Name_____ Date_____

In each lesson, navigate to the given page or pages by clicking on each of the provided links and review the information provided to respond to the questions that follow.

§1 - Program Background

New York State Energy Research and Development Authority (NYSERDA) *www.nyserda.org*

1. (***ABOUT NYSERDA***) *Fill in the blanks*: NYSERDA strives to facilitate change through the widespread development and use of select one to improve the state's select one , select one , and select one wellbeing.
2. (***Programs*** > ***Renewable Portfolio Standard***) *Fill in the blanks*: A Renewable Portfolio Standard (RPS) is a policy that seeks to increase the proportion of select one used by retail customers. New York State's goal is to reach select one by 2013.
3. (***Programs*** > ***New York Energy $mart Program***^{SM}) *Fill in the blanks*: The initial policy goals of the *New York $mart Energy Program*^{SM} were to promote competitive markets for select one services, and to provide direct benefits to select one .

§2 -Energy

Energy Information Administration (EIA) - Kid's Page *www.eia.doe.gov/kids/glossary/index.html*

1. Fill in the blank next to each definition with the term that is being defined. (*scroll to find terms*)

Word Bank: *biomass, fossil fuels, geothermal energy, global warming, greenhouse emissions, greenhouse gases, heliostat, hydrogen, hydropower, induction, inertia, nonrenewable, nuclear energy, renewable energy sources*

a. Any organic (plant or animal) material which is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants. select one
b. Gases that trap the heat of the sun in the Earth's atmosphere, producing the greenhouse effect. Water vapor, CO_2, methane, ozone, chlorofluorocarbons, and nitrogen oxides are examples. select one
c. Energy that comes from moving water. select one
d. Fuels that can be easily made or "renewed." Hydropower (water), solar, wind, geothermal, and biomass are examples. select one
e. Waste gases given off by industrial and power plants, automobiles, etc. select one
f. Fuels that cannot be easily made or "renewed", such as oil, natural gas, and coal. select one
g. The heat energy that is produced by natural processes inside the earth. It can be taken from hot springs, reservoirs of hot water deep below the ground, or by breaking open the rock itself. select one
h. Fuels (coal, oil, natural gas, etc.) that result from the compression of ancient plant and animal life formed over millions of years. select one
i. The process of producing an electrical or magnetic effect through the influence of a nearby magnet, electric current, or electrically charged body. select one

American Wind Energy Association (AWEA) *www.awea.org/faq/wwt_environment.html*

2. Wind energy system operations: select one

3. Match each of the following types of emissions to the left with its effect on the environment to the right by writing the term next to the letter that corresponds to the correct description.

   Word Bank: *carbon dioxide, particulate matter, sulfur dioxide and nitrogen sulfides, toxic heavy metals*

a. select one — **a.** A global warming pollutant that builds up in the atmosphere, contributing to global warming by trapping the sun's rays on the Earth (as in a greenhouse), causing a gradual rise in average temperatures and increasing fluctuations in weather patterns, resulting in more frequent and severe droughts and floods.

b. select one — **b.** Cause smog, as well as acid rain that harms forests and the wildlife they support, kills lakes, and also corrodes buildings and economic infrastructure such as bridges.

c. select one — **c.** Accumulate in the environment and up the biological food chain by making it dangerous to consume certain animal-byproducts due to concern of its presence in animal tissue.

d. select one — **d.** Has contributed to making asthma one of the fastest growing childhood ailments in industrial and developing countries alike, and it has also recently been linked to lung cancer, as well as major health problems in infants.

4. What percent of the nation's electricity would need to be provided by wind energy in order to displace more than a third of the emissions from coal-fired power plants? select one

Zero Footprint Kid's Calculator *www.zerofootprintkids.com/kids_home.aspx*

CarbonFootprint.com defines a *carbon footprint* as a measure of the impact of our activities on the environment, and in particular climate change relating to the amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation etc.

5. Use the **Zero Footprint Calculator** to calculate your carbon footprint and compare your score with the average American score by selecting the American flag from the drop-down menu under the **Carbon** tab in your score summary. What is your carbon footprint score?

What is the carbon footprint score of the average American? select one

For tips on how to reduce your carbon footprint, visit www.carbonfootprint.com/

6. What action contributes the most to the Average American carbon footprint? select one

§3 - Wind Energy

U.S. Department of Energy (DOE) – Energy Efficiency and Renewable Energy (EERE)
http://www1.eere.energy.gov/windandhydro/wind_basics.html

1. (***How Wind Turbines Work***) *Fill in the blanks*: Wind is a form of select one energy and is caused by select one
2. (***How Wind Turbines Work***) What are wind flow patterns modified by? *Check all that apply*.

