University of Delaware

College of Earth, Ocean, & Environment

Newark and Lewes, DE

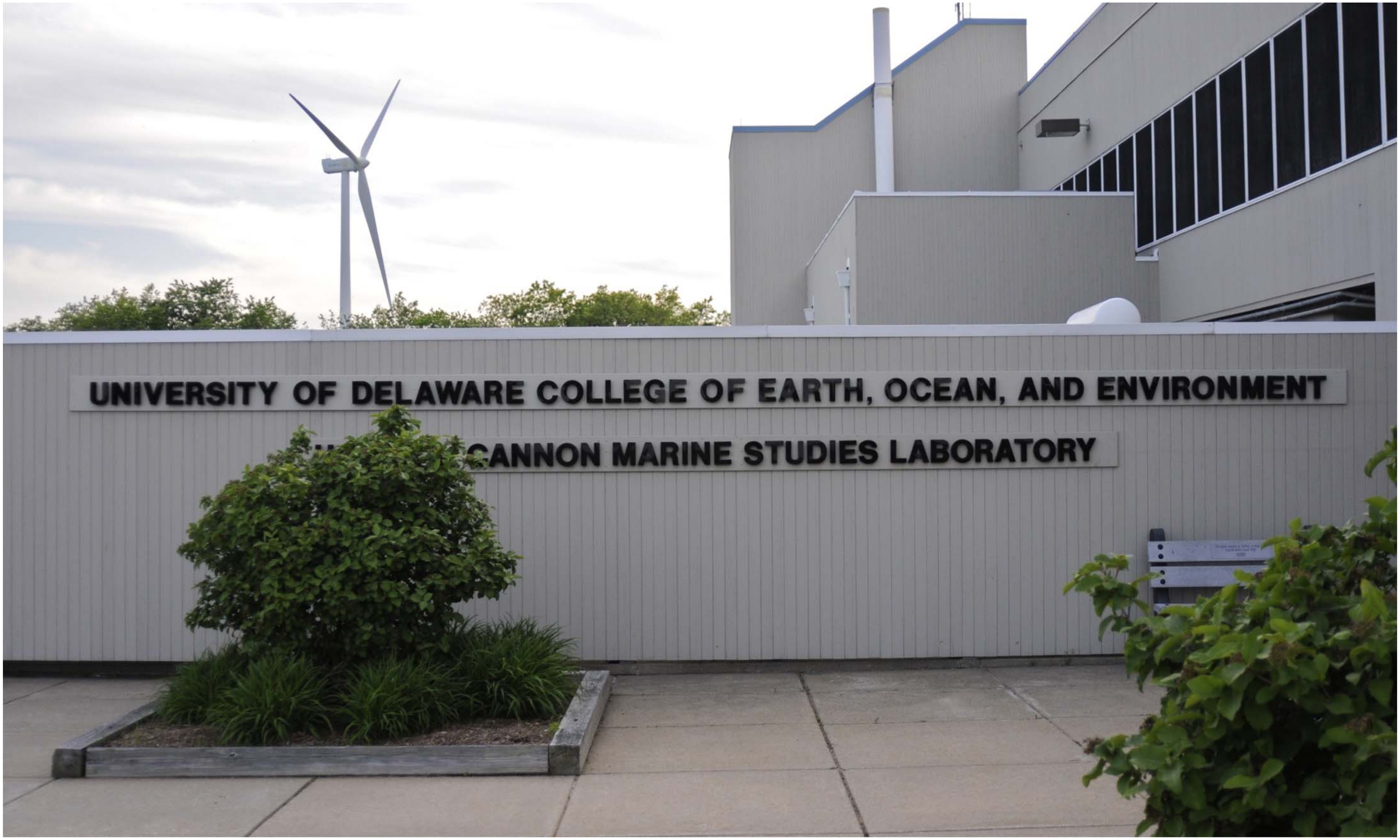
Turbine Commissioned, June 2010

Opportunities

- **Innovation/Research**
  - Advance next generation of offshore wind turbines through research
- **Education**
  - Train tomorrow's energy leaders and technicians
- **Positive Impact for Delaware**
  - Position the state today for tomorrow's technologies
  - Reduce pollution
- **Community Partnerships**
  - Work with the City of Lewes and the Board of Public Works to advance green technologies
  - Cost neutral to residents of Lewes

Energy Generation

- Will generate 5.25 to 5.5 million kWh/year
  - At times, will generate less energy than UD uses (low/no wind)
  - At other times, will generate more (high wind, low energy consumption)
    - Excess power will go to LPBW @ wholesale cost, this means that Lewes residents get clean power at no additional charge.
  - UD net usage ~5 million kWh/year



