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COAL

What is it? Coal is a sedimentary rock, a "fossil fuel" that forms beneath Earth's surface. Miners extract coal from Earth's *geosphere*, but the matter in the coal was originally a part of Earth's *biosphere*. Over many millions of years, dead plants and animals were buried and compressed, gradually changing into coal. Therefore, coal is considered *nonrenewable* because it takes millions of years to form and cannot be recreated on a human time scale.

Capacity factor: Plant operators can increase or decrease the electricity output of a coal plant to match demand by changing the amount of fuel used--therefore, energy from coal is *dispatchable*. In addition, the output of a coal plant is affected by weather events and temperature. As a result, coal-fired power plants produce **maximum energy about 85% of the time** on average. This is called the *capacity factor*.

Efficiency: When we burn coal to make electricity, not all the energy in the coal is transferred into the wires. If a pile of coal stores **100 joules of energy**, **only about 40 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

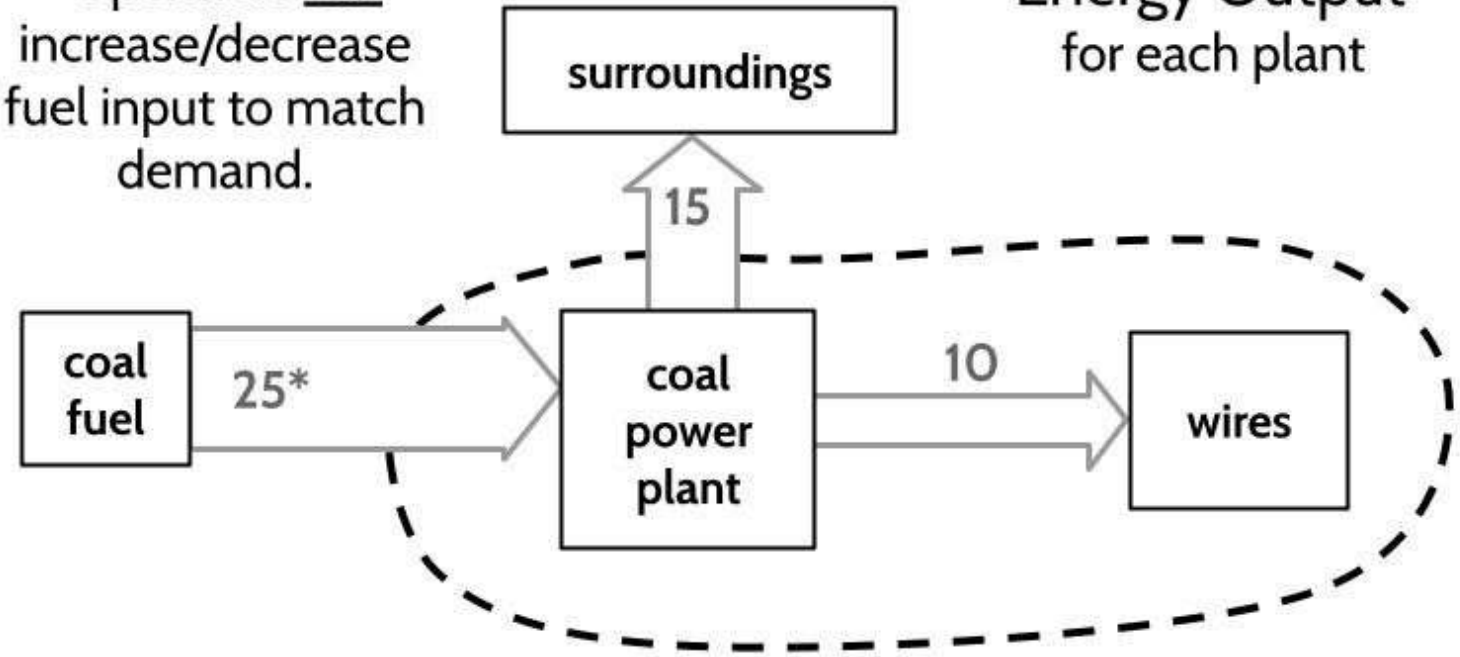
Power: How much energy transfers to electricity in the coal plant system every second is called *power*. An average-sized coal plant can put out a lot of energy--a maximum of about **250 megawatts of power**, or **250 million joules of energy** per second.

