# AP® Environmental Science
# 2004 Sample Student Responses

**The materials included in these files are intended for noncommercial use by AP teachers for course and exam preparation; permission for any other use must be sought from the Advanced Placement Program®. Teachers may reproduce them, in whole or in part, in limited quantities, for face-to-face teaching purposes but may not mass distribute the materials, electronically or otherwise. This permission does not apply to any third-party copyrights contained herein. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here.**

2. West Fremont is a community consisting of 3,000 homes. A small coal-burning power plant currently supplies electricity for the town. The capacity of the power plant is 12 megawatts (MW) and the average household consumes 8,000 kilowatt hours (kWh) of electrical energy each year. The price paid to the electric utility by West Fremont residents for this energy is \$0.10 per kWh. The town leaders are considering a plan, the West Fremont Wind Project (WFWP), to generate their own electricity using 10 wind turbines that would be located on the wooded ridges surrounding the town. Each wind turbine would have a capacity of 1.2 MW and each would cost the town \$3 million to purchase, finance, and operate for 25 years.

   (a) Assuming that the existing power plant can operate at full capacity for 8,000 hrs/yr, how many kWh of electricity can be produced by the plant in a year?

   (b) At the current rate of electrical energy use per household, how many kWh of electrical energy does the community consume in one year?

   (c) Compare your answers in (a) and (b) and explain why you would or would not expect the numbers to be the same.

   (d) Assuming that the electrical energy needs of the community do not change during the 25-year lifetime of the wind turbines, what would be the cost to the community of the electricity supplied by the WFWP over 25 years? Express your answer in dollars/kWh.

   (e) Identify and explain TWO environmental benefits to West Fremont of switching from coal to wind power and TWO environmental costs to West Fremont of switching from coal to wind power.

A) 12 MW
x 8000 hrs./yr.
96000 MW
x 1000 KW/MW
$\boxed{96,000,000 \text{ KWh/year}}$ is how much power the plant can produce at full capacity (8000 hrs./yr.)

B) 3000 homes
x 8000 kWh per home
$\boxed{24,000,000 \text{ KWh/year}}$ is what the community consumes yearly.

C) They are different, as expected. The constant power output of the plant must be substantially higher than average consumption by the community. This buffer must exist to account for abrupt ~~fluctuations~~ fluctuations in power

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

demands from the community as a random occurence, for loss of energy as the electricity travels down long lengths of power lines, and for other random occurences which may require additional power.

D) 1.2 MW × 10 units = 12 MW    3 million × 10 units = $30 million

$\frac{30000000 \text{ dollars}}{3000 \text{ homes}} = \frac{\$10000}{1 \text{ home}} \div 25 \text{ yrs.} = \frac{\$400 \text{ per home}}{1 \text{ year}}$

$\frac{\$400 \text{ home}}{1 \text{ year}} \div 8000 \text{ kWh/year} = \boxed{\$.05 / \text{kWh}}$ is the cost to the community over 25 years.

$8000 \overline{)400.0000} = .0500$

E) By switching from coal to wind power, West Fremont will reduce air pollution from the sulfur emissions of coal. This in turn will reduce acid deposition from the secondary pollutant $H_2SO_4$, or sulfuric acid, which is a direct result of the burning of coal. This wood prevent the degradation

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

of plant life within and surrounding the community. Also, by switching to wind power, particulate emissions and soot escaping from coal plant smokestacks will be reduced. This means that respiratory problems due to inhalation of particulates would ~~cease to~~ be reduced ~~a problem~~ for all organisms existing in West Fremont.

However, by placing wind turbines in wooded areas, trees would have to be cut down, resulting in loss of habitat for any creatures living there, and possible local extinction if too much habitat is degraded.

In addition, wind turbines present a threat to ~~[illegible]~~ migratory birds, who can be struck and killed by the spinning blades. This could result in the disruption of migration patterns for any bird species native to West Fremont that migrates.

GO ON TO THE NEXT PAGE.

2. West Fremont is a community consisting of 3,000 homes. A small coal-burning power plant currently supplies electricity for the town. The capacity of the power plant is 12 megawatts (MW) and the average household consumes 8,000 kilowatt hours (kWh) of electrical energy each year. The price paid to the electric utility by West Fremont residents for this energy is $0.10 per kWh. The town leaders are considering a plan, the West Fremont Wind Project (WFWP), to generate their own electricity using 10 wind turbines that would be located on the wooded ridges surrounding the town. Each wind turbine would have a capacity of 1.2 MW and each would cost the town $3 million to purchase, finance, and operate for 25 years.

   (a) Assuming that the existing power plant can operate at full capacity for 8,000 hrs/yr, how many kWh of electricity can be produced by the plant in a year?

   (b) At the current rate of electrical energy use per household, how many kWh of electrical energy does the community consume in one year?

   (c) Compare your answers in (a) and (b) and explain why you would or would not expect the numbers to be the same.

   (d) Assuming that the electrical energy needs of the community do not change during the 25-year lifetime of the wind turbines, what would be the cost to the community of the electricity supplied by the WFWP over 25 years? Express your answer in dollars/kWh.

   (e) Identify and explain TWO environmental benefits to West Fremont of switching from coal to wind power and TWO environmental costs to West Fremont of switching from coal to wind power.

