SAND2011-9238P

DOE / SNL Experimental Wind Farm at TTU

December 15, 2011

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Outline

- *DOE/SNL Objectives of Region-5 Test Facility*
- *Test Site Proposal Review*
- *Progress Updates*

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DOE/SNL Objectives of Region-5 Test Facility

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Exceptional service in the national interest

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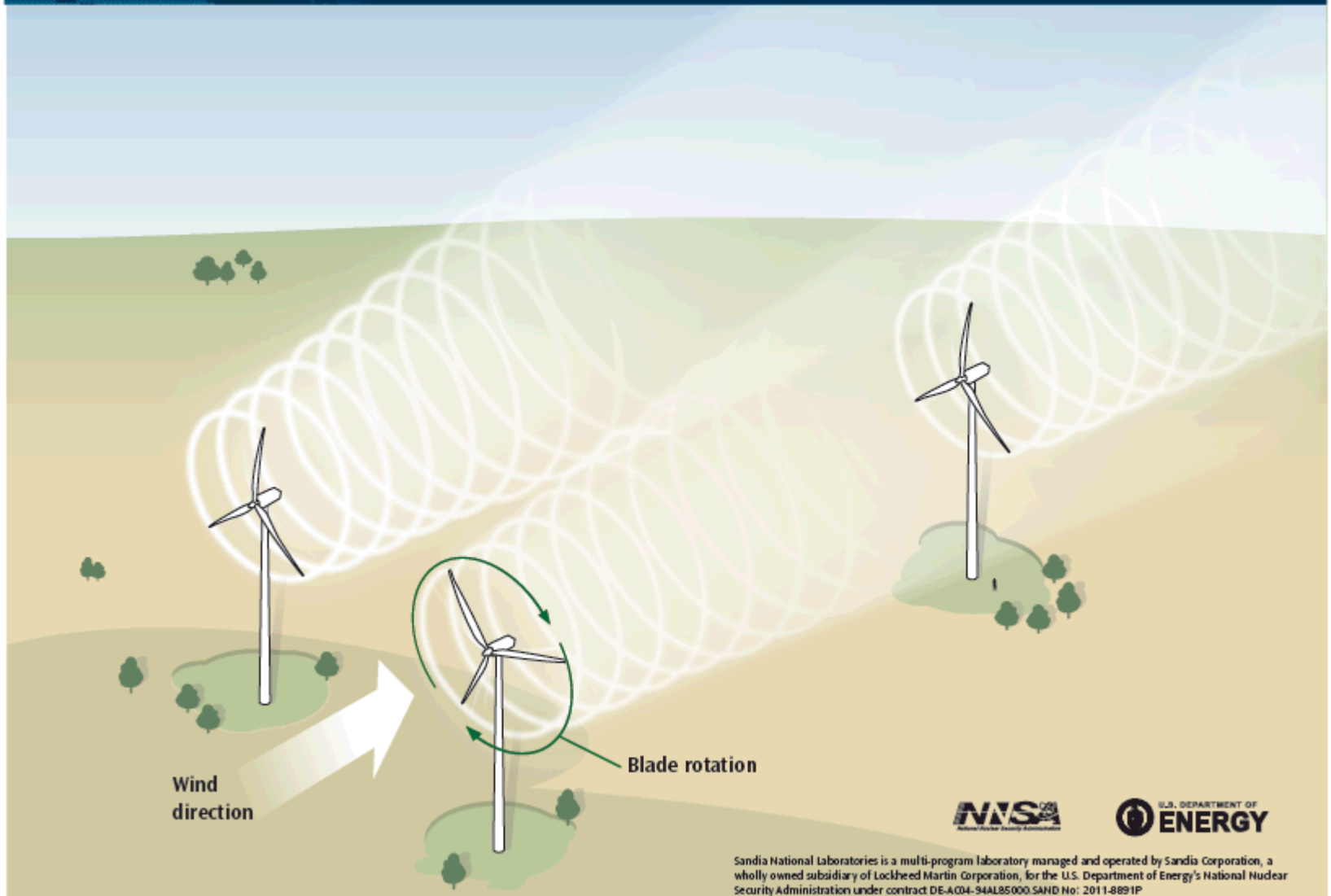

NNSA

U.S. DEPARTMENT OF ENERGY

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DOE/SNL Objectives

- ***Study of turbine to turbine interaction***
  - *Tip vortex, wake growth, wake mixing, meandering wakes*
  - *Inflow turbulence, low-level jets, advanced features*

- ***Advanced wind turbine rotor development***
  - *Passive load control: bend-twist coupling, blade sweep, flatback airfoils*
  - *Active load control: smart rotor, nonlinear wind turbine control, smart turbine design*
  - *Advanced sensing technologies: operational monitoring, structural health monitoring, prognostics*

DOE/SNL Objectives II

- ***Aerodynamics, aero-elasticity, and aero-acoustics testbed***
  - *Inboard aerodynamics, 3D blade flow, NUMAD / BPE design tool advancement, near-blade acoustic generation, acoustic propagation, acoustic beam-forming*

- ***Other suggestions***
  - *High-risk wind energy technology*
  - *Vertical Axis Wind Turbines and application to offshore*
  - *Damage-representative turbines for SHM qualification*