COAL

Efficiency = 40% or $\frac{10}{25}$

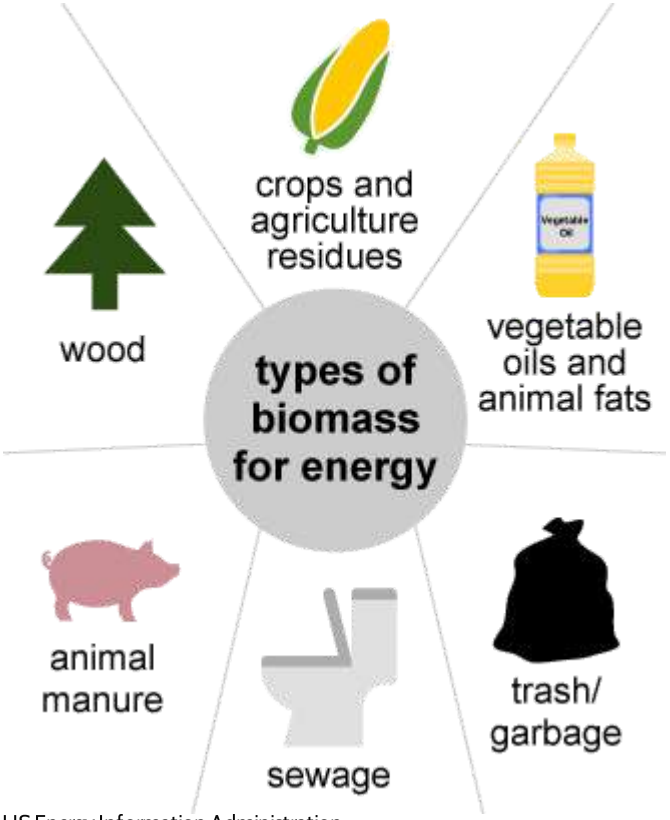
Energy Output = High
for each plant

*Operators can increase/decrease fuel input to match demand.



BIOMASS

What is it? Biomass is organic material that comes from Earth's *biosphere*--plants and animals that grew within our lifetime. Sources for biomass energy include: wood, farm waste, paper, cotton, wool, food, yard waste, animal manure, and even human sewage. It is considered *renewable* because we can make more plants, animals, or trash to replace what we use.



US Energy Information Administration

Capacity factor: Plant operators can increase or decrease the electricity output of a biomass plant to match demand by changing the amount of fuel used--therefore, energy from biomass is *dispatchable*. In addition, the output of a biomass plant is affected by weather events and temperature. As a result, biomass power plants produce **maximum energy about 90% of the time** on average. This is called the *capacity factor*.

Efficiency: When we burn wood pellets or grass to make electricity, not all the energy stored in the fuel is transferred into the wires. If a pile of wood pellets stores **100 joules of energy**, **only about 25 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

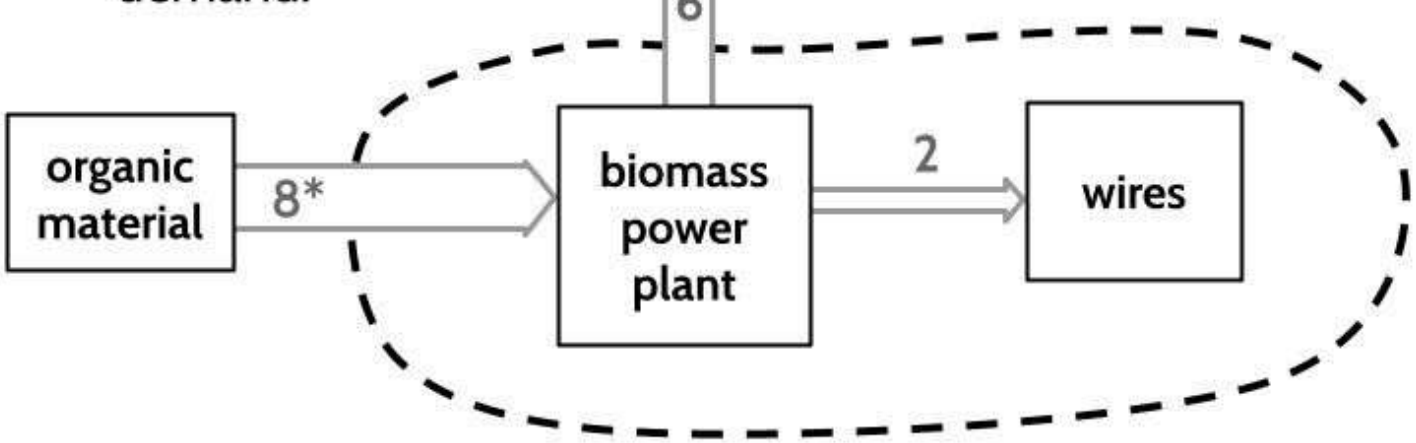
Power: How much energy transfers to electricity in the biomass plant system every second is called *power*. An average-sized biomass plant doesn't put out very much energy--a maximum of about **50 megawatts of power**, or **50 million joules of energy** per second.

BIOMASS

Efficiency = 25% or $\frac{2}{8}$

Energy Output = Medium
for each plant

*Operators can increase/decrease fuel input to match demand.



