Wind Energy Systems Laboratory (WESL)

Capabilities and Activities

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September 27, 2016

1. Laboratory overview
2. Research involvement
3. Wind Energy Student Organization (WESO)

Participating Programs:

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

Beyond Campus:

- Area schools, K-12
- Community involvement

Research, Educate, & Engage!

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.

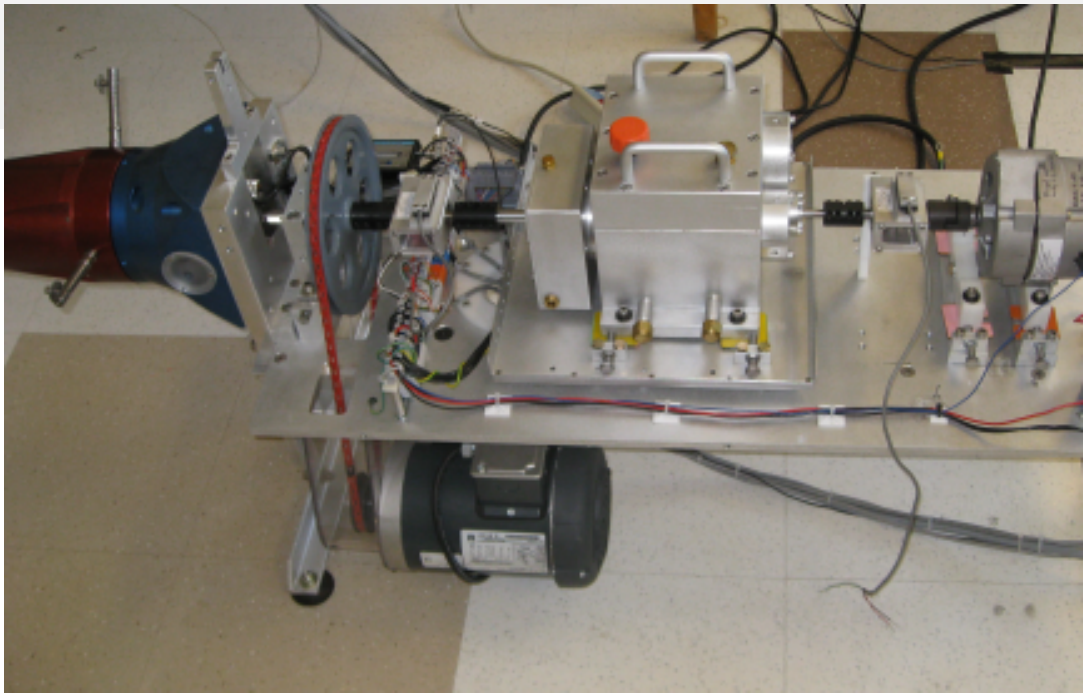
Resources:

- 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

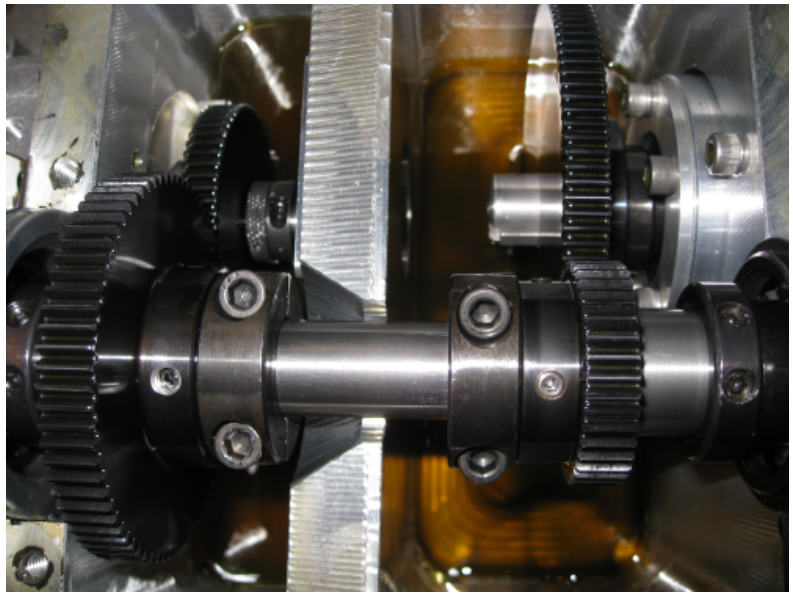
Mobile Wind Turbine

- 12' to hub
- 48" & 60" fiberglass blades
- 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

