Name ___________________________ Date _________
APES Topic 11 – Energy Resources Mr. Romano

AIM: How are energy resources used to make electricity?

What is electricity and how is it measured?

Electricity is the flow of electrical power or charge. It is a secondary energy source which means that we get it from the conversion of other sources of energy, like coal, natural gas, oil, nuclear power and other natural sources, which are called primary sources. The energy sources we use to make electricity can be renewable or non-renewable, but electricity itself is neither renewable or non-renewable.

Electrical power is usually measured in watt (W), kilowatt (kW), megawatt (MW)

- **Watts** describe the rate at which electricity is being used at a specific moment. For example, 100 watts describes the amount of electricity that a 100-watt light bulb draws at any particular moment.

- **Watt-hours** measure the total amount of electricity used over time. Watt-hours are a combination of the how fast the electricity is used (watts) and the length of time it is used (hours). For example, a 100-watt light bulb, which draws 100 watts at any one moment, uses 100 watt-hours of electricity in the course of one hour.

- **Kilowatts and kilowatt-hours** are useful for measuring amounts of electricity used by large appliances, such as refrigerators, and by entire households. Kilowatt-hours are what show up on your electricity bill. One kilowatt (kW) equals 1,000 watts, and one kilowatt-hour (kWh) is one hour of using electricity at a rate of 1,000 watts. New, energy-efficient refrigerators use about 1.4 kilowatt-hours per day – multiply that by 365 days, and it equals a little over 500 kilowatt-hours per year.

- **Megawatts** are used to measure the output of a power plant or the amount of electricity required by an entire city. One megawatt (MW) = 1,000 kilowatts = 1,000,000 watts. The average size of US power plants is 213 MW. A 1000 MW power plant is considered very large by this standard.

- **Gigawatts** measure the capacity of large power plants or of many plants. One gigawatt (GW) = 1,000 megawatts = 1 billion watts. In 1990, if all US electrical generating plants were operating at full capacity at the same time, they would produce approximately 690 GW.

As a home and/or business owner, if you know what a kilowatt hour is, it can help you understand:

- How your energy supplier works out your bills
- Why some appliances use much more gas or electricity than others - and how much individual appliances use
- Why you should turn appliances off at the wall to save energy costs, and not just leave them on standby

You can then use that information to help you monitor your gas and electricity use, cut costs and lower your bills. It's also a good way to make really accurate comparisons if you're thinking of switching gas or electricity provider, or want to check you're getting a good deal, because you can look at the exact cost of electricity per kWh – and then do the same for gas.

So what exactly is a kilowatt hour in practical terms?

A kilowatt hour (kWh) is a measure of your energy consumption, and the unit of measurement your utility bill is based upon.

It doesn't mean the number of kilowatts you're using per hour. It is simply a unit of measurement that equals the amount of energy you would use if you kept a 1,000 watt appliance running for an hour:

So if you switched on a 100 watt light bulb, it would take 10 hours to rack up 1 kWh of energy.

Or a 2,000 watt appliance would use 1 kWh in just half an hour.

While a 50 watt item could stay on for 20 hours before it used 1 kWh.

What else takes around 1 kilowatt hour?

It's hard to be precise, because the similar appliances can have very different wattages, but here are some examples of 1 kWh:

- Cooking in a 2,000 watt oven for half an hour
- An hour's ironing with a 1,000 watt iron or 45 minutes with a 1,500 watt iron
- Less than an hour using a dishwasher (1,000 - 1,500 watts)
- Keeping a fridge-freezer (200 - 400 watts) on for about three hours
- Keeping an electric blanket (130 - 200 watts) on all night
- Using a laptop (20 - 50 watts) all day
- Keeping a broadband router (7 - 10 watts) on for five days