☐ vegetation	☐ the Earth's terrain
☐ radio waves	☐ clouds
☐ bodies of water	☐ airplanes

The Department of Energy (DOE) defines *kinetic energy* as "energy in action". Therefore, the kinetic energy in the wind is a result of its motion.

3. (***How Wind Turbines Work***) *Fill in the blanks*: Wind turbines convert the kinetic energy in the wind into select one . This power can be used for specific tasks or a select one can convert this power into select one .
4. (***Advantages and Disadvantages***) *Fill in the blanks*: The major challenge to using wind as a source of power is that the wind is select one and it does not always blow when select one is needed.
5. (***History***) What were some of the earliest uses of wind energy? *Check all that apply*.

☐ powering cars	☐ cooking
☐ propelling boats	☐ pumping water
☐ heating homes	☐ grinding grain

6. (***History***) To what year does using wind energy to generate electricity date back? select one

§4 -Electricity Basics

Kid Wind *www.kidwind.org/lessons/BBelectricitybasics.html*

1. *Fill in the blanks*: Electricity is the flow of select one . Electricity is created when select one from atoms are loosened and begin to move from one atom to another.
2. *Fill in the* blanks: A generator, sometimes called a dynamo, operates based on select one Law, which states that when a select one is moved within a select one , select one flows in the select one .
3. In what units is electricity measured? select one
4. If it is estimated that one megawatt of electricity is enough for approximately 300 average homes here in the U.S., approximately how many average American households, calculated to three significant figures, could be powered with 93,881 megawatts (MW) of electricity (the amount of electricity being produced worldwide using wind energy at the beginning of 2008)? select one

5. According to the chart that shows the fuel sources that are used to generate electricity in the United States, what percentage of electricity is generated using renewable resources?*** select one
   What percentage of electricity is generated using nonrenewable resources?*** select one
   Do not include **Other 0.3%** or **Other Gases 0.4%
6. *Fill in the blanks*: In the U.S., select one , select one , and select one for homes and businesses make up the bulk of electric demand.

§5 -Turbine Concepts

National Renewable Energy Laboratory (NREL) *www.nrel.gov/learning/re_wind.html*

1. Wind turbines are mounted on select one that are typically more than select one meters (m) in height in order to take advantage of the select one wind.
2. *Fill in the blanks*: The combination of select one and select one causes the rotor to spin like a propeller, and the turning shaft spins a select one to make electricity.
3. Wind turbines can be used as select one applications, or they can be connected to a select one or even combined with a select one .

U.S. Department of Energy (DOE) – Energy Efficiency and Renewable Energy (EERE)
http://www1.eere.energy.gov/windandhydro/wind_how.html

4. (***Inside the Wind Turbine***) Fill in the blank next to each definition with the wind turbine component that is being defined. (*scroll to find terms*)

a. This component is made up of the blades and the hub together. select one
b. This component is used to keep the rotor of upwind turbines facing into the wind as the wind direction changes. It is not required by downwind turbines since the wind blows the rotor downwind. select one
c. This component sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some are even large enough for a helicopter to land on. select one
d. This component starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. (Turbines do not operate at wind speeds above about 55 mph because they might be damaged by the high winds.) select one
e. This component measures the wind speed and transmits wind speed data to the controller. select one
f. This component measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind. select one
g. This function is required to turn the blades out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity. select one
h. This component is costly (and heavy) and houses the gears that connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, the rotational speed required by most generators to produce electricity. select one
i. This component can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies. select one

Danish Wind Industry - Wind with Miller www.talentfactory.dk/en/kids/index.htm

5. Go to **Wind Turbine Simulator** and click on **When and How Quickly** to begin. When prompted, click on the **Choose Turbine** button and select the turbine type **Bonus 1000kW, 54m rotor** and answer the following questions as you complete the provided activities. ***Be sure to continue using the same turbine type.***
   a. What is the minimum wind speed, measured in meters per second (m/s), required to make the wind turbine *start* running? This is known as the *cut-in speed*. select one
   b. What is the maximum wind speed (m/s) at which the wind turbine will run? This is known as the *cut-out speed*. select one
   c. How much power, measured in kilowatts (kW), does the wind turbine generate at a wind speed of 9.7m/s? select one
   d. What is the maximum power output (kW) of the wind turbine? select one
   e. *True or False*? As the height of the tower increases, the wind speed at hub height decreases. select one
   f. What environment (roughness class) offers the best conditions for wind? select one

§6 -Wind Potential

American Wind Energy Association (AWEA) – Resources www.awea.org/faq/basicwr.html