Tabletop Simulator

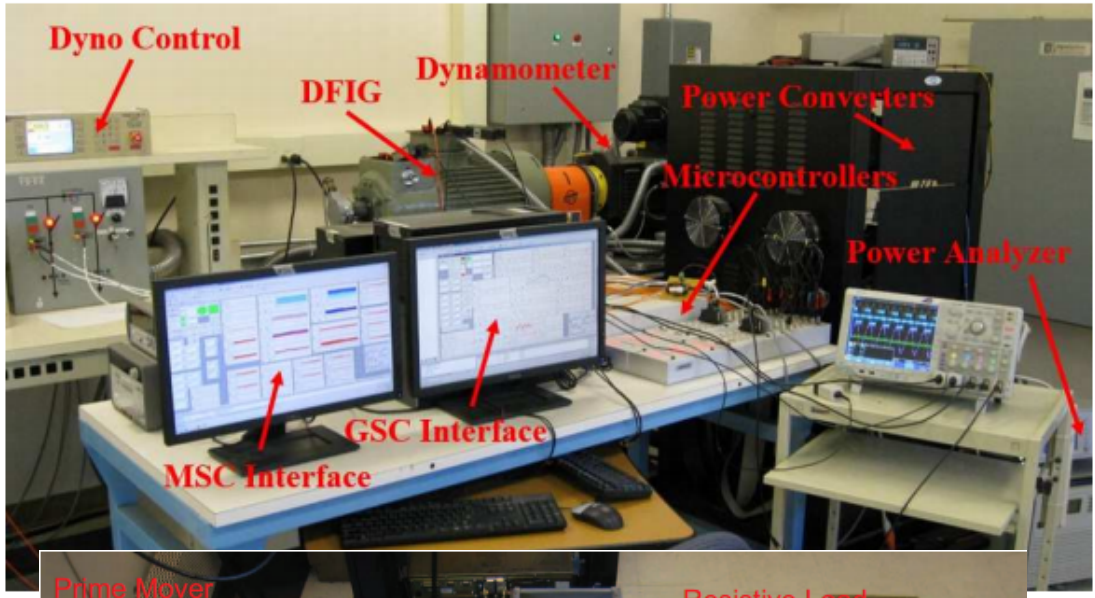


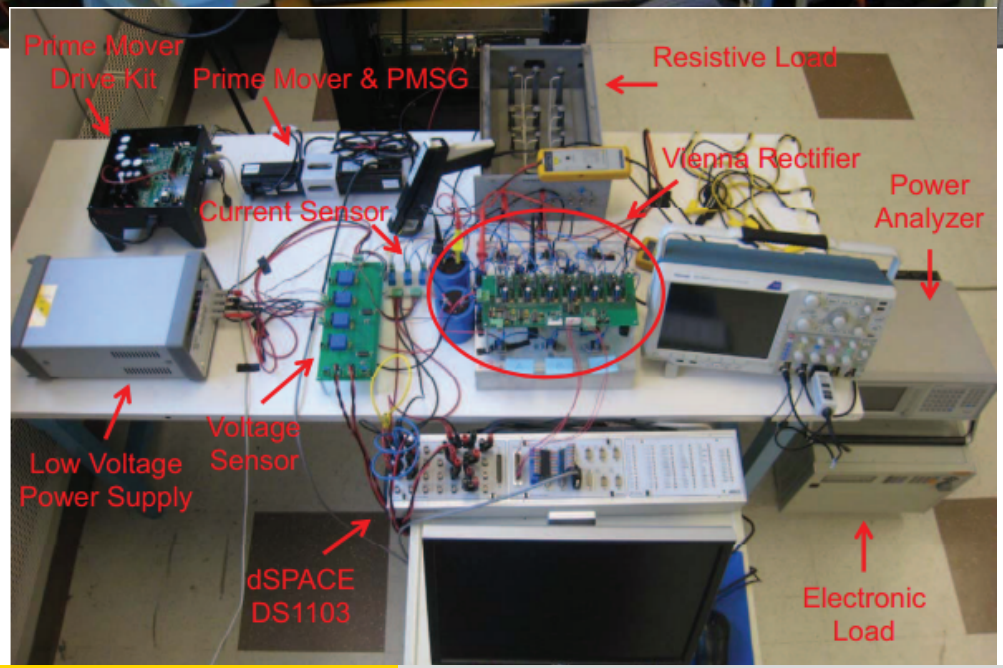
- Tabletop system
- Replaceable blades
- 1 HP auxiliary drive
- Pitch control module
- 500 W synchronous generator
- Planetary and Parallel-shaft gearbox
- Accelerometers for vibration
- Main shaft encoder for speed and angle
- Main Shaft torque transducer
- 16 ch DAQ, 200 – 5 kHz sampling



