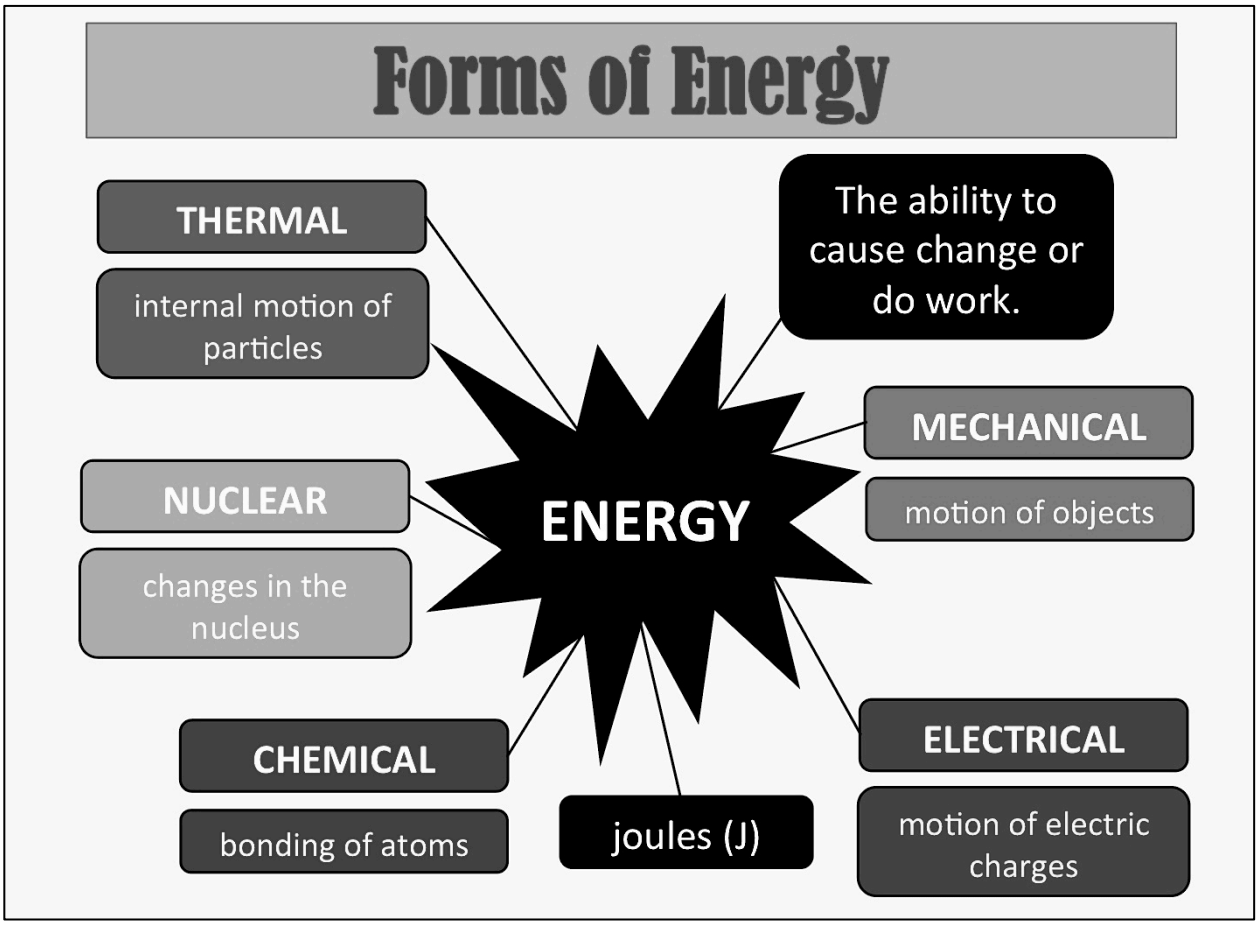
Name: _____ Date: _____

Period: _____ **AP Environmental Science**

Understanding Energy Units- Skeleton Notes



The Joule

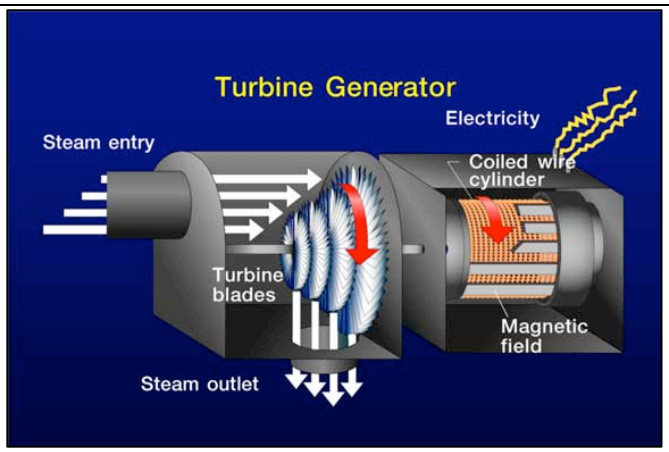
Energy is defined as the ability to do work. The Joule (J) is a unit of energy or work.

