



# APES in a BOX: The Review Sessions

## **Non-Renewable and Alternative Energy**

Nonrenewable energy resources, such as coal, oil, and natural gas account for the vast majority of the world's commercial and transportation energy. These fuel sources provide relatively inexpensive, high-quality energy. Yet, they are also responsible for several major environmental problems. By definition, a nonrenewable resource is one that will eventually run out. Here we will take a look at the major sources of nonrenewable energy, their advantages, and their disadvantages.

### **Coal**

Coal was formed when organic matter (mostly from plants) was exposed to increasing heat and pressure underground. Over long periods of time the organic matter is transformed into the compact carbon based matter that is coal. There are several types of coal that are formed depending on the amount of heat and pressure that the material is exposed to.

**Peat:** Peat is an early stage of coal that is formed under minimal pressure and has high moisture content. Peat has a very low heat and carbon content. Peat is harvested and burned for heat and cooking. It is found predominantly at higher latitudes in the northern hemisphere.

**Lignite:** Lignite is coal that has been formed under more pressure, heat, and time than peat. Lignite still has a relatively low heat and carbon content. It also has high moisture content. Lignite is burned to produce electricity, but is responsible for a great deal of air pollution due to its high sulfur content.

**Bituminous Coal:** This type of coal is used regularly as a fuel because of its high heat content. It also has high sulfur content.

**Anthracite (hard coal):** Anthracite is a very valuable energy resource because it has a high heat content with very low moisture and sulfur content. Anthracite takes much longer to form than the other types, and is more expensive.

Minerals such as coal are removed by either surface or subsurface mining techniques. **Subsurface mining** is used when the mineral deposit is too deep to extract using surface mining techniques. Surface mining techniques include:

**Open-pit mining:** Large holes are dug directly into the surface of the earth to remove ores.



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**Strip mining:** Heavy machinery is used to dig large trenches. The minerals are removed and the overburden is used to fill in the previous trench.

**Contour strip mining:** The same concept as strip mining is applied in mountainous areas.

**Mountain-top removal:** Heavy machinery or explosives are used to remove the top of a mountain in order to expose the minerals.

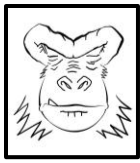
## Impacts of Mining

Surface mining disrupts habitat which can lead to loss of biodiversity. Disturbed soil is also more susceptible to erosion. Subsurface mining can lead to **subsidence** as the ground above the mine caves in over time. Fires can start in underground coal deposits, and burn out of control for long periods of time. Acid mine drainage can occur when rainwater leaches through mine waste, and causes acid to runoff into nearby bodies of water. Old mining sites can be restored or reclaimed by replanting native species of plants on the disrupted land. All too often mining companies go bankrupt or shut down operations without restoring the disrupted land.

## Coal Burning Power Plants

Coal is used throughout the world to directly heat homes, heat water, cook, and generate electricity. Approximately 40% of the world's electricity is generated by burning Coal. Electricity is produced from coal by the following process:

Coal is pulverized and then burned. The heat is used to boil water in a boiler. The steam that is generated is used to spin a turbine which in turn generates electricity. The steam is then condensed and the water is returned to the boiler to be used again. Waste heat generated during the process can be transferred to the atmosphere through a cooling tower or to a body of water. On a side note, it is possible to use the waste heat for commercial or residential hot water through a process called **cogeneration**.



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## **Good reasons to use coal!**

Coal is an abundant resource in the US with a relatively high net energy yield. The infrastructure for mining and using coal is well developed, and it is relatively inexpensive to use.

## **Negative impacts of using coal**

A great deal of CO<sub>2</sub> is released when coal is burned. The burning of coal also releases SO<sub>2</sub> which is involved in the formation of acid rain.

## **Crude Oil**

Crude oil is a fossil fuel that is produced by the decomposition of deeply buried dead organic matter. These plants, animals, and protists were exposed to high pressure and temperature over millions of years. The resulting product is crude oil that is composed of hydrocarbons and small amounts of sulfur, oxygen, and nitrogen. Crude oil is extracted by drilling holes into a deposit and pumping the oil to the surface for distribution. Petrochemicals are used not only for fuel, but in the production of plastics, asphalt, pesticides, grease, wax, and industrial solvents. A process called **fractional distillation** is used to separate the crude oil into the gas, jet fuel, heating oil, solvents, etc. that we use today.

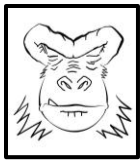
Oil is now the largest source of commercial energy in the world. The OPEC countries hold as much as 60% of the world's proven crude oil reserves. The three largest consumers of oil are the United States, China, and Japan.

