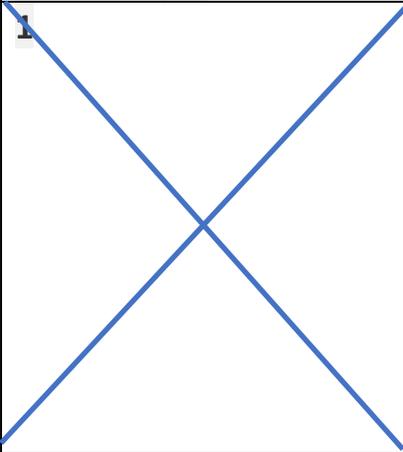
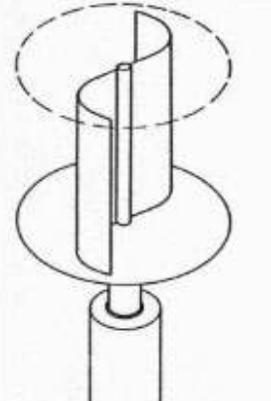


KEY

For #1-3, name the type of windmill and classify it as a Horizontal Axis Wind Turbine (HAWT) or Vertical Axis Wind Turbine (VAWT)

Windmill example	Is this an example of a VAWT or a HAWT?	Specific name given for the example
<p>1</p> 	<p>1</p> <p>HAWT</p>	<p>1</p> 
<p>2</p> 	<p>2</p> <p>VAWT</p>	<p>2</p> <p>Darrieus wind turbine</p>
<p>3</p> 	<p>3</p> <p>VAWT</p>	<p>3</p> <p>Savonius wind turbine</p>

For #4-9, refer to the diagrams in #1-3, then match each characteristic with the correct windmill (1,2,or 3). Choose only the single best answer for each description.

4. Tip speed ratios of 1 or below _____3_____

5. Ideal for areas with turbulent or variable winds, but efficiency is low— 15% __3__

6. High efficiency, but often requires an external power source or a second rotor to initiate movement __2_____

7. Must be turned to face into the winds _____1_____

8. Turns slowly with very high torque, so this design is better suited for work like pumping water than generating electricity. _____3_____

9. This design operates similarly to a cup anemometer. _____3_____

For questions 10-16, match these choices to the descriptions. Each choice may be used once, more than once, or not at all. When indicated, more than one choice is required.

- a. Biomass
- b. Geothermal
- c. Hydroelectric
- d. Nuclear
- e. Wind
- f. Hydrogen
- g. Solar

10. Which is not a renewable source of energy? __d_____

11. What **TWO** sources of energy for electrical generation rely on release of thermal energy from radioactive decay? __b_____ __d_____

12. Which includes methane produced by some methanogen bacteria? _____a_____

13. For which **TWO** resources is electricity generation most disruptive of animal migrations?
____c____ __e____ (0.5 points solar g, since large mirror concentrator kills birds)

14. Which **THREE** of these resources employ heated water for moving electrical turbines?
____a____ __b_____ __d_____ (0.5 solar g for heat concentrators)

15. Which **TWO** energy sources can be used to generate electricity without use of turbines?
_____f_____ _____g_____ (hydrogen fuel cells, PVC)

16. In 2016, 2% of new jobs in the United States were associated with which energy resource? _____g_____ (2016 jobs report, released in 2/2017)

For questions 17-22, match the form of energy storage with its example or description. Each choice may be used once, more than once, or not at all.

- A. Capacitor
- B. Battery
- C. Flywheel
- D. Pumped hydroelectric storage
- E. Compressed Gas

17. These **TWO** energy storage methods move matter to storage areas during periods when electricity demand is low, then release the matter and use it to spin electricity generating turbines during periods of higher demand. __d__ e__

18. This type of energy storage device is made of two conductive plates that can become oppositely charged, separated by an insulating material __a__

19. Chemical reactions release electric current from this energy storing device. __b

20. During a thunderstorm, a cloud serves as a natural version of this device. __a__

21. This type of energy storage requires two height separated reservoirs. __d__

22. This is sometimes called an electromechanical storage device. __c__

23. Electricity is transmitted over long distances at very high voltage for these two reasons:

i. to decrease amount of energy lost as heat during transmission since heat lost is proportional to the (current)²; keeping voltage high and assuming constant resistance through the wire, current is kept low.