NATURAL GAS

What is it? Natural gas is a "fossil fuel" energy source that forms beneath Earth's surface. Miners and drillers extract natural gas from underground, but the matter in the gas was originally a part of Earth's *biosphere*. Over many millions of years, dead plants and animals were buried and compressed, gradually changing into gas. Natural gas is considered *nonrenewable* because it takes millions of years to form and cannot be re-created on a human time scale.

Ikar.us, CC BY 2.0

Capacity factor: Plant operators can increase or decrease the electricity output of a natural gas plant to match demand by changing the amount of fuel used--therefore, energy from natural gas is *dispatchable*. In addition, the output of a gas plant is affected by weather events and temperature. As a result, gas-fired power plants produce **maximum energy about 90% of the time** on average. This is called the *capacity factor*.

Efficiency: When we burn natural gas to make electricity, not all the energy stored in the gas is transferred into the wires. If a tank of gas stores **100 joules of energy**, **only about 55 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

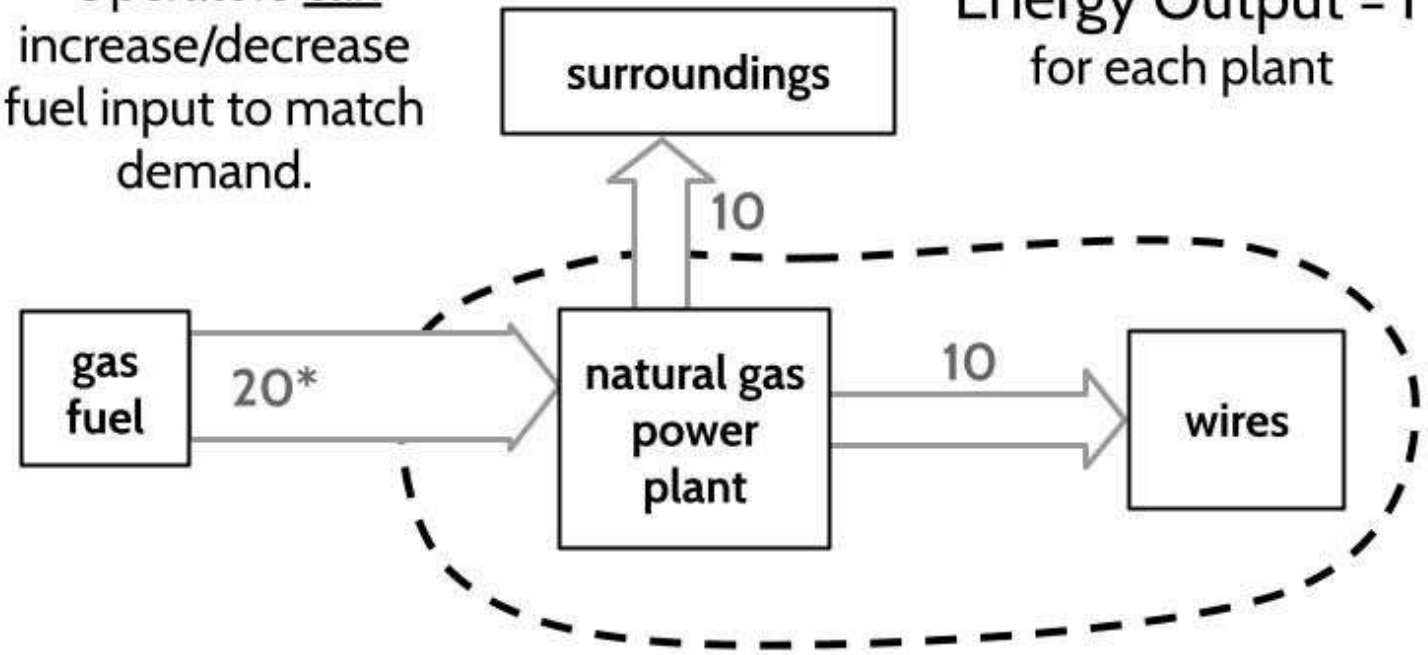
Power: How much energy transfers to electricity in the natural gas plant system every second is called *power*. An average-sized natural gas power plant can put out a lot of energy--a maximum of about **250 megawatts of power**, or **250 million joules of energy** per second.

NATURAL GAS

Efficiency = 50% or $\frac{10}{20}$

*Operators can increase/decrease fuel input to match demand.

Energy Output = High
for each plant



SOLAR CELLS

What is it? Energy from the sun is responsible for all life on Earth, but the technology to turn sunlight into electricity is quite new. Solar *photovoltaic* (PV) cells, or solar cells, change sunlight directly into electricity. The materials used to create many solar cells are usually derived from sand or crushed quartz rock. These materials can be acquired without damaging the mining sites. Solar energy is considered *renewable* because it won't run out.

