ISU Wind Energy Laboratory

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Concept, Design, and Call for Action
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1. Lab Vision and Overview
2. Education
3. Supporting Research
4. Development

Vision:

- Discover and share knowledge and information.
- Provoke thought and imagination.
- Provide resources and tools for analysis and understanding.
- Supplement ISU and K-12 coursework
- Support Research with Experimental Evidence.

Components:

- Complete wind turbine systems
- Motors, Generators, Dynamometers, Power Electronics
- Blades, Gearboxes, Structures
- Sensors & Actuators
- Design and Analysis Tools
- Data Acquisition Networks, Content Displays, and Archives

ISU Wind Energy Facilities

Aerospace Engineering:

- Bill James Wind Tunnel - 150 mph
- Aeronautic and Atmospheric Boundary Layer tunnel - 8x6ft, 110 mph
- Blue Tunnel - Particle Image Velocimetry
- Icing Tunnel - Low Speed, Ice Formation
- Laminar Flow Tunnel - Low Speed Aerodynamics
- M2I lab - Design and Fabrication

Industrial & Manufacturing Systems Engineering:

- Wind Energy Manufacturing Lab - Blade and Tower fabrication

Others:

- Agronomy - Mesonet
- Electric Power Research Center - Backbone Transmission System
- Center for Non-Destructive Evaluation - Detection & Characterization
- U.S. Dept. of Energy - 3D Metals Printing
- ISU Power Plant - 100 kW Wind Turbine

National University Wind Energy Facilities

Oregon State University

- Wind in AGC with Energy Storage

University of Massachusetts - Amherst

- Blade Test Facility - evolving with NREL
- Wind Tunnel - 1m x 1m, 15 m/s; Wake/Array Studies, Sensor Calibration
- Experimental Wind Turbine (ESI 80) - 250 kW
- Advanced Wind Data Logger

University of Massachusetts - Lowell

- Center for Wind Energy - Design, Manufacturing, Reliability, Energy Storage
- Fabric Characterization, Defect Detection, Acoustic Emissions

Texas Tech University

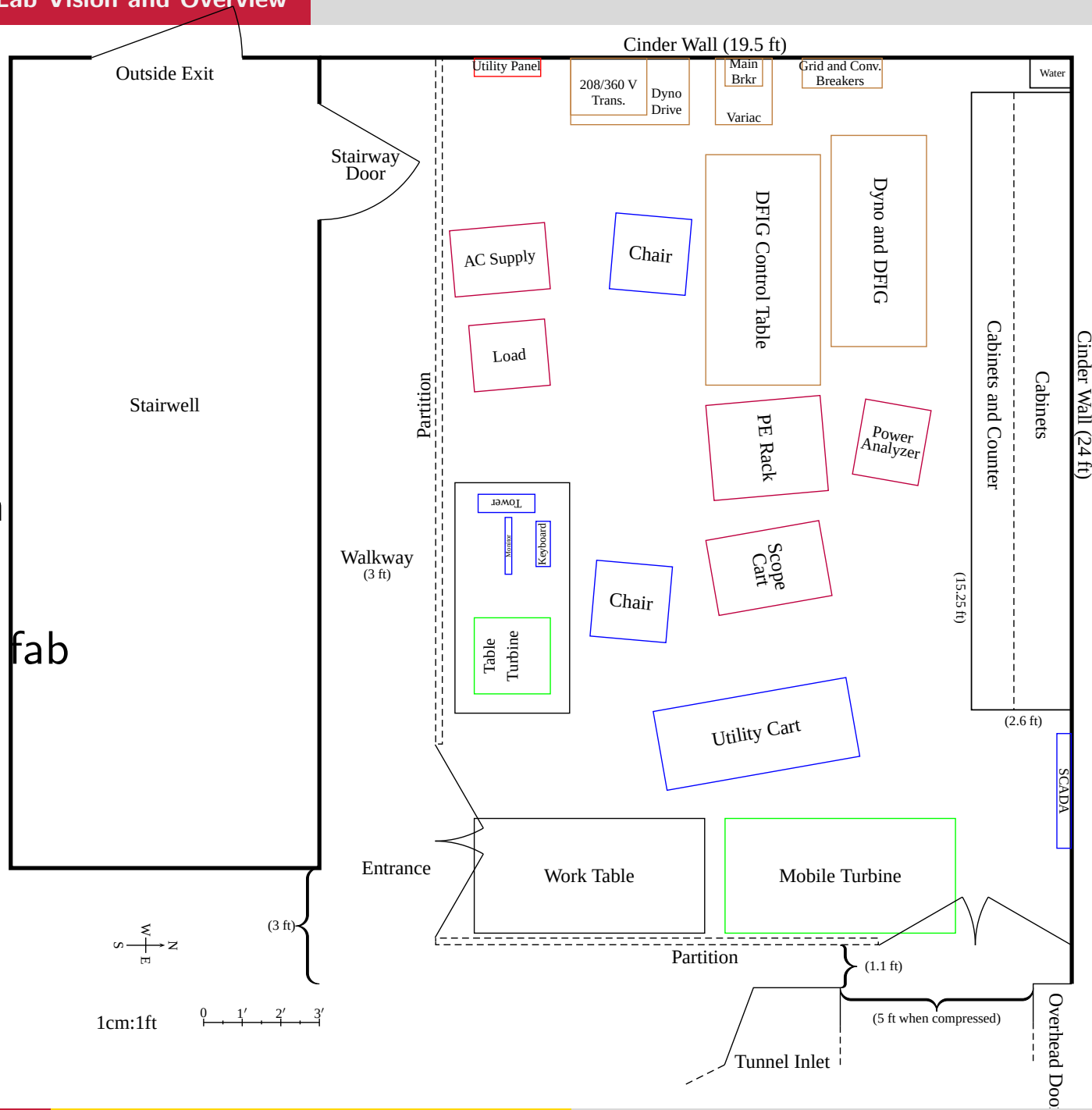
- National Wind Institute - Research & Education
- Boundary Layer Wind Tunnel
- Debris Impact Facility - 250 mph "spud gun"
- SWiFT Facility: Turbine-to-Turbine Interactions & Rotor Technologies (three V27, 300 kW turbines)
- West Texas Mesonet - 84 met stations ; Field Laboratories - wind pressures

