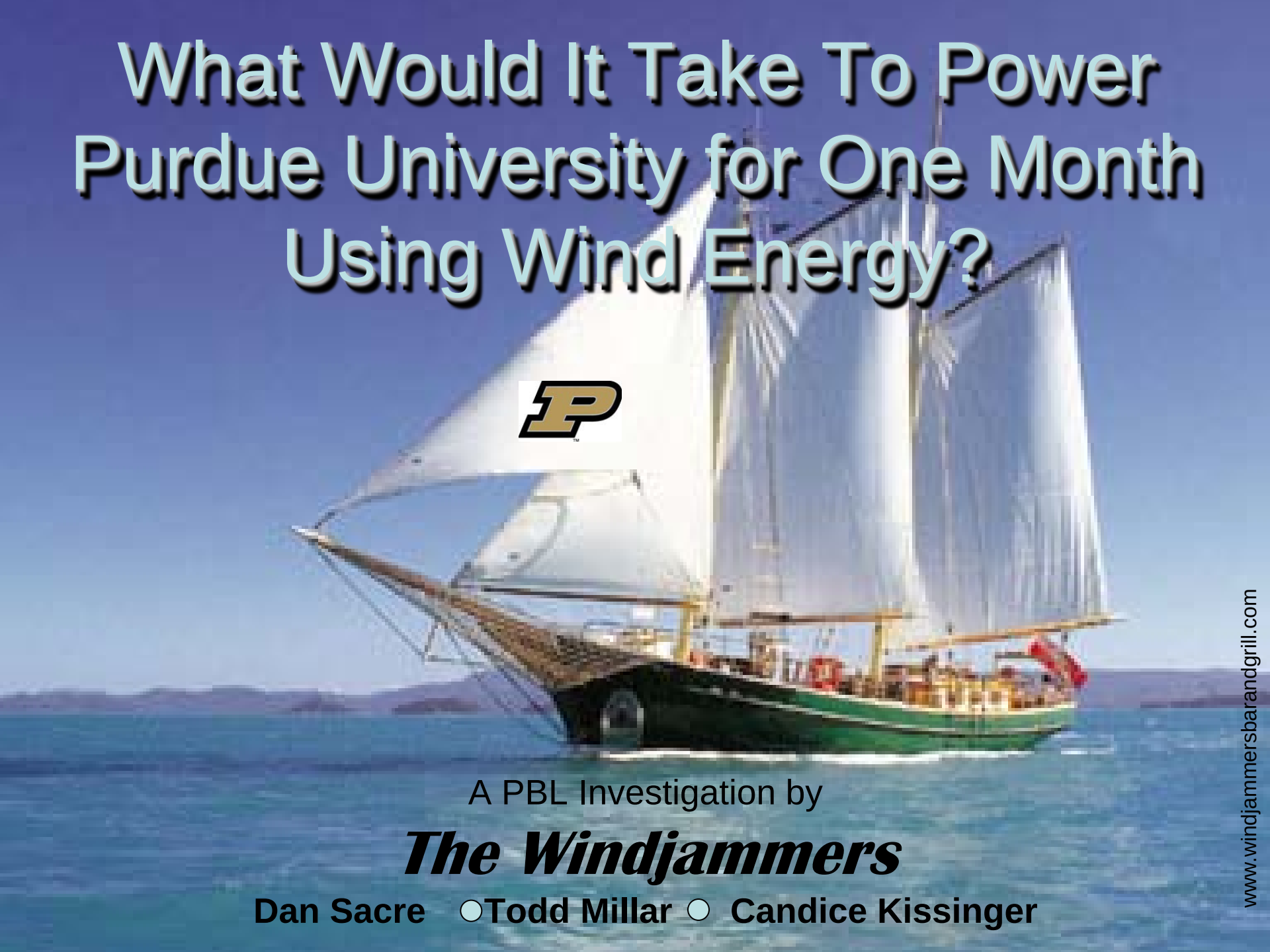
What Would It Take To Power Purdue University for One Month Using Wind Energy?



A PBL Investigation by

The Windjammers

Dan Sacre ○ Todd Millar ○ Candice Kissinger

www.windjammersbarandgrill.com

Plotting Our Course

http://commons.wikimedia.org/wiki/File:US_Navy_090624-N-3610L-388_Quartermaster_3rd_Class_Melissa_Pate_uses_a_compass_to_plot_the_movement_of_the_aircraft_carrier_USS_Ronald_Reagan_(CVN_76)_on_a_navigation_chart.jpg

Buy electricity from grid?

