

DOE / SNL Scaled Wind Farm Technology (SWIFT) Facility at TTU

May 30, 2012

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Sandia National Laboratories



Outline

- *DOE/SNL Objectives of Scaled Wind Farm Technology Facility*
- *SWIFT Overview*
- *Collaborative Partnerships*
- *Progress Updates*

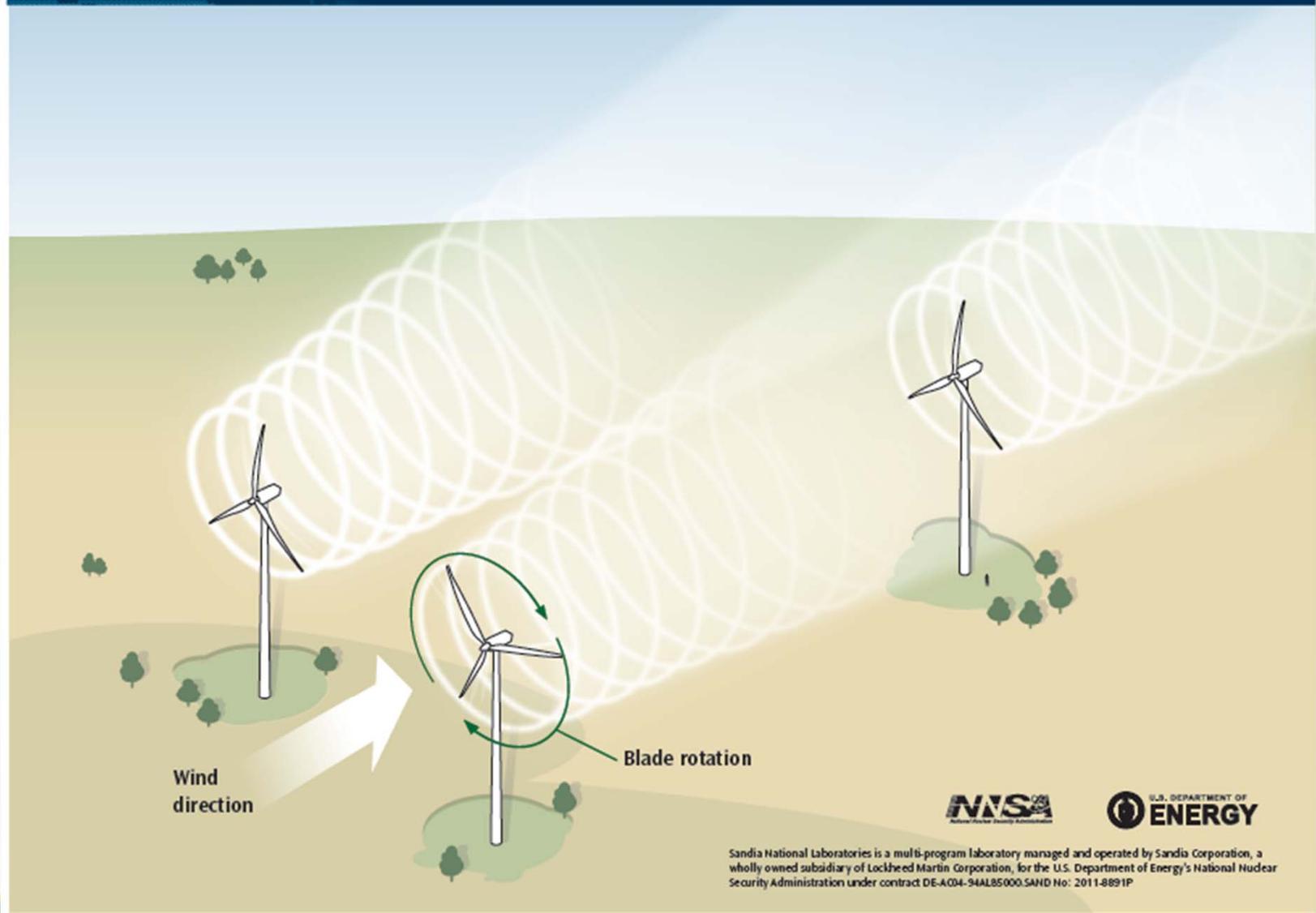




***DOE/SNL Objectives of Scaled
Wind Farm Technology Facility***



Exceptional service in the national interest



Wind
direction

Blade rotation



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atories

DOE/SNL Objectives

■ **Study of turbine to turbine interaction**

- *Tip vortices, wake growth, wake mixing, meandering wakes*
- *Inflow turbulence, low-level jets, advanced features*

■ **Advanced wind turbine rotor development**

- *Passive load control: bend-twist coupling, sweep-twist coupling, passive camber control, flat-back airfoils*
- *Active load control: smart rotor, nonlinear wind turbine control, smart turbine design*
- *Advanced sensing technologies: operational monitoring, structural health monitoring, prognostics*