Inaugural Year Review

UD's Wind Turbine

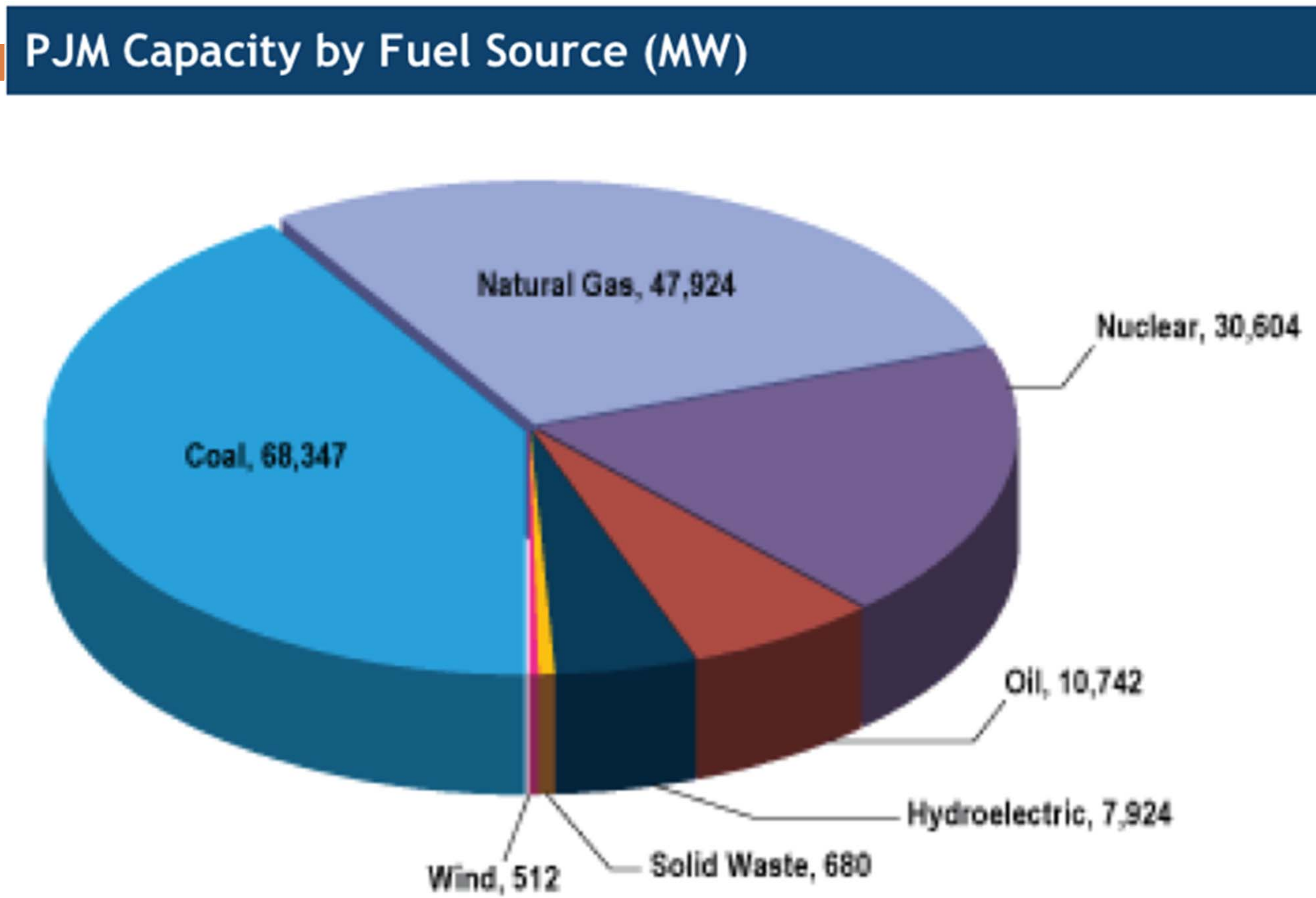
Outline

- Turbine Production
- Educational Opportunities
- Research
  - Avian
  - Corrosion
- Sound Study
- Public Outreach
- Q&A

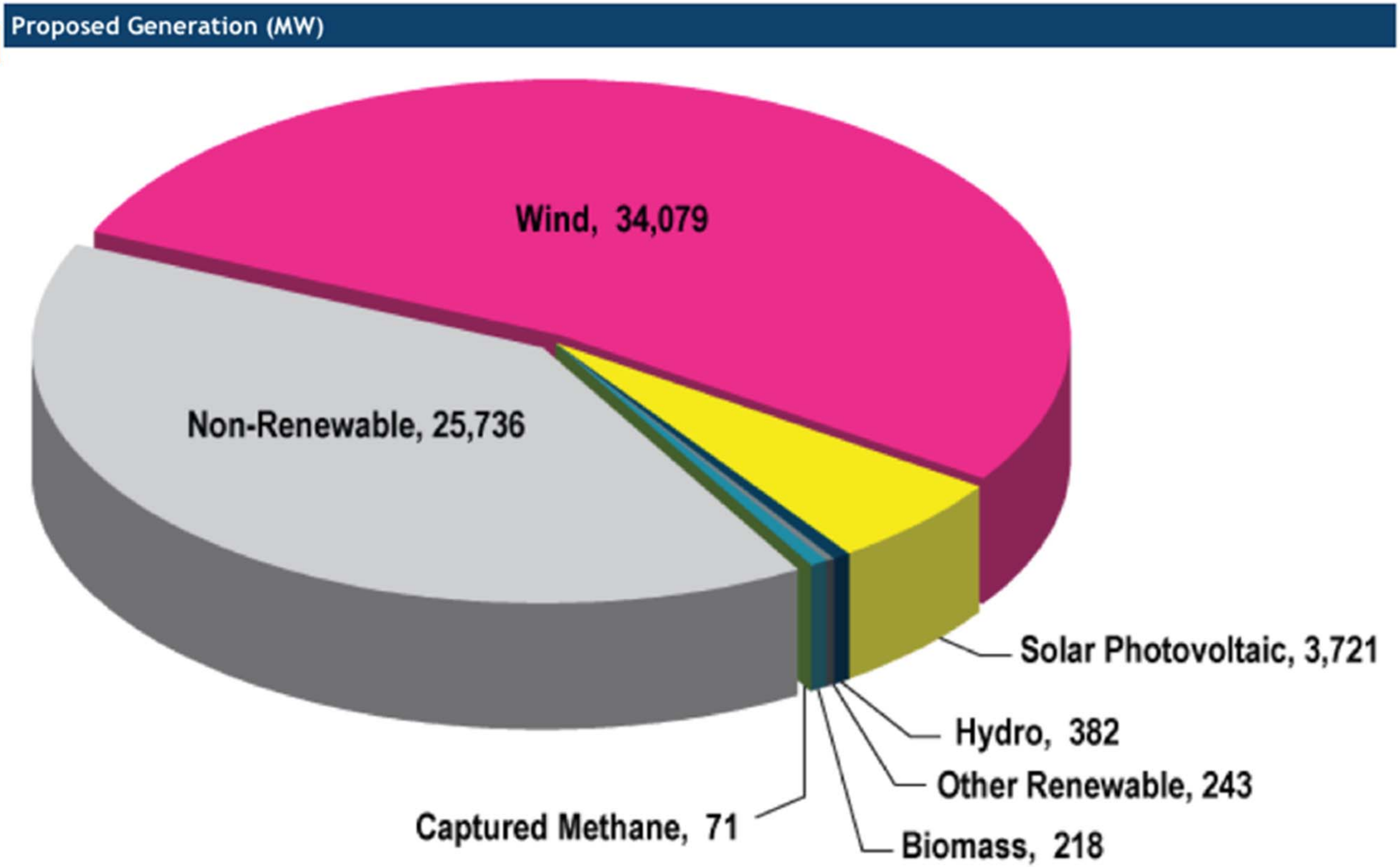
Why Wind Power?