Is that enough or do they have other forms of energy?

Other Energy?

How much does it cost to produce power now?

Could $ 0.05/kwh from subsidized wind compete?

How many wind turbines would it take to replace present power sources?

What would have to change about the infrastructure?

What are the winds like in this part of Tippecanoe County?

Is there a better location for Purdue Wind Farms?

PRF and Animal Science??

Wasn't there an announcement in the J&C about this?

How much land would that take?

Does PRF have enough land?

Does Purdue have this land?

What happens when the wind dies down at night?

How much power must be on hand?

Is Wind Power Enough?

Who buys the turbines? Funding?

Donors?

Any Wealthy Alumni Whose Names Begin with "W"??

Grants?

Indiana?

Is wind going to be enough?

Purdue Powered by Wind?

What powers Purdue now?

How much kwh/month are needed?

What does the coal-fired power plant in West Lafayette contribute?

Electricity?

Heat (steam)?

Where does that coal come from?

Assignments

Dan

Investigate current power needs at Purdue

Calculate kwh needed in the most recent month and show basis of calculation

Investigate infrastructure already in place

Investigate wind characteristics of W. Laf.

Todd

Provide background on wind power based on visit to Horizon Meadow Lakes farm

Calculate no. of turbines needed to produce kwh needed by Purdue

Calculate land needed to support each turbine

Propose feasibility

Candice

Interview an expert on power generation at Purdue

Investigate announced plans for a wind farm associated with PRF land at Purdue Animal Sciences facility (“Swine Farm”) on US 52

