2018

AP CollegeBoard

AP Environmental Science

Sample Student Responses and Scoring Commentary

Inside:

Free Response Question 2

- ☑ **Scoring Guideline**
- ☑ **Student Samples**
- ☑ **Scoring Commentary**

AP® ENVIRONMENTAL SCIENCE
2018 SCORING GUIDELINES

Question 2

An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

(a) **Describe** one environmental benefit associated with an offshore wind project.

(1 point for correct description of an environmental benefit associated with an offshore wind project)

- Reduced environmental damage from decreased reliance on fossil fuels, such as:
  - Less habitat/ecosystem destruction due to less exploration and extraction (less mining or drilling, etc.)
  - Less air/soil/water pollution (less exhaust emissions, pipeline leaks, tanker leaks) due to less transportation of fossil fuels
  - Less air pollution (no/fewer particulates, VOCs, NO_x, SO_x, CO_2, or greenhouse gases) due to less fossil fuel combustion
- Reduced environmental damage from decreased reliance on nuclear power, such as:
  - No risk of radioactive releases with accidents
  - No hazardous/radioactive wastes to store
  - Less exploration/ extraction/processing for uranium ore
- Increased aquatic habitat/artificial reefs for barnacles, sponges, other invertebrates, fish

AP® ENVIRONMENTAL SCIENCE
2018 SCORING GUIDELINES

Question 2 (continued)

(b) **Identify** and **describe** one potential economic effect of an offshore wind project.

(2 points; 1 point for correct identification of a potential economic effect and 1 point for correct description of an identified economic effect. The description point cannot be earned without correct identification of a potential economic effect.)

Identify one potential economic effect	**Describe one potential economic effect**
Job creation (+)	• Jobs will be created in construction, operation, maintenance, etc.
Additional income (+)	• Local municipalities receive more taxes (income, sales, property) paid by utility and workers • Wind power company will make money/profits in the long run
Decreased electricity costs (+)	• Electrical production costs will be lower, which will reduce electricity rates for consumers
Less reliance on foreign energy resources (+)	• Transportation costs to deliver fuels will be reduced
High initial construction/ high maintenance costs (-)	• Local taxes/fees/rates will increase to support construction costs associated with building of facility • Parts and personnel must be transported off-shore for construction, repairs and maintenance
Decreased property value (-)	• Property values will decrease in coastal areas due to unfavorable aesthetics
Loss of income (-)	• Turbines negatively affect the aesthetics, which negatively impacts tourism, fishing, whale watching, etc. • Local fishing opportunities will be disrupted • Less revenue for fossil fuel companies as demand decreases
Job loss (-)	• Jobs will be lost in the traditional energy production sectors (coal, nuclear)
Subsidies cost (-)	• State subsidies to offset cost of building offshore and transmission lines to coast will increase; costs may be recovered with increased taxes

Question 2 (continued)

(c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

(1 point for correct description of energy source from ocean)

- Use of tidal movement/currents to turn turbines
- Utilize a device designed to capture energy from wave motion
- Harness the solar energy absorbed by the oceans/use natural thermal gradient in tropical and temperate oceans to create electricity (OTEC — Ocean Thermal Energy Conversion)
- Harvest algae and convert to biofuel

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs $1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0 x 10^6 MWh per year.

(d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$(0.80) \times (2.0 \times 10^6 MWh) = 1.6 \times 10^6 MWh$$

(e) Customers in the service area pay $0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$1.6 \times 10^6 MWh \times \frac{\$(2 \times 10^{-1})}{kWh} \times \frac{1 \times 10^3 kWh}{1 MWh} = \$3.2 \times 10^8 = \$320,000,000 = \$320 \text{ million}$$

(f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$1.6 \times 10^6 MWh \times \frac{1 \text{ turbine}}{4MW} \times \frac{1}{2 \times 10^2 \text{ turbines}} = 2 \times 10^3 \text{hr} = 2,000 \text{ hours}$$

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

   (a) **Describe** one environmental benefit associated with an offshore wind project.

   (b) **Identify** and **describe** one potential economic effect of an offshore wind project.