- No pollution, no greenhouse gases
- Energy independence
- Potential for job growth in DE
- Wind is a mature renewable energy technology
- UD research & training goals: Reduce cost, improve performance; train engineers for this growing industry

Existing Generation in our Region



Proposed Generation in our Region



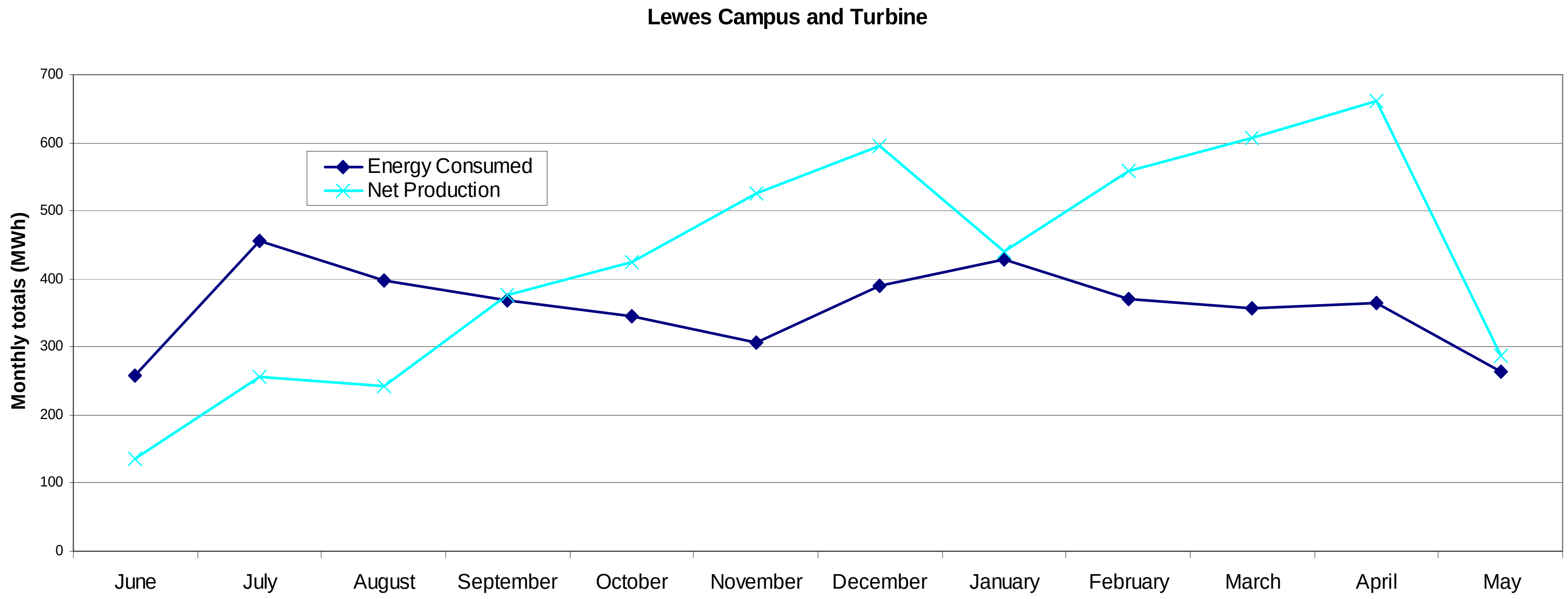
from: PJM renewable-dashboard, May 2011

Turbine Production Overview

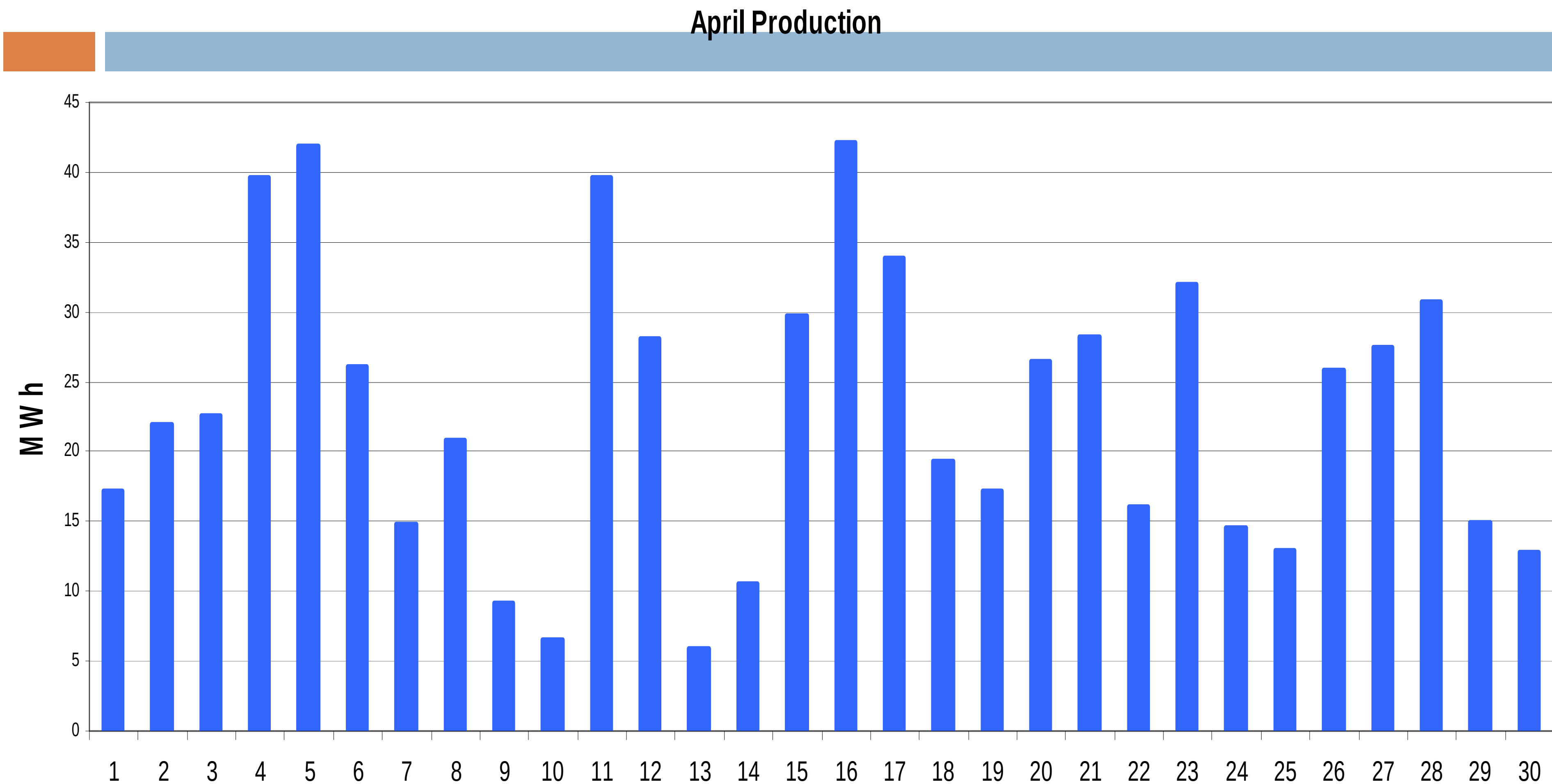
(June 11, 2010-May 31, 2011)

