NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Unit 9 Producing Energy**



There are many reasons that the United States should aggressively pursue making alternative energy the new norm. Fossil fuels are non-renewable. We are running out & our dependence on them is polluting our water and air. *Fossil fuel emissions are accelerating the rate and intensity of global warming*. And the consequences of global warming are so serious that alternative energy should be required by *all nations within 5 years*. A third reason for developing and using alternative energy is that once these methods have been installed, consumers will save significant amounts of money on their energy bills. So what’s holding us back? Is it possible that the Fossil Fuel Lobby in Congress has blocked significant development of alternative energies? What a cynical thought!

**WATCHING THE VIDEOS PROPERLY IS HIGHLY RECOMMENDED FOR THIS UNIT!**

**Electrical Generation (*Video 9.1 Energy Basics AND Video 9.2 Energy Consumption due \_\_\_\_\_\_\_)* (pg.406)**

1. **What is a joule (J**)? / is equal to the energy transferred (or work done) to an object when a force of one newton moves that object a distance of one meter
2. **What is a watt (W)?** / equivalent to one joule per second (1 J/sec), one kilowatt = 1,000 watts,

1 kWh = 3600 kJ, one megawatt (MW) = 1 million watts, one gigawatt (GW) = 1 billion watts

1. **What is a British Thermal Unit (BTU**)? / is a traditional unit of energy; the amount of energy needed to cool or heat one pound of water by one degree Fahrenheit One kilowatt-hour = 3,413 BTU
2. **Know how to identify and label the parts of a conventional power plant** /
	1. **Generator** / a device that converts mechanical energy (i.e. a spinning turbine) and converts it to electric current by rotating a conductor (wire) in a magnetic field

**NONRENEWABLES (*Video 9.3 Fossil Fuels due \_\_\_\_\_\_\_\_\_\_\_\_)* (pages 397 – 429 Chapter 12)**

**Petroleum**

1. **Crude oil was formed by** / the decomposition of ancient microscopic aquatic organisms exposed to high pressure and temperature over millions of years converting them to a mixture of hydrocarbons
2. **Crude oil (petrochemicals) are used in** / fuel, plastics (yes that means your cellphone and computers!), asphalt, pesticides (DDT), grease, wax, and solvents (it is linked to pretty much everything we have…)
3. **Fractional Distillation** / a process used to separate crude oil into gas, jet fuel, heating oil, etc. by heating it till it boils. The vapor then cools (condenses) at different levels where it is extracted. About 50% of barrel of crude oil becomes gasoline (think of image of what percentages a barrel of oil is made into)
4. **OPEC stands for** / Organization of Petroleum Exporting Countries controlling about 80% of the world’s known oil reserves (Iran, Iraq, Kuwait, Saudi Arabia, United Arab Emirates, Venezuela, Nigeria, Qatar)
5. **Advantages of Oil** / it is relatively inexpensive with a high net energy yield. It is easily transported in liquid form. The comfortable life you have today is due in part to oil (AKA High Quality Energy)
6. **Disadvantages of Oil** / demand for oil may exceed production in the next 50 years (it’s non-renewable). Production and transport of oil leads to environmental degradation (oil spills). Burning oil produces CO2 (greenhouse gas) which is a leading contributor to climate change.
7. **Substitutes for Oil-Based Products** / natural fibers like cotton, hemp, bamboo, wood fibers in reusable bags, garments, fabrics, beeswax, also corn-based plastics like those used in some bottled water containers.
8. **Three largest consumers of oil are** / United States, China, and Japan; oil is the largest source of commercial energy in the world
9. **The idea of Peak Oil (AKA Hubbert Curve)** / an event proposed by Marion King Hubbert a Shell Company geophysicist, the point in time when the maximum rate of extraction of petroleum is reached, after which the rate of production is expected to decline (bell-shaped curve). Some experts say it has passed, some say it is 20 years away. Nevertheless we have about 53 years left of crude oil…
10. **The ANWR (Arctic National Wildlife Refuge) Debate** / Alaska’s North Slope is an extremely slow growing and fragile ecosystem; considered a treasure of wildlife and would be fragmented, impacting migratory animals like caribou. Developers estimate an average of 10 billion barrels of oil which would last the US about a year and three months. It would have no real impact on global oil prices. Classic Lorax battle is it worth it? Obama wants to make it a wilderness area which means it could never be developed.