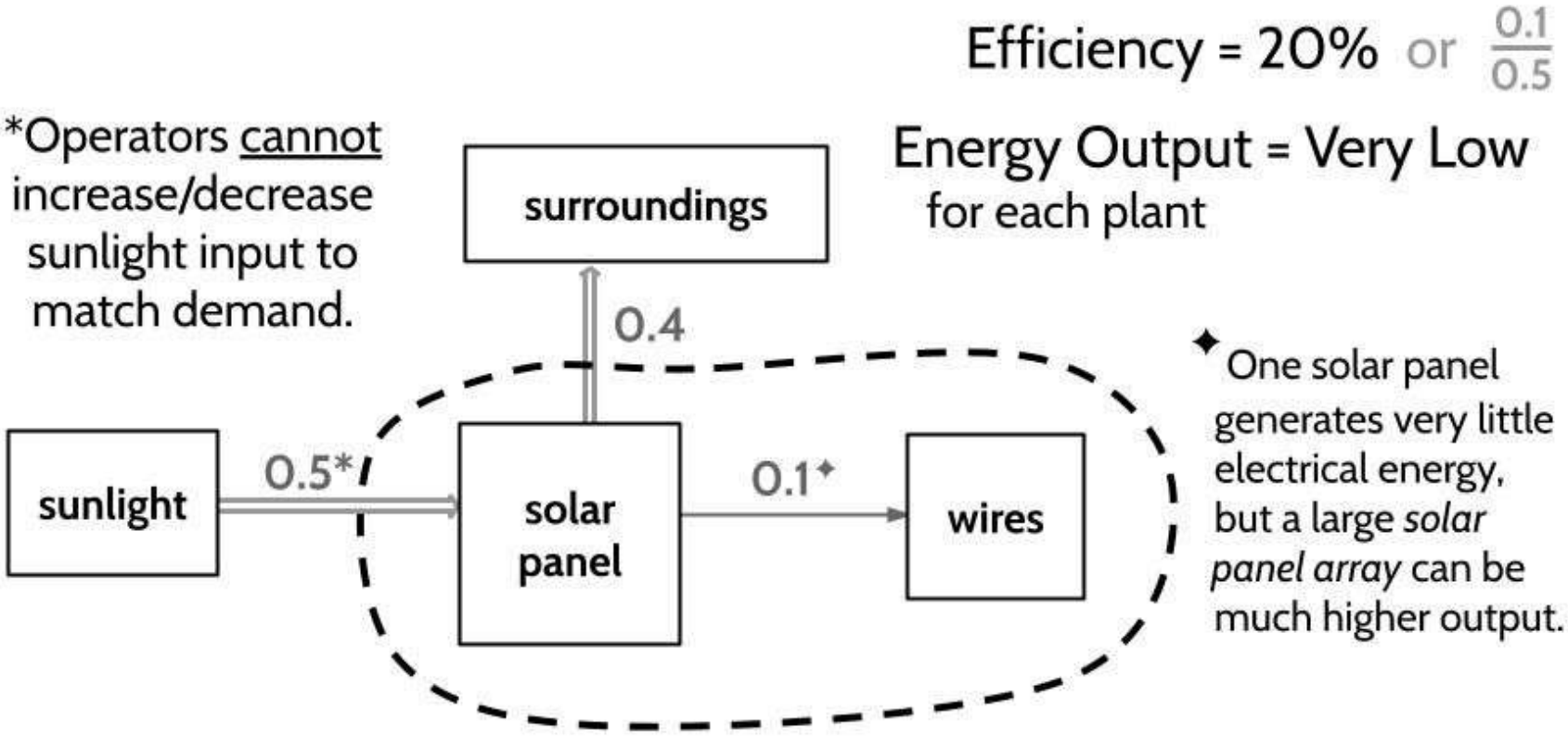
Túrelio, CC BY-SA 3.0

Capacity factor: Solar panels will put out the same energy whether or not plant operators watch them, so energy from solar cells is *non-dispatchable*. However, output depends a lot on the weather, and solar panels produce zero energy at night. As a result, solar panels produce **maximum energy about 20% of the time** on average. This is called the *capacity factor*.

Efficiency: Not all the solar energy that hits a solar panel is transferred into electricity. If **100 joules of energy** from the sun hits a panel, **only about 20 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

Power: How much energy transfers to electricity in the solar panel system every second is called *power*. An average-sized rooftop system can deliver around **0.01 megawatts of power**, or **0.01 million joules of energy** per second, whereas the largest system in the United States delivers more than **500 million joules of energy** per second.

SOLAR CELLS


Efficiency = 20% or 0.1 / 0.5
*Operators cannot increase/decrease sunlight input to match demand.
surroundings
Energy Output = Very Low for each plant
0.4
sunlight
0.5*
solar panel
0.1✦
wires
✦ One solar panel generates very little electrical energy, but a large solar panel array can be much higher output.

NUCLEAR FISSION

What is it? Nuclear power plants use heat produced during nuclear fission. In nuclear fission, atoms split into smaller parts, releasing energy. This *nuclear reaction* is contained at the center of a reactor, called the *core*. Uranium is mined from Earth's geosphere and extracted from rocks. Uranium fuel is classified as *nonrenewable* because uranium was formed in explosions of stars billions of years ago, and thus it cannot be replenished on a human time scale.