Assemble PPT slides

http://www.purdue.edu/stemgoesrural/About/2nd_cohort.html

Purdue Wade Utility Plant

Map data: copyright 2011, Goggle Earth

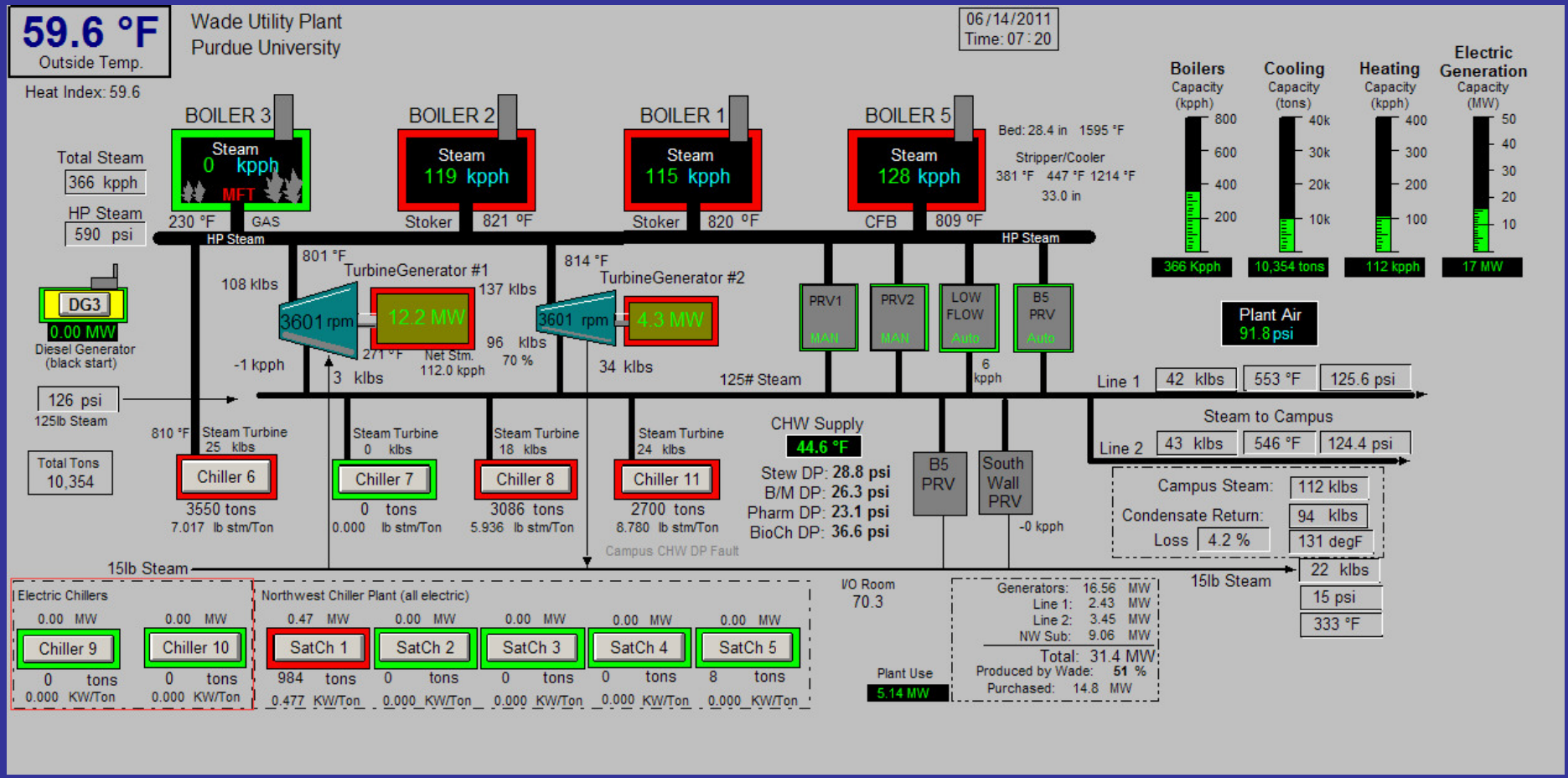
Photographs: 2011, C. Kissinger

Purdue Wade Utility Plant

- Indiana coal is the prime fuel source for the Wade Utility Plant at Purdue
- During fiscal year 2009-10, Wade consumed 70,162 ton of high-sulfur coal, 108,830 ton of low-sulfur coal, 12,020 ton of limestone, and 1,613,990 Therms of natural gas
- The average fossil fuels delivered cost was approximately $3.625/Mbtu.

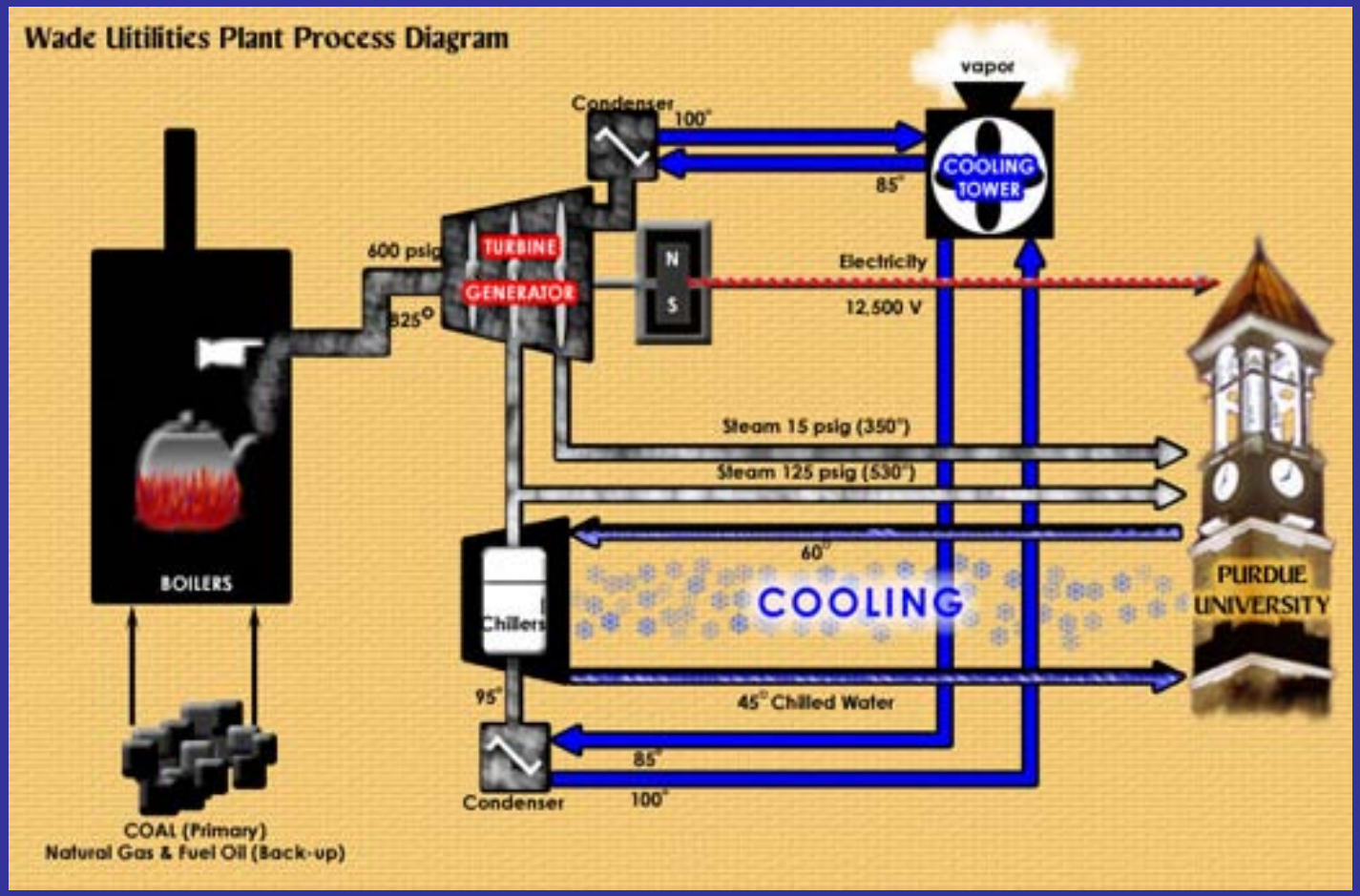
Purdue University: Energy, Engineering, and Sustainability. Plant Operations. http://www.purdue.edu/ees/energy/wade/plantoperation.htm