Test Site Proposal Review

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Existing SNL/USDA Test Facility

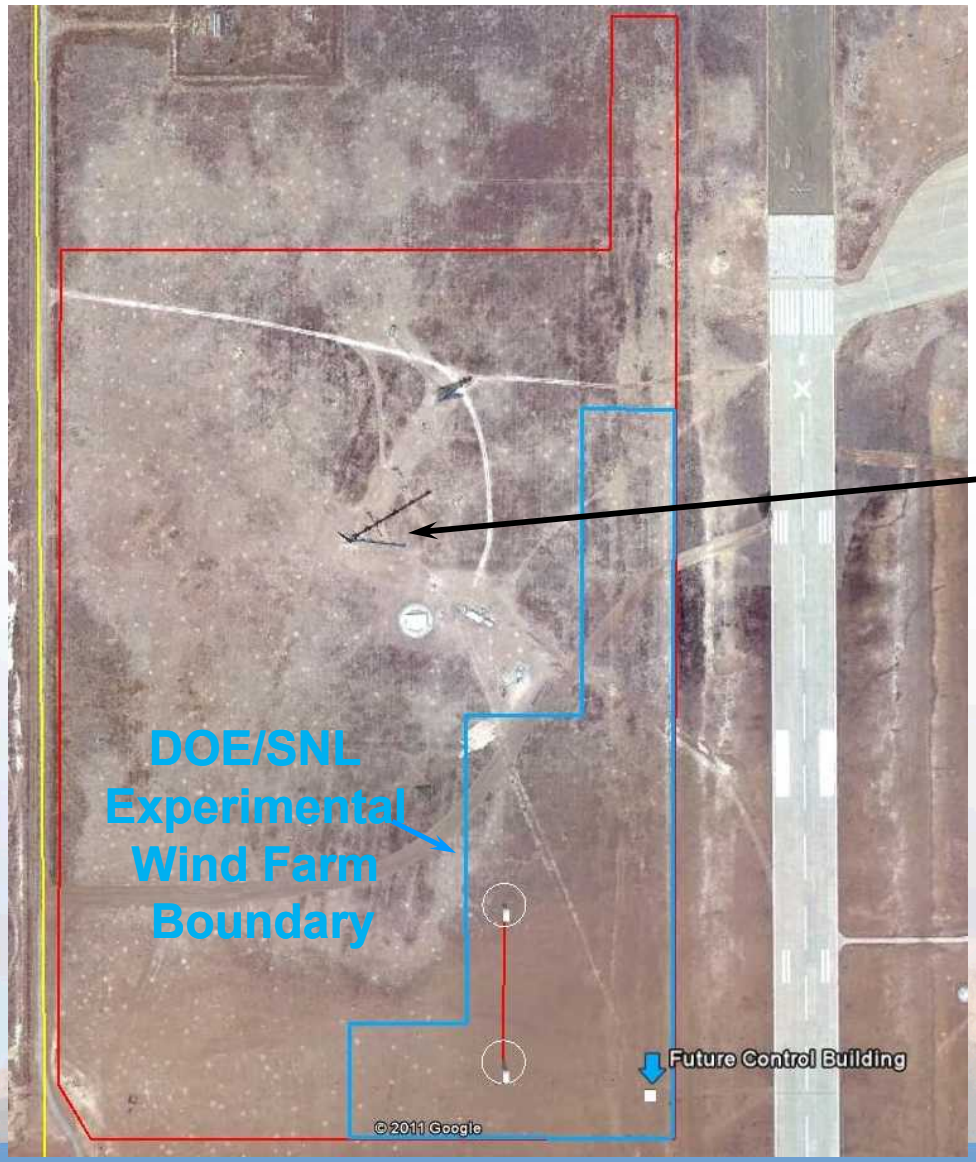
DOE/SANDIA 34-METER VAWT TEST BED
USDA AGRICULTURAL RESEARCH SERVICE, BUSHLAND, TEXAS
DEDICATED MAY 10,1988

Objectives and Approach

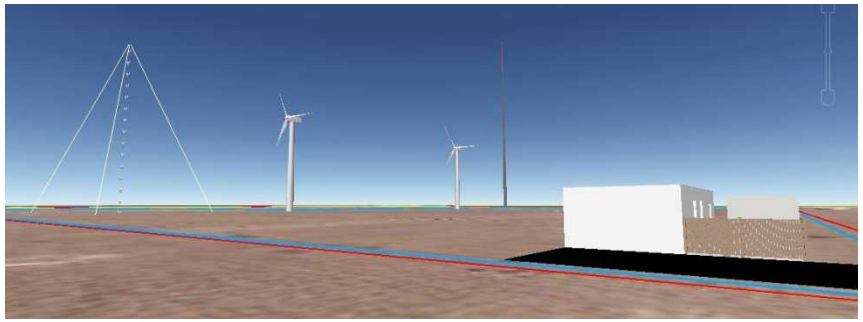
- **What:** SNL is recapitalizing the DOE / SNL testing facilities.
- **Why:** Variable-speed variable-pitch turbine operation with relevant Reynolds numbers are required to transfer new innovative technologies to industry, i.e. buy down high-risk. USDA is less committed to supporting wind energy (Change in mission).
- **Who:** A research institution committed to wind energy research and education, capable of supporting testing facilities, personnel, schedule, and process.
- **When:** Currently awaiting NEPA and PREP approval from DOE SSO. Working to finalize turbine procurement (critical path).
- **Where:** Texas Tech University most committed and viable to hosting the site.

