The FUTURES Channel®

MOVIE GUIDE

MOVIE NUMBER 1010

Electricity from the Wind

The Movie:

The natural force of the wind is harnessed by mathematics and physics to generate clean electricity. Featured: Robert Gates, senior vice president, Zond Industries. *(Movie length: 3:24)*

Background:

An industrialized society runs on energy, and nearly every aspect of life in Earth's industrialized nations is powerfully affected by the cost and availability of energy to families and industries. The controversy and conflicts that stem from dependence on fossil fuels are well known, but what may not be so well known is that there are other, very practical solutions to energy needs.

Wind turbines produce electricity with generators driven by the force of the wind. Projections indicate that wind power sources could supply 20% to 30% of the energy needs of the United States, at a cost which is competitive with current rates. Although the initial costs of building a wind power plant are relatively high, the operating costs are much lower than plants which require a continuous supply of fuel.

Curriculum Connections:

Fractions 1

The amount of power carried by wind at 30 miles per hour is 8 times the amount carried at 15 miles per hour. However, wind turbines operate best at certain wind speeds, and not so well at other speeds.

Suppose that a wind turbine is only 1/10 as efficient at 30 miles per hour as it is at 15 miles per hour. At which speed will the turbine produce more electricity?

Percents 2

Wind turbines cannot change all of the energy of the incoming wind into electricity. Only about 59% of the energy of the wind can be converted to motion of the blades, and only about 75% of the motion of the blades can be changed into electrical energy by the turbine.

If the wind blowing on the area covered by one wind turbine carries 16 megawatts of power, how many megawatts of electricity would be produced?

Circles

The blades on this wind turbine are rotating at a rate of 80 revolutions per minute.

a) What is the area of the circle through which the blades are moving?

b) What is the speed at which the tip of the blade moves through the air?

Statistics

This table shows wind speed data for three different locations over a period of three months. Which site has the highest average wind speed? For which site is the wind speed most often above 10 miles per hour? If you plan to use a wind turbine which operates best at speeds around 18 miles per hour, which site would you choose, and why?

Week	Site 1	Site 2	Site 3
1	6	6	13
2	10	3	4
3	8	7	17
4	12	16	6
5	13	6	19
6	4	22	20
7	40	25	16
8	30	4	12
9	4	19	32
10	9	16	15
11	12	11	2
12	11	12	2
13	5	14	19

Algebra (coordinates)

As wind moves along the ground, the section of air closest to the ground is slowed down by contact with the ground. This data presents an example of wind speed related to height above the ground:

Height (meters)	Wind Speed (meters/sec)
0	0
10	7.0
20	7.8
30	8.5
40	8.7
50	9.0
60	9.2
70	9.4
80	9.6
90	9.8
100	10.0

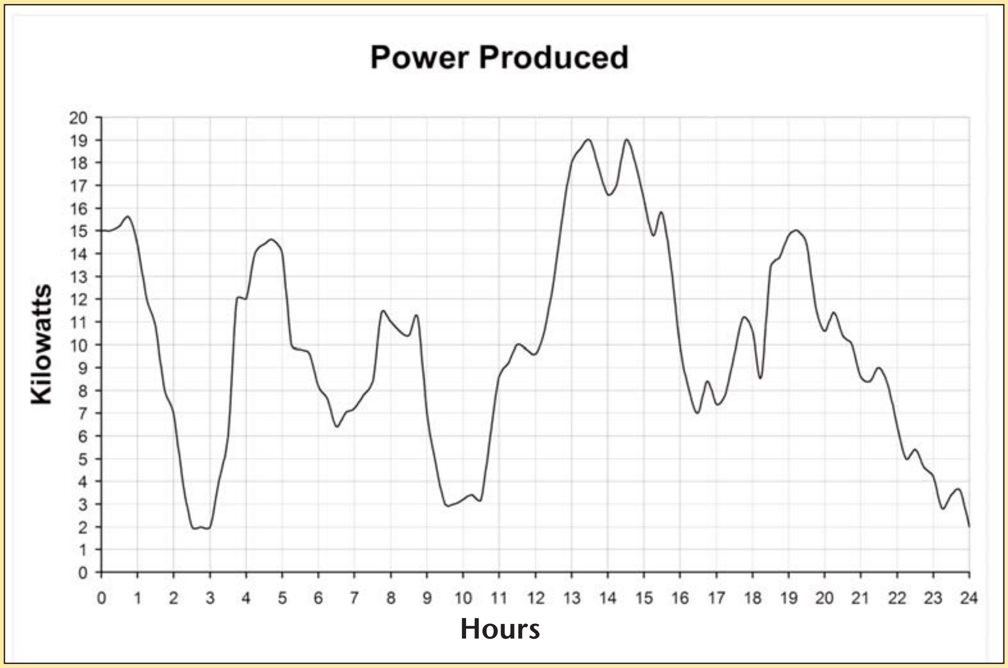
a) Plot these points in a coordinate system in which the height above ground is given on the horizontal axis and the wind speed is given on the vertical axis.