■ **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*





SWIFT Overview



Existing SNL/USDA Test Facility



DOE/SANDIA 34-METER VAWT TEST BED
USDA AGRICULTURAL RESEARCH SERVICE, BUSHLAND, TEXAS
DEDICATED MAY 30, 1988



© 2011 Google
35° 11' 17.99" N 102° 05' 23.45" W elev 0 ft

Objectives and Approach

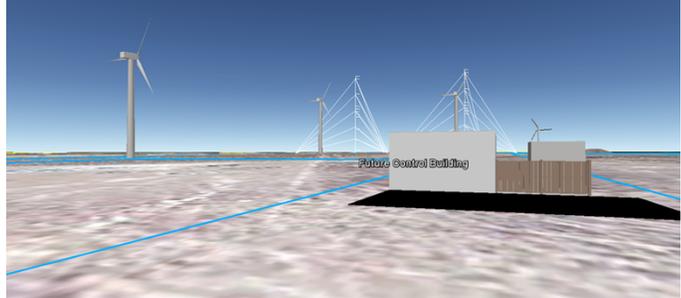
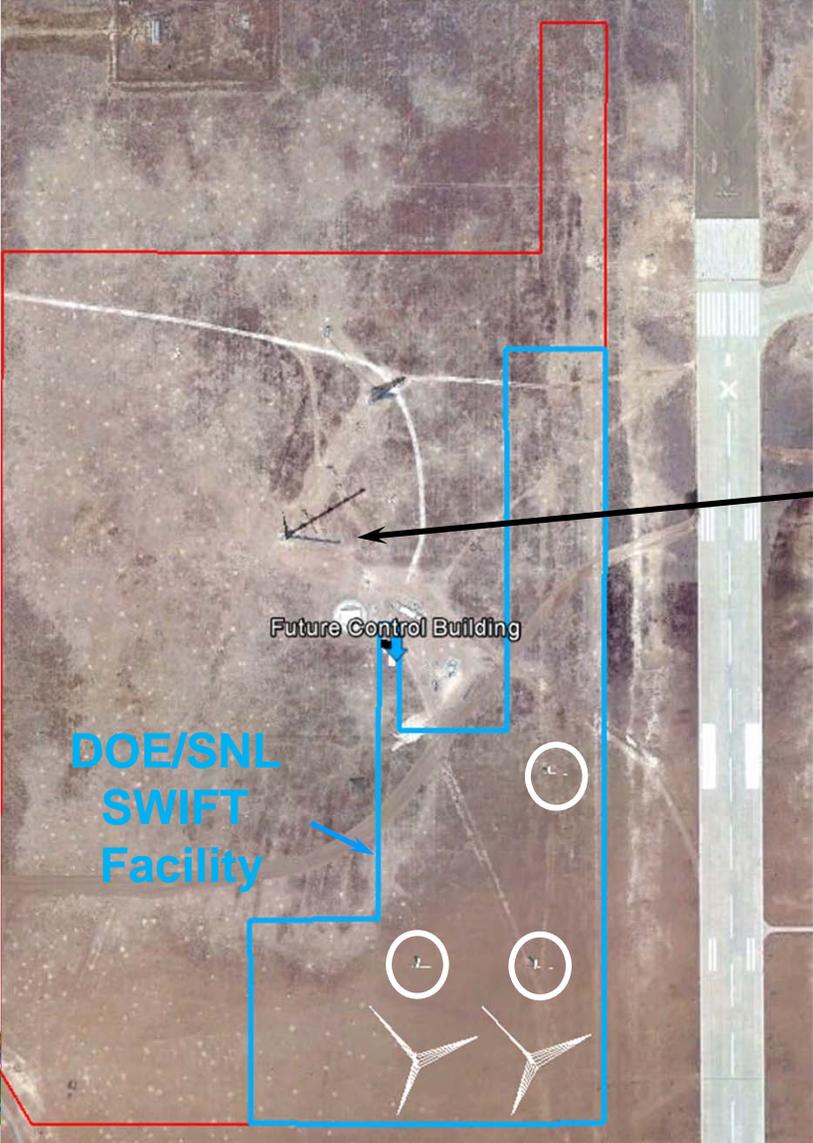
- **What:** SNL is recapitalizing the DOE / SNL wind turbine testing facilities.
- **Why:** Variable-speed variable-pitch turbine operation with relevant Reynolds numbers and acceptable testing cost/time is required to transfer new innovative technologies to industry, i.e. buy down high-risk. USDA is 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:** ~ 3 months. Currently finalizing turbine procurement.
- **Where:** Texas Tech University most committed and viable to hosting the site.