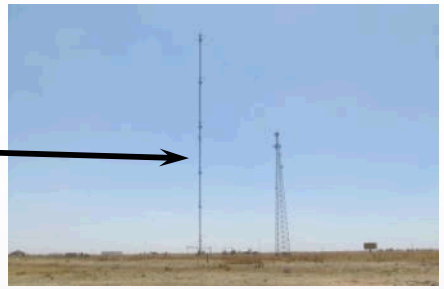
Tentative Site Plan

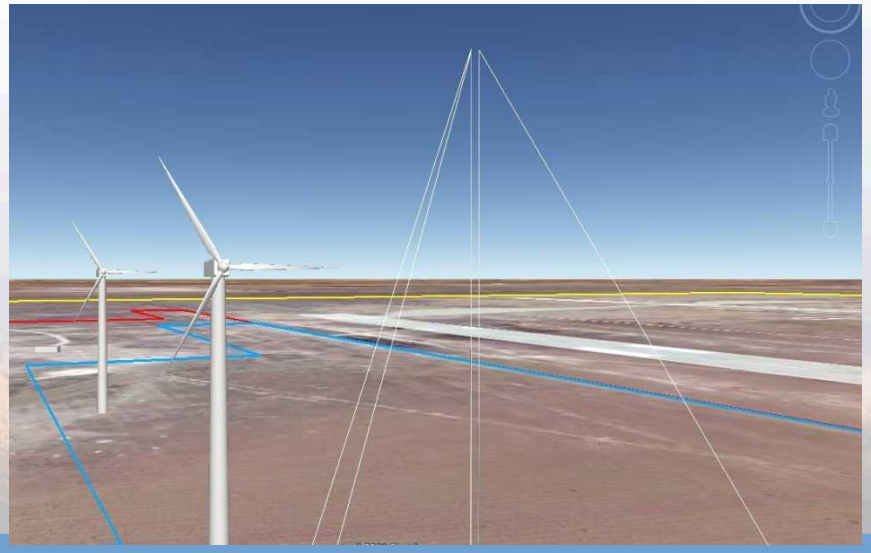
Tentative Turbine Site Plan



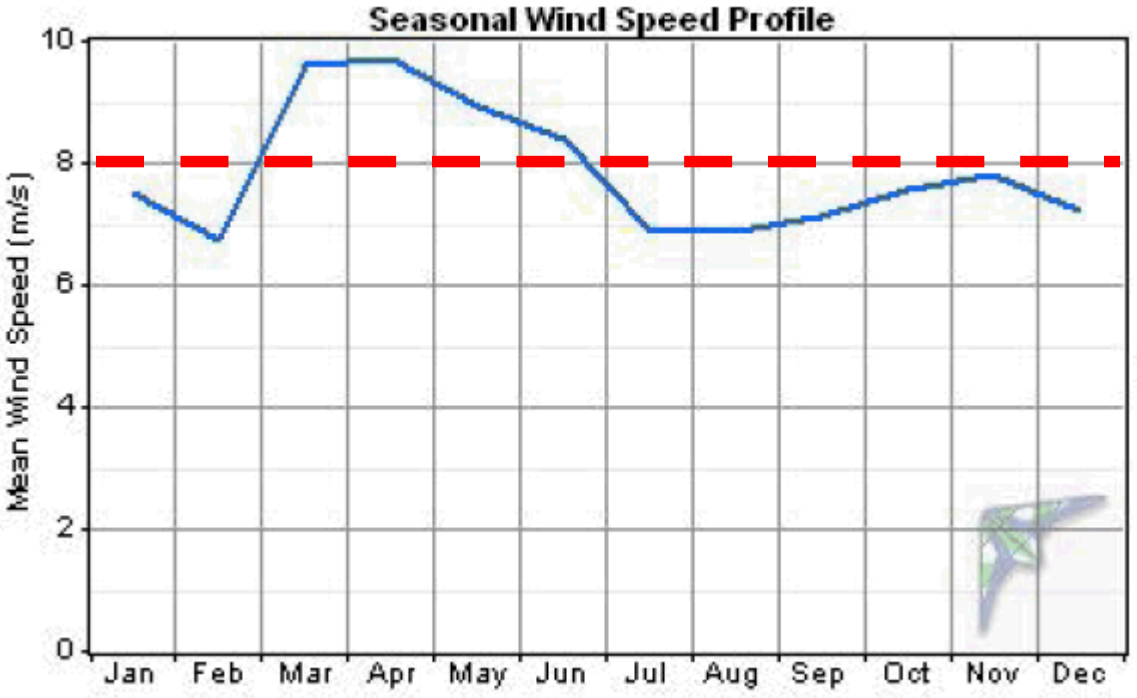
200m
Met
Tower





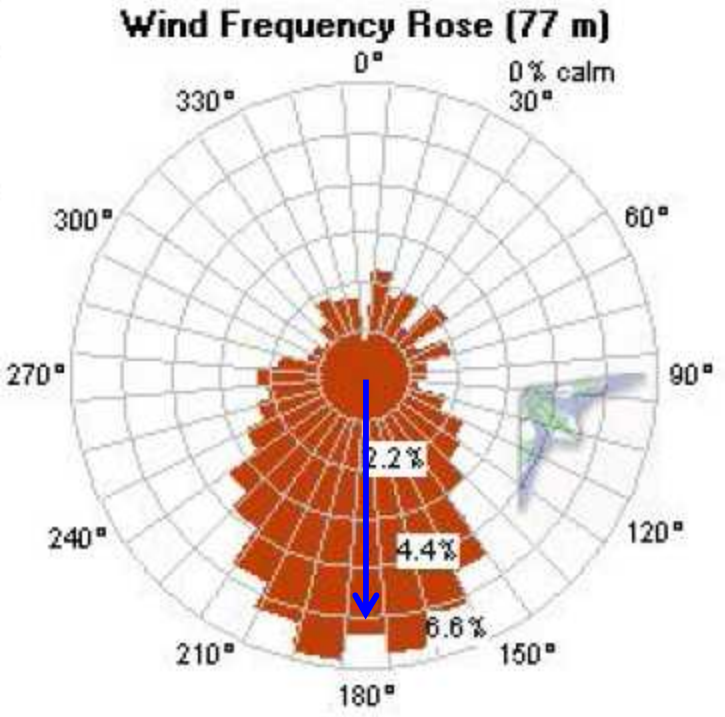


Wind Resource Assessment



8 m/s at 77 m
(7.5 m/s at 50 m)

Class 5 Wind Site!



Consistent Wind
South
180.5°Average

What is Research-Scale?