- Howe Hall: WiST
- Wind Tunnel
- Overhead Door
- Expand South
- *480 V, 208 V, 3-ph
- 120 V 1-ph
- Wood, Metal, Glass fab

* $30 - 50k

* Coover 1101

* Others?

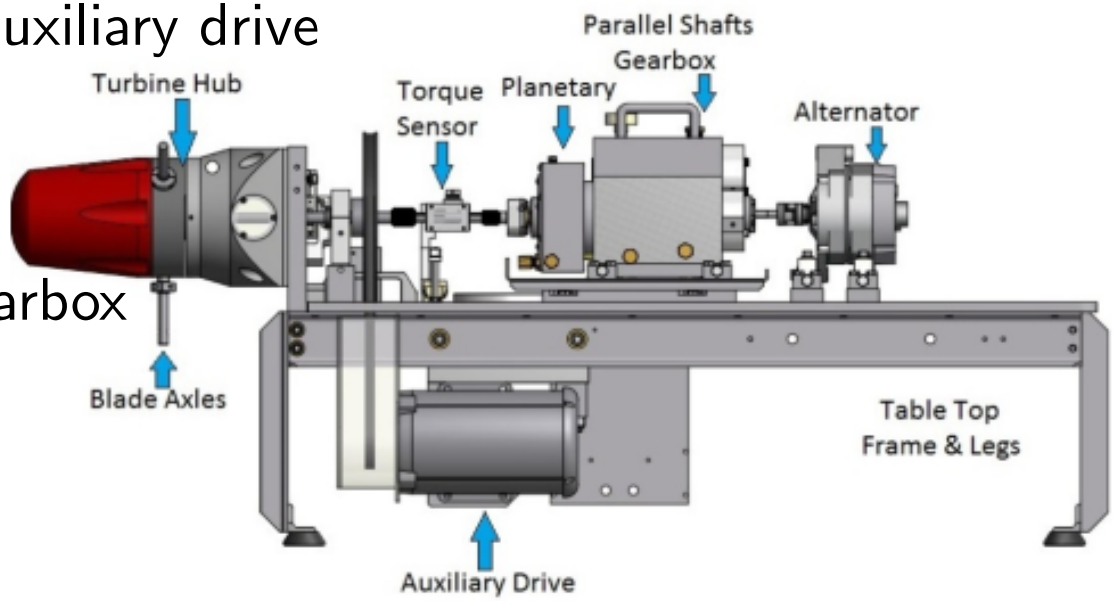


Mobile Wind Turbine - Jan 2015

- 8' to hub
- 48" fiberglass blades, replaceable with 5' custom
- Pitch and yaw control
- 500 W DFIG with drive and controller
- Planetary and Parallel shaft gearbox
- Anemometers and wind vanes
- Strain gauge for Lift and Drag
- Strain gauge for tower tilt
- Main Shaft torque transducer
- 1 HP auxiliary drive
- AC/DC power measurement
- 16 ch DAQ with Vibraquest for LabVIEW