Purdue Wade Utility Plant



http://pf1web1.physfac.purdue.edu/wadestats/dash1.jpg

Purdue Wade Utility Plant



http://www.purdue.edu/ees/energy/wade/images/plant.jpg

Purdue Wade Utility Plant

2009-2010 Fiscal Year

Total Power consumption: 292,592,911 kWh

Power Produced by Wade Utility Plant: 120,327,862 kWh

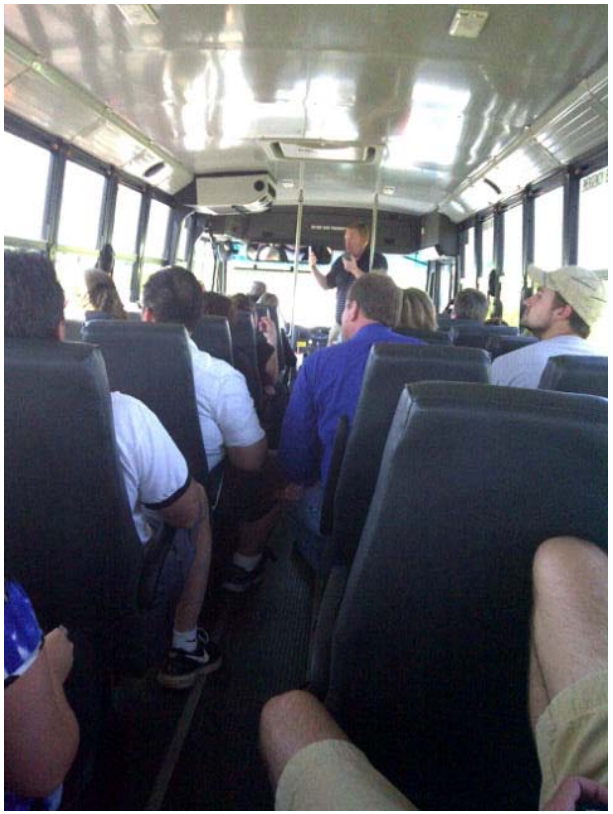
Power Purchased: 172,265,049 kWh

Peak Demand: 51,200 kW

Electricity Production

The Wade Plant produces electricity using two steam turbine driven generators and one diesel engine driven generator that operate in parallel with the local electric utility. Because of campus seasonal process steam requirements of winter heating and summer cooling, electricity is generated through a topping cycle that often results in production costs that are lower than those available from local utility tariff pricing. During fiscal year 2009-10, the University had a peak system demand level of 51,200 kW and consumed a total of 292,592,911 kWh of electricity. Wade generation equipment produced 120,327,862 kWh with remaining balance supplied by local electric utility.