- Gross Turbine Production: 5,143,200 kWh
- Energy Sent to Turbine: 34,800 kWh
- Net Turbine Production: 5,108,400 kWh
- **Lewes Wind Energy Consumption**: **1,283,880 kWh**
  - **Enough Electricity for about 120 Lewes homes**
- Capacity Factor: .3

Wind Turbine Production and Campus Consumption



Daily Variation (April, Example)



Avian and Bat Protection Plan *Objectives*

- 2-year post-construction avian and bat survey
  - I. Enhance scientific knowledge and understanding
  - III. Components
    - Avian & Bat Surveillance and Assessment
    - Advisory Group
    - Recommendations and Reporting

- Partnership between University of Delaware and Delaware State University

Avian Survey Seasons

- 2011 and 2012 Field Seasons
  - Spring (March 1 – May 31): Daily
  - Summer (June 1 – July 15): Every three days
  - Fall (July 15 – October 31): Daily
  - Winter (November 1 – February 28): Once/week
- Started Monitoring March, 2011

Avian Fatality Searches

- 170m x 170m square plot centered on turbine
  - Searchers walk transects 10m apart

- Correction for Sampling Bias
  - Weather-related fatalities
  - Removal by scavengers
  - Searcher efficiency
  - Influence of vegetation type on ability to detect fatality

Avian Acoustic Monitoring

- Detects nocturnal bird and bat activity
- Two systems record acoustic calls
  - Nighttime flight calls of migrating birds
    - Records flight altitude
    - Species determined through by flight pattern and sonogram analysis

Image: www.wildlifeacoustics.com

  - Six bat detectors, record echolocation calls of bats
    - 2 on meteorological tower
    - 2 on top of turbine
    - 2 on isolated weather balloon (control)

UD's Wind Turbine

Thermal Imaging

- Captures nocturnal bird and bat activity with cameras
- Records animals passing through the rotor swept area
- Camera located on ground, oriented vertically

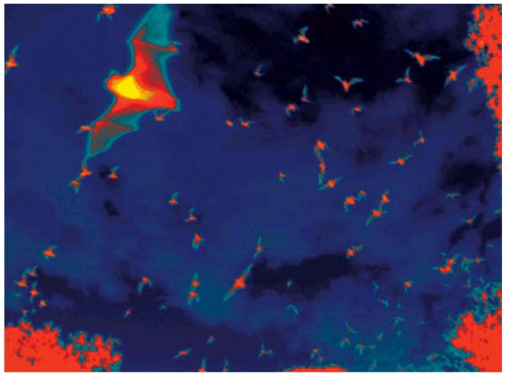


Image: www.bu.edu

Weather Radar Data

- Collect Level II data from Dover (WSR-88D)
- Analyze for nocturnal migration rates in the region and near turbine
- Analyze bird/bat activity related to weather patterns

Sound Study

December 2010

by Tech Environmental

DE Sound Limits (Residential)

- Cumulative Limits
  - 65 dBA in the daytime
  - 55 dBA at night (10 pm to 7 am)
    - L_{eq} (equivalent/average sound level)

- Incremental Limits
  - 10dBA
    - L_{90} (sound level that is exceeded 90% of time—that is the 10% quietest interval of any time period)

Measurements

- Consultant took 24 Measurements at Hoornkill Ave, December 6, 3:20 pm to Dec. 7, 12:20 am
  - No precipitation
  - Ground dry
  - Partly cloudy, 30-40°F.

- Hub Height wind speed
  - 8.6-12.9 m/s, thus at maximum sound power
  - Hoornkill, downwind

FIGURE 1.

Sound Monitoring and G90 Turbine Location
Lewes, Delaware

TECH environmental

UD's Wind Turbine

Cumulative Sound Results

- **Study Results**
  - L_{eq} 43-51.3 dBA (daytime)
  - L_{eq} 41.9-45.1 dBA (nighttime)
- **Delaware Standard**
  - 65 dBA (daytime)
  - 55 dBA (nighttime)

UD's Wind Turbine

Incremental Sound Results

MEASURED INCREASE IN THE L_{90} SOUND LEVEL (dBA)
FROM THE UD-GAMESA WIND TURBINE, ANALYZED BY TIME OF DAY
AT 16 HOORNKILL AVENUE, LEWES, DELAWARE

Turbine	Average Daytime L_{90} Sound Level	Average Nighttime L_{90} Sound Level
Operational	43.3	40.2
Paused	42.2	37.3
Increase Due to Wind Turbine	1.1	2.9

Incremental Sound Results - Binned

MEASURED INCREASE IN THE L_{90} SOUND LEVEL (dBA)
FROM THE UD-GAMESA WIND TURBINE, ANALYZED BY WIND SPEED BINS
AT 16 HOORNKILL AVENUE, LEWES, DELAWARE

Turbine	Wind Speed Bin 10.0 – 10.6 m/s	Wind Speed Bin 12.4 – 13.0 m/s
Operational	42.3	47.0
Paused	37.7	42.6
Increase Due to Wind Turbine	4.6	4.4