**Natural Gas**

1. **Natural gas is a** / mixture of mostly methane, some propane, butane, and ethane; usually found above conventional oil deposits because it has a lower density (Russia and Iran have the most reserves)
2. **Advantages of Natural Gas** / low cost with a high net energy yield. World reserves about 125 yrs. left. Lower carbon dioxide emissions and air pollution as compared to the other fossil fuels.
3. **Disadvantages of Natural Gas** / still a nonrenewable resource producing CO2 and air pollution. It is four times more expensive to transport compared to crude oil because it must be liquefied. Damaged pipes and/or leaks releases methane which is a 23x more powerful greenhouse gas than CO2.
4. **Hydrofracking** / is a way to extract natural gas from rock by pumping water and chemicals to fracture the rock releasing the trapped gas; is highly polluting to and uses millions of gallons of ground/drinking water and can cause constant but minor earthquakes

**Oil Shale and Tar Sands (AKA synfuels)**

1. **Shale Oil and Tar Sands** / the oil/tar is embedded in the shale/sand making it harder to extract than conventional oil deposits. They have a lower net energy yield because it take more energy to extract is and is significantly more destructive to the environment when mined
	1. The oil shale is solid, waxy hydrocarbon mixture is called **KEROGEN** 1:2 ratio
	2. The tar sands are a mixture of sand, water, and **BITUMEN** 1:5 ratio
2. **Keystone XL Pipeline Debate** / originating in Alberta Canada holding about 30 years of world oil use (if all of it was extracted), would create 3,900 temporary construction jobs and 42,000 permanent jobs (mostly in Canada) while decreasing US reliance on foreign oil. Environmentally it would drastically increase CO2 emissions, destroys boreal forests, and could lead to major oil spill above the Ogallala aquifer
3. **Dakota Access Pipeline Debate** / it would efficiently transport about 500,000 barrels of crude oil a day across four states, from North Dakota to a terminal in Illinois, where it can be shipped to refineries. Environmentally it *could* lead to major oil spill contaminating the drinking water of millions including both surface waters and groundwater (Ogallala aquifer), right next to a Native American reservation

**Coal**

1. **Coal was formed by** / organic matter (mostly plants, think swamps) exposed to increasing heat and pressure transforming it into a compact carbon based rock. The type of coal changes depending on how much heat and pressure it was exposed to. Largest deposits are in China, US, Russia, and India
	1. **Peat is** / an early stage of coal that forms under minimal heat and pressure; has a high moisture content low heat and carbon content. Found mostly in higher latitudes of the northern hemisphere (ex. Ireland)
	2. **Lignite formed** / under more heat, pressure, and time than peat; still low heat and carbon content with high moisture. It is burned for electricity but responsible for great deal of air pollution due to its high sulfur content
	3. **Bituminous Coal** / formed under more heat and pressure than lignite; has a high heat content but also has a high sulfur content and used widely around the world
	4. **Anthracite (metamorphosed “hard” coal)** / very valuable energy resource due to its high heat, low moisture and sulfur content. Took more heat, pressure, and time to form therefore is more expensive
2. **Electricity from coal is produced by** / pulverizing then burning it to boil water. The steam generated is used to spin a turbine which generates electricity. Approximately 40% of the world’s electricity is generated by burning coal.
3. **Advantages of Coal** / it is a cheap, abundant energy resource with a high yield. The infrastructure for mining and using coal is well developed.
4. **Negative impacts of using Coal** / a great deal of CO2 is released when it is burned, it is a major contributor to climate change. Burning coal also releases SO2 which is involved in the formation of acid rain. Major source of mercury pollution. Health effects for the workers and nearby residents; acid mine drainage, lead arsenic and acid leach into streams from the acids due to mining coal