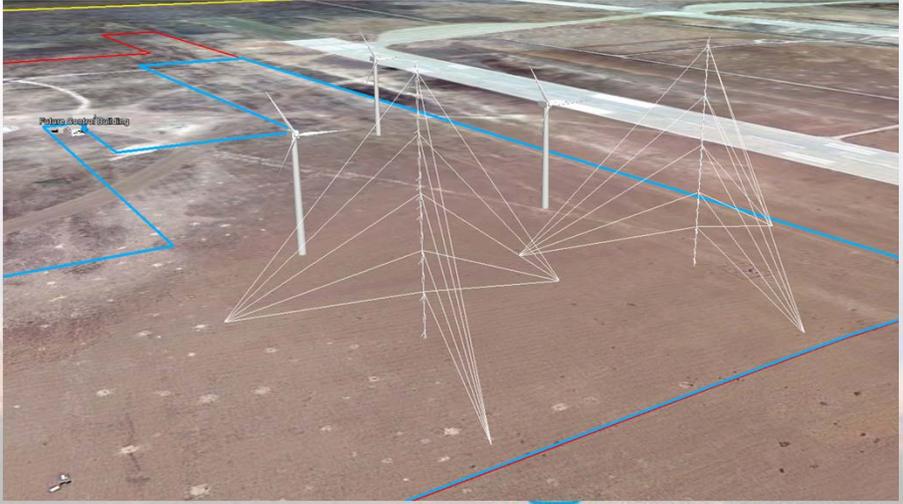
Site Plan



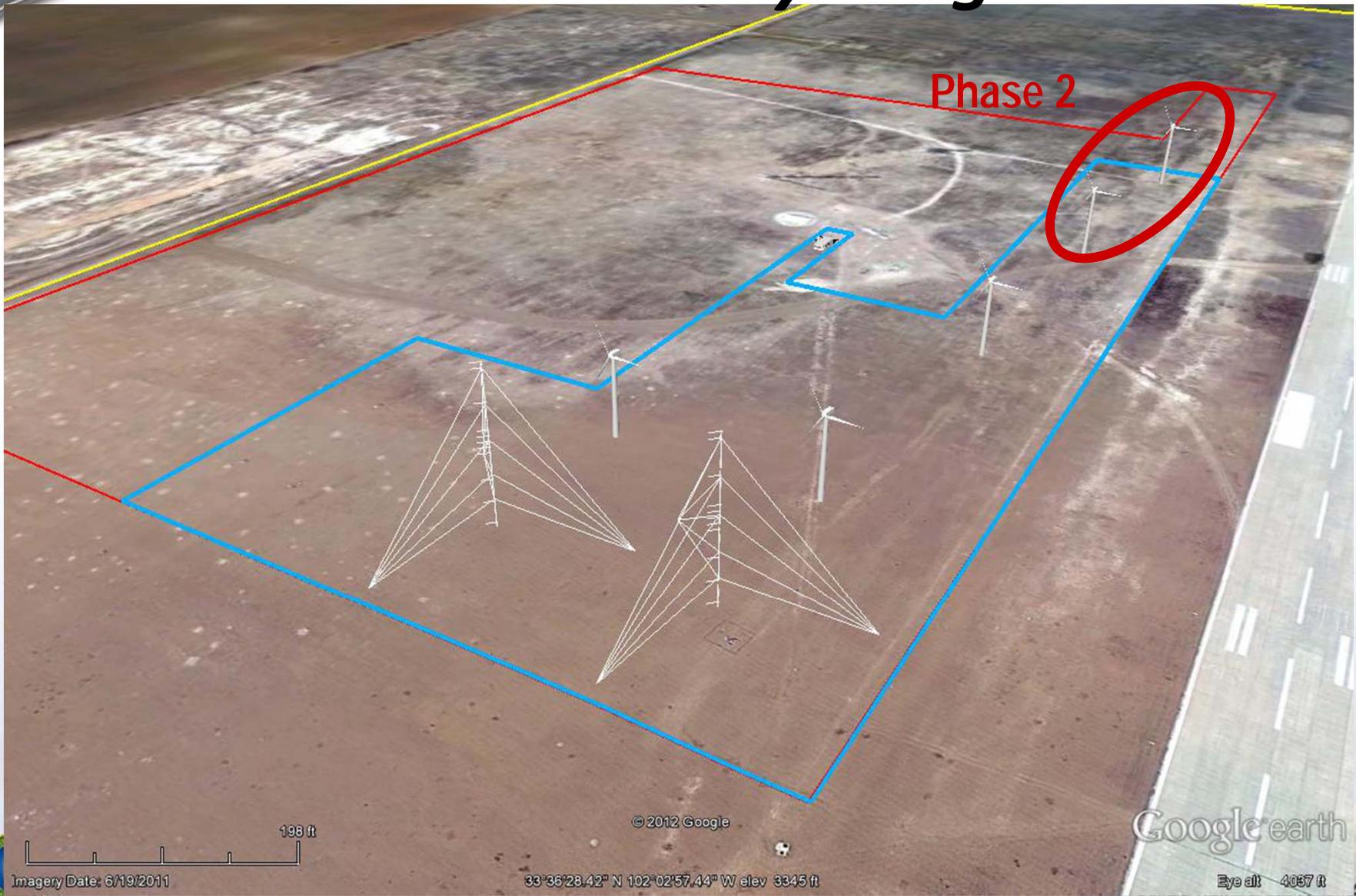
Turbine Site Plan



200m
Met
Tower



SWIFT Array Long-Term Plan



Phase 2

198 ft
Imagery Date: 6/19/2011