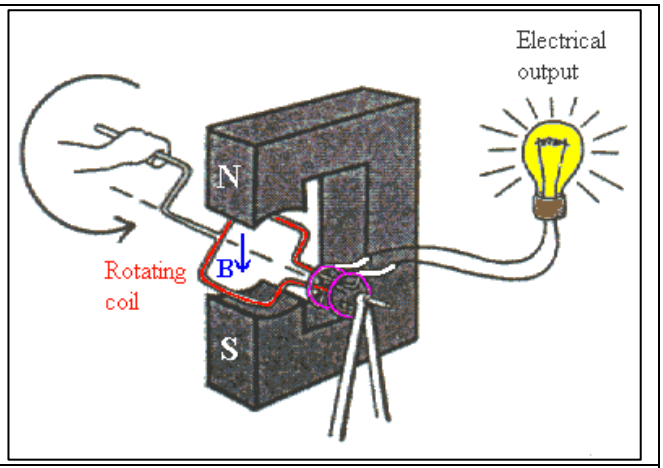
10 Joules of energy are required to lift a 1 kg mass 1 meter vertically.

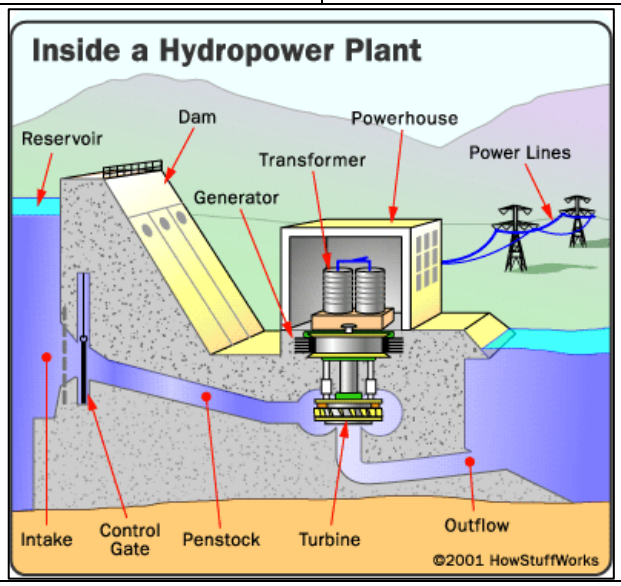
1 liter water bottle; full of water; 1 mL of water = 1 gram × 1,000 mL = 1 kg

- If you lift a water bottle 1 meter, you have just done 10 Joules of work on it.
- If you let a water bottle fall 1 meter, you have just converted gravitational potential energy (GPE) to kinetic energy (KE) and released 10 Joules of energy. In this way, transferring GPE to KE allows work to be done on an object such as a turbine generator.

A _____ is a device that converts mechanical energy to electrical energy by rotating a coil of wire in a magnetic field to produce an electric current. A _____, which, resembles the blades of a fan, is forced to revolve by a fast-moving flow of high-pressure water or steam, thus rotating the coil of wire in the generator.







So, in the case of a hydroelectric dam, if I let 1 liter of water, fall 300 hundred meters, how many Joules of work can be done on a turbine generator?

After falling 300 meters, the liter of water (1 kg mass) does _____J of work on the turbine generator and transfers _____J of energy from GPE to mechanical energy and then to electrical energy. We have just generated _____J of electrical energy.

The Watt

The watt is a unit of power and is equal to one Joule per second.

$$1 \text{ watt (W)} = \frac{1 \text{ Joule (J)}}{\text{second (s)}}$$

A 60-watt light bulb uses 60 Joules per second. So, if you let a liter (1 kg) of water, fall six meters you get 60 J, this is enough energy to power a 60 W light bulb for 1 second.

How many Joules would it take to power a 60-watt light bulb for one minute?