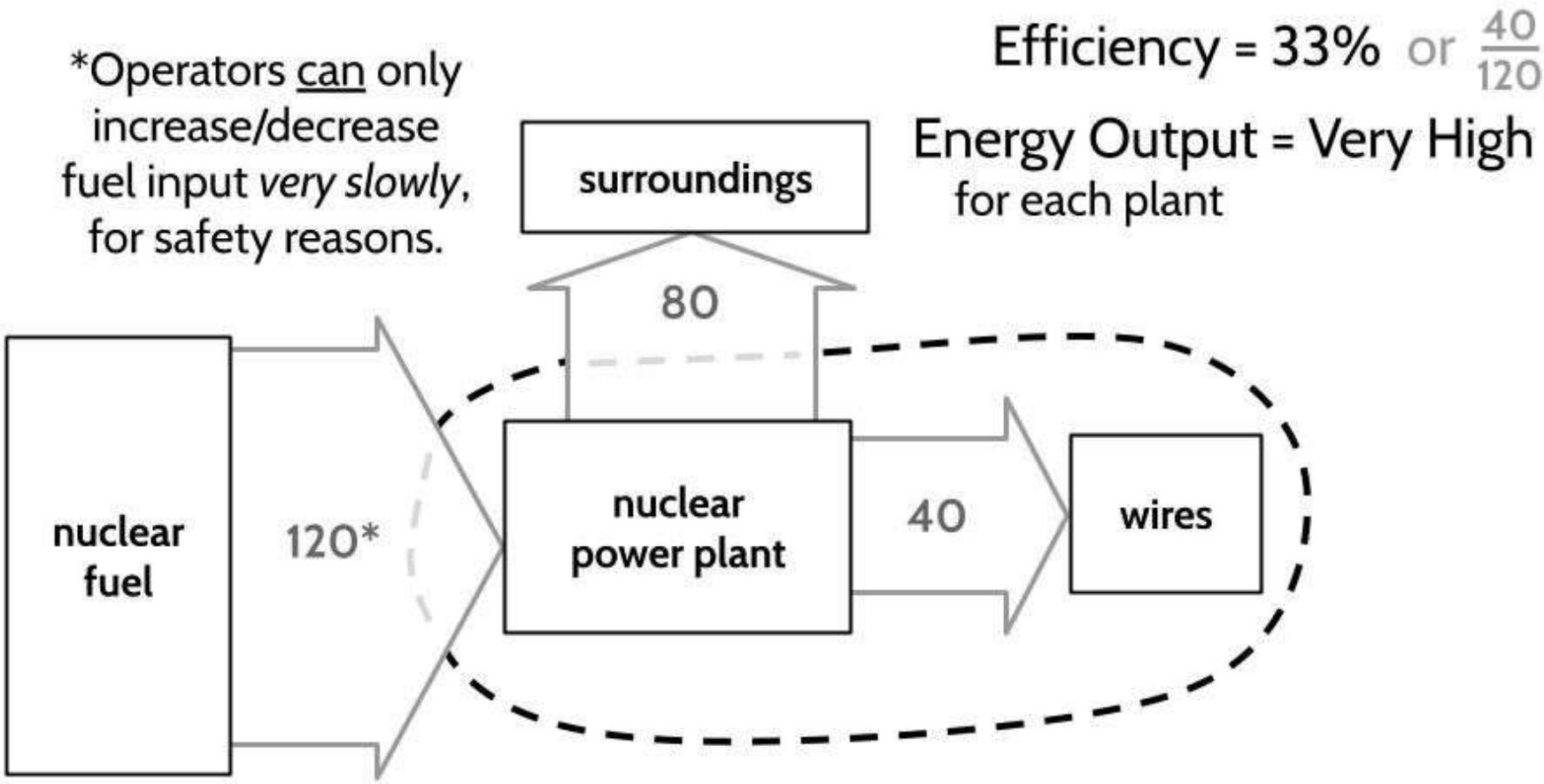
FirstEnergy Corp, CC BY-ND 2.0

Capacity factor: Plant operators can increase or decrease the electricity output of a nuclear plant, but these changes must be gradual or safety problems can occur. Therefore, energy from nuclear fission is usually considered *non-dispatchable*. Nuclear plants are less affected by temperature because the core is well-protected. As a result, nuclear power plants produce **maximum energy about 90% of the time** on average. This is called the *capacity factor*.

Efficiency: When we heat up nuclear fuel to make electricity, not all the energy stored in the fuel is transferred into the wires. If a pellet of uranium stores **100 joules of energy**, **only about 33 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

Power: How much energy transfers to electricity in the nuclear plant system every second is called *power*. An average nuclear power plant can generate huge amounts of energy--a maximum of about **1,000 megawatts of power**, or **1,000 million joules of energy** per second.