   (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

   The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

   (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

   (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

   (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

a) An offshore wind project can reduce the need for electricity from other, more detrimental energy sources, particularly from fossil fuels. Reducing the reliance on fossil fuels lessens greenhouse gas emissions and helps to combat global climate change.

b) An offshore wind project can stimulate the economy by providing new construction and "green" jobs.

the construction of the wind project will bring new jobs as well as the maintenance that will be required for years to come

c) The ocean can provide renewable energy for electricity through the use of tidal turbines. As the tides come in and out, they rotate a turbine that produces electricity.

d) 2.0×10^6 MWh * (.80) = 1.6×10^6 MWh = 80% of annual electric demand

If the wind project produces 1.6×10^6 MWh of electricity,

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

then it will provide 80% of the annual electrical demand for the service area.

e)

$1.6 \times 10^6 \text{ MWh} * \left(\frac{1000 \text{ kWh}}{1 \text{ MWh}}\right) = 1.6 \times 10^9 \text{ kWh}$ of electricity

$1.6 \times 10^9 \text{ kWh} * \left(\frac{\$0.20}{1 \text{ kWh}}\right) = 3.2 \times 10^8 \$ = \$320{,}000{,}000$

The revenue will be $\$3.2 \times 10^8$ or \$320 million

f)

$200 \text{ turbines} \times \left(\frac{4 \text{ MW}}{\text{turbine}}\right)$ 800 MW = capacity of all turbines

80% of annual electrical demand $= 1.6 \times 10^6$ MWh

$(1.6 \times 10^6 \text{ MWh}) \times \left(\frac{1}{800 \text{ MW}}\right) = 2 \times 10^3 \text{ h} = 2000$ hours

In order to provide 80% of the annual electrical demand in the service area, the turbines have to operate for 2,000 hours

GO ON TO THE NEXT PAGE.

1,000,000 watts = 1 MW
1000 watts = 1 KW

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

   (a) **Describe** one environmental benefit associated with an offshore wind project.

   (b) **Identify** and **describe** one potential economic effect of an offshore wind project.

   (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity. tidal power

   The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs $1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

   M K H D B D C M

   (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

   (e) Customers in the service area pay $0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

   (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

a) Offshore wind projects provide a source of renewable, non-damaging source of energy and is growing in popularity as fossil fuels become scarce. Since wind power is readily available and cannot be depleted, there is no risk of running out; it is thus renewable and emits much less, if any greenhouse gases. Its only emissions of GHGs may come from its construction.

b) An economic benefit of offshore wind projects would be the creation of jobs. People are necessary to construct and design such large turbines, which opens up a position to be filled and money to be made by the individual.

c) Tidal power is an additional way that oceans can provide renewable energy. These method of energy generation harnesses the strong movements of ocean currents and tides to spin a turbine to generate electricity.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

a) $.80 \times (2.0 \times 10^6) = \boxed{1.6 \times 10^6 \text{ MWh}}$

$2.0 \times .80 = 1600$

The wind project needs to produce 1.6×10^6 MWh of electricity to service 80% of the region's needs.

c) $\$0.20 \cdot \frac{1000 \text{ KWh}}{1 \text{ MW}} \cdot 1.6 \times 10^6 \text{ MWh}$

200×1000

$200 \times 1.6 \times 10^6$

$2 \times 10^2 (1.6 \times 10^6)$

3.2×10^8

$\boxed{\$320000000}$

The amount of revenue collected would be $320,000,000.

$1.6 \times 2 = 32$

f) $\frac{1.6 \times 10^6 \text{ MWh}}{200 \text{ turbines (4 MW)}} = \frac{1.6 \times 10^6 \text{ MWh}}{800 \text{ MW}} = \frac{1.6 \times 10^6}{8 \times 10^2} =$

8×10^2

$8 \overline{)1.6\,0}$ (0.2; -16; 00)

0.20×10^4

$\boxed{2000 \text{ hours}}$

These turbines must operate for 2000 hours to produce enough energy to satisfy 80% of the needs.

GO ON TO THE NEXT PAGE.

2. An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

   (a) **Describe** one environmental benefit associated with an offshore wind project.

   (b) **Identify** and **describe** one potential economic effect of an offshore wind project.