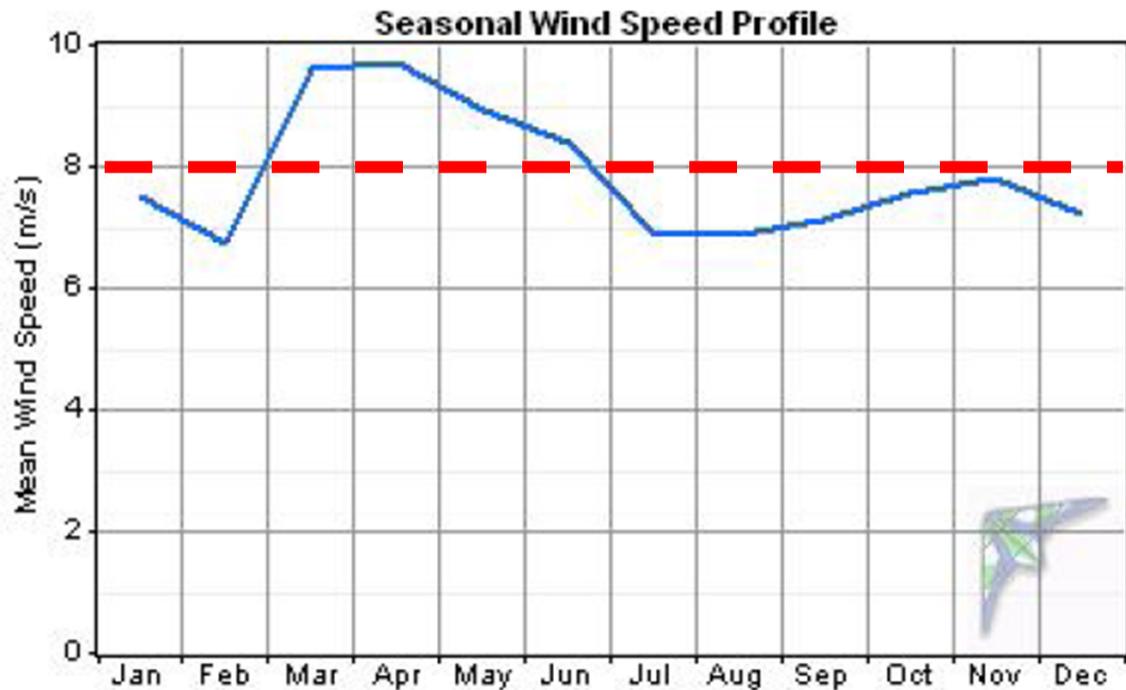
© 2012 Google

33°36'28.42" N 102°02'57.44" W elev 3345 ft

Google earth

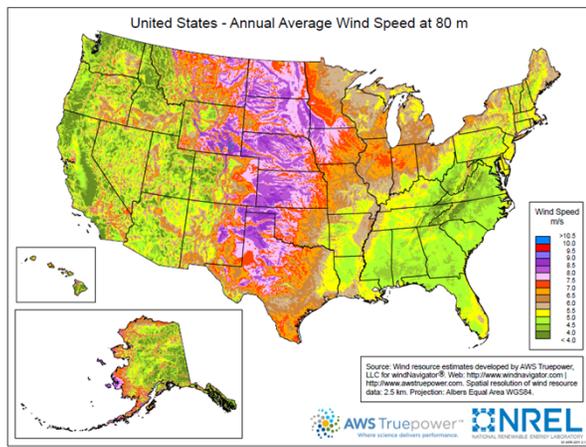
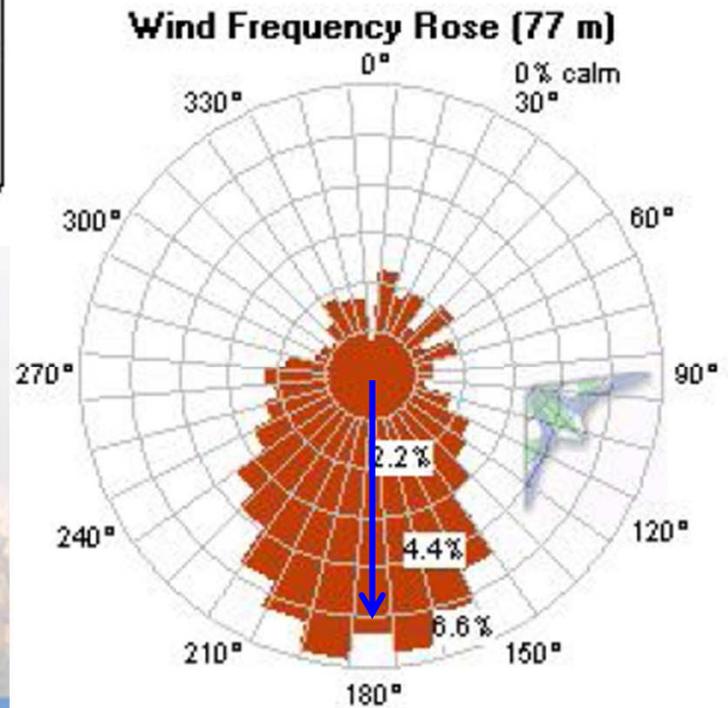
Eye alt 4067 ft