NUCLEAR FISSION



HYDROELECTRIC

What is it? Hydroelectric power plants are powered directly by energy in Earth's *hydrosphere*. Hydropower is *renewable* because rain and snow will keep moving water upwards in the water cycle. Hydro facilities have to be built into a water source, such as a river, and this is only possible at some specific sites. Because hydroelectric technology has been around for so long, there are not many undammed potential sites left in the US.

Neonbunyip, CC BY-SA 4.0

Capacity factor: The amount of rain and snow in an area affects how much water is available for hydropower. Dam operators carefully control the flow of water to meet electricity demand, so hydropower is usually considered *dispatchable*. Most dams produce **maximum energy about 50% of the time** on average This is called the *capacity factor*.

Efficiency: When we use moving water to generate electricity, most but not all the energy stored in the water is transferred into the wires. If a reservoir of water above a hydro dam stores **100 joules of energy**, **about 90 joules ends up in the power grid**. A very small amount of the energy ends up outside the system in the surroundings.

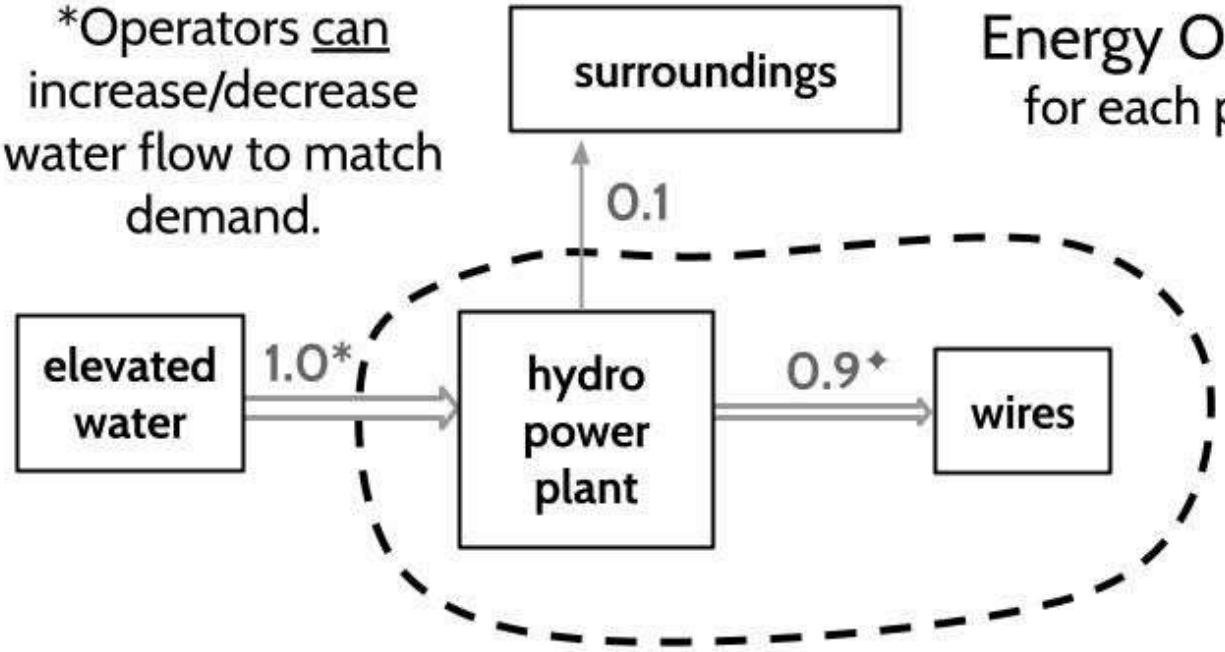
Power: How much energy transfers to electricity in the hydroelectric plant system every second is called *power*. Just like rivers vary greatly in size, hydro plants vary greatly in power. The largest hydro dam in the United States reaches almost **7,000 megawatts of power**, or **7,000 million joules of energy** per second, whereas most dams put out **1 million to 20 million joules** of energy per second.

HYDROELECTRIC

Efficiency = 90% or $\frac{0.9}{1.0}$

Energy Output = Medium
for each plant

*Operators can increase/decrease water flow to match demand.



✦ The energy output of hydro plants varies greatly with plant size. Most are low output, but some are very high output.