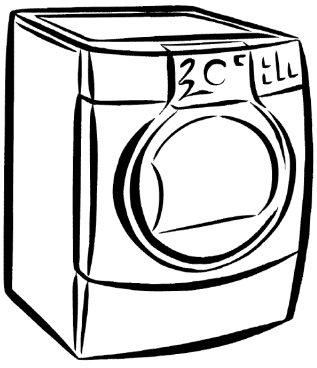
How many bottles of water (1 L = 1 kg) would you have to let fall 1 meter to generate enough Joules to power the 60-watt light bulb for one minute?

Appliances

Dryer = 3,500 watts

Drying a load of laundry takes approx. 1 hour.

How many Joules will the dryer use in one hour?

Energy Servants

Imagine that instead of using hydroelectric dams to produce electricity, you had energy servants in your basement cranking on pedals attached to generators. Research has shown that 1-energy servant can generate about 100 watts (1 J/s) on a stationary bicycle such as the one shown in the picture.

How many energy servants would you need to run your dryer for one hour?

The average American needs 9,500 watts to meet their energy needs and wants (refrigeration, lights, TV, computer, iPhone, etc.). These are watts so this means the average American needs 9,500 Joules per second.

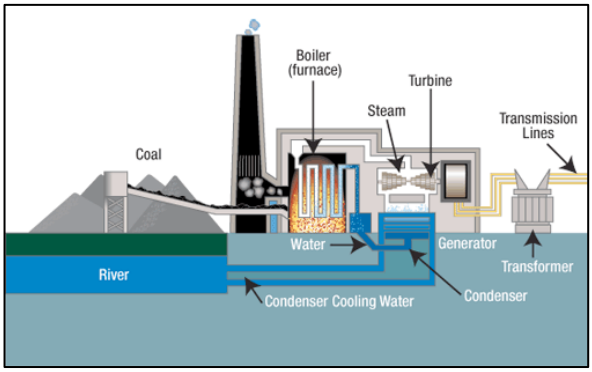
How many energy servants would it take to make the average American happy?

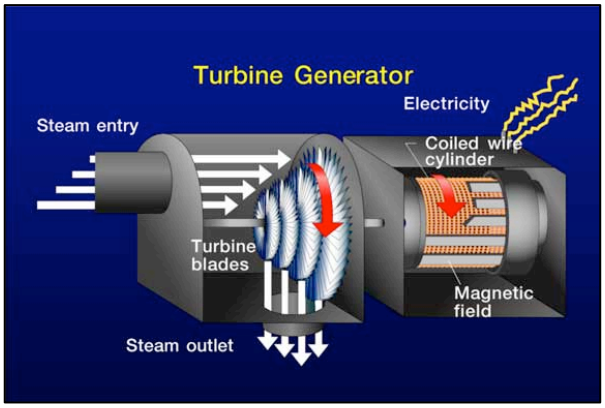
This means _____ servants pedaling continually in your basement. But no human can pedal continuously, forever. So, to be humane you would have to have three 8-hour shifts. 3 ×_____ = _____energy servants.

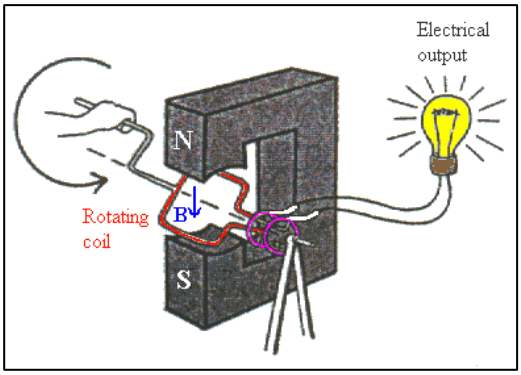
Electricity from Coal

The largest coal fired power plant in the U.S., The Scherer Power Plant, near Macon Georgia, generates 880 megawatts (880 million watts). To do this the plant burns coal to heat a massive boiler in each of the units to produce steam that drives turbine generators. Each boiler reaches 2,800 degrees F° and can produce 5.8 million pounds of steam per hour—that's 8,000 gallons of water evaporated every minute. At full capacity, the facility burns roughly 1,288 tons of coal every hour—11 million tons a year. To maintain a steady supply of fuel for the plant, coal is delivered by train from Wyoming's Powder River Basin; 1,800 miles away, by trains that are 124 cars long.

