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Rigorous wind curriculum for secondary schools

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Part of a 90-minute session at the Interstate Renewable Energy Council's 2011 Clean Energy Workforce Conference at Saratoga Springs, March 10, 2011.
http://irecusa.org/irec-programs/workforce-development/2011-clean-energy-workforce-education-conference/

About Shawn and ETO

Shawn Reeves

- Physics teacher, Ithaca, NY. Home school and public school.
- For master's (1997) studied how solar power could serve NYS Math Science and Technology standards.
- Meets hundreds of other educators working on energy curriculum.

EnergyTeachers.org

- Started by Shawn and two other science teachers in 2004.
- A charity, funded by donations and grants.
- More a network for sharing good ideas than a curriculum generator.
- A highly organized web site with thousands of contributions: Links, projects, news, workshops, field trip sites, bibliography, discussions, and even haiku, all user-generated.

Please visit EnergyTeachers.org to learn more. Click the Join link to get a free subscription.

Abstract

- The traditional view of the proper sequence of curriculum is that younger students should only be exposed to the most basic ideas in any physical science, or worse, that they can only take lessons in engineering after taking courses in science. However, recent research has shown that younger students are capable of more complex tasks and so-called applications of science; also, forward-looking states like Massachusetts are emphasizing or requiring engineering education K-12.
- Members of the EnergyTeachers.org network are now teaching rigorous curriculum about siting wind turbines to younger students. We have found that students as young as ten years have successfully analyzed wind resources using complex wind roses. In this presentation, we will discuss:
- 1) software that helps convolve power curves and wind data,
- 2) freely available sources of wind data,
- 3) how students develop understanding, meaning, and expertise when they are taught to analyze wind roses for known locations, and power curves,
- 4) how students may also analyze solar data for siting PV or thermal, and
- 5) whether students who won't go into energy careers should still learn deep lessons about the science, technology, and engineering of energy production.
- Participants in this presentation will see the range of capabilities of younger (5th-12th grade) students, discuss resources, and reconsider what lessons are possible for the general public, scientists, engineers, and trades-people.

This is the abstract as submitted to the conference organizers. Maybe there are people in the audience to whom this is not new, this idea that students can do much more than the standard curriculum.

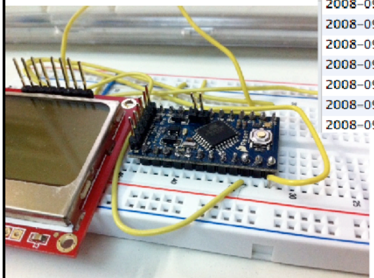
Tech is not just for tech students in tech classes.

While this curriculum is mostly derivative, we will discuss how appropriate it is for younger students.

What is a rigorous wind curriculum?

- Telling students wind power is good, and then a few factoids, is not enough education.
- Model student activities on professional activities.
- Develop scientific and engineering and math and communication skills.
- Let students know they can create technology, not just use it.
- Work with real data.
- Do work relevant to the future.

This is just Shawn's view of requirements for *a* rigorous curriculum. There can be many others.
Future>Past: students will be living for scores of years in the future, so future-proof their education, as well as possible.
The distinction between "real data" and "real-world data" is significant.



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DATA-OBSERVATION

1 Students can assemble their own anemometers.

2 Students can program micro-controllers to collect data from anemometers.

3 Students can store data in databases capable of handling millions of records.

4 Tools that continuously analyze are useful for showing the relationship between observations and analysis. [see next slide.]

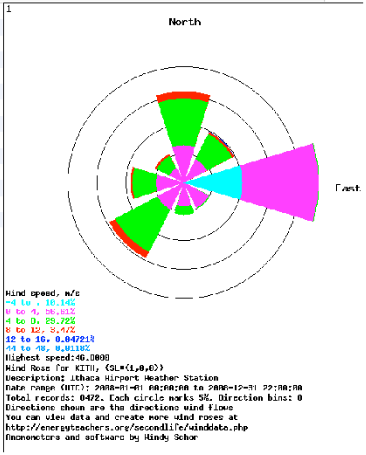
Compare to store-bought comprehensive kits.
Compare to minimal tables usually found 7-12.
The anemometer shown is an Inspeed Vortex.
The microcontroller shown is an Arduino.
The database we use is MySQL.

This is a virtual wind rose that can be reset and shows the development of wind direction frequencies over time.
At first there's only wind from the SW, then NW, more NW, S, more NW filling in, then more S, then all directions with a prevalence for W and SW.

```
SELECT ROUND(speeddmps/10) as speedmps, COUNT(*) AS records
FROM winddata INNER JOIN regions USING (regionid)
WHERE regions.regionname = "KITH"
GROUP BY speedmps
```

Query Favorites ▾ Query History ▾ Run Current Run All

speedmps	records
NULL	967
0	3054
2	2093
3	2727
4	2021
5	1595
6	1035
7	614
8	381
9	189
10	87
11	53
12	15
13	3



DATA-ANALYSIS

1 Students can calculate statistics.

2 Students can draw and interpret wind roses.

3 Students can predict power output. Students will learn how wind power is very dependent on the characteristics of the speed and direction. [see next slide.]