**Nuclear Energy (*Video 9.4 Nuclear Energy due \_\_\_\_\_\_\_\_\_\_\_\_)* (pages 418-423)**

1. **Nuclear Fission** / chain reaction produced when nucleus splits by neutron collision. It is not a fossil fuel but uses Uranium-235 which has to be mined and is a nonrenewable resource. Produces of 12% of world’s electrical energy, 20% for U.S.
2. **Electricity from nuclear power is produced by** / controlling nuclear reactions in the reactor core which generates tremendous amounts of heat. The heat is then used to boil water and spin a turbine just like in a coal power plant. ***Know the parts of a nuclear power plant! SEE ATTACHED DIAGRAM!***
3. **Advantages of Nuclear Power** /
	1. Does not directly contribute to climate change
	2. Relatively large supply of nuclear fuel
	3. Are heavily regulated and relatively safe
4. **Disadvantages of Nuclear Power** /
5. Nuclear waste is extremely dangerous and very expensive to dispose of
6. Possible targets for terrorist attacks
7. A tremendous amount of waste heat is generates leading to thermal pollution
8. Nuclear disasters, while unlikely, are devastating and unsafe for a long time after the accident
9. **What Happens to the High Level Radioactive Waste?** / was first going to be stored in a massive underground facility in Nevada called Yucca Mountain, but Obama defunded it for political reasons. Now most spent nuclear fuel remains on site in storage containers
10. **Ionizing Radiation** / has a lot of energy, shorter wavelengths; knocks of electrons, can cause cancer examples Gamma, x-rays, and ultra-violet energy
11. **Describe the Three Major Nuclear Disasters /**
12. **Chernobyl, Ukraine** /April 26, 1986, unauthorized safety test (irony), leads to fire, explosion, and total meltdown of the core—millions exposed to unsafe levels of radiation
13. **Three-Mile Island, Pennsylvania /** March 29, 1979, nuclear power plant loses cooling water, 50% of core melts, and radioactive materials escape into the atmosphere, near meltdown
14. **Fukushima, Japan** / March 12, 2011, after a 9.0 earthquake, tsunami, and power outages the plant was unable to keep the reactor cool as backup systems failed allowing the reactor to overheat, explode, and leak radiation
15. **Nuclear Fusion** /two isotopes of light elements (H) forced together at high temperatures till they fuse to form a heavier nucleus (He). Process is expensive; break-even point has not yet been reached. Happens in the Sun. Produces virtually no long-term high level radioactive waste and limitless power

**RENEWABLES (*Video 9.5 Renewable Energy due \_\_\_\_\_\_\_\_\_\_\_\_)* (pages 431 – 466 Chapter 13)**

1. **Passive Solar** / using the structure and orientation of a house to regulate temperature and energy use (Earthship homes!) ***KNOW some*** e***xamples of passive design features:***
	1. No windows on the North side of home, big double pane windows on the south side, overhang on the south side windows (think our school!), deciduous trees on the south side and evergreens on the north side, well insulated thermal mass (stone or earth) to hold onto the heat in the winter
2. **Photovoltaic Cells** / collect sunlight and convert it to electricity. This can be used to charge batteries or supply energy directly to a motor, light, etc.
3. **Solar Thermal Conversion (Active Solar Heliostat)** / making hot water for home use or making electricity from steam using the sun’s heat. An example are mirrors tracking the suns path, reflecting light to a central point or tower. Requires a lot of land and a lot of sunlight
4. **Advantages of Solar Energy** /
	1. No fossil fuels are used, producing no greenhouse gases or air pollution
	2. They well suited for remote locations or “off the grid” living
	3. Once it is installed it requires low maintenance, is “free” energy, and renewable
5. **Disadvantages of Solar Energy** /
	1. Energy is only produced when the sun is shining (cloudy days and night; needs battery storage)
	2. Pollution is generated from the manufacture and transportation of solar systems
	3. The initial cost is high as compared to fossil fuels
6. **Advantages of Wind Power** /
	1. Many places throughout the U.S. and the world have enough wind suitable for energy production
	2. Once it is installed it requires low maintenance, is “free” energy, and renewable
	3. No fossil fuels are used, producing no greenhouse gases or air pollution
7. **Disadvantages of Wind Power** /
	1. Energy is only produced when the wind is blowing
	2. The initial cost is high as compared to fossil fuels
	3. Windmills can be disruptive and even kill birds and bats
	4. Some consider them to visually unappealing and noisy (NIMBY) - noise pollution too
8. **Geothermal** / using Earth’s internal radioactive heat energy to produce steam and turn turbines in large power plants. Also can be used as a home temperature regulating system by dumping excess heat in the summer and gaining heat in the winter. Earth’s temperature is constantly between 50°F – 60°F
9. **Tidal and Ocean Waves** / use the constant motion of the ocean to turn turbines, but can be expensive, needing large areas, and interfering with aquatic ecosystems
10. **Biomass Energy is** / burning or digesting of wood, dung, or other waste materials to provide heat or turn a turbine, biogas digesters convert animal or food waste into biogas which can be used as fuel
	1. **Biodiesel is produced by** / mixing plant oil with an alcohol which can run in a diesel engine with limited modifications. Biodiesel has great promise because any type of plant oil, even algae, can be used to produce it
	2. **Ethanol is produced by** / fermenting sugar or starches, then it is distilled. The pros are it can be produced locally reducing our dependence on foreign oil (like in Brazil), but involves large amounts of cropland which are already stressed for food production
11. **Hydroelectric Power is produced by** / water flowing over a turbine that is connected to an electrical generator to produce energy. Produces 16% of the world’s electric power, 9% in the U.S.
12. **Hydrogen Fuel Cells produce energy by** / separating hydrogen’s proton and electron, the proton passes through a membrane, eventually combining with oxygen to form water as a waste product. The separated electrons produce electricity.