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**



Proposed Test Turbine

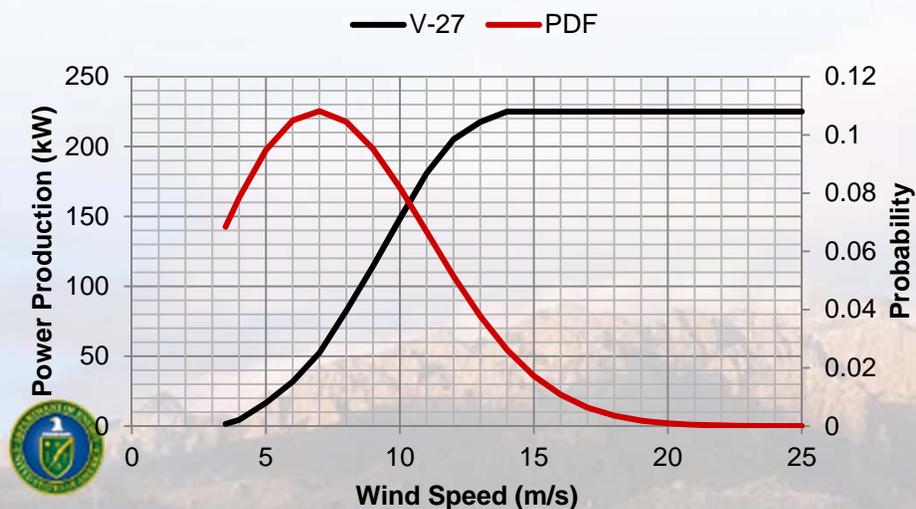


Site Production

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

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 $\sim 2 \times 10^6$
- Highly reliable

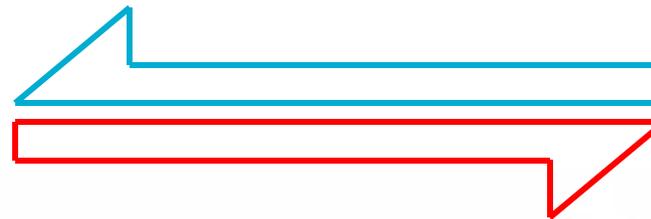


What is Research-Scale?