~~A)~~

~~12 MW = $\frac{8,000 \text{ kWh/yr}}{1 \text{ household}} \times \frac{3000 \text{ households}}{\text{yr}}$ = 24,000,000 kWh~~

~~$3\times10^3 \cdot 8\times10^3 = 24\times10^6$~~

~~24,000,000 kWh of electricity can be produced by a plant in a year if the plant is operating at full capacity for 8,000 hrs/yr.~~

A) If the existing power plant can operate at full capacity for 8,000 hrs/yr, ~~96,000 kWh~~ 96,000,000 kWh can be produced each year.

$(12 \text{ MW})\left(\frac{1000 \text{ kW}}{1 \text{ MW}}\right)\left(\frac{8,000 \text{ hrs}}{\text{yr}}\right)(1 \text{ yr}) = 12,000 \times 8000$ kw·hrs

$12\times10^3 \times 8\times10^3 = 96\times10^6$ kWh

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

B) At the current rate of electrical energy use per household (8,000 kWh per year), the community consumes 24,000,000 kWh of electrical energy each year.

$24{,}000{,}000 \text{ kWh} = \frac{8{,}000 \text{ kWh/yr}}{1 \text{ household}} \times \frac{3{,}000 \text{ households}}{\text{yr}}$

✓ $8 \times 10^3 \cdot 3 \times 10^3 = 24 \times 10^6$

C) I would not expect the community to use the electricity produced ~~of~~ by the plant working at full capacity because the plant is a small coal-burning plant and probably does not function at full capacity and efficiency the whole year round.

D) $1.2 \text{ MW} \times \frac{1000 \text{ kW}}{1 \text{ MW}} = \frac{1200 \text{ kW}}{24{,}000{,}000 \text{ kWhr}} = 20000 \text{ kWh} \times \$3 \text{ mil} = \$ 6 \times 10^{10}$

It would cost $\$6 \times 10^{10}$ million ~~to maintain~~ to supply 24,000,000 kWh ~~each year of~~ for 25 years.

~~\$0.002 kWh~~ ~~to~~ The community would pay 0.002 \$/kWh.

E) Two environmental benefits to West Fremont of switching from coal to wind power are less sulfur dioxide emissions into the atmosphere, reducing acid rain, and the reduced need for coal to be mined, prevent mining wastes and acid leaching into the ground.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

Two environmental costs of switching from coal to wind would be (1) the risks of birds flying into the windmill systems and dying, thus decreasing the ethical ~~[illegible]~~ value of the WFWP and the bird population, and (2) taking up many hectares of land for windmill energy-generation use instead of agriculture, a park, or even instead of setting up an ~~[illegible]~~ animal refuge.

GO ON TO THE NEXT PAGE.

2. West Fremont is a community consisting of 3,000 homes. A small coal-burning power plant currently supplies electricity for the town. The capacity of the power plant is 12 megawatts (MW) and the average household consumes 8,000 kilowatt hours (kWh) of electrical energy each year. The price paid to the electric utility by West Fremont residents for this energy is $0.10 per kWh. The town leaders are considering a plan, the West Fremont Wind Project (WFWP), to generate their own electricity using 10 wind turbines that would be located on the wooded ridges surrounding the town. Each wind turbine would have a capacity of 1.2 MW and each would cost the town $3 million to purchase, finance, and operate for 25 years.

(a) Assuming that the existing power plant can operate at full capacity for 8,000 hrs/yr, how many kWh of electricity can be produced by the plant in a year?

(b) At the current rate of electrical energy use per household, how many kWh of electrical energy does the community consume in one year?

(c) Compare your answers in (a) and (b) and explain why you would or would not expect the numbers to be the same.

(d) Assuming that the electrical energy needs of the community do not change during the 25-year lifetime of the wind turbines, what would be the cost to the community of the electricity supplied by the WFWP over 25 years? Express your answer in dollars/kWh.

(e) Identify and explain TWO environmental benefits to West Fremont of switching from coal to wind power and TWO environmental costs to West Fremont of switching from coal to wind power.

a) $12\text{ MW} \times \frac{1000\text{ kWh}}{1\text{ MW}} = 12000\text{ kWh} \times \frac{8000\text{ hr}}{1\text{ year}} = 96{,}000{,}000\text{ kWh/year}$

b) $3000\text{ homes} \times \frac{8000\text{ kWh/year}}{1\text{ home}} = 24{,}000{,}000\text{ kWh/year}$

c) currently the power plant produces three times what all the houses consume. However, this would be expected because the power plant would also have to provide energy for business, schools, & industry. They also might produce a little more electricity than necessary so that there wasn't a shortage.

d) Total it would cost the people 30 million dollars for the WFWP or $0.05 per kWH. to maintain for 25 years

e) By switching from coal to wind power, the people of West Fremont would reduce

GO ON TO THE NEXT PAGE.

2C2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

their sulfur dioxide emissions, lessing the possibility for acid rain. They would also cut back on tropospheric ozone that results from photochemical reactions from fossil fuel emissions. In general, the overall air quality of their community would be greatly improved. An environmental cost or switching to wind power would be the destruction of habitat and large amount of land surface required by a wind power facility. Another cost would be possible noise pollution from the wind powered turbines.

GO ON TO THE NEXT PAGE.