For more info on sites:
bit.ly/ushydrosites

WIND

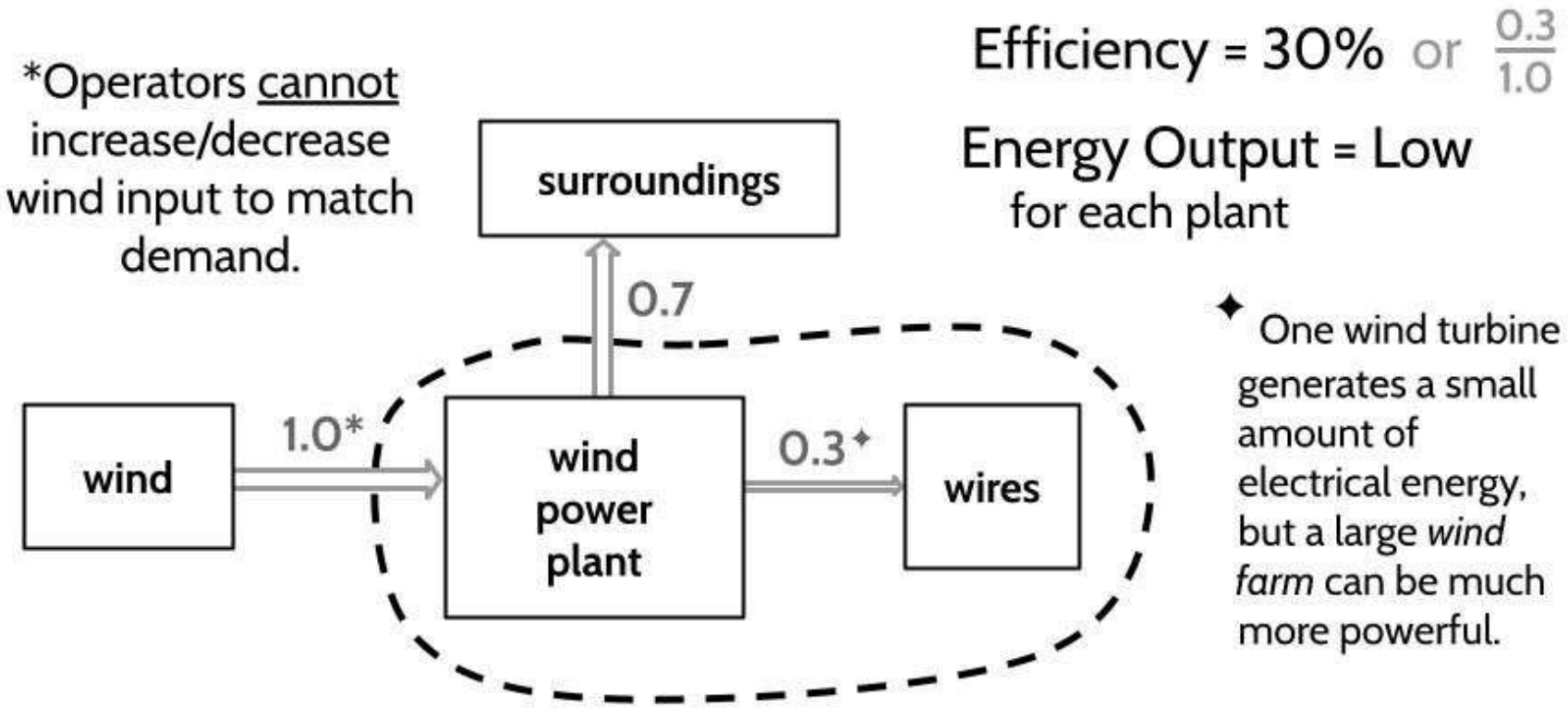
What is it? Wind power comes directly from Earth's atmosphere. Wind *turbines* use blades that turn when they are pushed by moving air particles. Wind energy is considered *renewable* because using it does not reduce the wind energy available in the future. Wind is caused by temperature differences driven by sunlight, and sunlight is not affected by our use of wind power.

Capacity factor: A *wind farm* (a group of wind turbines in one area) will put out the same energy whether or not plant operators watch them, so wind energy is *non-dispatchable*. Output is also affected by weather events and temperature, and when the wind dies down, the turbines stop generating electricity. As a result, wind farms produce **maximum energy about 40% of the time** on average. This is called the *capacity factor*.

Efficiency: When we use wind to make electricity, not all the energy stored in the moving air is transferred into the wires. If a gust of wind stores **100 joules of energy**, **only about 30 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

Power: How much energy transfers to electricity in the wind turbine system every second is called *power*. One turbine can emit as much as **2 megawatts of power**, or **2 million joules of energy** per second. But a large wind farm can produce more than **500 million joules of energy** per second if the wind is strong.

WIND


*Operators cannot increase/decrease wind input to match demand.
surroundings
0.7
wind
1.0*
wind power plant
0.3✦
wires
Efficiency = 30% or 0.3/1.0
Energy Output = Low for each plant
✦ One wind turbine generates a small amount of electrical energy, but a large *wind farm* can be much more powerful.

GEOTHERMAL

What is it? Geothermal energy is heat produced deep within Earth's *geosphere*. The decay of radioactive particles in Earth's core, a process that happens in all rocks, produces heat. Geothermal energy is considered *renewable* because heat is continuously produced inside Earth, whether or not we use it. However, geothermal power can only be used for electricity at specific sites where the geology already results in lots of heat reaching within 1 mile of Earth's surface.

