



AP^{*} ENVIRONMENTAL SCIENCE

RENEWABLE ENERGY

What I Absolutely Have to Know to Survive the AP Exam

The world-wide demand for energy has soared. Human population is increasing exponentially with the emergence of large developing countries onto the global stage. It is projected that by 2030 the world-wide demand for energy will be 695 quadrillion Btu.¹ That prediction is double the amount of energy used in 1990. Fossil fuels account for the vast majority of energy use world-wide; however, to become a sustainable society renewable energy sources and conservation practices have to be developed.

Solar energy or energy derived from the sun offers numerous renewable energy options. The options listed below include the capturing of energy from the sun directly and indirectly.

Solar Electricity

Description: Photovoltaic cells or solar cells contain silicon, a semiconductor, which absorbs a portion of the energy from a photon of light. This energy knocks electrons loose within the material which in turn creates a flow of electric charge or electricity. These solar cells are arranged in **solar panels** and then into **solar arrays**. These arrays can be the stand alone variety or tied into the electric **grid**.

Advantages:

- moderate to high net energy yield
- no greenhouse gas emissions or air pollution generated after initial construction
- no moving parts

Disadvantages:

- cost of photovoltaic cells is high
- storage of excess electricity generated during the day is a problem

Active and Passive Heating

Description: Passive heating captures sunlight directly within a structure (solar hot water heater, water wall, etc.) and converts it into low-temperature heat. The **thermal mass** is the material found within the structure that stores the absorbed heat. It uses this heat to warm a room or to heat water. Active heating is essentially the same as passive heating but it employs the use of a fan or pump to circulate the heat throughout a structure. Both systems allow energy from the sun to be used throughout the day and night.

¹ Energy Information Administration, *International Energy Outlook 2008*, Figure 9, web site www.eia.doe.gov/oiaf/ieo/world.html

Advantages:

- highly energy efficient
- conserves fossil fuels
- no greenhouse gas emissions produced
- no additional land is needed

Disadvantages:

- initial construction and design of structures can be more costly than traditional construction

Hydroelectric Power

Description: Hydroelectric power can be produced both in a large-scale project (large dam and reservoir) and a small-scale hydroelectric project (low dam with no reservoir). It produces electricity much in the same way as a traditional coal-fired power plant. The flow of water past a turbine rotates the turbine and an attached shaft. The shaft turns within a generator producing electricity. Hydroelectric power is currently the leading renewable energy source which accounts for almost 20 % of the world's production of electricity. The reservoirs created also provide a means to control flooding. Most data supports that Canada produces the most hydroelectric power world-wide but followed closely or even shadowed by China's recent projects. Projects designed to capture the energy from ocean waves and the fluctuations of tides are also becoming more prevalent.

Advantages:

- does not produce greenhouse gases or other air pollution
- often produces reservoirs used for recreational use and water supply
- proven technology

Disadvantages:

- floods large areas that destroy wildlife habitat
- high investment costs
- precipitation-dependent
- passage restriction of migrating fish (ex. salmon)
- silt and sediments are trapped behind dam in reservoir (This reduces soil and water quality downstream and also reduces the life-span of the reservoir.)

Key Projects: Three Gorges Dam, Aswan High Dam, James Bay Project



Wind Energy

Description: Wind turns a turbine that is connected to a shaft within a generator which will in turn produce electricity. Large numbers of these turbines are arranged in **wind farms**. Texas has recently passed California in total electricity produced by wind.

Advantages:

- clean, renewable energy
- land around the wind turbines can be used for grazing

Disadvantages:

- large, windy areas of land are often far removed from highly populated areas and require much infrastructure to be added
- high initial investment
- bat and bird kills have been reported
- much controversy on placement of wind farms along the coast in migratory bird flight paths

Producing Energy from Biomass

Description: Biomass or organic matter, such as manure and wood burned directly as a fuel, may be converted into a liquid or gas fuel. This can be accomplished through the production of **ethanol** or **biodiesel**.

Advantages:

- renewable energy source
- can easily be used for transportation
- reduces demand of foreign oil in the United States

Disadvantages:

- low net energy gained
- at present, production requires large amounts of fossil fuels
- produces greenhouse gas emissions and air pollution through combustion
- requires large areas of land that traditionally have been used for food production



Renewable energy can also be obtained through sources indirectly related to the sun. Geothermal energy is one of these sources.

Geothermal Energy

Description: Geothermal energy is produced by harnessing the heat found below the earth's crust. This heat which is transferred from the mantle can be used to heat spaces and to generate electricity through the production of steam and the use of turbines.