**Conservation and Energy Efficiency (*Video 9.6 Energy Conservation due \_\_\_\_\_\_\_\_\_\_\_\_)***

1. **Best Solution to Energy Shortage /** conservation, increase efficiency, then explore alternative energy options
2. **Ways to Decrease Oil Use** / carpool and use the HOV lane. Drive at 55 miles an hour (most efficient speed), make sure tires are properly inflated. Buy a fuel efficient, hybrid, or electric car
	1. **The Corporate Average Fuel Economy (CAFE) standards** / are regulations in the United States, first enacted by the U.S. Congress in 1975, in the wake of the Arab Oil Embargo, to improve the average fuel economy of cars and light trucks (trucks, vans and sport utility vehicles) produced for sale in the United States.
3. **Ways to Decrease Energy Use at Home** / replace incandescent light bulbs with LED bulbs, turn down the heat and turn up the AC a few degrees, insulate attic and use spray foam insulation when remolding, install energy efficient windows, buy energy star rated appliances, turn off lights and unplug electronics when not in use, green roofs
4. **Cogeneration** / capturing excess heat, which would normally be exhausted, to increase the efficiency of a power plant. It’s a way to save money and conserve energy



**WORD BANK:**

Containment Building Control Rods Core Condenser

Heat Exchanger Turbine Cooling Tower or Nearby Water Source

**ENERGY CALCULATIONS**

You ***MUST*** show your work every time. On the AP exam, you are ***not*** allowed to use calculators, so try to get used to it now. Set up all equations to cancel out the units.

**Example:**



**Practice Problems:**

1. A major coal fired electrical power plant produces 13,000 MW-hr of electrical energy per day.

 a. Assuming that 1.0 MW-hr corresponds to 3,400,000 BTU’s, how many BTU’s are produced by the plant each day?

 b. Assuming that one pound of coal can produce 5000 BTU’s, how many pounds of coal are used by the plant each day?

2. A major coal fired electrical power plant uses 4500 tons of coal each day. Each pound of coal can produce 5000 BTU’s of heat energy.

 Given: 3400 BTU’s are equivalent to 1.0 kW-hr of energy. 1 ton = 2,000 lbs

 a. How many kW-hr of electrical energy are produced by the plant each day?

3. A family is building a new home in Alaska which experiences severe winters.

 Assume the following:

• The house has 4000 square feet

• 100,000 BTU’s of heat per square foot are required to heat the house for the winter

• Natural gas sells for $5.00 per thousand cubic feet

• One cubic foot of natural gas supplies 1000 BTU’s of heat energy

• 1 kilowatt-hour of electricity supplies 10,000 BTU’s of heat energy

• Electricity costs $50 per 500 kWh

 a. Calculate the number of cubic feet of natural gas required to heat the house for the winter

 b. Calculate the cost of heating the house using natural gas

4. Use the following conversion factors to answer the questions:

1 gallon of water = 8 lbs. of water

1 kWh = 3,400 BTU’s

1 BTU = the amount of energy to raise 1 lb. of water 1o F

1 lb. of coal can produce 5,000 BTU’s.

Coal is 5% sulfur by mass.

1 ton = 2,000 lbs.

1 cubic foot of natural gas can produce 1,000 BTU’s.

Natural gas is available at $5.00 per one thousand cubic feet.

 a. An average coal power plant produces 10 million kWh of electricity each day, how many pounds of coal are required to power an average electric plant each day?

 b. How much natural gas would be required to produce the same amount of energy as a single day at the coal power plant?

 c. How much sulfur is produced by the coal power plant each day?

5. Sachem East High School might require 120 MBtu of heat for the average winter. One cubic foot of gas yields 1000 BTU of heat. The abbreviation ccf stands for 100 cubic feet.

 If this heat were supplied by a natural gas furnace operating at 60% efficiency…

 a. How many BTU is needed to heat our school?

 b. How many cubic feet of gas would need to be purchased?

 c. At a cost of $0.90/ccf, what would it cost to heat Sachem East for the season?

6. A new 80% efficient furnace is installed (at a cost of $4000) in the school mentioned in Question #5,

 a. How many BTU is needed for the *new furnace*?

 b. How many cubic feet of gas would be needed for the *new furnace*?

 c. What would it cost to heat the house for the season with the *new furnace*?

 d. How long would it take to pay back the initial cost of this new furnace (assuming natural gas prices stay the same)?