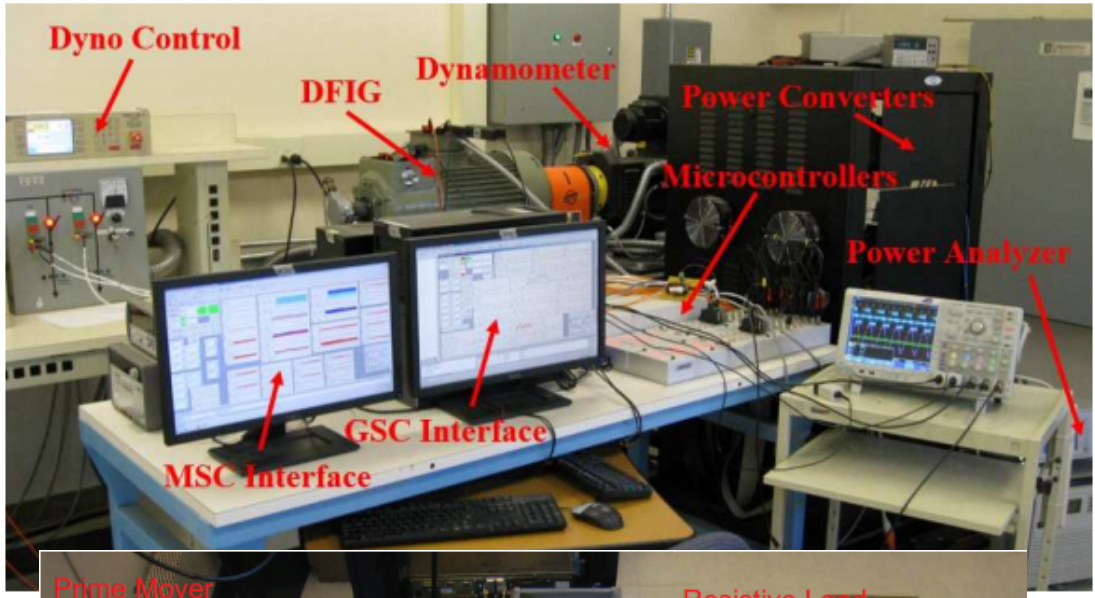
Tabletop Simulator - Jan 2015

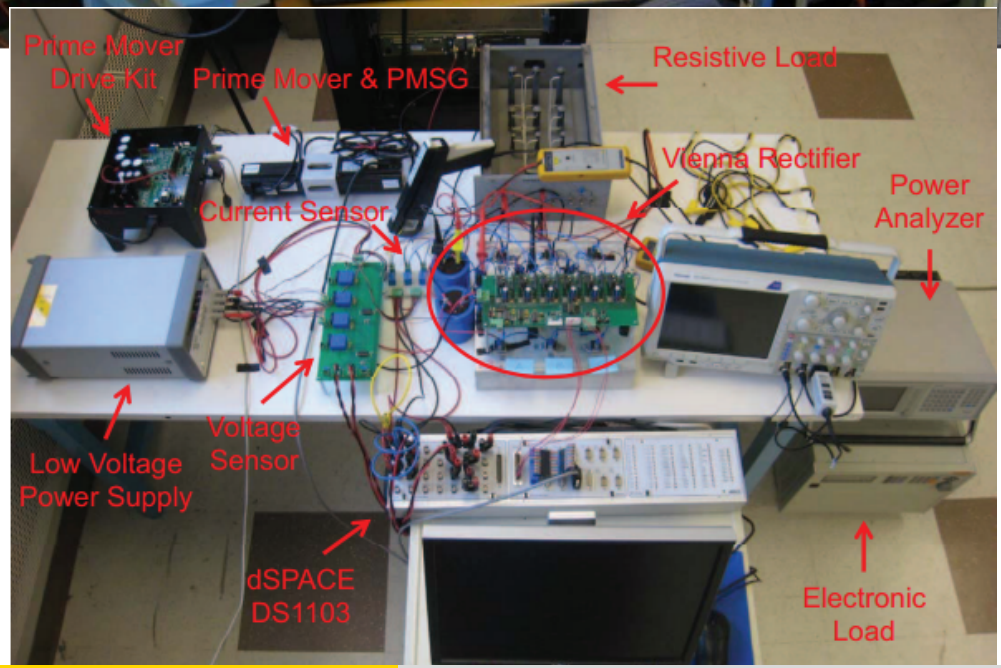
- Tabletop system
- Replaceable blades to 2.5' custom
- Use with wind tunnel or 1HP auxiliary drive
- Pitch control module
- 500 W PMSM and DFIG
- Planetary and Parallel shaft gearbox
- Strain gauge for Lift and Drag
- Strain gauge for Shaft Shear
- Main Shaft torque transducer
- 8 ch DAQ with Vibraquest for LabVIEW
- Time and frequency, statistics, signatures, data recording



Dynamometer, Machines, and Electronics

- 12 kW, 3200 rpm, 56 Nm Dyno
- 7.5 kW DFIG
- 2.5 kW Back-to-Back Converter
- Vienna Rectifier & 3-ph Bridge
- PMSM and ACI machines
- Custom Interfacing
- dSPACE controllers; MATLAB
- cRIO controller; LabVIEW
- DC and AC power supplies
- Programmable Loads
- DC–102 kHz Signal Analyzer
- Scopes, probes, etc.