Denver's Cherokee Generating Station (Coal & Natural Gas)





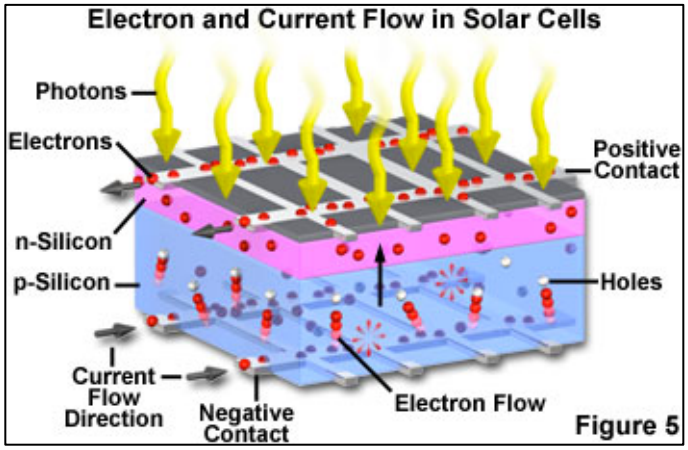


Excel's Cherokee Generating Station generates 502 megawatts (MW) or 502,000,000 watts (502 million watts). Cherokee burns coal and natural gas to boil water and produce high-pressure steam that moves a turbine generator (chemical to mechanical to electrical).

How many energy servants would it take to match Cherokee's electricity output?

Remember this is continuous pedaling. So, to be humane you would have to have three 8-hour shifts. 3 ×_____ = _____energy servants to match Cherokee's electricity output. However, the 2015 estimated population of the Denver Metro Area was 2,814,330 people.

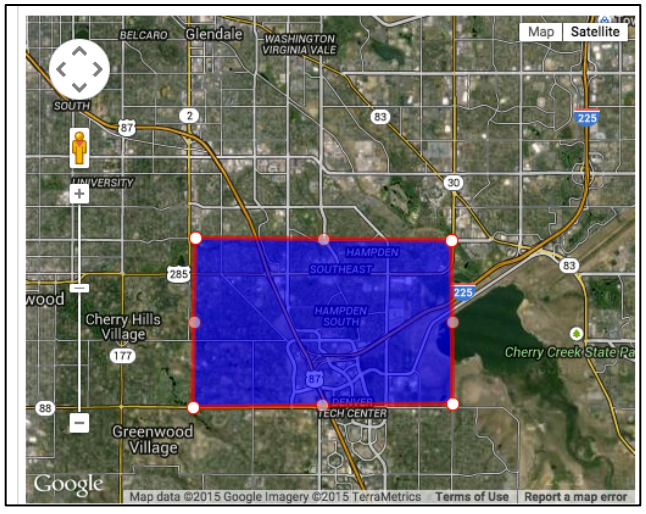
Solar Power



Photovoltaic (PV) solar panels generate electric power by using solar cells to convert energy from the sun into a flow of electrons (electricity). Solar cells are often made of monocrystalline silicon or other semiconductor materials. When photons of light from the sun excite electrons in a solar cell, into a higher state of energy, an electric current flows through the semiconductor and into an electric circuit.

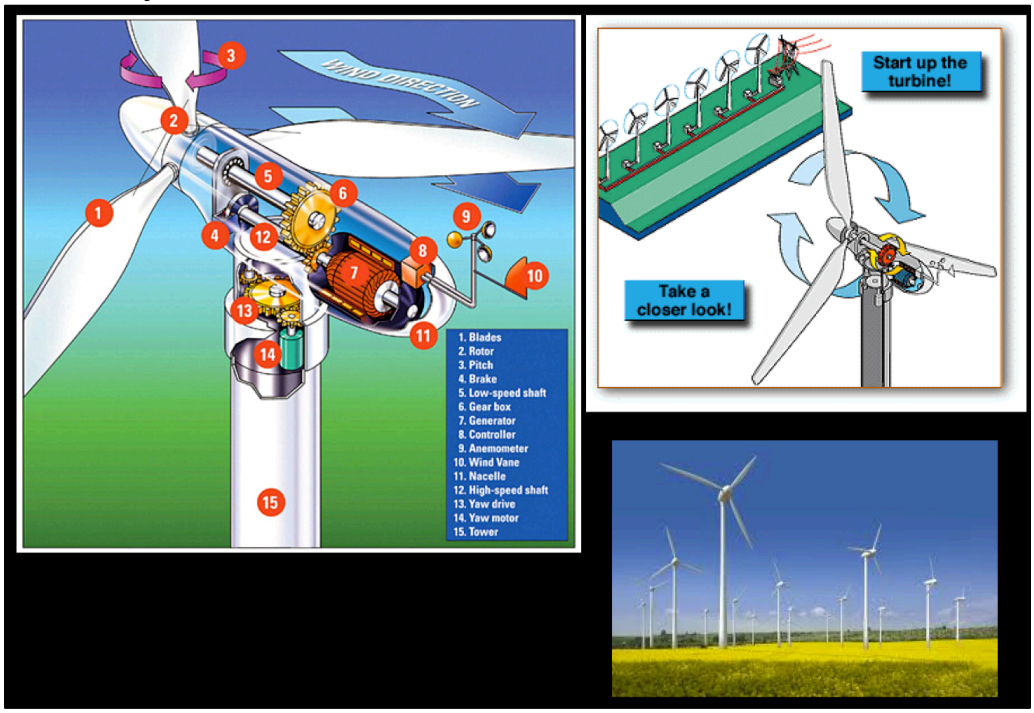
If the average solar panel can generate 20 watts per square meter, what area of solar panels would be required to match Cherokee's electricity output of 502 MW?