A Whirlwind Tour



Photos: C. Kissinger, 2011. Horizon Logo is the trademark of Horizon Wind Energy

Wind Farm Criteria

1. Wind Speed
2. Transmission Lines
3. Agricultural Land Use
4. Community Support
5. Demand

http://www.horizonwind.com/projects/developingawindfarm.aspx

GE Energy Turbines

- The GE 1.5 megawatt series of wind turbines was developed with the cooperation of the United States Department of Energy.[1][3] It consists of three fiberglass blades attached to a horizontal axis hub. The hub is connected to the main shaft which turns a multi-stage system of gears. The gears increase the rotational rate and send the kinetic energy obtained from the wind to an electric machine, where it is converted into electrical energy.

- The generator has a maximum output of 1.5 megawatts (1,500 kW). The generator and gearbox are contained in the nacelle which is further insulated to minimize noise emissions. [1]

Sources:

[1] http://www.ge-energy.com/products_and_services/products/wind_turbines/ge_1.5_77_wind_turbine.jsp

[2] http://www.nrel.gov/analysis/power_databook/calc_wind.php

[3] http://www1.eere.energy.gov/windandhydro/large_wind_tech.html

Turbine Wind Class

- Turbine wind class is just one of the factors which need consideration during the process of planning a wind power plant. Wind classes determine which turbine is suitable for the normal wind conditions of a particular site. They're mainly defined by the average annual wind speed (measured at the turbine's hub height), the speed of extreme gusts that could occur over 50 years, and how much turbulence there is at the wind site.
- The three wind classes for wind turbines are defined by an International Electrotechnical Commission standard (IEC), and correspond to high, medium and low wind as follows:

Turbine Class	IEC I	IEC II	IEC III
Annual average wind speed	10 m/s	8.5 m/s	7.5 m/s
Extreme 50-year gust	70 m/s	59.5 m/s	52.5 m/s
Turbulence classes	A 18%	A 18%	A 18%
	B 16%	B 16%	B 16%

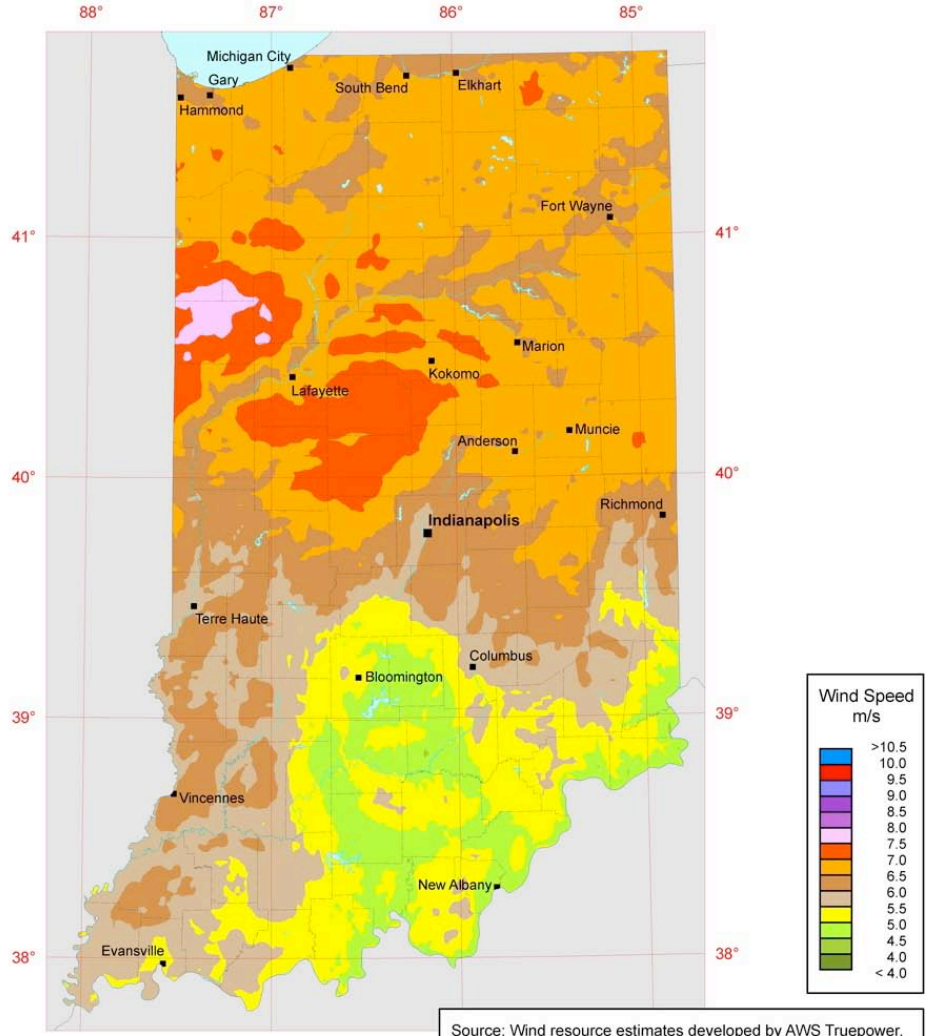
http://www.vestas.com/en/wind-power-plants/wind-project-planning/siting/wind-classes.aspx#/vestas-univers