Research-Scale

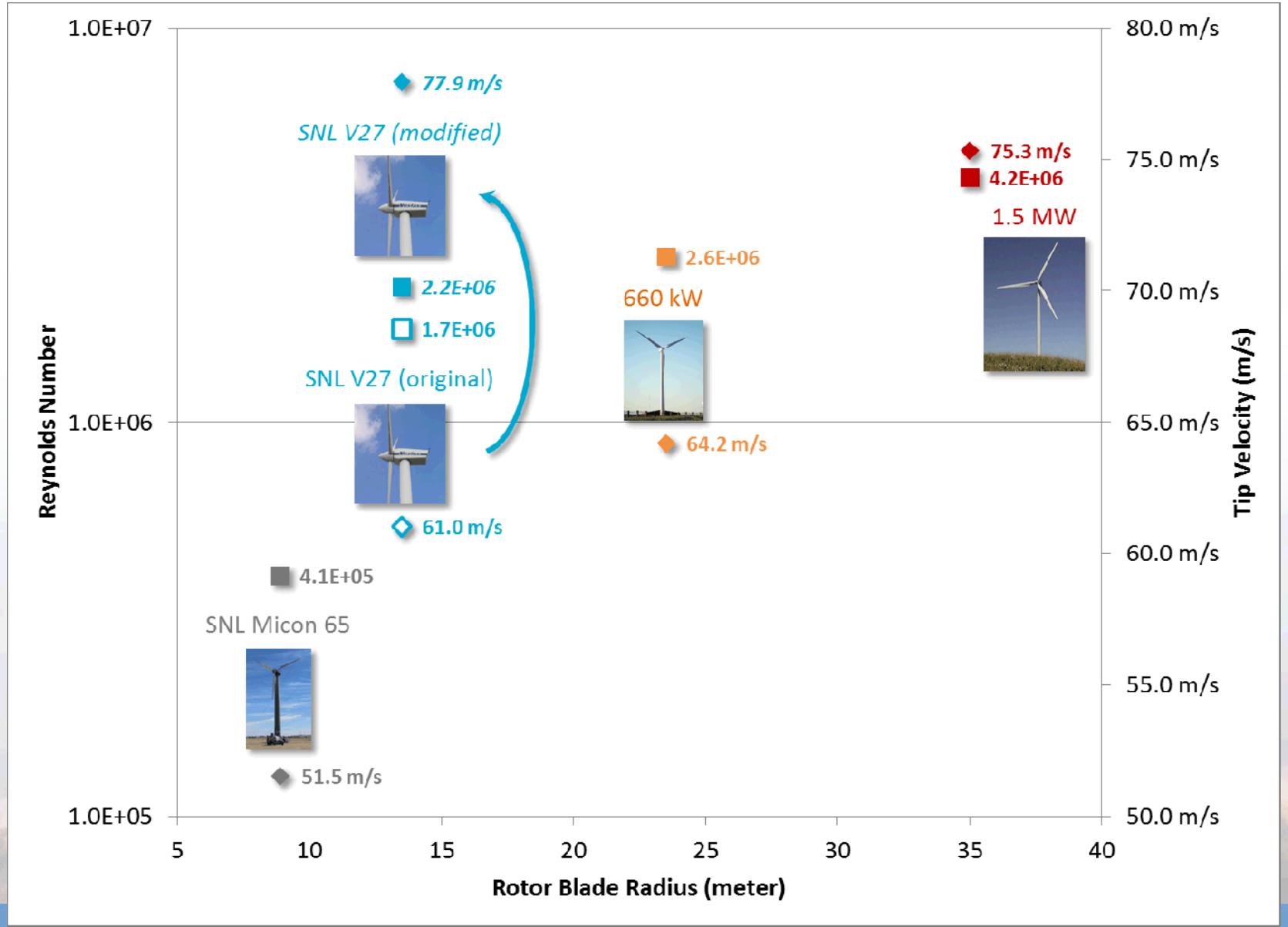
Minimum research cost and time

Exact Scaling

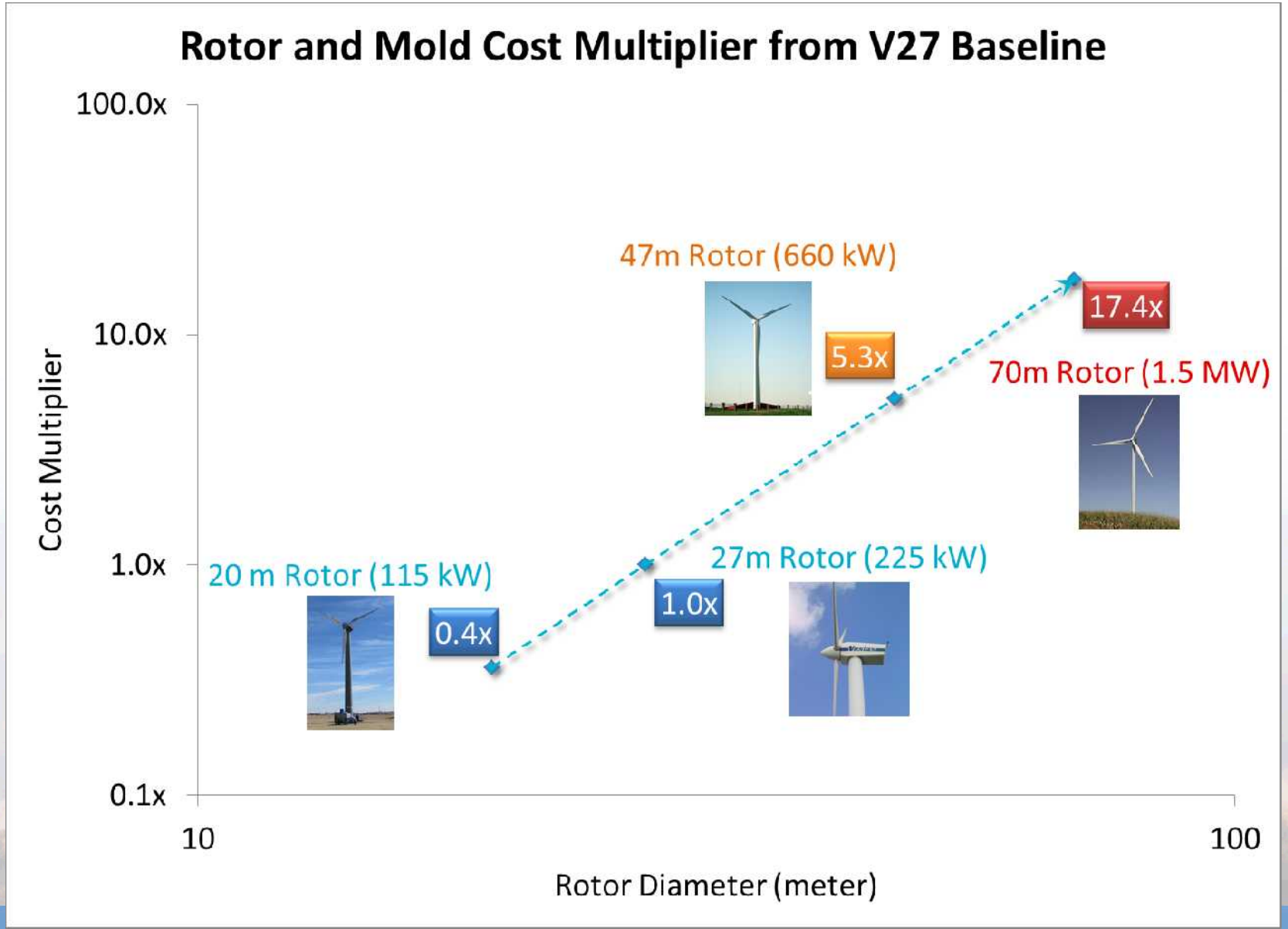
Megawatt-Scale

- **A cost-efficient size for which research can be directly scaled to larger, more costly and time-consuming sizes.**
- **Requirements:**
  - Operation at Reynolds Number (scaling parameter) between 10^6 and 10^7
  - Tip speeds approaching 80 m/s for acoustics and large rotor projects
  - Variable-speed variable-pitch operation
  - Minimal cost and time associated with research operations
  - Highly reliable turbine
  - Minimal restrictions on publication and intellectual property

Aerodynamic Scaling



Cost Efficiency



Crane Cost Comparison

Research Scale (225 kW)