## **There are many advantages to using oil as a fuel source such as:**

Oil is relatively inexpensive. It is easily transported with pipelines, trucks, and ocean tankers. There is relatively low land use associated with drilling for oil. Oil has a relatively high net energy yield.

## **Some disadvantages to using oil as a fuel source include:**

Demand for oil may exceed production in the next 50 years. Throughout the life cycle of the production and use of oil it causes environmental degradation. Drilling for oil causes land disruption which can lead to more rapid soil erosion. Oil spills can be very disruptive to aquatic habitats. Petroleum products can contaminate groundwater supplies. Burning oil for energy produces CO<sub>2</sub>, a greenhouse gas, as well as sulfur dioxide and nitrogen oxides which lower air quality and contribute to acid rain.



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## **The Fine Print**

The **Oil Pollution Act of 1990** gives the EPA the ability to respond to oil spills and to regulate oil storage facilities.

## **Shale Oil and Tar Sands**

Shale oil is extracted from shale rock that contains a mixture of hydrocarbons called kerogen. The rocks are crushed and then heated to separate the shale oil from the rock. The majority of the world's shale oil can be found in the United States. Unfortunately it takes a great deal of energy and water to extract the shale oil. Tar Sand is a thick substance made of sand and bitumen. The majority of the world's tar sand can be found in Alberta, Canada. The tar sand must be heated significantly to extract the oil. Both shale oil and tar sands require a great deal of land disruption during the mining process. Shale oil and tar sands have a lower net energy yield than conventional oil and share the same environmental concerns when used as a fuel source.

## **Natural Gas**

Natural gas is a mixture of methane, butane, ethane, and hydrogen sulfide. Natural gas is found above conventional oil deposits. A pipeline must be in place to trap the natural gas. Gas is often burned off as a waste product in oil production. Components of natural gas are compressed and stored as liquefied petroleum gas. The natural gas that is sent through a pipeline to be used for heating and electricity production is methane. Natural gas can be refrigerated and liquefied for transport over long distances.

### **Some benefits of natural gas include:**

Natural gas has a relatively low cost with a high net energy yield. There are plentiful reserves of natural gas in oil producing countries. Natural gas has lower carbon dioxide emissions than conventional oil and contributes less air pollution.

### **Some disadvantages of natural gas include:**

While it is better than conventional oil, natural gas is still a nonrenewable resource that produces CO<sub>2</sub> and air pollution when it is used. Damaged pipelines can release methane, which is a powerful greenhouse gas, into the troposphere.

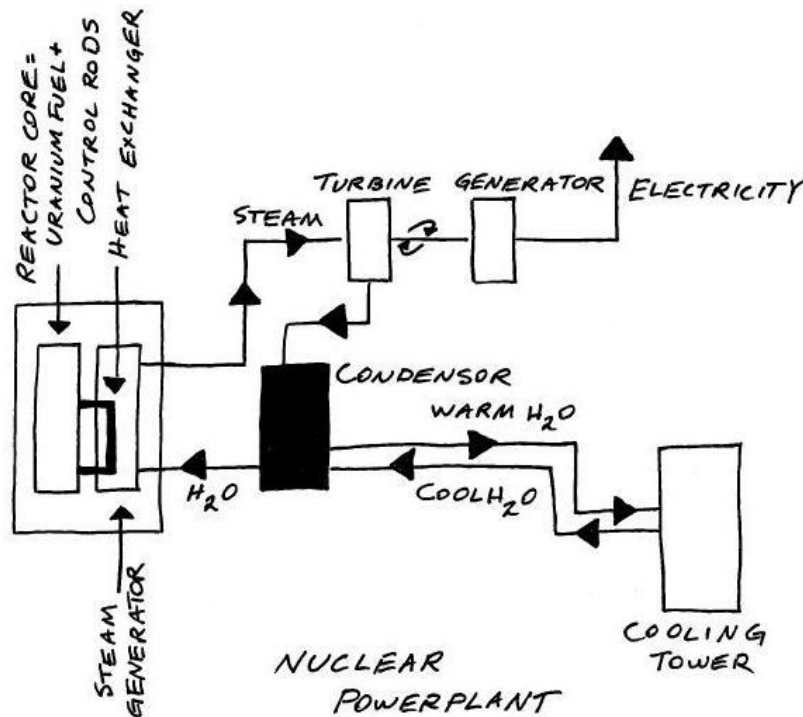


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## Nuclear Power

Nuclear power is considered an alternative energy source as it does not directly use fossil fuels. However, nuclear power uses fissionable materials such as Uranium-235 which has to be mined, and is technically a nonrenewable resource.