Well under DE Sound Standards

COMMON INDOOR AND OUTDOOR SOUND PRESSURE LEVELS

Outdoor Sound Levels	Sound Pressure (µPa)	Sound Level (dBA)	Indoor Sound Levels
	6,324,555	110	Rock Band at 5 m
Jet Over-Flight at 300 m		105	
	2,000,000	100	Inside New York Subway Train
Gas Lawn Mower at 1 m		95	
	632,456	90	Food Blender at 1 m
Diesel Truck 60 mph at 15 m		85	
Noisy Urban Area--Daytime	200,000	80	Garbage Disposal at 1 m
		75	Shouting at 1 m
Automobile 45 mph at 15 m	63,246	70	Vacuum Cleaner at 3 m
Suburban Commercial Area		65	Normal Speech at 1 m
	20,000	60	
Quiet Urban Area--Daytime		55	Quiet Conversation at 1m
	6,325	50	Dishwasher Next Room
Quiet Urban Area--Nighttime		45	
	2,000	40	Empty Theater or Library
Quiet Suburb--Nighttime		35	
	632	30	Quiet Bedroom at Night
Quiet Rural Area--Nighttime		25	Empty Concert Hall
Rustling Leaves	200	20	Average Whisper
		15	Broadcast and Recording Studios
	63	10	
		5	Human Breathing
Reference Pressure Level	20	0	Threshold of Hearing