Research-Scale



*Minimum research
cost and time*



*Exact
Scaling*

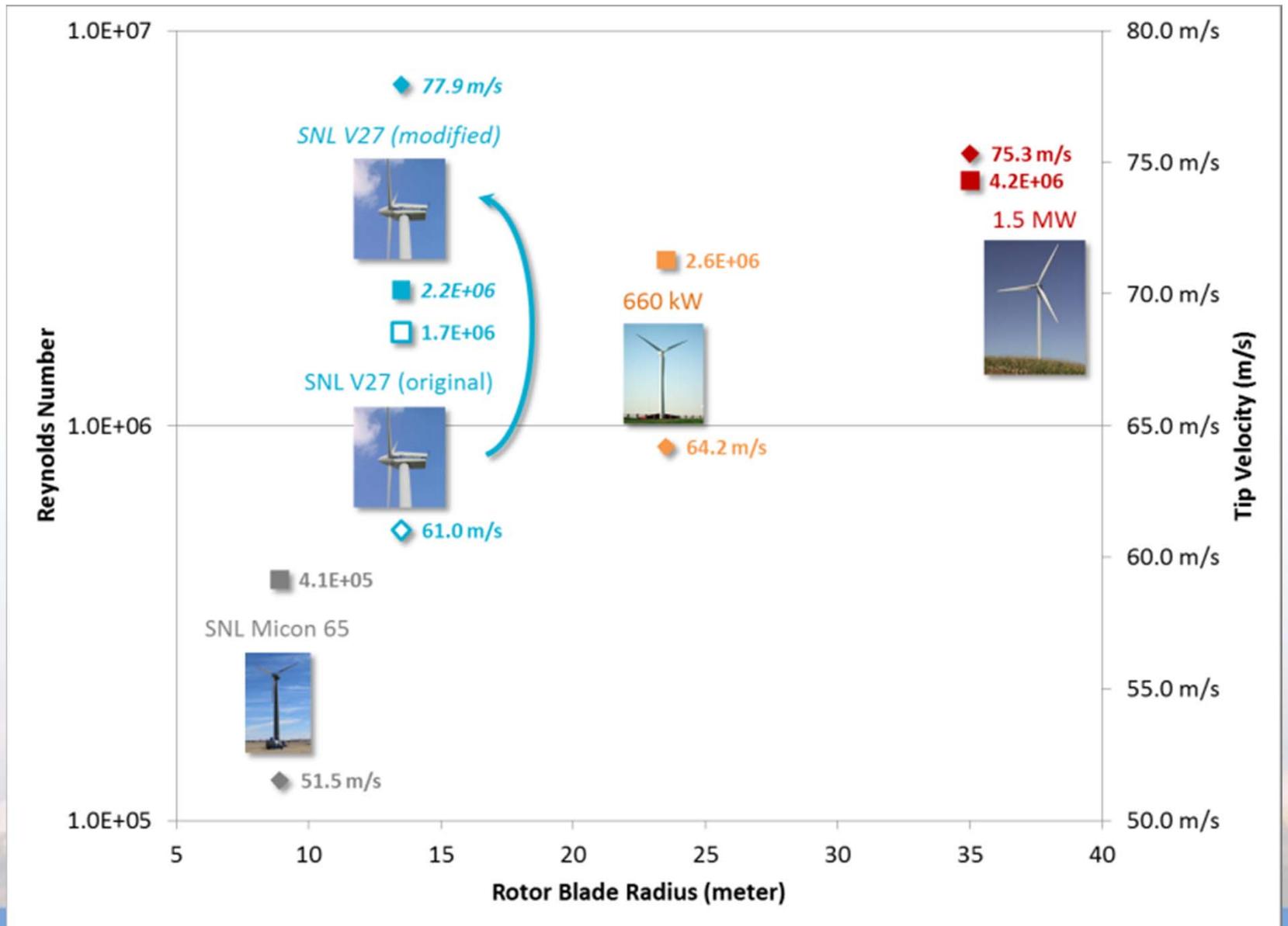
Megawatt-Scale



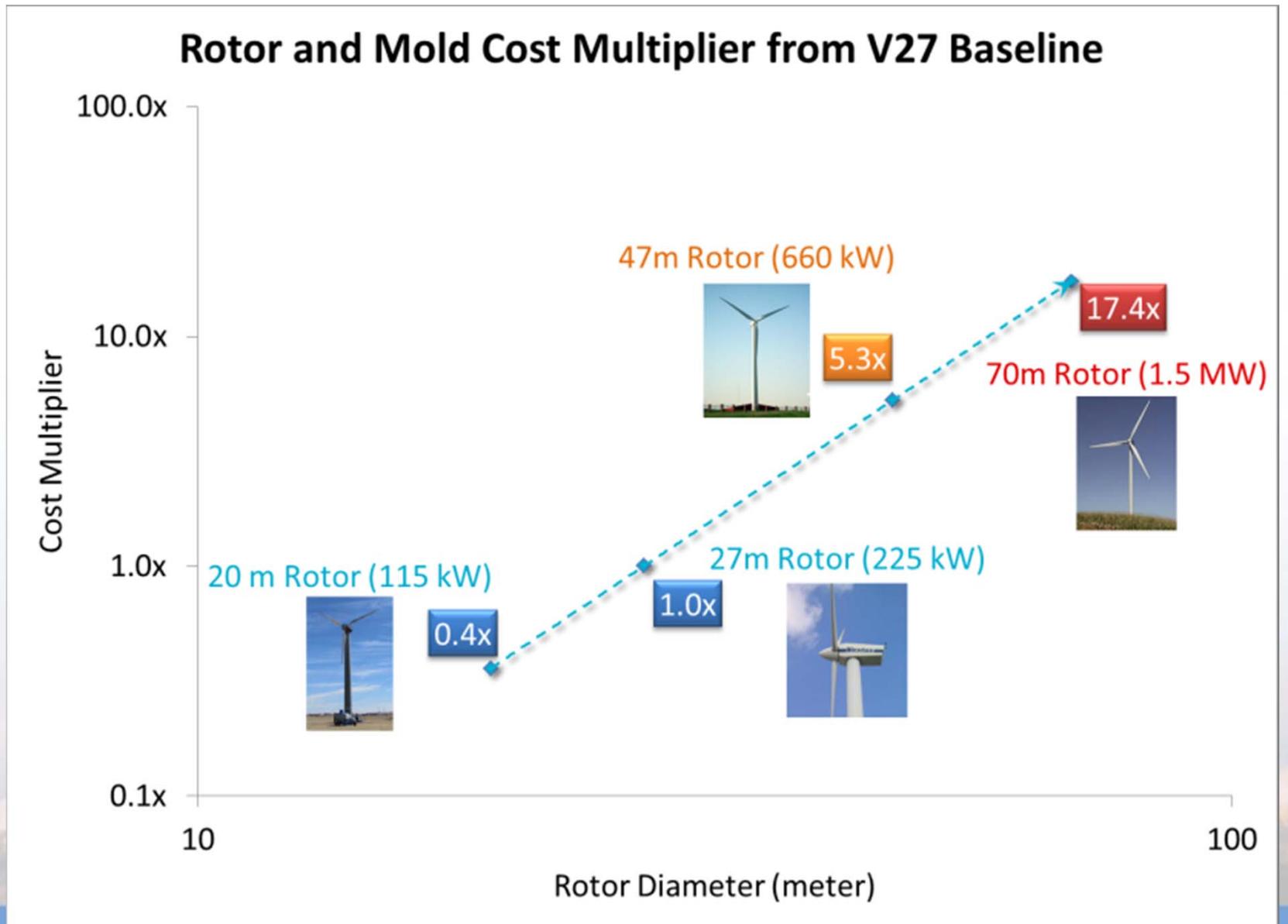
- A cost-efficient size for which research can be directly scaled to larger, more costly and time-consuming sizes.
- Requirements:
 - Operation at Reynolds Number (scaling parameter) between 10^6 and 10^7
 - Tip speeds approaching 80 m/s for acoustics and large rotor projects
 - Variable-speed variable-pitch 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)



Costs
\$5,000 v. \$250,000

Scheduling
Days Ahead v. Months Ahead

Testing Risk
Low v. High

Megawatt Scale



National Open-Source Research Asset

DOE / SNL Rotor Blade
Designs



Feasibility Proof



DOE / SNL
FAST / ADAMS
Model of V27

Technology Demonstration Commercialization



Basic Research

Technology Development

Sub-Scale Testing



DOE / SNL Advanced Blade
Testing at NREL-NWTC



DOE / SNL
SWIFT
Facility
at TTU



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Research-Scale Examples of Success

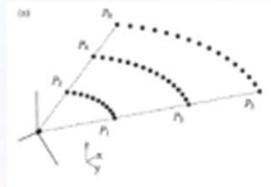
Risø DTU
National Laboratory
for Sustainable Energy