1. How does the available energy in a wind stream relate to wind speed and, what happens to the amount of available energy if the wind speed doubles?
   select one
2. What factors cause variation in wind speed? select one

Wind Energy Resource Atlas of the United States http://rredc.nrel.gov/wind/pubs/atlas/maps.html

3. (***Map 2-2 Winter season, Map 2-3 Spring season, Map 2-4 Summer season, Map 2-5 Autumn season***) The *Seasonal Average Wind Resource Maps* developed by the Renewable Resource Data Center (RReDC) depict the seasonal average wind resources for the U.S. by means of a color scale. View and compare Maps 2-2 through 2-5 in order to determine the best season of the year for generating wind energy in New York State: *autumn*, *winter*, *spring*, or *summer*? select one

NYSERDA – New York Wind Resource Explorer http://windexplorer.awstruewind.com/NewYork/NewYork.htm

The Department of Energy (DOE) explains that wind is classified according to wind power classes, which are based on typical wind speeds. These classes range from Class 1 (the lowest) to Class 7 (the highest). Class 4 and above are considered good wind resources.

4. (*links for the **Static PDF Wind Maps** are in a blue box on the right side of the screen*) Follow the links to view each of the **Static PDF Wind Maps** at 30, 50, 70, and 100 meters above effective ground level and compare the color schemes on each map to determine whether wind speed increases or decreases as the height above effective ground level is increased. select one
5. Using the same **Static PDF Wind Maps** from the previous question, determine the areas of New York State that provide the overall best wind resources for wind farm installation.
   select one

American Wind Energy Association (AWEA) *www.awea.org/faq/windpower.html*

6. Identify the correct expression of the *Power in the Wind* equation.

◯ $P = ¼ \times \rho \times A^2 \times C_p \times V^4 \times N_g \times N_b$ ◯ $P = ½ \times \rho \times A \times C_p \times V^3 \times N_g \times N_b$ ◯ $P = ½ \times \pi \times A^3 \times C_p \times V^2 \times N_g \times N_b$

KidWind.org explains that the *swept area* (A) of a wind turbine rotor refers to the area of the circle that is created by the rotor blades as they "sweep" through the air. Therefore, to find the *swept area*, use the same equation as you would to find the area of a circle ($A=\pi r^2$) where π is the constant approximately equal to 3.14, and r is the length of one rotor blade. ***It is important to note that the wind industry typically uses the metric system.***

7. Use the *Power in the Wind* equation identified in the previous question to calculate to three significant figures the amount of available power (P) in watts at a wind speed (V) of 15mph*** if the air density (ρ) is equal to 1.225 kg/m^3, the length of one turbine blade is 100ft***, the coefficient of performance (C_p) is .35, the generator efficiency (N_g) is 83%, and the gearbox/bearings efficiency (N_b) is 87%. select one
   ****Conversions: 1 mph = .447 m/s, 1ft = .3048 m, 1 W = 1Js^{-1} = 1kgm^{2}s^{-3} = 1Nms^{-1}, 1 kW = 1000 W*

8. Convert your answer in the previous question from watts (W) to horse-power (hp). Again, your answer should be calculated to three significant figures. ****Conversion: 746 W = 1 hp* select one

§7 -Site Selection: Physical Factors

Power Naturally – Wind Guide *www.powernaturally.org/programs/wind/WindGuide.pdf*

1. Sustained wind speeds are critical to a wind farm's efficiency. What is the minimum annual average wind speed measured in meters per second (m/s) required to operate wind turbines efficiently? select one
2. *Fill in the blanks*: Due to the high costs associated with building transmission lines, most wind projects are located within select one of high-voltage transmission lines, which is equal to select one .
   ****Conversion: 1 mile = 1.61 kilometers*
3. What are some physical characteristics of the land that create an ideal site for wind farm installation? *Check all that apply*.

☐ elevated plateaus ☐ onshore locations relatively free of trees and buildings

☐ ridgelines ☐ offshore locations

☐ high hilltops ☐ locations accessible for construction

4. Approximately what size area of land, measured in acres, is required for large wind projects? select one
   This is equal to approximately how many square kilometers? select one
   **** Conversion: 1 acre = 4.05 x 10^{-3} km^2*