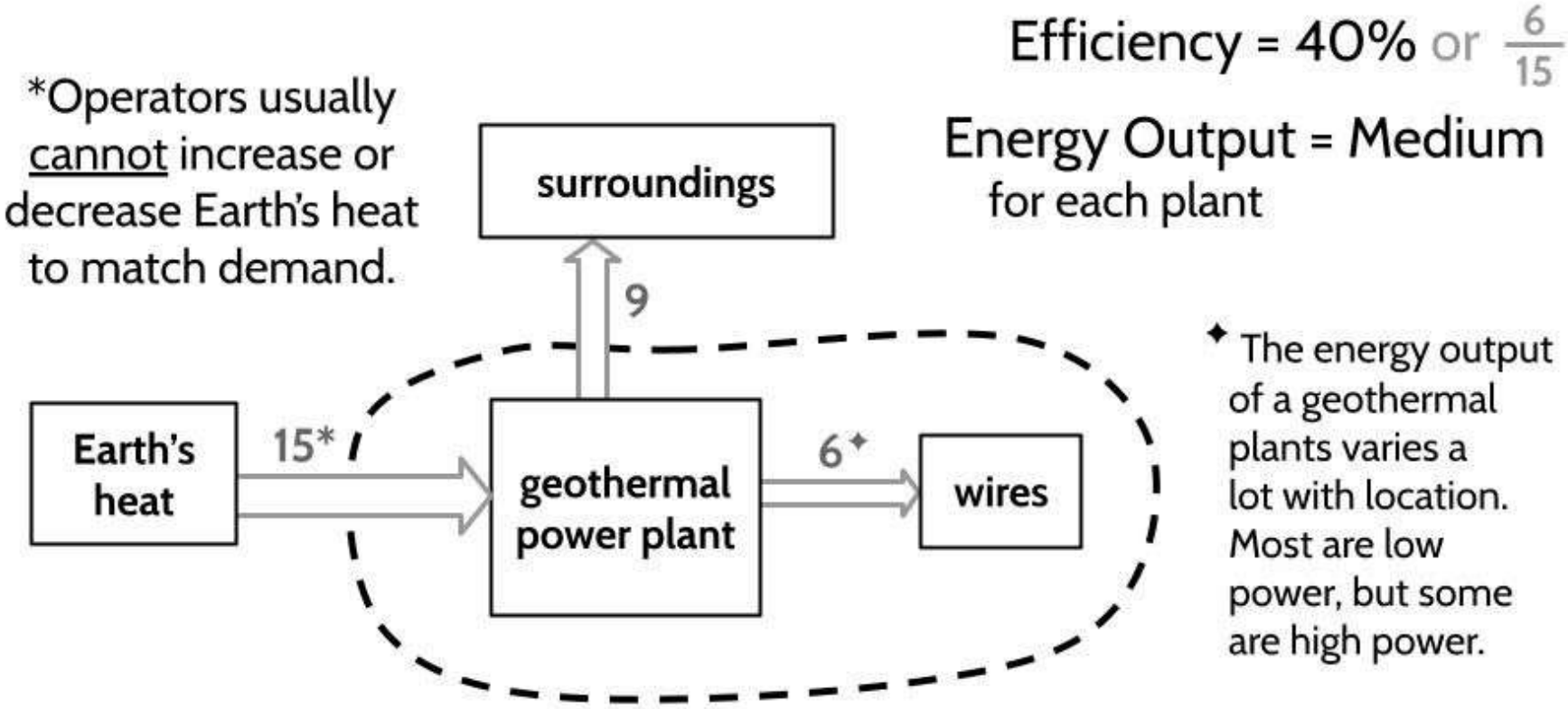
Gretar Ivarsson

Capacity factor: A geothermal heat source does not naturally respond quickly to changes in demand--therefore, geothermal energy is *somewhat dispatchable*. Geothermal power plants produce **maximum energy about 90% of the time** on average. This is called the *capacity factor*.

Efficiency: When we use heat from Earth to make electricity, not all the energy removed from Earth is transferred into the wires. If a quantity of heat from Earth stores **100 joules of energy**, **only about 40 joules ends up in the power grid**. The rest of the energy ends up outside the system in the surroundings.

Power: How much energy transfers to electricity in the geothermal plant system every second is called *power*. The power of a geothermal plant depends greatly on the site itself. Small plants might produce **4 megawatts of power**, or **4 million joules of energy** per second. Large plants can produce over **400 million joules of energy** per second.

GEOTHERMAL


Efficiency = 40% or 6/15
*Operators usually cannot increase or decrease Earth's heat to match demand.
surroundings
Energy Output = Medium for each plant
9
Earth's heat
15*
geothermal power plant
6✦
wires
✦ The energy output of a geothermal plants varies a lot with location. Most are low power, but some are high power.