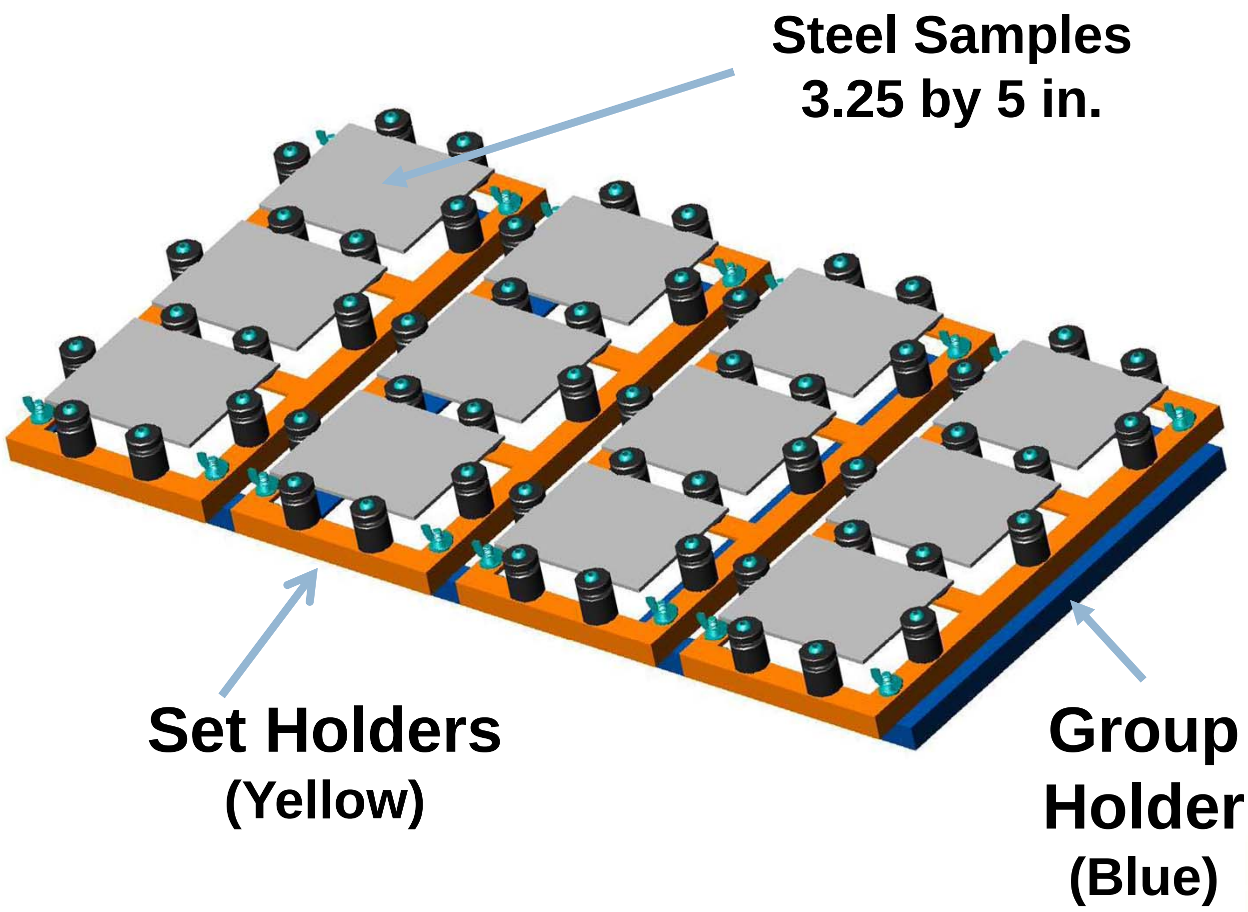
UD's Wind Turbine

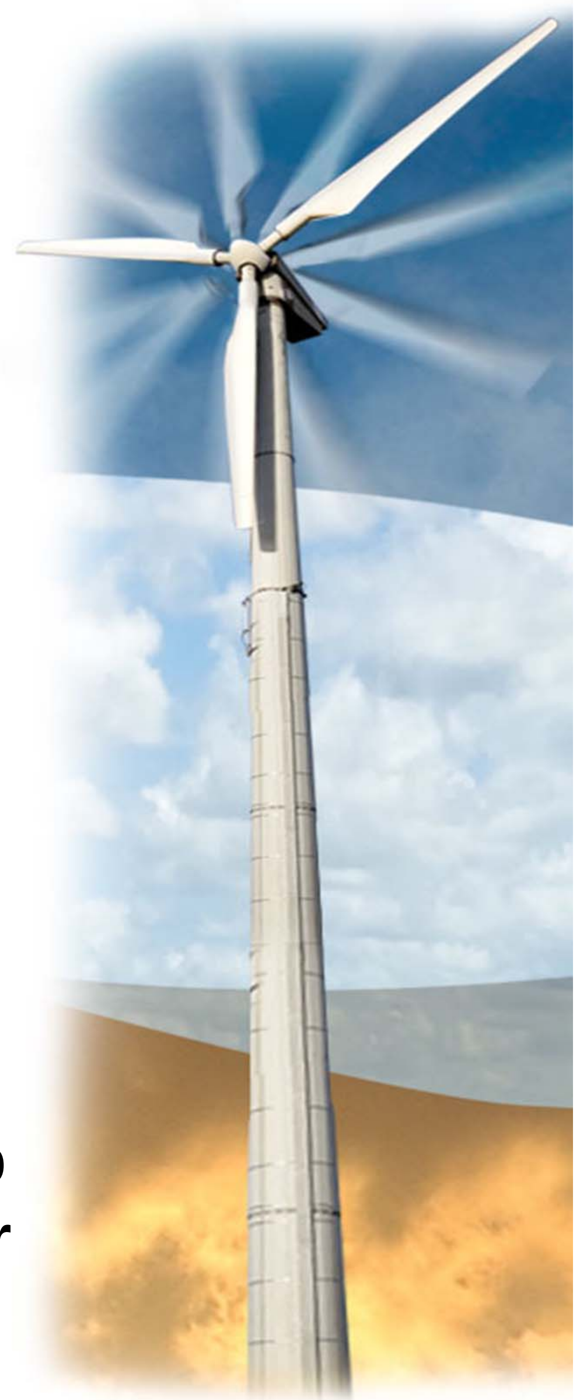
Turbine-related DOE research

- Corrosivity study- Steve Dexter
- Drive train wear and monitoring – David Burris

- Safety training for selected student researchers to install and repair instruments

Construction of Corrosivity Samples and Holders





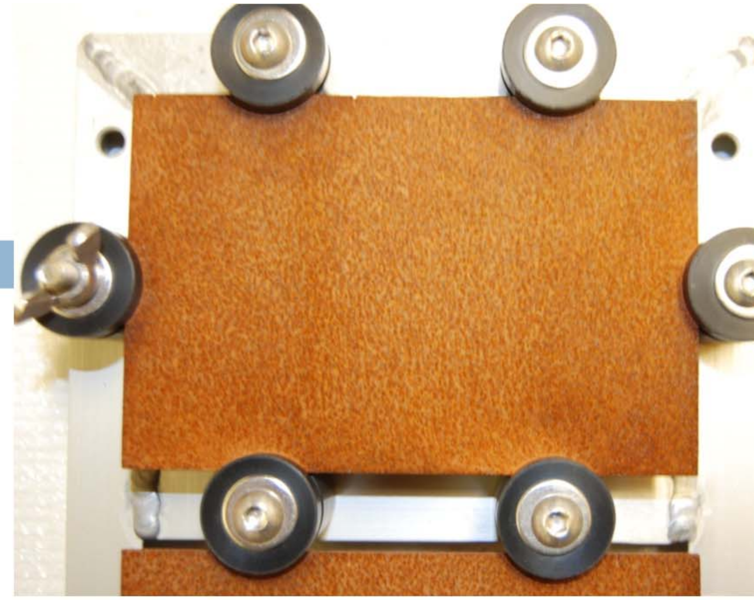
Testing

Location A

(MOB High)

(100 ft back 30 ft high)

Location A
(MOB High)