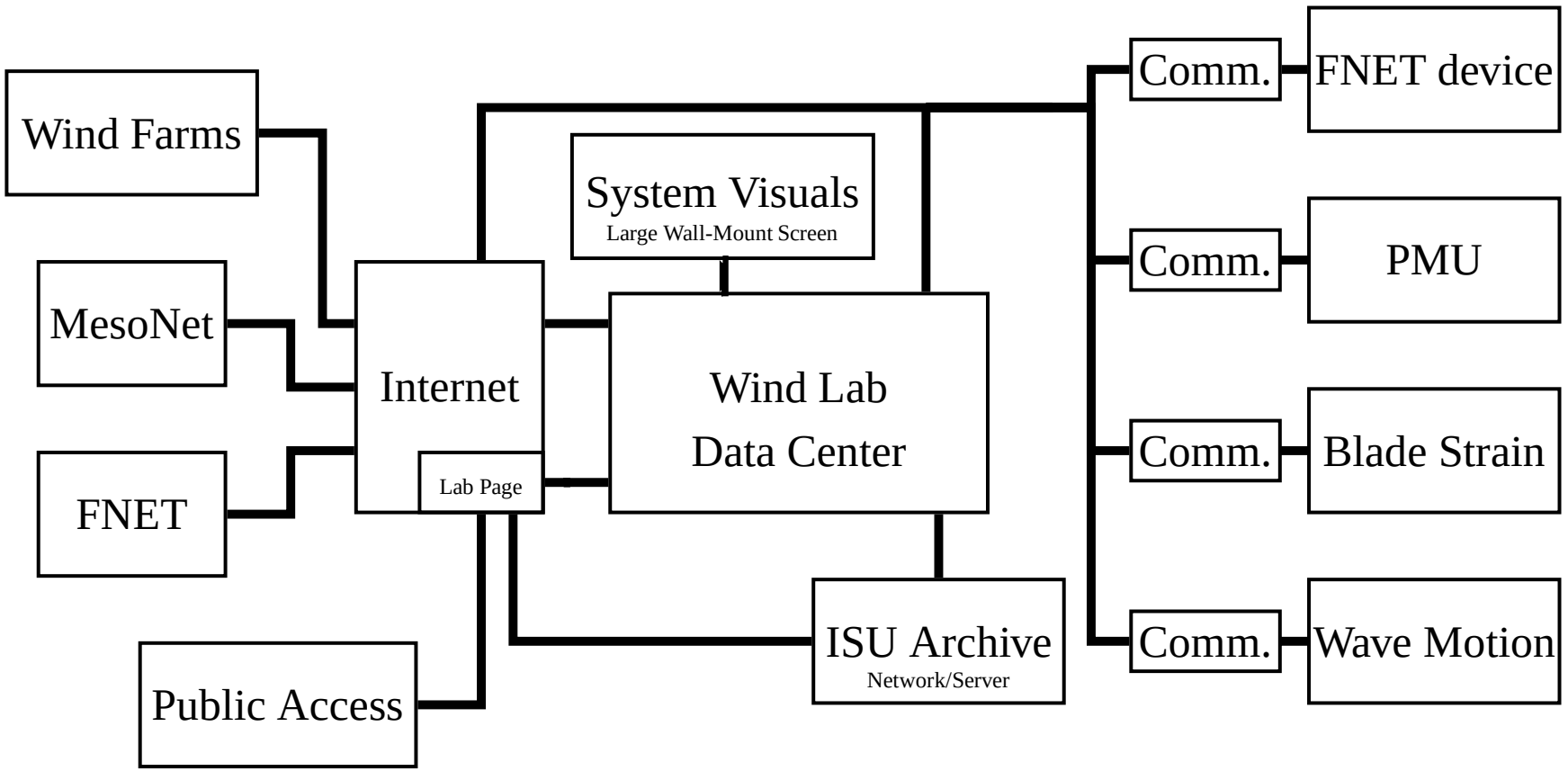




Data Center

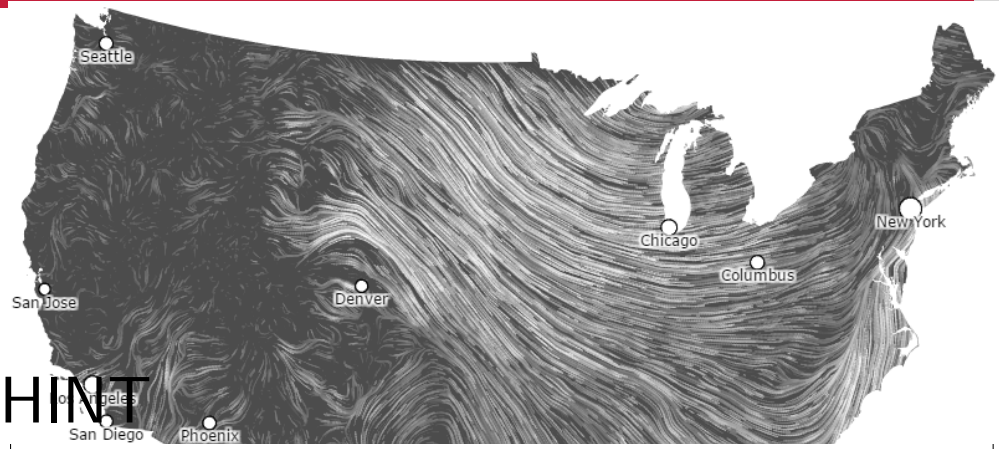
External Networks & Archives

Internal Network Devices

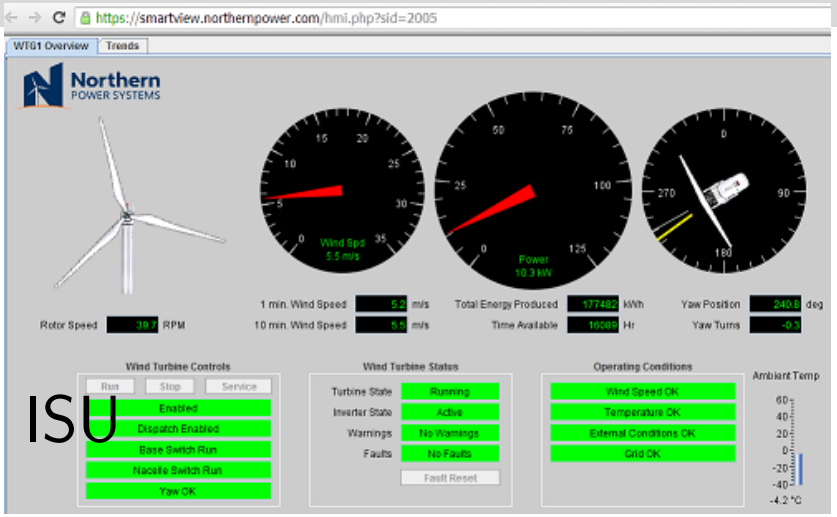


Potential for Data & Information:

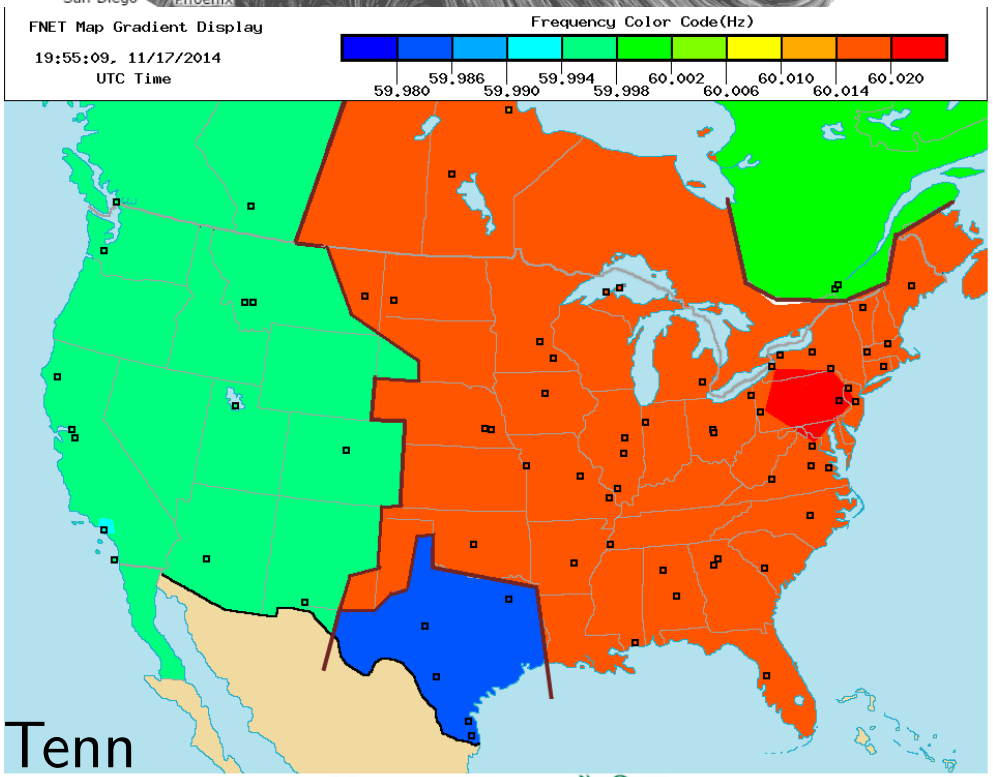
- Iowa Energy Center
- ISU Wind Turbine "Smart View"
- Community Wind Projects - stock data and/or custom sensors
- Met Towers - ISU Agronomy Mesonet + others
- Collection and Distribution systems - Rock Island Clean Line
- University of Tennessee Wide Area Frequency Measurement System (WaFMS)
- Utilities and ISOs
- Research Projects!



