind Grand Challenge 4

*4. Facilitate the contribution of SWTs to the energy demand and electrical system integration*

The ability of distributed wind to provide low-cost energy close to consumers with a higher energy density and smaller footprint of other distributed technologies provides an important tool to achieve low-carbon energy system goals.

*Project connections:*

In this session, *Hybrid Systems, Vehicle-to -Grid (V2G) and Power-to -X for Distributed Wind Technologies* – Caity Clark, NREL

*Photo from NREL, 500122*

# Small Wind Grand Challenge 5

## *5. Foster engagement, social acceptance, and deployment for global distributed wind markets*

- Engaging communities, societies, and regulatory authorities is key for SWT development.
- Permitting requirements, based on science and modern understandings of potential impacts, are needed to streamline development timelines and reduce costs.
- Incentives, standards, and promotional policies should also be aligned to allow deployment of the technology in a more effective way.

*Project connections:*

NREL's Strategize, Engage, Network, Deploy Distributed Wind (SEND) project and in this session, *Advancing Distributed Wind Energy Valuation*– Sarah Barrows, PNNL

Chesapeake Bay Brock Environmental Center, Virginia Beach, Virginia. *Photo from PNNL Distributed Wind Photo Gallery*

# 10 Key Enablers

To catalyze significant development of SWTs worldwide, the following key enablers are identified:

1. More effective use of aeroelasticity for SWTs
2. Improvement in control strategies
3. Improvement in design, with a focus on the characterization of airfoil aerodynamics at low Reynold's numbers (Re)
4. Open data from both wind tunnel and field experiments
5. More accurate performance and resource assessments
6. Variable validation and verification of SWTs, especially for nontraditional archetypes
7. Standardization
8. Detailed studies on cost and life cycle analysis
9. Grid compliance and integration, including storage systems
10. Shared programs of incentives and new paradigms to support SWT diffusion, with a special focus on social acceptance.

# 10 Key Enablers

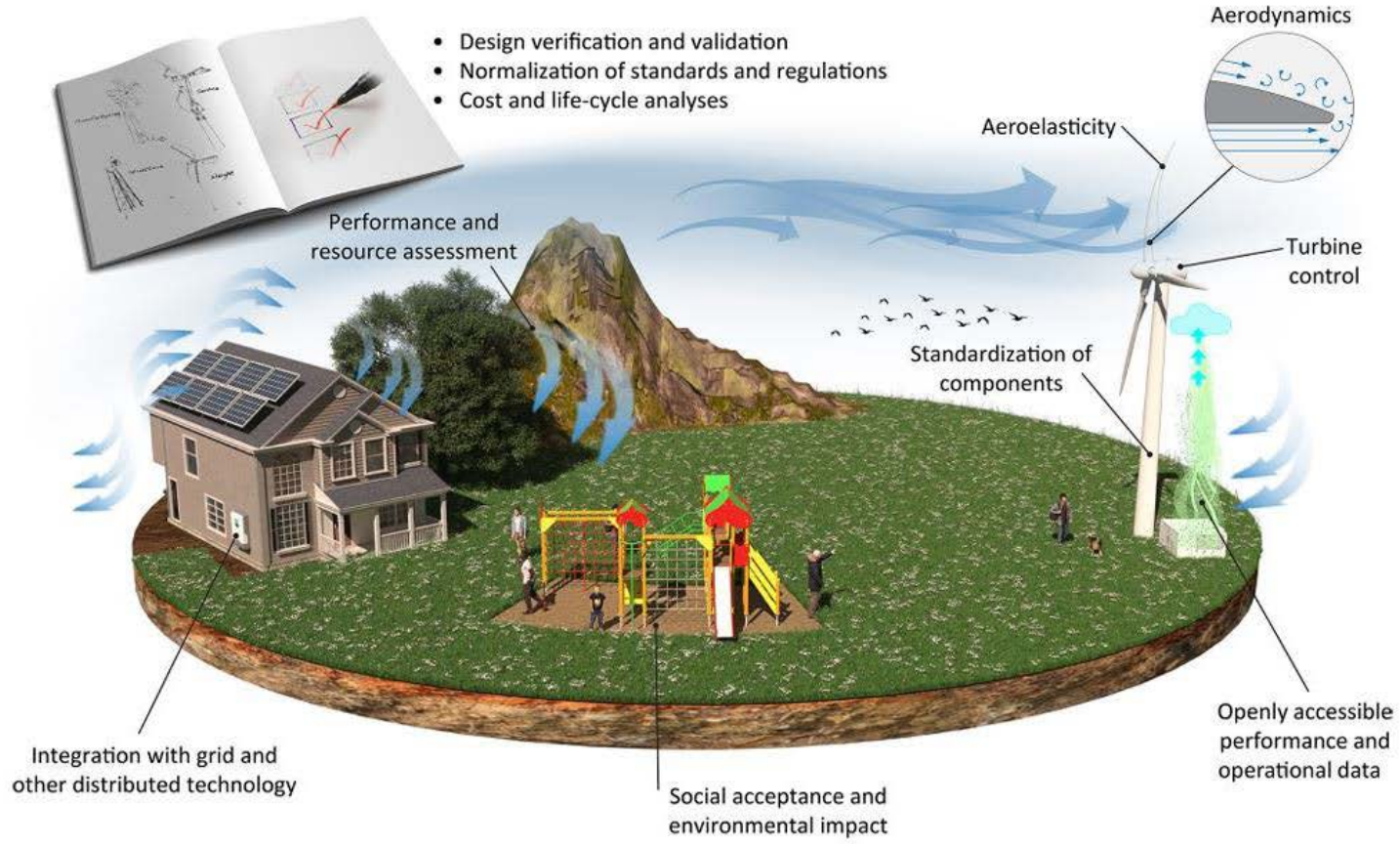



*Image from NREL*

# Thank you.

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