Megawatt Scale

Costs

$5,000 v. $250,000

Scheduling

Days Ahead v. Months Ahead

Testing Risk

Low v. High

National Open-Source Research Asset

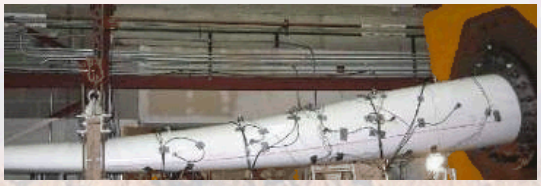
DOE / SNL Rotor Blade Designs

DOE / SNL FAST / ADAMS Model of V27

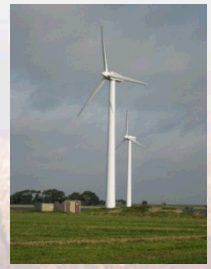
Feasibility Proof **Technology Demonstration** **Commercialization**

TRL-1 **TRL-2** **TRL-3** **TRL-4** **TRL-5** **TRL-6** **TRL-7** **TRL-8** **TRL-9**

Basic Research **Technology Development** **Sub-Scale Testing**



DOE / SNL Advanced Blade Testing at NREL-NWTC



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Research-Scale

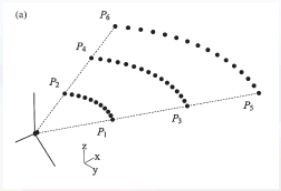
Examples of Success

Risø DTU
National Laboratory
for Sustainable Energy

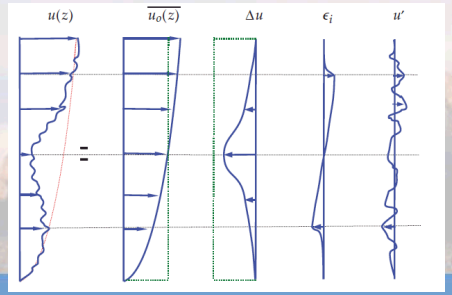
DTU

- *"Light detection and ranging measurements of wake dynamic Part I & II" 2011*

LIDAR Scanning of 95 kW Turbine Wake



Decomposition of Wake Deficit



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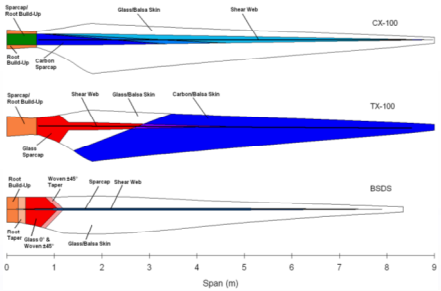
- CX / TX / BSDS Blade Family Study



Fabrication and Testing at the 115 kW Scale

tpi

USDA United States Department of Agriculture
ARS Agricultural Research Service
Conservation & Production Research Laboratory

Result: **24% reduction in damage equivalent load and initiated industrial use of carbon, flatback airfoils and twist-bend coupling.**

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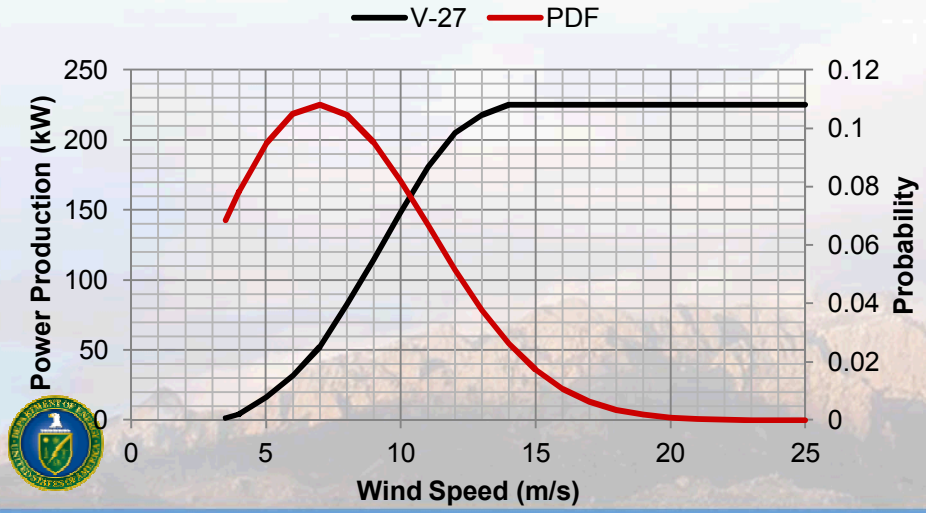
Proposed Test Turbine

Modified Vestas V-27

- 300 kW (0 – 55 rpm)
- 13 m (43 ft) Blade Length
- Pitch Control in Region 3
- 30 m (98 ft) Tower Height
- Reynolds Number ~2×10^6
- Highly reliable