- “Light detection and ranging measurements of wake dynamic Part I & II” 2011



LIDAR Scanning of 95 kW Turbine Wake

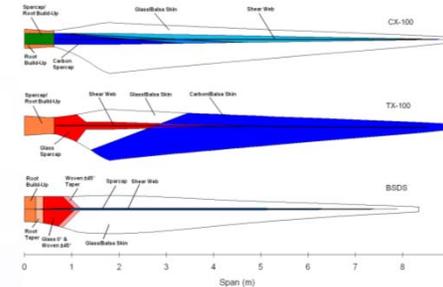


Decomposition of Wake Deficit



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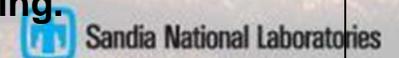
- CX / TX / BSDS Blade Family Study



Fabrication and Testing at the 115 kW Scale



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





Development Partnerships



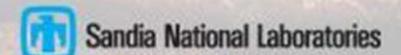
SWIFT Partnerships



U.S. DEPARTMENT OF
ENERGY



Vestas



DOE/SNL/TTU Partnership

- **Wind Science and Engineering Research Center (WISE) has a 40 year history in wind-related research and development**
- **Unique Capabilities and Facilities**



TEXAS TECH
UNIVERSITY.

Distributed Wind Resource Assessment

West Texas Mesonet (60x)

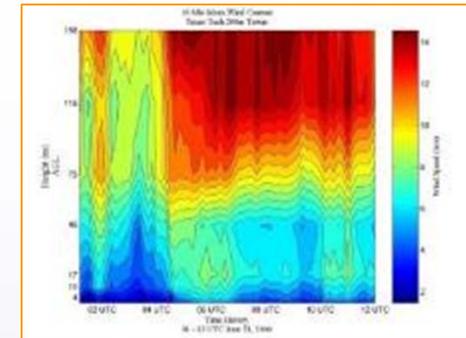


2x mobile Doppler research radars



Large-scale Test Infrastructure

200 meter anemometer tower

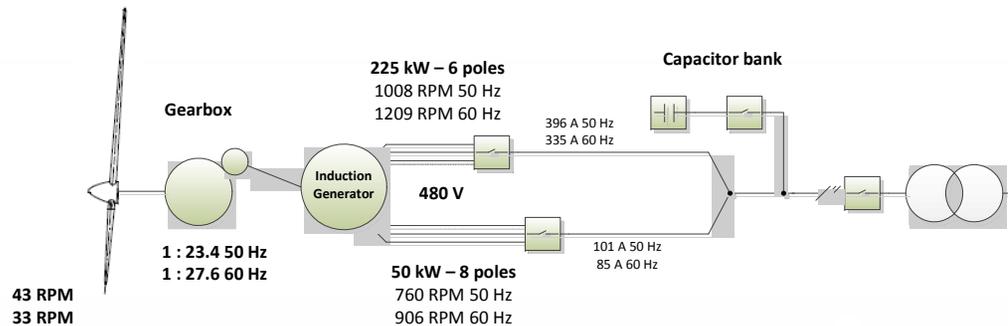


MW Wind Turbines

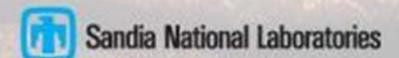
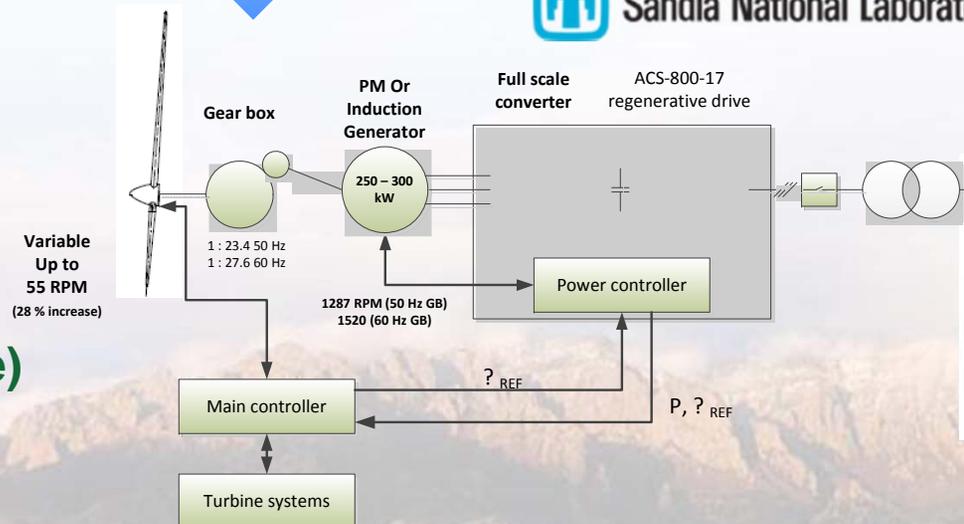