Dynamometer, Machines, and Electronics

- 12 kW, 3200 rpm, 56 Nm Dyno
- 7.5 kW DFIG with passive loads
- 2.5 kW Back-to-Back Converter
- Vienna Rectifier & 3-ph Bridge
- Synch. and induction machines
- Custom Interfacing
- dSPACE controllers; MATLAB
- cRIO controller; LabVIEW
- DC and AC power supplies
- Programmable Loads
- DC–100 kHz Signal Analyzer
- Scopes, probes, etc.





Microgrid power system Hardware-in-loop

Human Interaction — SCADA - NI PXI or RIO Chassis Computer and display

Distribution system simulation
OPAL-RT

Programmable AC Power Supply
AC Interconnection Emulator
Chroma Grid-Emulator

Programmable 2Q DC Power Supply
DC Interconnection Emulator
Chroma DC Supply

Legend
- Network data/communication
- AC power network
- DC power network
- HIL voltage and current I/O
- User input/output

Live Data Sources
Local Wind and Solar Plants
MISO Pricing signals
PMU measurements

MG1

Local Loads
3-ph programmable Load

400 W PMSG
Wind Turbine Emulator

MG2

7.5 kW DFIG Generator
Wind Turbine Emulator

1kW PMSG Generator
Wind Turbine Emulator

1-ph AC motors, lights, etc.

Energy Storage Emulators
AC/DC power sharing
Ammetek AC Power
Chroma DC Supply

Power Quality Analyzer
Oscilloscope
Data Recorders

MG3

DC appliances; heater, cooler, lights, etc.

Programmable 1Q DC Power Supply
Solar Generator Emulation

Solar Panels and irradiance sensors

Additional Resources

Aerospace Engineering:

- Bill James Wind Tunnel - 150 mph
- Aeronautic and Atmospheric Boundary Layer tunnel - 8x6 ft, 110 mph
- Blue Tunnel - Particle Image Velocimetry
- Icing Tunnel - Low Speed, Ice Formation
- Laminar Flow Tunnel - Low Speed Aerodynamics
- M2I lab - Design and Fabrication

- IMSE - Wind Energy Manufacturing Lab; Blade fabrication
- Civil Engineering - Structures Lab; Concrete towers

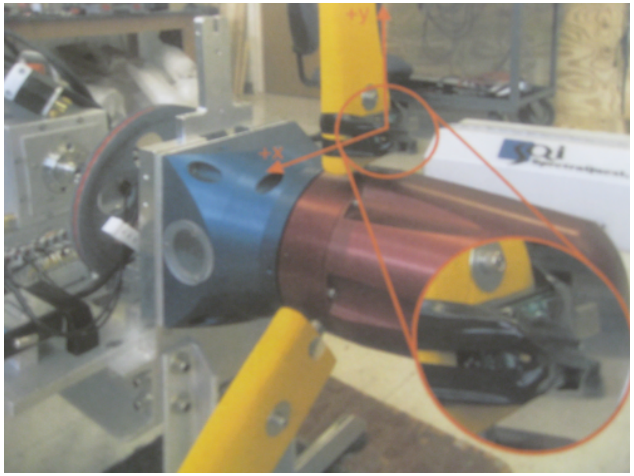
Others:

- Agronomy - Mesonet 120 m tower
- 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
- ISU solar photovoltaic

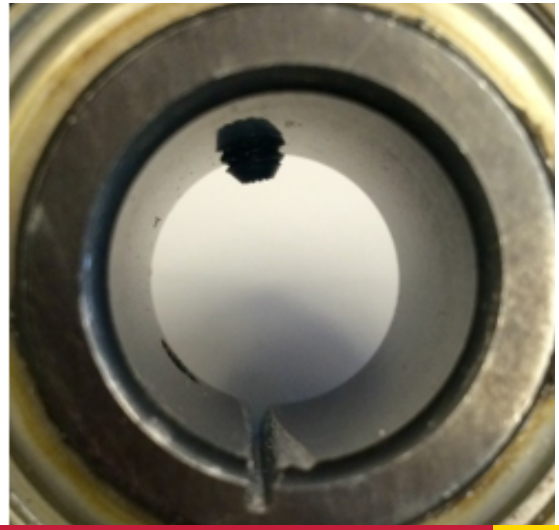
Research Ideas

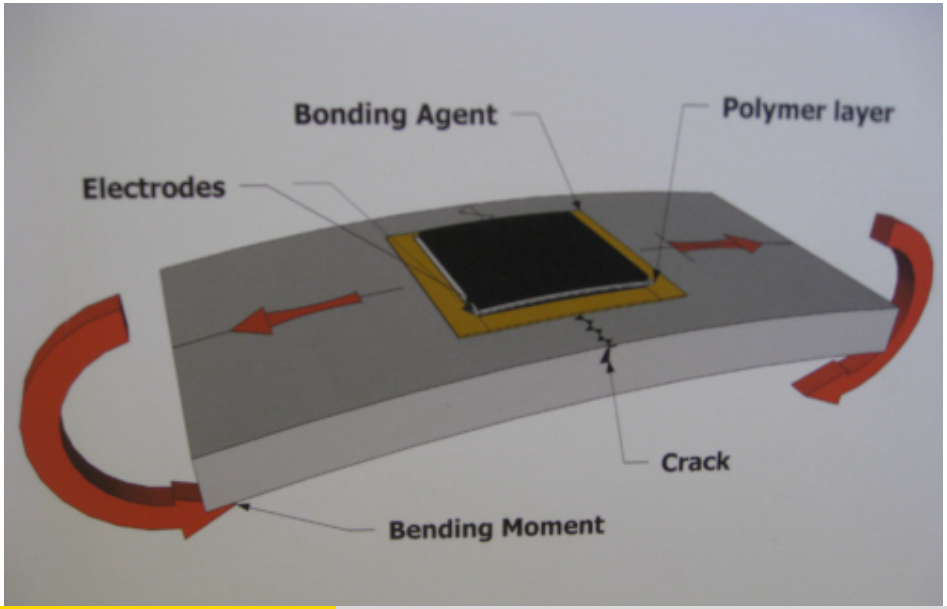
- Day-Ahead Wind and Power Forecasting
  historical meteorological & SCADA analysis
- Turbine/Farm Wake and Interference Impacts
  relative rotation directions, complex terrains, fixed/floating
- Aerodynamics and Blade performance
  Blade dynamics, acoustic noise modeling, dual-rotor designs
- Preventive and Predictive Maintenance, and End of life planning
  crack detection, strain gauge forces, wireless monitoring
- Electricity markets and transmission constraints
  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, vertical yaw

Past and ongoing research:



- Helena Khazdozian: PMSG characterization
- Austin Downey: Sensory material
- Mat Wymore: Wireless sensing
- Drs. Chao Hu & Zhixiong Li: Gearbox health
- Nick David: DFIG & PMSG Control
- Research Experience for Undergraduates (REU):
  Website dataset, Nanobarometer validation
  PMSG stand and tests, Gearbox monitor
- **What do you need to study?**





ISU Course Activities

Courses:

ENGR 340

AER E 341

AER E 481

EE 459/559

WESEP 501

WESEP 502

WESEP 511

WESEP 512

Lab Activities:

- Power Conversion Concepts
- Generators and System Topologies
- Aerodynamic load and blade pitch
- 3D Blade Profiling
- Wind Resource Characterization
- DFIG Control Design and Dynamic Response
- Sensing and Health Monitoring
- NEW - Video demonstration series

Wind Energy Student Organization (WESO)

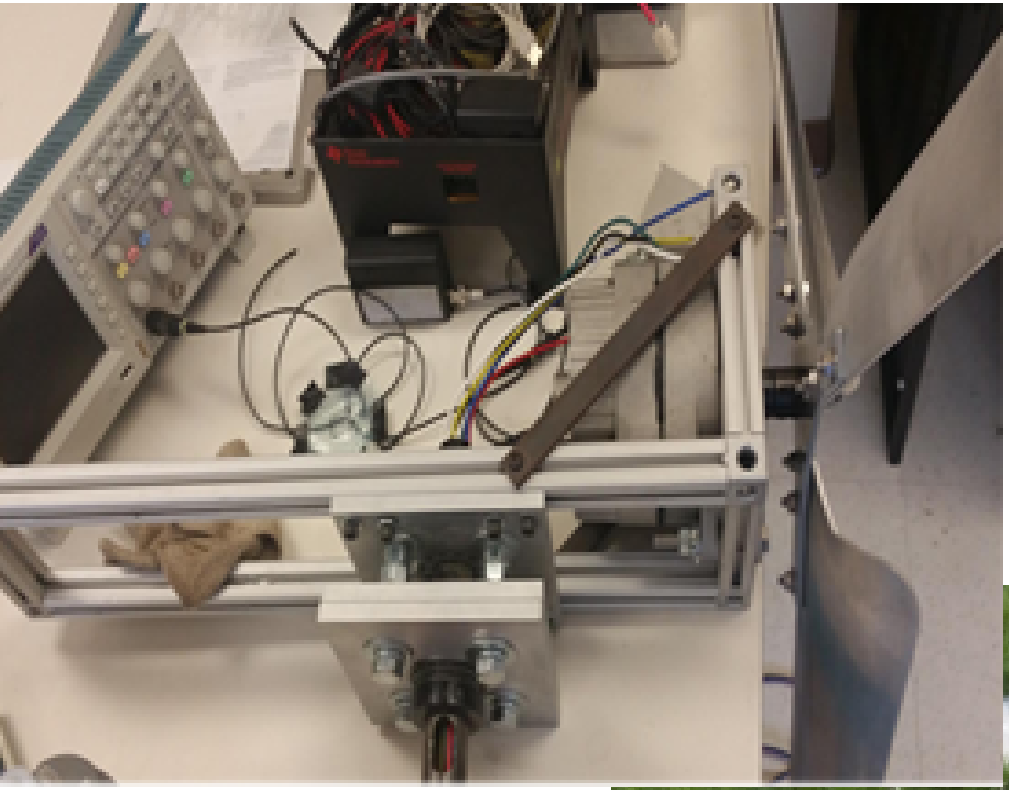
Foundations and Purpose:

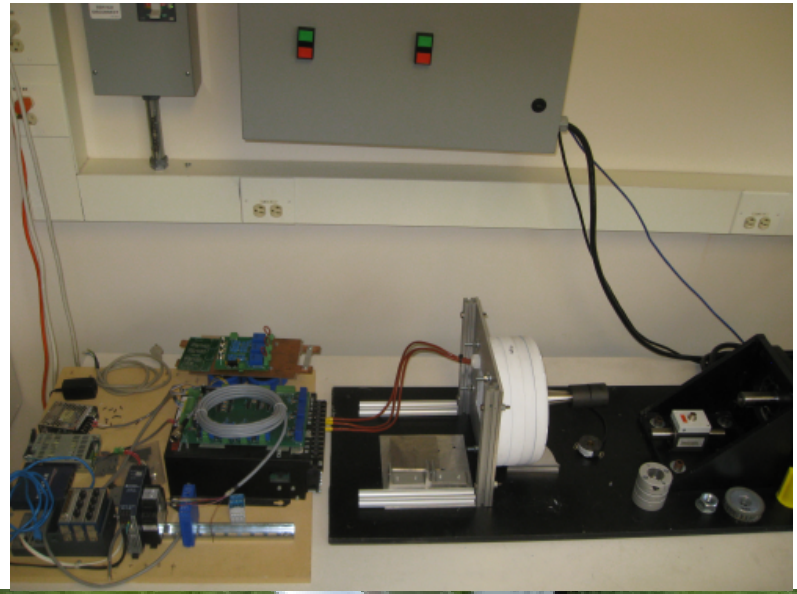
- Graduate and Undergraduate
- Relatively new; 2nd year
- Learn about the industry
- Connect with colleagues
- Build wind turbines
  Mondays at 5:30 pm