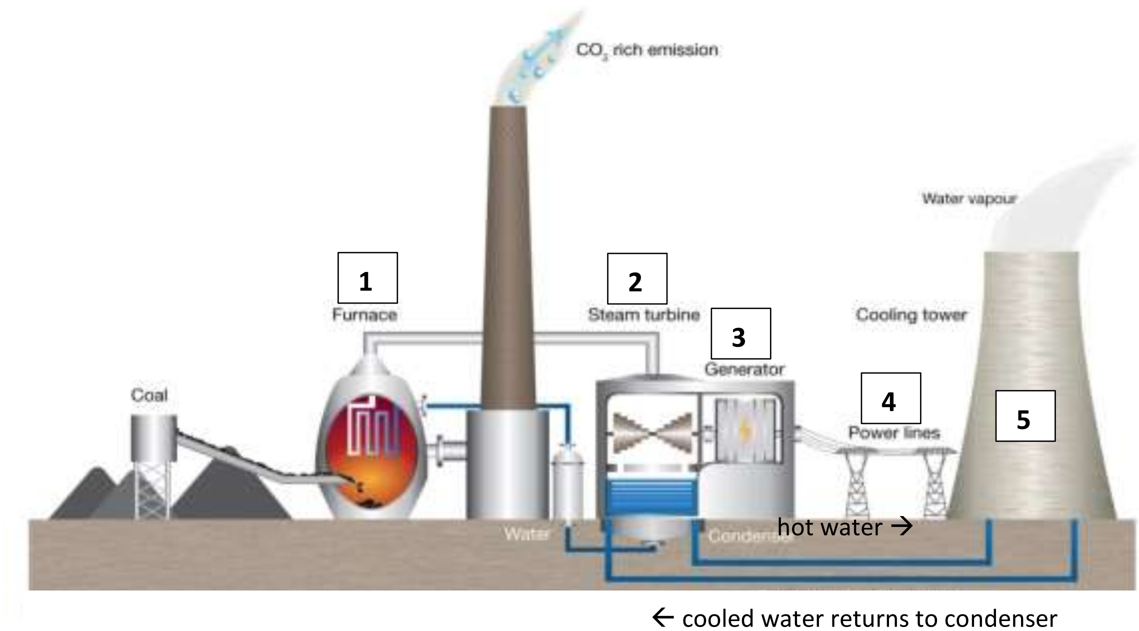
So how does it all work?

Electricity for powering our homes is made in power stations. A power station contains large machines called turbines, which are turned very quickly.

In the United States, 90 percent of electricity comes from thermoelectric power plants—coal, nuclear, natural gas, and oil. The remaining ten percent is produced by hydroelectric and other renewable energy facilities. Power stations need large amounts of energy to generate the steam that spins the turbines. The spinning turbine causes large magnets to turn within wire coils - these are the generators. The moving magnets within the coil of wire cause the electrons (charged particles) to move within the coil of wire. This is electricity.

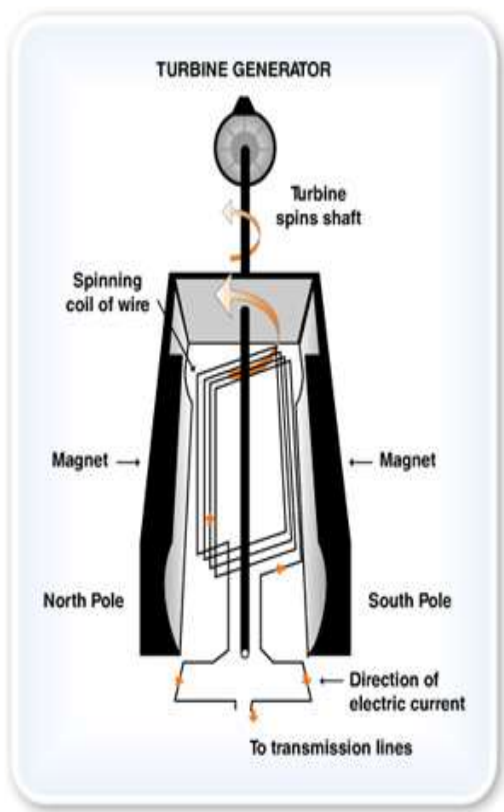
Steam turbine generators, gas turbine generators, diesel engine generators, and other alternate energy systems (even nuclear power plants) all operate on the same principle: magnets + copper wire + motion = electric current. This principle of "electromagnetic induction" was discovered in 1831 by Michael Faraday, a British scientist. Faraday discovered that if an electric conductor, like a copper wire, is moved through a magnetic field, electric current will flow (or "be induced") in the conductor. So the mechanical energy of the moving wire is converted into the electrical energy that flows in the wire.

The diagram below shows a typical design for a power plant that uses a fossil fuel (in this case coal) as its source of energy.