Variable-Speed Upgrade

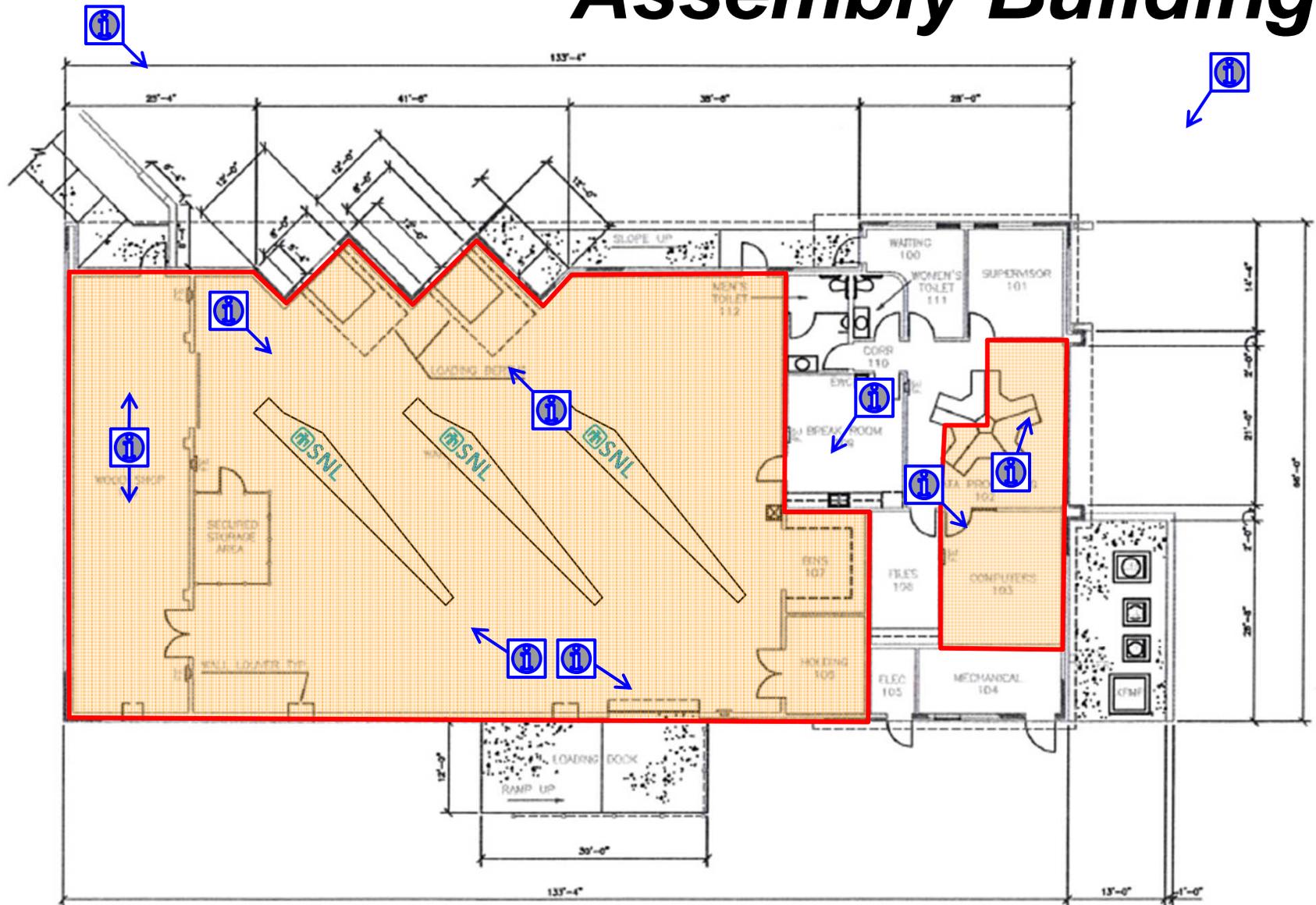
Fixed Speed



DOE/SNL
Variable
Speed
(Open-source)



Re-purposed Assembly Building





Progress Updates



Current Work

- **VESTAS:** Vestas R&D Americas, Houston, TX is the worldwide leader in wind turbines and is committed to installing an additional Vestas-owned V27 at the new DOE/SNL SWIFT Facility.
- **SNL/TTU/NIRE/VESTAS Agreement:** A four-party Memorandum of Understanding has been accepted.
- **SNL/TTU Operations:** Annual operating contract has been placed and a full-time staff member has been hired.
- **NEPA:** NEPA was approved by DOE/SSO on December 12.
- **Land-Use Agreement:** PREP was approved by DOE/SSO on March 1.
- **Procurement:** Turbines are being refurbished, control building is being fabricated, anemometer tower has been delivered, assembly building is being renovated.
- **Turbine Siting Analysis:** Revisions were made from reviewer's comments.
- **Installation Execution:** Turbine installation contract has been placed and will proceed in late summer.



Progress!



SANDIA REPORT
SAND2011-4438 UNCLASSIFIED - NOT FOR DISTRIBUTION
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Public Release

SNL-TTU Wind Turbine Test Site:
Research Opportunities for Study of
Turbine-Turbine Interaction

Matthew Barone and Jonathan Shinn, Sandia National Laboratories

Report Number: SAND2011-4438
Publication Number: SAND2011-4438
SANDIA REPORT FOR SAND CORP. (SAND2011-4438)
SANDIA NATIONAL LABORATORIES, ALBUQUERQUE, NEW MEXICO 87185
SANDIA REPORT NUMBER SAND2011-4438
Approved for Release: Sandia National Laboratories

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