_____ square meters, is equal to _____ square miles. ***Problem! It is not sunny all of the time!***



Wind Power

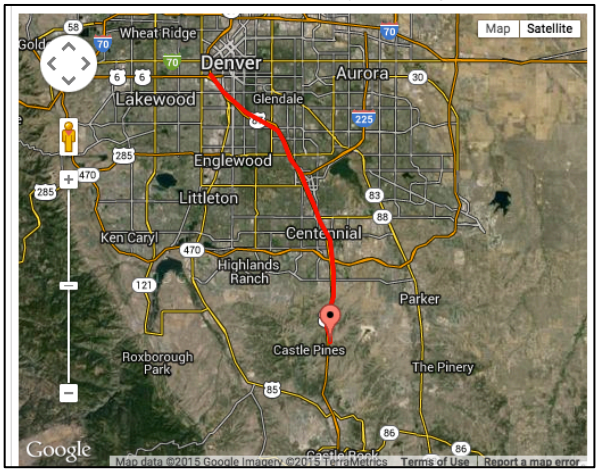
Wind turbines are propelled by Earth's surface winds and use the same basic type of generator as hydro, coal, etc.



One 48-meter wind turbine generates 750,000 watts. How many wind turbines are necessary to match Cherokee's electricity output of 502 MW?

This output would require _____ 48-meter wind turbines. If lined up right next to each other (not realistic) they would stretch 32,160 meters or 32.16 kilometers. For a familiar frame of reference, this would start near I-25 and downtown Denver and stretch along I-25 to Castle Pines.

Problem! It is not windy all of the time!



The Kilowatt & the Kilowatt-Hour

1 watt (W) = 1 Joule per second (J/s)
1 kilowatt (kW) = 1,000 watts (W)
1 kilowatt (kW) = 1,000 Joules per second (J/s)

The Kilowatt-Hour

A kilowatt-hour (kWh) is an amount of Joules. How many Joules are in a kilowatt-hour?

1 kWh is equal to _____ J. Electrical energy is sold in kilowatt-hours; cost of running equipment is the product of power in kilowatts multiplied by running time in hours and price per kilowatt-hour. In 2015, the average annual electricity consumption for a U.S. residential utility customer was 10,812 kilowatt-hours (kWh), an average of 901 kWh per month. U.S. average retail price per kilowatt-hour is about $0.11 (11 cents).

How much energy, in kWh, does a 100-Watt computer running for 5 hours use?

Suppose a 1,450-watt microwave is used for 30 minutes each day. How many kWh per year does the microwave use? Calculate the cost of using the microwave for one year.

The British thermal unit (Btu) is a traditional unit of work. It is the amount of work needed to raise the temperature of one pound of water by one degree Fahrenheit. The Btu is often used by energy utilities to measure natural gas and electricity production and consumption.

One cubic foot of natural gas supplies approximately 1,031 Btu of energy. 1 kWh of electricity is equal to 3,413 Btu. How much natural gas would be needed to power the 1,450-watt microwave for one year?

A typical coal-burning power plant uses 4,500 tons of coal per day. Each pound of coal produces 5,000 Btu's of electrical energy. How many Btu's are produced each day from such a plant?

A compact hybrid gets 51 miles per gallon of gasoline in highway driving. A luxury sedan averages only 25 miles per gallon on the highway. If gas costs $3.00 per gallon, how much money will a person who drives 10,000 miles per year save by choosing to purchase the hybrid?