Land required

- 60 x 1.5 MW = 90 MW
- 60 x 0.6 acre = 36 acres directly used (Horizon Wind)
- GE 1.5 series uses 37 m blade
- Typical turbine spacing in wind farms is placing the towers 5 to 10 turbine diameters apart, depending on local conditions.
- 60 x 37 m x 2 x 5 = 22,200 acres
- 60 x 37 m x 2 x 10 = 44,400 acres perimeter

http://www.nrel.gov/analysis/power_databook/calc_wind.php

Indiana - Annual Average Wind Speed at 80 m



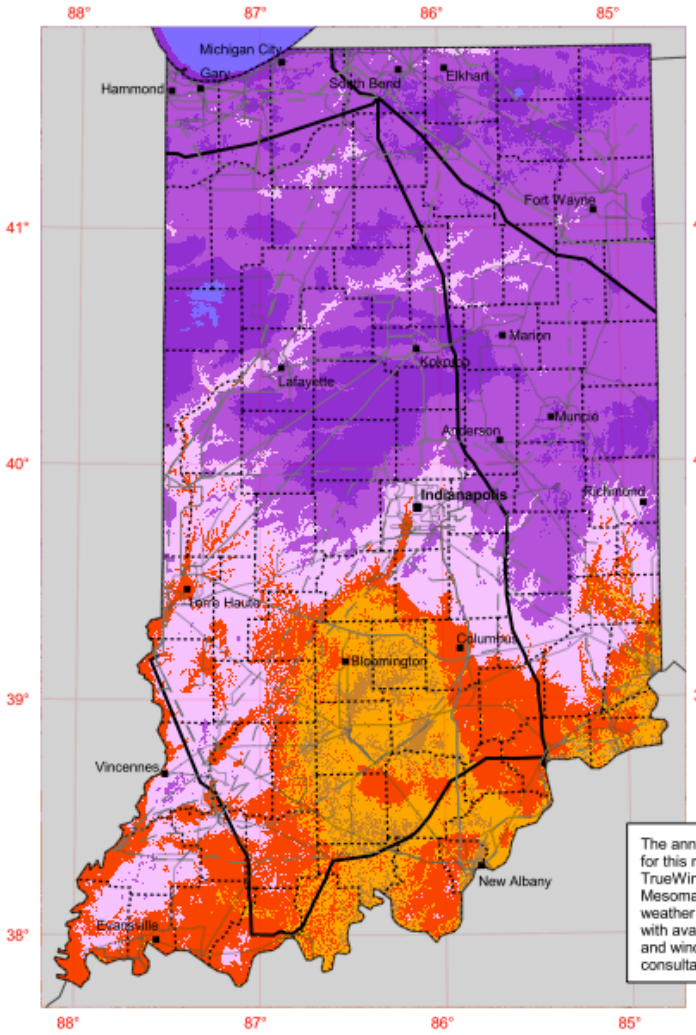
Source: Wind resource estimates developed by AWS Truepower, LLC for windNavigator®. Web: http://www.windnavigator.com | http://www.awstruepower.com. Spatial resolution of wind resource data: 2.5 km. Projection: UTM Zone 16 WGS84.