ii. to decrease diameter of conductive transmission wires (higher diameter makes them heavier and also makes them more expensive)

24. What percent of power will be lost during transmission of 130 W of electricity if it is transmitted with a current of 1.3 A over a conductive wire having a resistance of 12 ohms? 3 points total

$$\underline{P_{\text{loss}}=I^2R} = (1.3 \text{ A})^2 (12\Omega) = \underline{20.4 \text{ W}} \quad (\text{keep extra digit until final calculation})$$

% lost = 20.4W*100%/130W= 15.7% =**16%** **2 significant figures**

1 point for final answer rounding 16 but with too many digits, 1 point for final 16 answer with 2 sig digits, 1 point for unit %)

25. How much electrical power is available from a current of 15.4 A at a voltage of 30.36 V? 3 points total

$$V=IR = (15.4A)(30.36V) = \mathbf{468\ W} \quad 3 \text{ significant digits}$$

(1 point answer that rounds to 468, 1 point correct unit, 1 point for correct sig figs)

26. Which of these two metals would comprise a transmission wire having lower tensile strength? A) Copper B) Aluminum b

27. Which of these two metals would comprise a transmission wire having lower conductivity? A) Copper B) Aluminum b

28. Which of these two metals would comprise a transmission wire having lower weight? A) Copper B) Aluminum b

29. Which of these two metals would comprise a transmission wire having lower cost per meter? A) Copper B) Aluminum b

30. What part of a wind power generator is show below?

A) Turbine B) Gearbox C) Yaw controller D) Capacitor b



31. Voltage is the measure of: A

- A. the amount of work done per group of charge
- B. the amount of charge per unit of work
- C. the number of Coulombs per Joule
- D. the amount of work per unit energy
- E. the number of Joules per electron

32. Voltage is analogous to: c

- A. energy
- B. Joules
- C. Pressure
- D. Charge
- E. Coulombs

33. Power is a measure of how much: A
- A. energy is used over a period of time
 - B. resistance a device has over time
 - C. current passes through a device over time
 - D. energy is used by a resistance
 - E. voltage passes through a device over time

34. If you connect a capacitor to a battery, what will happen? d
- A. The battery will charge up.
 - B. The capacitor will discharge and release energy.
 - C. Current will flow, and the capacitor will charge up, then release its energy.
 - D. Current will flow, and the capacitor will charge up.
 - E. Nothing will happen.

35. What is the benefit of using capacitors instead of batteries? a
- A. They can release charge (energy) more quickly and release energy repeatedly in bursts.
 - B. They are cheaper to make than batteries.
 - C. They can release charge (energy) more slowly than a battery and release energy repeatedly in bursts.
 - D. They are more efficient than batteries.
 - E. They release more energy than batteries.

36. Which of the following statements is true concerning high voltage, long-distance power transmission: d
- A. It is typically a single-phase, DC power system
 - B. It is typically a single-phase AC power system
 - C. It is typically a three-phase, DC power system
 - D. It is typically a three-phase AC power system

37. Earliest known windmills of any function were found in: b
- a. Egypt B. Iran C. Holland D. Denmark E. Scotland

38. Earliest known windmill used to generate electricity was built in 1860 in: e
- A Egypt B. Iran C. Holland D. Denmark E. Scotland

39. The first electricity generating windmills having blades whose pitch could be adjusted and which could be turned to face the wind was built about: d (1919)
- A 1860 B) 1880 C) 1900 D) 1920 E) 1940

40. Which of these was most important for stimulating the resurgence of United States interest in wind generated electricity during the late 1900's? _____c_____
- A) The cold war raised concerns of Russian fossil fuel embargos
 - B) Concerns about greenhouse gas emissions causing climate change
 - C) The 1970's oil crisis raised concerns about national fuel dependence
 - D) The war with Iraq raised concerns about oil supply interruptions
 - E) The Environmental Protection Agency enforced tighter air pollution standards.
41. Electromagnetic induction was discovered by _____d_____
- A) Alexander Graham Bell
 - B) Thomas Edison
 - C) Benjamin Franklin
 - D) Michael Faraday
 - E) Nikola Tesla
42. The first known offshore windfarm was built in 1991 off the coast of _____c_____
- A) United States
 - B) Scotland
 - C) Denmark
 - D) United Kingdom