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.

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)

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