1. **Boiler/Furnace**
   The boiler in a power plant has two basic functions: to burn fuel to produce heat and to use the heat to turn water into steam. Fuel enters the boiler's furnace and is ignited, producing heat. Inside the walls of the boiler are long, vertical tubes that contain water. As the temperature inside the boiler increases, the water begins to boil, forming tiny steam bubbles. The steam rises to the top of the boiler to a steam collection drum. From there, the steam travels through pipes to the turbine.

2. **Turbine**
   The turbine transforms the thermal energy in the steam into mechanical energy. It provides the mechanical motion necessary for the generator to do its job. A turbine is constructed of a long shaft to which a series of blades are attached. This is called the rotor. As steam enters the turbine, it is directed through the sets of blades. The force of the steam against the blades causes the rotor to spin. It is similar to blowing on a pinwheel, but much faster. Steam turbines spin at 3,600 revolutions per minute (60 cycles per second or 60 Hz).



3. **Generator**
   The generator is directly connected to the turbine, so when the turbine spins, the generator also spins. It transforms the mechanical energy (provided by the spinning turbine) into electrical energy. Electricity is produced by rotating a conductor through a magnetic field or by rotating a magnetic field around the conductor. Each time the conductor travels, or cuts, through the magnetic field, a voltage is created (induced). After leaving the generator, the electricity travels to the plant's substation where transformers are located. The transformer increases the voltage of the electricity so it can travel through the distribution lines efficiently. Then, in local areas, the electricity travels to another substation where transformers reduce the voltage again for consumer use. All this happens at the speed of light.

4. **Power Lines**
After electricity is produced at power plants it has to get to the customers that use the electricity. Our cities, towns, states and the entire world are crisscrossed with power lines that "carry" the electricity.

5. **Cooling**

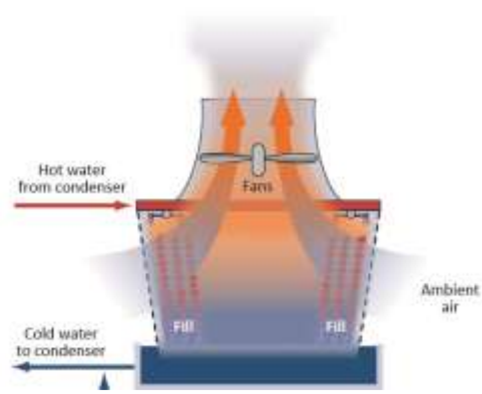
. Once steam has passed through a turbine, it must be cooled back into water before it can be reused to produce more electricity. Colder water cools the steam more effectively in a condenser and ultimately allows for more efficient electricity generation.

Even though all thermoelectric plants use water to generate steam for electricity generation, not all plant cooling systems use water. There are three main methods of cooling:

- **Once-through** systems take water from nearby sources (e.g., rivers, lakes, aquifers, or the ocean), circulate it through pipes to absorb heat from the steam in systems called condensers, and discharge the now warmer water to the local source. Once-through systems were initially the most popular because of their simplicity, low cost, and the possibility of siting power plants in places with abundant supplies of cooling water. This type of system is currently widespread in the eastern U.S. Very few new power plants use once-through cooling, however, because of the disruptions such systems cause to local ecosystems from the significant water withdrawals involved and because of the increased difficulty in siting power plants near available water sources.

- **Wet-recirculating or closed-loop** systems reuse cooling water in a second cycle rather than immediately discharging it back to the original water source. Most commonly, wet-recirculating systems use cooling towers to expose water to ambient air. Some of the water evaporates; the rest is then sent back to the condenser in the power plant. Because wet-recirculating systems only withdraw water to replace any water that is lost through evaporation in the cooling tower, these systems have much lower water withdrawals than once-through systems, but tend to have appreciably higher water consumption. In the western U.S., wet-recirculating systems are predominant.

Basic Cooling Tower Design



- **Dry-cooling** systems use air instead of water to cool the steam exiting a turbine. Dry-cooled systems use no water and can decrease total power plant water consumption by more than 90 percent. The tradeoffs to these water savings are higher costs and lower efficiencies. In power plants, lower efficiencies mean more fuel is needed per unit of electricity, which can in turn lead to higher air pollution and environmental impacts from mining, processing, and transporting the fuel. In 2000, most U.S. dry-cooling installations were in smaller power plants, most commonly in natural gas combined-cycle power plants.

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