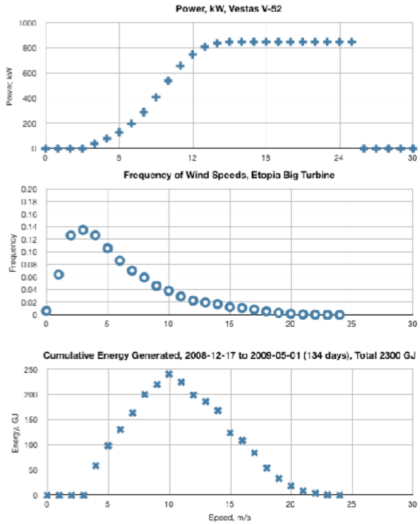
If you don't have your own data, you can still perform these analyses, with NOAA data or data from wind test sites.

EnergyTeachers.org hosts some NOAA data and can host data from any school/site and provide analysis tools for free.

Wind rose issues: Splitting the compass numerically; visual issues, including binning speeds not as much an issue.

Sample Power Analysis

speed, m/s	frequency of this speed	speed, m/s	cumulative energy made this speed	speed, m/s	power, kW
0	0.8%	0	0	0	0
1	6.4%	1	0	1	0
2	12.7%	2	0	2	0
3	13.5%	3	0	3	0
4	12.7%	4	58.968	4	40
5	10.8%	5	98.592	5	80
6	8.6%	6	130.455	6	130
7	7.1%	7	163.92	7	200
8	6.0%	8	200.622	8	290
9	4.6%	9	220.539	9	410
10	3.8%	10	241.38	10	540
11	2.9%	11	224.928	11	660
12	2.3%	12	199.35	12	750
13	2.0%	13	186.381	13	810
14	1.7%	14	168.336	14	840
15	1.3%	15	124.185	15	850
16	1.1%	16	100.035	16	850
17	0.9%	17	84.405	17	850
18	0.5%	18	54.06	18	850
19	0.3%	19	33.15	19	850
20	0.2%	20	18.615	20	850
21	0.1%	21	8.37	21	850
22	0.0%	22	3.825	22	850
23	0.0%	23	0.755	23	850
24	0.0%	24	0.255	24	850
	100.0%		2330.296	25	850
				26	0
				27	0
				28	0
				29	0
				30	0



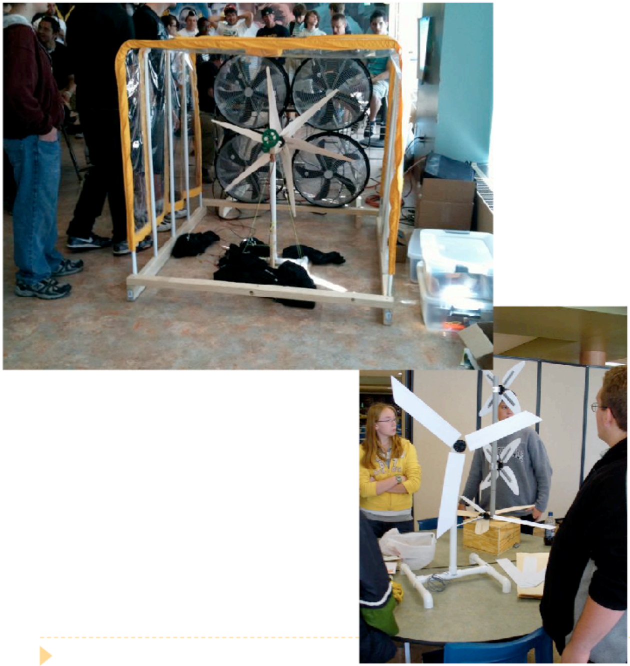
Multiplying the top graph (power) by the middle graph (frequency of wind speed), piece by piece, to get the bottom (energy) graph, is called convolution.

MODELING

Shawn was inspired by building a model wind lab.

Virtual worlds allow anyone to make a system to study issues with wind sites. Some have wind modeled using computational fluid dynamics.

Virtual worlds can be a place to prototype innovative ways to measure and deliver information. This picture is from a lab we maintain in Second Life, which has a virtual wind blowing through it based on a dynamic model.
In these simulated worlds, you can entertain inquiries like “what if you could place a grid of 16 anemometers instead of just one?”



Other curricula

1 KidWind and WindWise

2 NESEA and NYSERDA's kits

Building a turbine to understand the engineering process and issues with turbines.

We are not presenting KidWind and other turbine-building curricula because other presenters here will.
KidWind has most comprehensively addressed wind curriculum for general education.