AWS Truepower™ Where science delivers performance.

NREL NATIONAL RENEWABLE ENERGY LABORATORY

18-OCT-2010 1.1.1

Indiana - 100 m Wind Speed



Wind Speed m/s | Capacity Factor (%)

Wind Speed m/s	Capacity Factor (%)
8.5	
8.0	39
7.5	35
7.0	30
6.5	
6.0	
5.5	Net capacity factor with 12% losses.
5.0	
4.5	
4.0	
3.5	
3.0	
0	

Transmission Line*
Voltage (kV)
69
115 - 161
230
345
765

* Source: POWERmap, ©2005 Platts, a Division of the McGraw-Hill Companies

The annual wind speed estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

U.S. Department of Energy
National Renewable Energy Laboratory

NREL

23-JAN-2006 1.1.14

Interview with an Expert

Bruce High, Wade Utility Plant Manager, Purdue University
Interview: 4:00 pm, Tuesday, June 14, 2011

http://purdue.photoshelter.com/gallery-image/Campus-Events/G0000GLjeiRA_ng0/I0000moa76QVHb4E/P0000yi2gKiHy3Ec

Interview with an Expert

Q. Is it true that Purdue mostly gets its electricity from this coal-fired power plant?

A. Well, in fact we have 3 coal-fired plants, with one of them being retired and 1 gas-fired plant with another gas-fired plant being built. Our current facilities are capable of producing 100% of Purdue's electrical power in addition to providing both heat and refrigeration.

Q. We read about Purdue buying electricity from other sources, such as the grid. Why would you do that if you can already supply power from here?

A. We have approval to purchase as much as 60% of our electrical power from other sources but the reasons for doing that are sometimes more related to political interests than lack of power-producing capacity here. The Trustees are under pressure from environmental groups for example.

Interview with an Expert

Q. Why is another gas-fired plant being built instead of another coal plant, or instead of a renewable energy plant, such as a wind farm? For example, we read a press release about the Purdue Board of Trustees approving a wind farm at the Animal Sciences farm on US 52?

A. We are proposing coal because that is the most economical form of energy available to us now and in the near future. The wind facility you described is actually not going to be part of the university: it would be owned by PRF. Electricity from that farm would go to the grid rather than solely to Purdue. The trustees have been under some public pressure from groups like the Sierra Club to make changes and that wind farm is a response and experiment.

Q. By the way, do you still use that rail spur to bring in coal?

A. No! We stopped that 30 years ago. We bring all of our coal here by truck, from Terre Haute.

Interview with an Expert

Q. What do you think about the potential for wind? For example, what types of challenges would you face if a new president came to Purdue with a mandate to switch to wind?

A. That would make it tough to meet demand! I must provide constant electricity to the university, day and night. Right now, I can have the formula for doing that by knowing exactly how much coal or natural gas I should feed into my system to generate that much electrical power. Wind is variable. You can't dial up wind on demand. If you depend on it 100%, then someone is going to be disappointed.