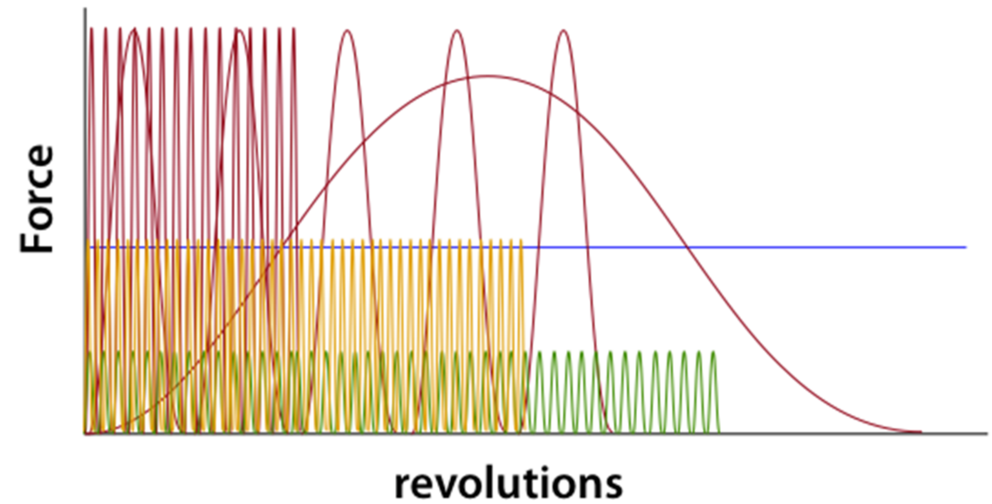


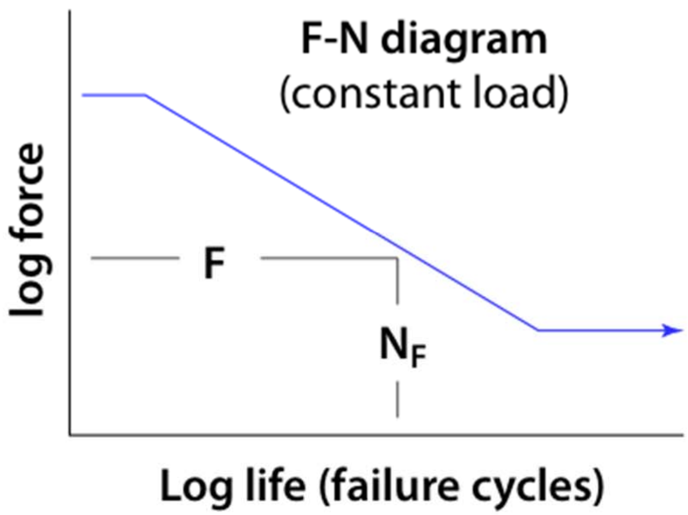
Change in Weight Over Time

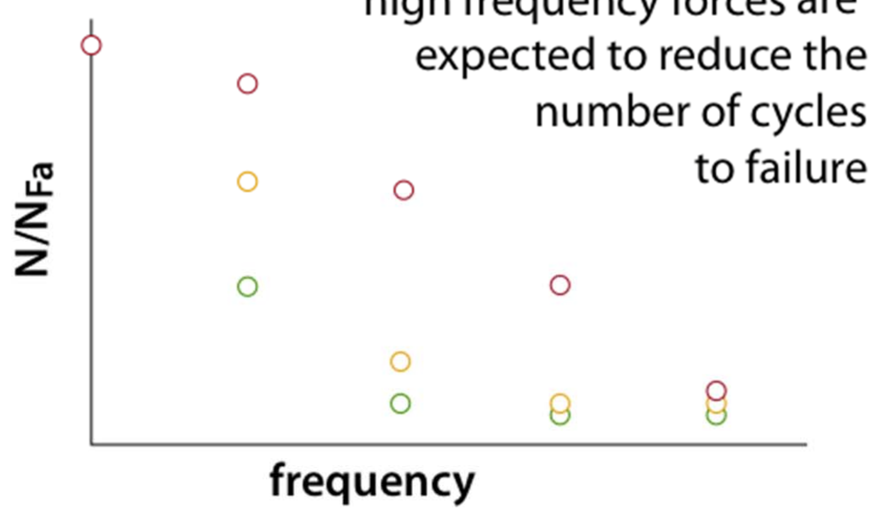
Location	Sample #	Initial Wt (gm)	Final Wt (gm)	Wt Loss (gm)	Wt Loss (%)
MOB Low	1	244.374	241.638	2.735	1.119
10 ft back 8 ft high	2	244.028	241.325	2.703	1.108
	3	242.991	240.205	2.785	1.146
MOB High	1	241.089	238.953	2.136	0.886
(100 ft back 30 ft high)	2	243.901	241.817	2.084	0.855
	3	243.782	241.663	2.118	0.869
At Turbine	1	244.165	242.650	1.515	0.620
(3ft high 1150 ft back)	2	241.941	240.428	1.513	0.625
	3	241.880	240.320	1.560	0.645

Q4-5: Effect of Dynamic Loads: Implications for Planet Bearing Life

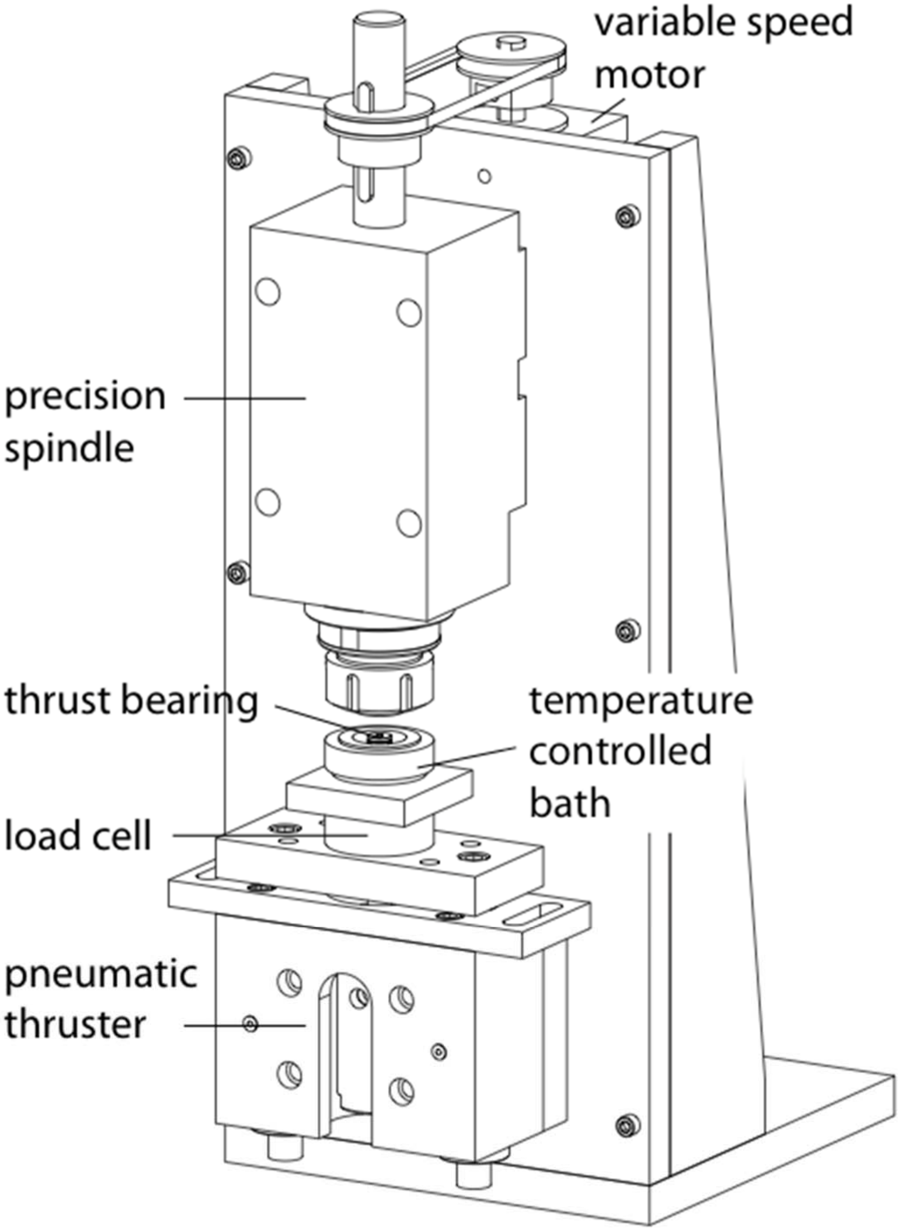
- *Wind loads are dynamic*
- *There have been no studies of this potential effect*
- *This is an area where we are unique*
- *Stationary contacts are the limit*
- *Design team working on force control system*

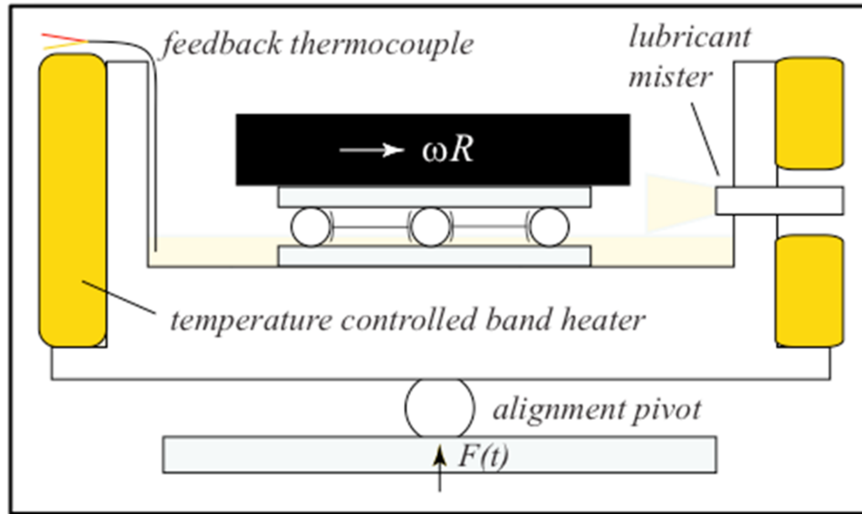






Q2: Thrust Bearing Tribometer





Features

temperature control
continuous access to samples
controllable loads and speed

Current

-Thermal control system is done
-spindle, thruster, motor controller, load cell, DAQ here and set up
-air lines have been run
-machining, assembly, software incomplete

The goals of this project are to: 1) understand the effects of wind specific factors on the lives of gear-box bearings; 2) identify design solutions for impr-oved reliability of the drivetrain.