b) Estimate the wind speed 150 meters above ground level.

c) If this data is typical for wind at a certain location, how high would you want to put the rotor for your wind turbine? Why?

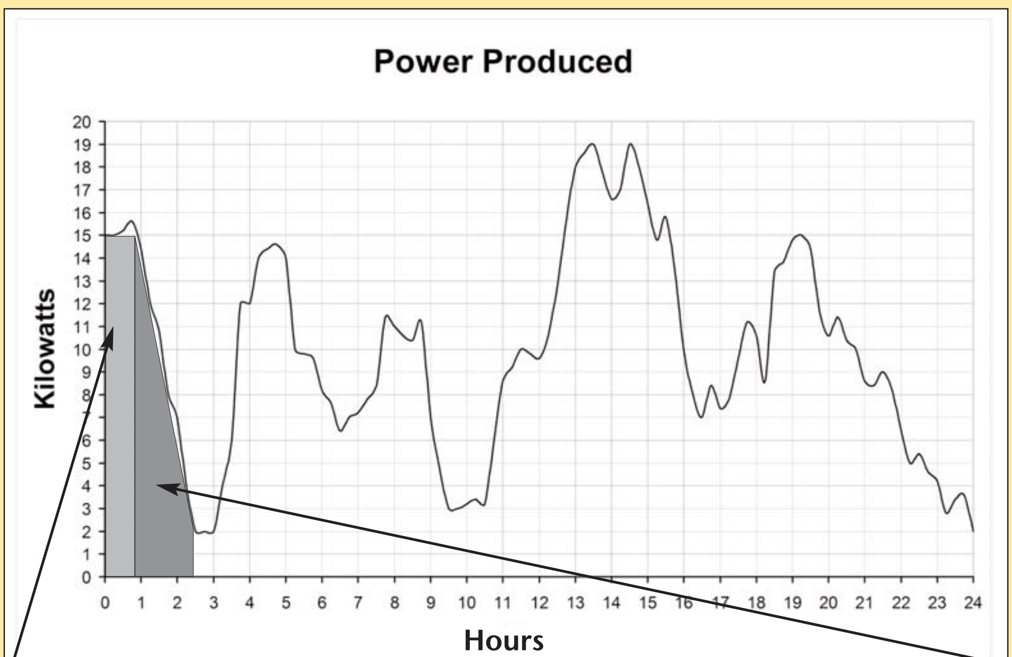
Measurement (area), Algebra (coordinates)

This graph represents the amount of power produced by a wind turbine over a 24-hour period.



To find the total amount of energy produced by the turbine, you would find the area of the space under the power curve. (Each small rectangle on the graph represents 1 kilowatt-hour of energy).

Instead of counting the rectangles, you can estimate the amount of energy by drawing rectangles and trapezoids under the curve, as shown. Do this to estimate the total amount of energy produced by the turbine.



Area of rectangle
= length x width
= 15 x 1
= 15 kilowatt-hours

Area of trapezoid
= ½ $(b_1 + b_2)$ x h
= ½ (15 + 2) 1.5
= 8.5 x 1.5
= 12.75 kilowatt-hours

Algebra 7

Suppose it costs $20,000 to build a wind turbine, and another $150 per day to operate it. Then the total amount of money invested to produce power (*y*) will be related to the number of days of operation (*x*) by this linear function:

$$y = 150x + 20{,}000.$$

Assume you can sell the power for $500 per day. How many days will it take to earn back the money that was invested to build the wind turbine?

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