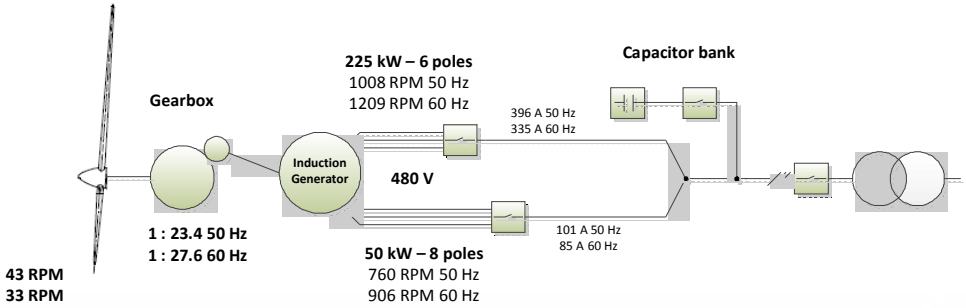
Site Production

- 7 m/s hub-ht. average
- 92 kW Average
- 41% Capacity Factor



Variable-Speed Upgrade

Fixed Speed



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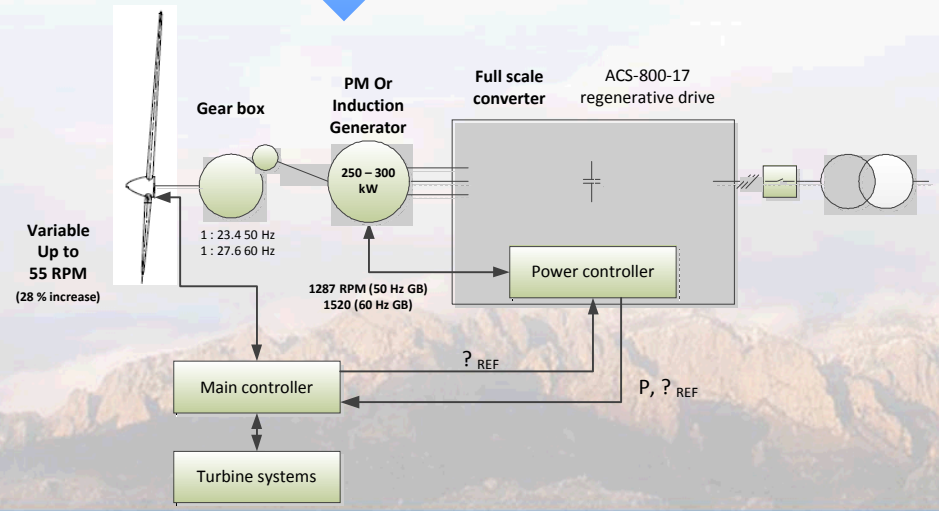
Variable Speed



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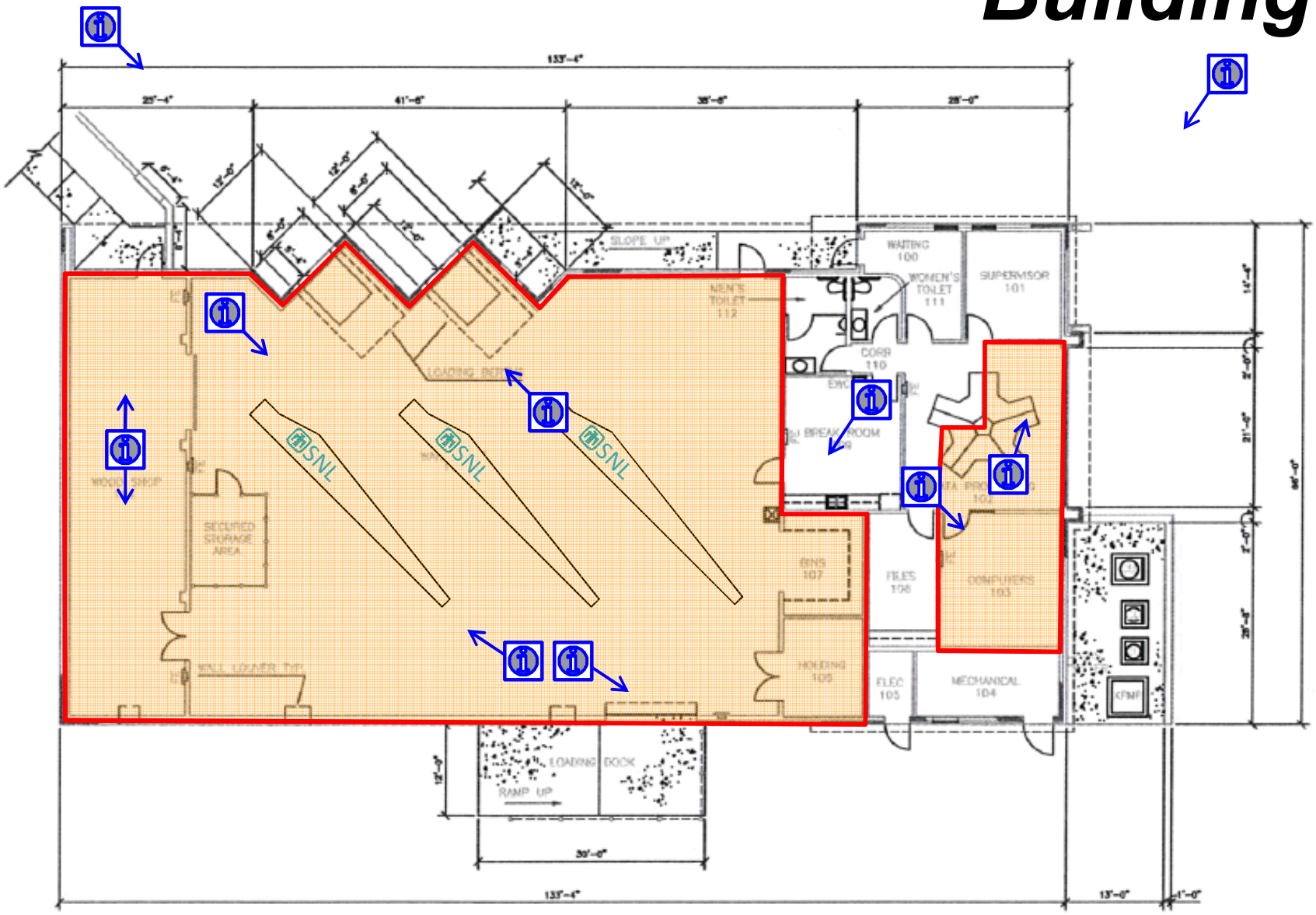
Repurposed Assembly Building