Proposed Work

A. Collect relevant load data from NREL Gearbox Reliability Collaborative; Q1

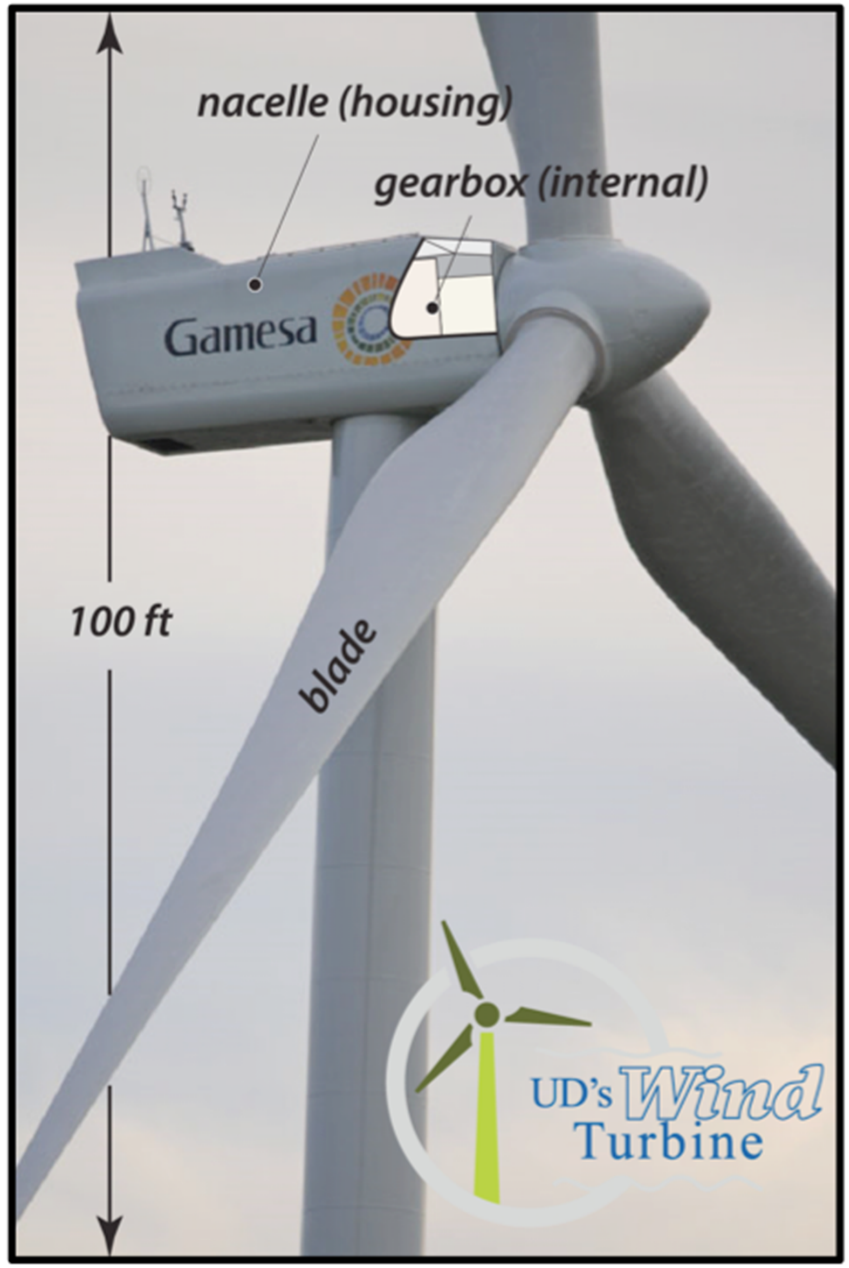
B. Reliability experiments - *Custom tribometry to assess and understand failure sensitiviy to lubricant, contaminants, and loads; Q3-6*

C. Instrument Lewes Turbine - *Evaluate the loads on a large-scale turbine; Q4*

D. Collect Turbine Data; Q4-8

E. Simulation Experiments - *Using reliability data, GRC data and turbine data, evaluate conditions for which failures are most likely; Q7*

F. Develop design strategies - *Use results of simulation experiments to develop strategies to minimize failure probability; Q8*



Student Education- An Outdoor Classroom

Turbine

Ongoing Public Outreach

Public Outreach
(July 2010 to present)

- Coast Day Showcase Exhibit
- Turbine bookmarks
- Multiple news stories
- Several visits to schools,
- Coastal News display in *Cape Gazette*
- *Webs*ite updates (added publications, Q&As)

Wind Turbine Signage

- **2nd Place**, National Federation of Press Women in the category of Print Media Advertising—Billboard and **First Place**, Delaware Press Association


UD's Wind Turbine
Gamesa
SED SUSTAINABLE ENERGY DEVELOPMENTS
Home | About Us | News and Events | Turbine Info | FAQ | Multimedia
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UNIVERSITY OF DELAWARE COLLEGE OF EARTH, OCEAN, AND ENVIR
CANNON MARINE STUDIES LABORATORY
Photo Caption
Current
Turbine Conditions
Wind speed: 20 mph
Wind direction: N/A
Rotor rotational speed: 16.7 rpm
Power output: 1049.5 kW
UD's Wind Turbine
Welcome
The University of Delaware and Gamesa Technology Corporation joined forces to install a utility-scale 2-
Latest Updates
Turbine Info
Turbine model Gamesa G90
Generator power 2 MW
Tower height 256 feet
Tower weight 203 tons
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Thank You

Q & A