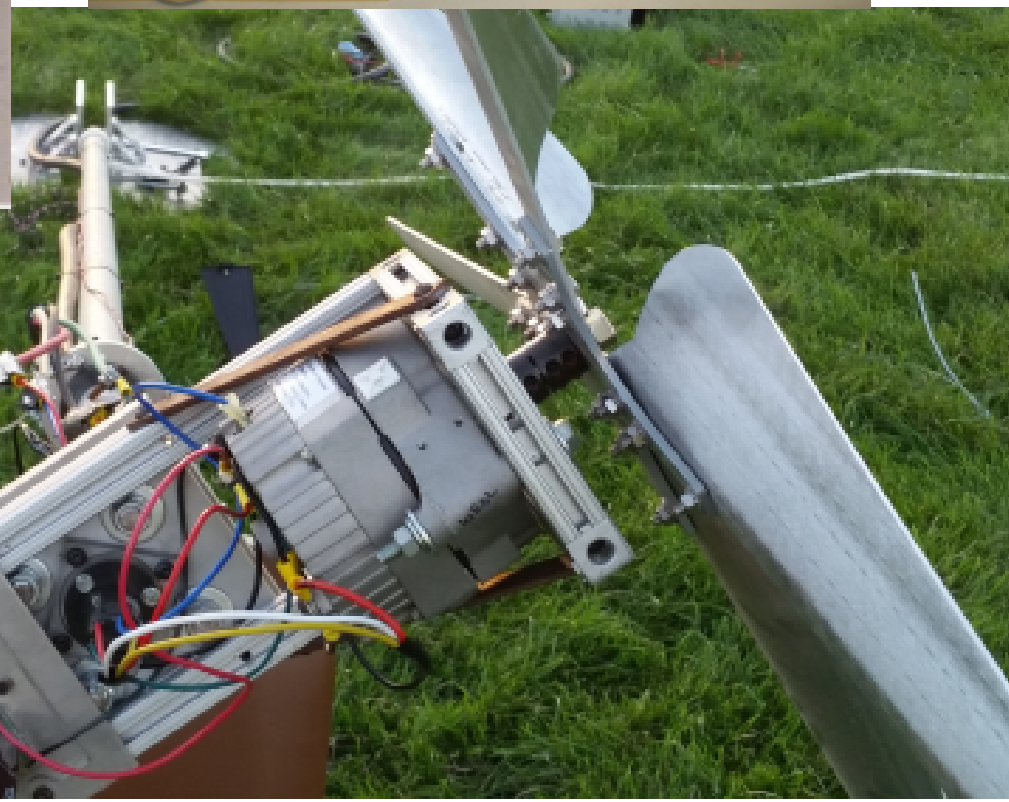
Ongoing activities:

- Outreach events
  on & off campus
- Mentor and advise
  Influence change!
- Educational seminar series
  Blade airfoil, generator winding, tower loading, material engineering, power system operations, etc.

We need you!







K-12 and Public Outreach

Support STEM curriculum in Ames and surrounding communities

K-12 Activities & Use:

- Energy conversion and power use.
  (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).
- Turbine demonstration platform; measured power generation.
- Engaging activities to raise awareness and interest.
- K-12 education group - volunteers??

Public Outreach:

- Resource for knowledge; disseminate results
- Link between public and university programs
- Organize tours and speakers
- Community engagement (energy fairs, forums, policy support, etc.)