Progress Updates

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Current Work

- **VESTAS:** Vestas R&D Americas, Houston, TX is the worldwide leader in wind turbines and is committed to collaborating at the new DOE/SNL Experimental Wind Farm. Vestas is quickly working to place contracts and agreements to purchase a refurbished V-27 and install the foundation within the DOE/SNL Experimental Wind Farm.
- **SNL/TTU/NIRE Agreement:** Annual operating contracting is being finalized and a staff posting is currently open for applicants.
- **NEPA:** Completed documentation was submitted to DOE/SSO on October 3. Awaiting direction on next steps.
- **Preliminary Real Estate Property Agreement (PREP):** PREP was submitted to DOE/SSO on November 17. Awaiting direction and next steps.
- **Turbine Procurement:** Finalizing request for quote (RFQ).
- **Turbine Siting Analysis:** Completed, awaiting approval of list of reviewers submitted to DOE Wind.
- **Installation Execution:** Awaiting placement of turbine contract and NEPA feedback from DOE SSO.

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TEXAS TECH
SEAL OF TEXAS TECH UNIVERSITY

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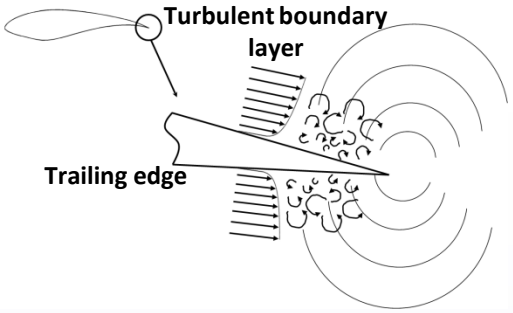
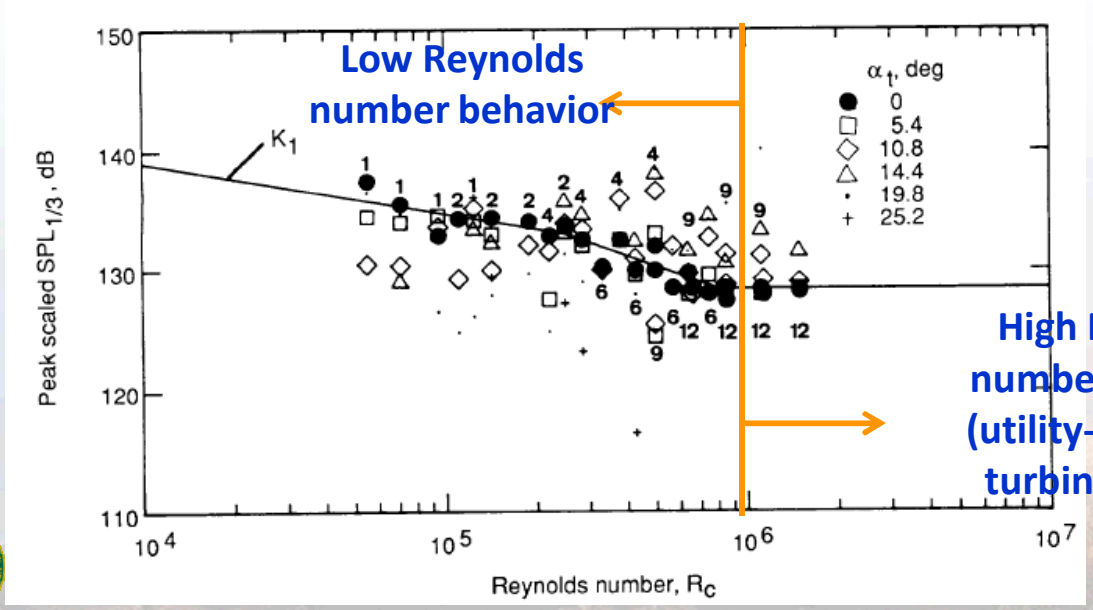
WIND ENGINEERING

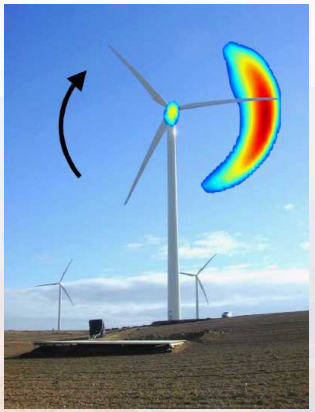
Wind turbine aerodynamic noise scaling

Wind Turbine Trailing Edge Noise



Dependence of trailing edge noise amplitude on Reynolds number





Measurement of blade trailing edge noise *(S. Oerlemans, Ph.D. Thesis, U. of Twente, 2009)*

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