Advantages:

- inexhaustible supply
- does not produce greenhouse gas emissions

Disadvantages:

- scarcity of geothermal sites
- local climate destruction
- high initial cost

Hydrogen Fuel Cell

Description: A fuel cell device which combines hydrogen (fuel) and oxygen electrochemically to generate electricity. This electricity can power electric motors to propel a vehicle. The only byproducts are water and heat. Fuel cells produce electricity without combustion so they are quiet and pollution-free. They are also two to three times more efficient than burning fuel. Hydrogen fuel is obtained through a process called **electrolysis** that splits hydrogen atoms away from oxygen atoms in water.

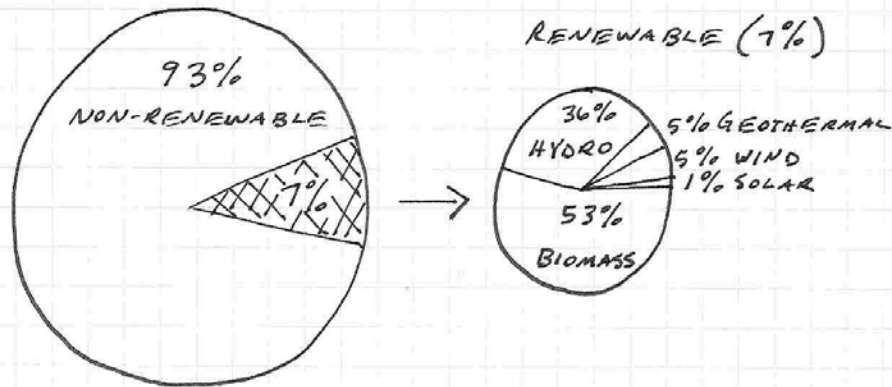
Advantages:

- no pollution in energy production
- renewable energy source

Disadvantages:

- production of hydrogen fuel with present technology is costly
- massive infrastructure with high initial costs would have to be created to support fuel cells

2007 TOTAL ENERGY USE



Source: EIA, Renewable Energy Consumption of Electricity Preliminary 2007 Statistics, Table 1.
http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/table1.html

The government can perpetuate the use and development of these sources through several ways:

1. tax breaks and government subsidies for companies providing alternate energy sources
2. reduced subsidies and tax breaks for fossil fuels and nuclear power
3. tax breaks for individual homeowners who choose renewable sources of energy.

These sources provide an alternative to traditional non-renewable energy sources, nevertheless conservation will be critical in reaching a sustainable level of energy use. **Hybrid cars** and **mass transit** are two ways in which we can reduce the use of fossil fuels for transportation. Governments can also create policies to reduce use of fossil fuels and create avenues in which information about efficiency can be disseminated to the public. The **Corporate Average Fuel Economy (CAFE)** was established to set a standard for fuel economy expressed in miles per gallon to a manufacturer's fleet of passenger cars or light trucks. It also levied penalties to manufacturers who do not meet these standards.



Multiple Choice

1. All of the following are methods of biomass energy production except
 - A. Burning manure to cook food
 - B. Collecting wood to burn for heat
 - C. Collecting methane from animal waste to produce electricity
 - D. Using moving water to generate electricity
 - E. Producing ethanol to be used in automobiles

2. Biofuels include which of the following
 - I. Ethanol
 - II. Biodiesel
 - III. Vegetable oil
 - A. I only
 - B. I and II only
 - C. I and III only
 - D. I, II, and III
 - E. None of the above

3. All of the following are negative environmental impacts of hydroelectric power except
 - A. Damming rivers destroys habitat
 - B. Damming disrupts the natural flooding of rivers
 - C. Hydroelectric power contributes directly to acid rain
 - D. Hydroelectric dams can create thermal pollution downstream
 - E. Sediment, and nutrients, are trapped behind dams

4. Which of the following is a benefit of using biomass to produce energy?
 - A. Biomass energy production is near Carbon neutral.
 - B. Using biomass supports local economies
 - C. Biomass is a perpetual resource
 - D. Both A and B
 - E. All of the above



Questions 5-9 refer to the following choices.

- A. Biomass
 - B. Hydroelectric
 - C. Passive solar
 - D. Geothermal
 - E. Wind
5. This type of renewable energy relies on a constant source of moving water.
6. Involves the combustion of organic material associated with living organisms.
7. This type of energy production is the fastest growing renewable energy sector.
8. This type of energy is not directly derived from the sun.
9. Involves the direct use of radiant energy from the sun to heat water or air.
10. Which of the following are waste products of hydrogen fuel cells?
- I. Water
 - II. Heat
 - III. Carbon Dioxide
 - IV. Methane
- A. I only
 - B. I and II only
 - C. I, II, and III
 - D. I, II, III, and IV
 - E. None of the above



Free Response

1. Renewable energy resources will become more and more important as countries look for ways to meet their energy demands while fossil fuel resources begin to dwindle.
 - A. Identify and describe two renewable energy resources.
 - B. Identify and describe one negative impact and one positive impact for each of the renewable energy resources identified in part A.
 - C. Imagine that you are the president of a country, and describe two incentives that you would provide to encourage your citizens to use renewable energy resources.