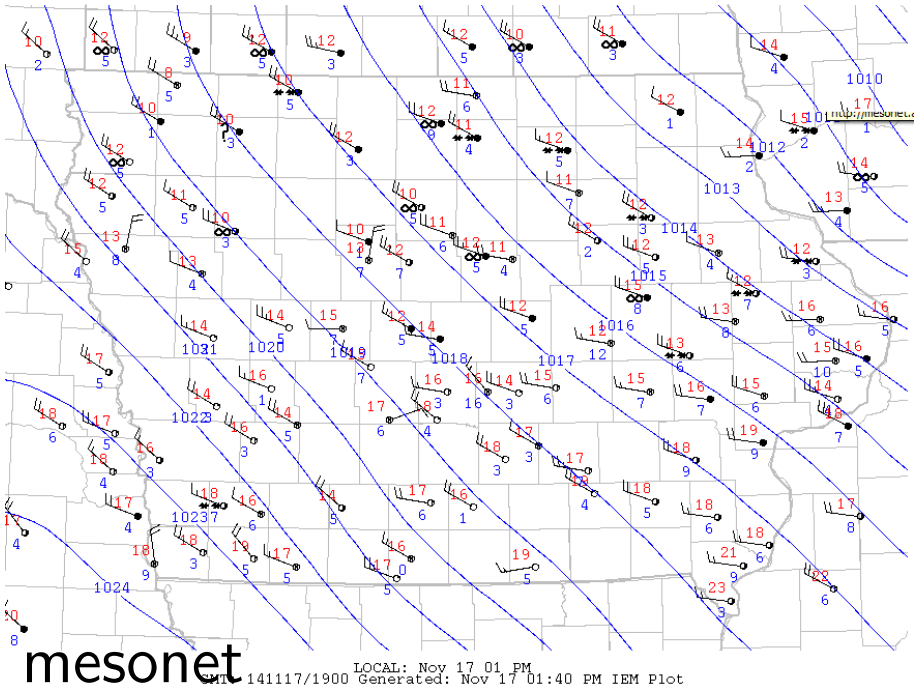
HINT



ISU



Tenn

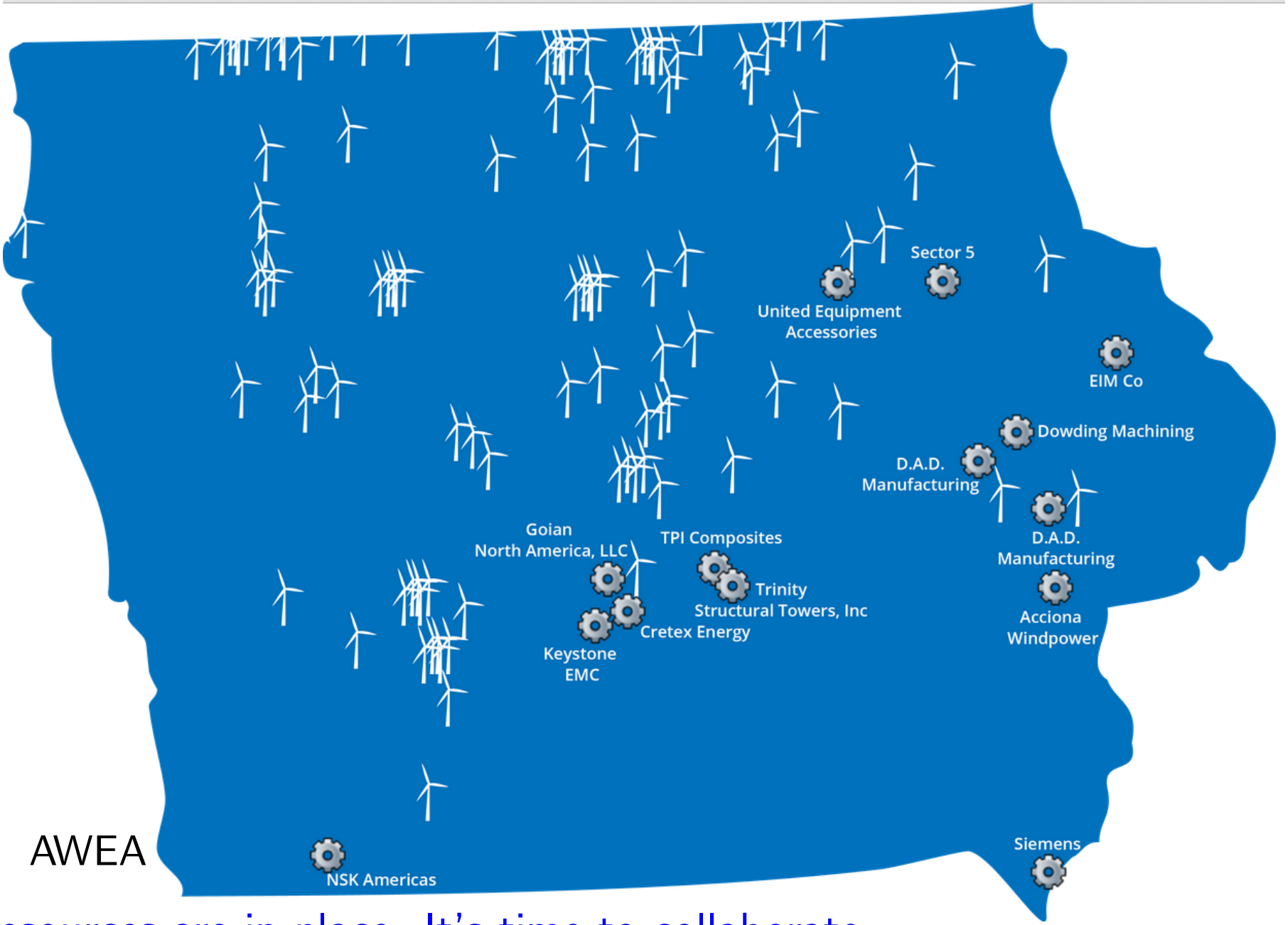


mesonet

THE UNIVERSITY of TENNESSEE
OAK RIDGE National Laboratory

UMASS

What Data Interests You?



AWEA

Resources are in place. It's time to collaborate.

Participating Programs:

- Wind Energy Science, Engineering, and Policy
- Aerospace Engineering
- Agronomy
- Civil, Construction, and Env Engineering
- Electrical & Computer Engineering
- Geological & Atmospheric Sciences
- Industrial & Mfg Systems Engineering
- Mechanical Engineering

Beyond Campus:

- K-12
- General Public

Financial Resources:

- ECpE: \$2.5k + space
- IMSE: \$2.5k
- AeroE: \$2.5k + space
- Agron: \$2.5k
- COE: \$5k
- EPSCoR: \$35k
- IGERT: \$130k
- Total: \$180k

Research, Educate, & Engage!

Additional Funding Sources?

ISU Course Activities

Courses:

- Engr 340
- AER E 341
- AER E 481
- EE 459/559
- WESEP 501
- WESEP 502
- WESEP 511
- WESEP 512
- Others?

Example Labs:

- Power Conversion Concepts
- Yaw and Pitch
- Aerodynamics and Loading
- Blade Kinematics
- Resource Characterization
- Collection and Distribution
- Control Design and System Response
- System Topologies
- Sensing and Health Monitoring
- Others?

K-12

Support science and engineering curriculum in Ames and Surrounding Communities

Activities & Use:

- Energy Conversion and Use Perspectives.
  (how much wind to do work: toast bread, light a room, charge a phone?).
- Wind Turbine system components.
  (Blade design comparisons, geared vs. Direct Drive)
- Hands-on, engaging activities (3D Printing).
- Effects of location and orientation within resource.
- Predicted vs. Measured power generation.
- Ideas?

Create a "K-12 education group". Volunteers?

General Public

Public Outreach:

- Resource for data and information; Web Portal
- Link between public and university programs
- Access data archives
- Promote Activities
- Disseminate results
- Community engagement (energy fairs, forums, policy support, etc.)

Research Areas

- Day-Ahead Wind and Power Forecasting
  historical met & SCADA analysis
- Turbine/Farm Wake and Interference Impacts
  relative rotation directions, complex terrains, fixed/floating
- Aerodynamics
  acoustic noise modeling, dual-rotor designs
- Preventive and Predictive Maintenance, and End of life planning
  optical crack detection, strain sensors, wireless monitoring, blade re-use
- Electricity markets and transmission
  grid flexibility, generation and transmission operations with new technologies
- Electric machines, control, and SCADA systems
  PMSG efficiency, distributed wind farm control, cyber-physical security
- Increasing Turbine Capacity
  hub height, capacity factor

Supporting Research

WESEP Students:

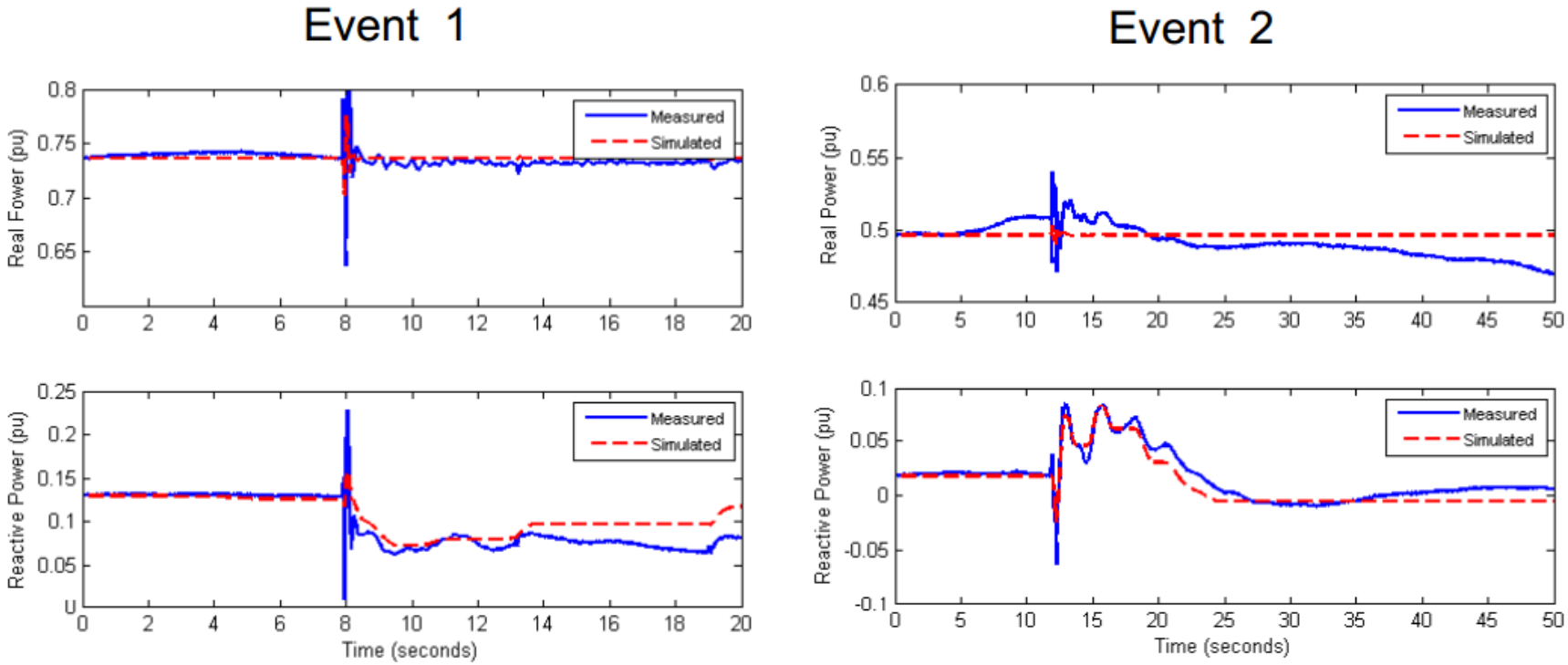
- Helena Khazdozian - PMSG design validation
- Jeremy Van Dam: Acoustic Emissions from Blade Impacts
- Mat Wymore: Wireless sensors and turbine/component health
- Austin Herrema: Blade design/structure interactions - load testing
- Michael Czahor: Lifetimes - operation/failure data and prediction
- Morteza Khosravi: Experimental Aerodynamics with turbine motion
- David Jahn:
- Nick Brown: Demand Response - Experimental Device Modeling
- Huiyi Zhang: Automated Blade Defect Inspection - Imaging Drones
- Heather Sauder: Blade response in gusty winds - 3' turbine in tunnel
- Armando Figueroa: Hi-res wind power data - Collection Network
- Matt Fischels: Algorithm optimization- Turbine model validation
- Aaron Rosenberg: Dual-Rotor Design Validation
- Austin Downey: SCADA - sensors and data acquisition/reporting
- Bin Cai: Tower segment design validation
- Robert Peggar:

What evidence adds value to your claim? What tools are required?

Supporting Research

Don't just simulate, Experiment!

Wind Plant Model Validation:



http://www.ieee-pes.org/presentations/gm2014/PESGM2014P-000535.pdf

Moving Forward

- Acquire Equipment - Project Driven
- Establish Curriculum and Content
- Plan and Build meaningful Experiments
- Collect Data and Provide Access
- Augment and Customize Systems
- Disseminate Results and Conclusions
- Create Partnerships and Opportunities

Future Plans

- Combine ISU Wind Energy Labs - Establish a "Wind Energy Center"
- Expand Space and Share Capabilities under One Roof
- Lead Evolution of the Wind Industry