   (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

   The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs $1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

   (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

   (e) Customers in the service area pay $0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

   (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

A. Less fossil fuels need to be used for energy leading to the release of fewer green house gasses (CO_2).
B. The initial cost will be expensive to build but the project will lead to cheaper energy once it is functional. consumers will have to pay less for energy as the wind is not a cost power companies must obtain like coal or oil.
C. Tidal energy can produce renewable energy. The movement of the tides moves turbines and generates electricity and energy.

GO ON TO THE NEXT PAGE.

kee

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

D. 2,000,000
× ,8
1,600,000.0 1.6×10^6 MWh

E. 1,600,000
.2
320,000

200 × 4 = 800 MW

$1.6 \times 10^6 \times 1 \times 10^3 = 1.6 \times 10^9$
$1.6 \times 10^9 \times .2$
3.2×10^8 $\$ 3.2 \times 10^8$

F. $4 \times 200 = 800$MW
$800 \overline{)1.6 \times 10^6}$

$800 \times 2 = 1,600$
$1600 \times 1000 = 1.6 \times 10^6$
$2 \times 1000 = 2000$

2000 hours

GO ON TO THE NEXT PAGE.

AP® ENVIRONMENTAL SCIENCE
2018 SCORING COMMENTARY

Question 2

Overview

The intent of this question was for students to evaluate a renewable energy resource, wind energy, and to complete several calculations relating to the energy that could be produced by a wind farm. Students were asked to describe an environmental benefit and an economic effect of an offshore wind project. Additionally, students were asked to describe how the oceans, aside from wind energy, could provide renewable energy for the generation of electricity. These concepts were drawn from the following section of the course description: V. Energy Resources and Consumption, G. Renewable Energy.

In the second part of this question, students were asked to calculate the amount of energy the wind project would have to produce in order to meet 80% of the annual consumption of the service area and how much revenue this would generate for the wind power company. Finally, the students were asked to calculate the number of hours the wind turbines would have to operate in order to produce 80% of the annual electricity consumed in the service area. These concepts were drawn from the following sections of the course description: V. Energy Resources and Consumption, A. Energy Concepts and B. Energy Consumption.

Sample: 2A
Score: 10

The response earned 1 point in part (a) for describing that "reducing the reliance on fossil fuels lessens greenhouse gas emissions." The response earned 2 points in part (b): 1 point for identifying "new … 'green' jobs" as an economic benefit and 1 point for describing that there will be new jobs in "the construction of the wind project … as well as the maintenance that will be required." The response earned 1 point in part (c) for correctly describing that "the use of tidal turbines … rotate[s] a turbine that produces electricity." Both points were earned in part (d): 1 point for the correct setup with units and 1 point for the correct answer. Both points were earned in part (e): 1 point for the correct setup with units and 1 point for the correct answer. Both points were earned in part (f): 1 point for the correct setup with units and 1 point for the correct answer.

Sample: 2B
Score: 8

No points were earned in part (a) because a direct relationship between an increase in wind energy and a decreased reliance on fossil fuels is not described. The response earned 2 points in part (b): 1 point for identifying "the creation of jobs" and 1 point for describing "[p]eople are necessary to construct and design such large turbines." The response earned 1 point in part (c) for describing that "the strong movements of ocean currents … spin a turbine to generate electricity." The response earned 1 point in part (d) for the correct answer. No points were earned for the setup because the units are missing from the calculation. Both points were earned in part (e): 1 point for the correct setup with units and 1 point for the correct answer. Both points were earned in part (f): 1 point for the correct setup with units and 1 point for the correct answer.

AP® ENVIRONMENTAL SCIENCE
2018 SCORING COMMENTARY

Question 2 (continued)

Sample: 2C
Score: 6

The response earned 1 point in part (a) for describing that "less fossil fuels need to be used for energy leading to the release of fewer greenhouse gases (CO_2)." The response earned 1 point in part (b) for identifying "the initial cost will be expensive to build." The description point was not earned, as the response does not describe how or why the initial construction costs of the wind farm would be high. The response earned 1 point in part (c) for describing "[t]he movement of the tides moves turbines and generates electricity." The response earned 1 point in part (d) for the correct answer. No points were earned for the setup because units are missing from the calculation. The response earned 1 point in part (e) for the correct answer. No points were earned for the setup because units are missing from the calculation. The response earned 1 point in part (f). No points were earned for the setup because units are missing from the calculation.