1. 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.
	1. 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?
	2. At the current rate of electrical energy use per household, how many kWh of electrical energy does the community consume in one year?
	3. Compare your answers in (a) and (b) and explain why you would or would not expect the numbers to be the same.
	4. 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

You ***MUST*** show your work every time. On the AP exam, you are ***not*** allowed to use calculators, so try to get used to it now. Set up all equations to cancel out the units.

1. **Efficiency of power plants**

Assume the following:

* One truckload of woodchips = 40 tons
* 1 kWh = 3400 BTU
* Burning 1 cubic foot of methane = 560 BTU
* Burning 1 lb. woodchips = 4,500 BTU
* Burning 1 lb. of coal = 8,000 BTU
* 1MWh = 1000 kWh
1. Ryegate Woodchip Electrical Generating Plant consumes 22,000 tons of woodchips per month and generates 16,000 MWh of electricity per month. What is the efficiency of the plant?
2. Grayling Generating Station uses 150,000 tons of coal a month to produce 150,000,000 kW of electricity per month. What is the efficiency of the plant?
3. In a given month, Waste Management, Inc produces an average of 26,000 MW of electricity by burning 700 million cubic feet of methane. What is the efficiency of the plant?
4. **Heating an office building**

Assume the following:

* The office building has 15,000 square feet of office space.
* 500,000 BTU’s of heat are needed per square foot to heat the office building for the winter.
* Natural gas is available for large use customers at a cost of $4.00 per thousand cubic feet.
* One cubic foot of natural gas supplies 1,000 BTU’s of heat energy.
* The furnace in the building is 80% efficient.
1. Calculate the number of cubic feet of natural gas required to heat the office building for one winter.
2. What is the cost in dollars to heat the office for one winter?

10. **Should you buy a new refrigerator?**

Assume the following:

* The cost to repair the old refrigerator is $375; no other repairs are needed during the 5 yr. period.
* The old refrigerator uses 200 kWh of electricity per month.
* The total cost of a new refrigerator is $1,000.
* The new refrigerator is 60% more efficient than the old refrigerator.
* Your electric company charges you $0.10 per kWh.
1. Calculate the cost to repair and continue running the OLD refrigerator for the next 5 years.
2. Calculate the cost to purchase the NEW refrigerator and run it for the next 5 years.
3. Compare the total 5-year cost for the old and new refrigerators. Which is more cost efficient?

**Energy** **Speed Dating**

My Dating Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Card # & suit \_\_\_\_\_\_\_\_

You are responsible for researching your energy type and you will “become” your energy. Don’t just tell facts to your date that is boring. Try to talk yourself up. For example, let’s say you are nuclear energy instead of saying “I am fission, I work by splitting atoms” leave a little mystery and say “I just recently split from my spouse.” Everyone loves humor, it breaks the ice, but please keep the comments PG!

**Use this website as a resource** [***https://www.studentenergy.org/topics***](https://www.studentenergy.org/topics) **or just google your topic:**

**Pick-up line☺**

**A little bit about me?** **What turns me on?** (Where are you born? How are you processed to make energy or fuel, what family are you from? Fossil fuels family, renewables etc.) Where is your power source mined or produced?:

**What makes you a real catch?** (advantages):

**Now that you are feeling more comfortable—“Something I am not so proud of**” (disadvantages)

**How do you make your mark on the earth?** (Any problems with mining, burning, or do you need some minerals, are you good for the future?:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Card # and Suit** | **A lil about your date** | **Date’s advantages** | **Dates negatives** | **Dates impact on the environment/pollution left behind** | **Rate your date from** **1 – 7** **1 best** **7 worst** |
| Guess: |  |  |  |  |  |
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| --- | --- | --- | --- | --- | --- |
| **Energy Source** | **Percent of Energy Use** | **Advantages** | **Disadvantages** | **Pollution** | **Is it Renewable?** |
| Petroleum | World:USA: |  |  |  |  |
| Natural Gas | World:USA: |  |  |  |  |
| Coal | World:USA: |  |  |  |  |
| Nuclear | World:USA: |  |  |  |  |
| Solar | World:USA: |  |  |  |  |
| Wind | World:USA: |  |  |  |  |
| Geothermal  | World:USA: |  |  |  |  |
| Biomass | World:USA: |  |  |  |  |
| Wave/Tidal  | World:USA: |  |  |  |  |
| Hydroelectric | World:USA: |  |  |  |  |