To produce electricity, controlled nuclear reactions are used to generate a tremendous amount of heat which is used to create steam which spins a turbine. The spinning turbine generates electricity, and the waste water must be cooled and condensed much like a coal power plant. Nuclear power currently accounts for only a small percentage of the world's electricity production, and that percentage is actually predicted to decrease as the rate of decommissioning of old nuclear power plants exceeds the development of new nuclear power plants. Nuclear fission, the splitting of atoms, is responsible for generating the heat that is used in a nuclear power plant. Experiments have been done with hopes of using nuclear fusion for energy production, but attempts have been unsuccessful.





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Radioactive material such as Uranium-235 decays into other lighter radioisotopes. As the isotopes decay, they give off radiation and sub-atomic particles. The rate at which the isotope decays is its **half-life**. Half-life is the amount of time that it takes for half of the atoms in a given amount of radioactive material to decay. Uranium-235 has a half-life of 700 million years.

Yucca Mountain in southern Nevada has been chosen as a central site for nuclear waste disposal in the United States. If approved, radioactive waste from the military and power plants would be stored underground at the Yucca Mountain site indefinitely. Chernobyl (Ukraine 1986) was a large nuclear disaster caused by a meltdown in a nuclear power plant. Human error was the main cause cited in the disaster. Three Mile Island (Pennsylvania 1979) was a nuclear incident involving a partial core meltdown.

### **Benefits of using nuclear Power**

Using nuclear power does not directly contribute to greenhouse gases or air pollution.

There is relatively little land disruption.

There is a relatively large supply of nuclear fuel.

Nuclear power plants are heavily scrutinized and relatively safe.

### **Some disadvantages of nuclear power include:**

Nuclear waste is extremely dangerous and very expensive to dispose of.

Nuclear power plants serve as potential terrorist targets.

A tremendous amount of waste heat is generated by the power plants.

While the risk is low, nuclear disasters are very dangerous.



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## **Nonrenewable and Alternative Energy Review Questions**

Use the following answer choices for questions 1-5

A) Peat

B) Bituminous

C) Lignite

D) Anthracite

1. High quality coal with high heat content and low sulfur content.
2. Precursor to coal with low heat and carbon content.
3. Medium grade coal with high heat content and high sulfur content.
4. Coal with high moisture content and relatively low heat and carbon content.
5. Most expensive type of coal.

6. Waste hot water from electricity production could be used for other commercial or residential purposes. This process is called.

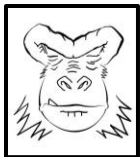
A) Gasification

B) Recycling

C) Cogeneration

D) Fractional Distillation

E) Thermal pollution



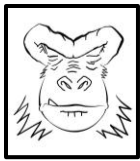
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7. Which of the following is an advantage of using oil as a fuel source
- A) Oil is derived from organic sources, and is therefore a renewable energy source.
  - B) Oil prices are projected to decrease as we use it more.
  - C) The infrastructure for transporting and using oil is already in place.
  - D) Using oil does not contribute to greenhouse gasses.
  - E) There are no sulfur and nitrogen compounds (components of acid deposition) produced by using oil.

### **Free Response**

1. Nuclear power has the ability to provide large amounts of electricity. The advantages and disadvantages of using nuclear power have been greatly debated.
- A. Describe one advantage of using nuclear power.
  
  - B. Describe one disadvantage of using nuclear power.
  
  - C. Identify the fuel that is used by nuclear power plants.
  
  - D. Describe two similarities between coal-fired power plants and nuclear power plants.





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## Multiple Choice Scoring Guidelines

1. D	3. B	5. D	7. C
2. A	4. C	6. C	

## Free Response Scoring Guidelines

1.A. (1pt only) 1pt is earned for correctly describing an advantage of nuclear power

Little to no emission of greenhouse gasses	Relatively minor land disruption
Abundant supply of fuel	Generally safe when appropriate safety measures are taken

1.B. (1pt only) 1pt is earned for correctly describing a disadvantage of nuclear power

Disposal of nuclear waste is difficult and costly	Potential terrorist target
Potential for meltdown or radiation leaks	Potential for thermal pollution

1.C. (1pt only) 1pt is earned for correctly identifying Uranium as the fuel source for nuclear power plants

1.D. (2pts total) 1pt each is earned for each correct description of similarities between coal and nuclear power plants.

Both produce steam in order to power an electricity generating turbine	Both require cooling towers or ponds to dissipate waste heat
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Multiple choice points earned + Free response points earned / 12 \* 100 = Quiz average

( \_\_\_\_\_ + \_\_\_\_\_ ) / 12 \* 100 = \_\_\_\_\_ Quiz Grade

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