Danish Wind Industry *www.talentfactory.dk/en/tour/wres/shear.htm*

5. (***Roughness and Shear***) *Fill in the blanks*: In the wind industry one distinguishes between the select one of the terrain, the influence from select one , and the influence from the select one .
6. (***Roughness and Shear***)What roughness class does a landscape with many trees and buildings fall into? select one What roughness class do sea surfaces fall into? select one
7. (***Park Effect***) Though land use and the cost of connection to the local power grid indicate that wind turbines should be spaced closer together, the *wake effect* tells us to space turbines as far apart as possible. The *wake effect* states that each wind turbine will slow down the wind behind it as it pulls energy out of the wind and converts it to electricity. How many rotor diameters are required between wind turbines in the prevailing wind direction? select one How many rotor diameters are required between wind turbines in the direction perpendicular to the prevailing winds? select one
8. (***Tunnel Effect***) Placing a wind turbine in a "tunnel" that is formed naturally by the landscape is a clever way of obtaining higher wind speeds than in the surrounding areas since the air becomes compressed on the windy side of the "tunnel", and its speed increases considerably as it travels between the obstacles to the wind. What would happen "tunnel" were to be formed by hillsides that are very rough and uneven? select one
9. (***Hill Effect***) *True or False*? It is always an advantage to have as wide a view as possible in the prevailing wind direction at a wind turbine site. select one

§8 -Site Selection: Environmental Factors

American Wind Energy Association (AWEA) – Wind Energy and Wildlife Fact Sheet
www.awea.org/pubs/factsheets/Wind_Energy_and_Wildlife_Mar09.pdf

1. According to the National Academy of Sciences, what percent of bird deaths caused by human (and feline) activities can be attributed to wind energy generation? select one
2. *Fill in the blanks*: Wind businesses have implemented many strategies to attempt to reduce bird impacts at Altamont Pass. Over the years, wind companies have select one wind turbine select one , reduced select one , added " select one " to prevent perching on turbine towers.
3. What do the letters in the acronym *BWEC* stand for? select one
4. Nonrenewable sources of energy (such as coal, oil, and fossil fuels) can have far-reaching effects on the environment due to the drilling, mining, and compressing of fuels, as well as other manufacturing processes that cause flooding of land, stream flow changes and waste water disposal. *True or False*? The use of wind energy largely avoids these far-reaching effects. select one

American Wind Energy Association (AWEA) *www.awea.org/faq/wwt_offshore.html*

5. *True or False*? It is likely that offshore wind farm installations will disturb the sea bed and cause coastal erosion. select one
6. It has been suggested that the noise from wind turbines will travel underwater and could disturb sea life. What have studies indicated regarding the impact of noise from existing offshore turbines on marine life? select one

§9 -Site Selection: Social Factors

Power Naturally – Wind Guide *www.powernaturally.org/programs/wind/WindGuide.pdf*

1. What organization requires turbines to be illuminated at night with red or clear strobe lights? select one
2. Name the two pre-construction tools mentioned that are used to provide communities with realistic examples of how a potential wind project layout will look from different perspectives: select one and select one
3. *Fill in the blanks:* Noise issues were associated with some early wind projects; however, noise has been reduced through select one in select one and the appropriate use of select one from select one .

American Wind Energy Association (AWEA) – Myths vs. Facts
www.awea.org/pubs/factsheets/050629_Myths_vs_Facts_Fact_Sheet.pdf

4. *Fill in the blanks*: An operating modern wind farm at a distance of select one ***meters*** (****Conversion*: *1 foot = 0.305 meters*) is no noisier than a select one or a select one .
5. *Fill in the blanks*: According to the chart, wind turbines operate at approximately select one decibels, which is louder than select one , but quieter than select one .
6. *Fill in the blanks*: Shadow flicker is the term used to describe what happens when select one come between the select one and the select one , causing a moving shadow. The effect can be precisely calculated to determine whether a flickering shadow will fall on a given location near a wind farm, and how many hours in a year it will do so. Solutions range from providing an appropriate select one from the turbines to select one to disrupt the effect.
7. The American Wind Energy Association (AWEA) explains that ice throw occurs when the weather conditions are such that the blades of a wind turbine become covered in ice resulting in ice fragments being thrown by moving turbine blades or falling down from static blades. *True or False*? Ice throw is considered to be of great danger. select one

§10 -Wind Power Economics

Power Naturally - Economic and Socioeconomic Impacts
www.powernaturally.org/programs/wind/toolkit/20_economicandsocioeconomicimpacts.pdf

1. (***Land Owner Revenue***) Land lease payments provide an additional source of income for rural land owners who allow wind farms to be developed on their property. Approximately what percent of the land *may still be utilized* by landowners to continue the previous use of the land once a wind farm has been installed? select one
2. (***Property Taxes***) Who are the largest beneficiaries of the added revenue provided by property taxes that are paid into a community by wind farm developers? select one
3. (***Job Creation***) In general, the employment opportunities associated with a wind power plant are in select one , select one , and select one .
4. (***O&M Employment***) Which are cheaper to maintain: a few large turbines or many small turbines? select one