Wind On, Wind Off

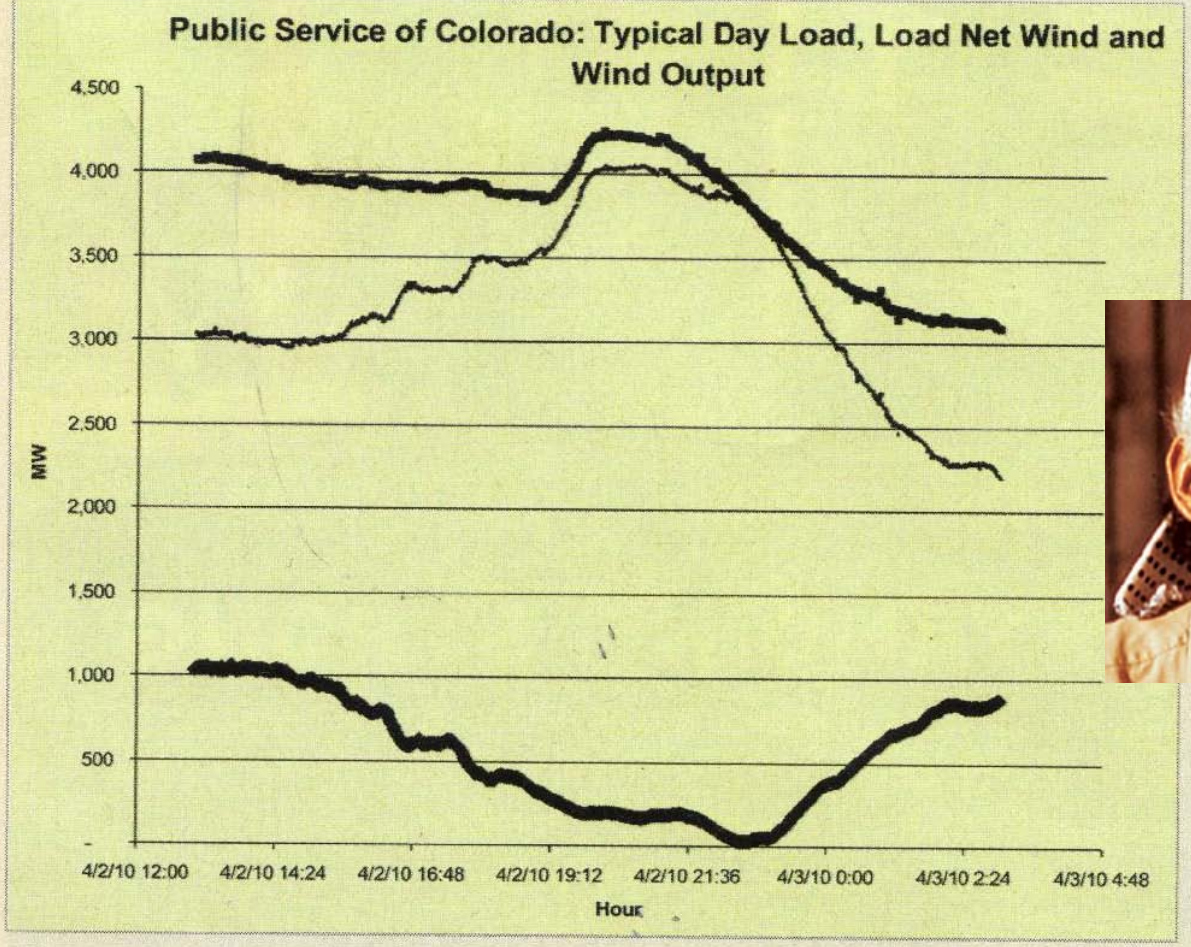


Figure 1. Public Service of Colorado: Typical day Load, Load Net Wind and Net Wind Output

E.R. Danneman and S.J. Beuning, Wind Integration – System and generation issues, Energy-Tech, June 2011, 19-23

Purdue wind energy park would offer research, education

February 4,2011

Print Version

WEST LAFAYETTE, Ind. - Purdue's Board of Trustees on Friday (Feb. 4) permitted the university to pursue leasing land as part of a 60-turbine commercial wind energy park to create and enhance Purdue research and educational opportunities for Indiana students.

The project of the university, Purdue Research Foundation, General Electric Co. and Performance Services Inc. is proposed for Purdue's Animal Sciences Research and Education Center (ASREC) and adjacent private property. The location was selected for its ideal wind conditions.

Performance Services would develop the Purdue Energy Park at ASREC as a commercial venture, leasing the property from the foundation. The operation would be available to Purdue for research and education.

"Renewable energy has been a focus of the College of Agriculture for many years," said Jay Akridge, Glenn W. Sample Dean of Purdue Agriculture. "This project presents an excellent opportunity to explore bringing wind energy to our animal sciences farm, and we look forward to investigating the research and education activities this new park would make possible."

The Purdue Energy Park at ASREC would be powered by GE's 1.5 Series wind turbines, the most widely deployed wind turbines in the world. The 100 megawatts of electricity the total operation could produce - enough to power 25,000 U.S. homes for a year - would be sold to a utility. Some of the power would be a potential additional energy source for the university.

•http://www.purdue.edu/newsroom/general/2011/110204BOTWindpark.html

What Would It Take To Power Purdue University for One Month Using Wind Energy?

- A willingness to go without power when the wind is not blowing or accept a contribution by wind without total reliance
- More land than is presently available on campus to support the needed turbines
- A direct feed from the proposed PRF wind farm to the infrastructure of the existing power plant
- Retraining of personnel
- Funding for development and implementation