

Basics of Energy Use

A practical (and short) guide

Heat engine

Heat engine: a device that can convert heat energy to mechanical energy

Fancy name for a car engine, a power plant, your refrigerator, air conditioner, etc.

Device works by moving heat from hot to cold, (Heat Pumps actually go the other way), and using the energy liberated

Efficiency

Efficiency of a heat engine is expressed in terms of the temperature difference between the hot side and the cold side.

$$\text{Efficiency} = (T_{\text{hot}} - T_{\text{cold}})/T_{\text{hot}}$$

Usually we multiply by 100 to get a percentage

Efficiency

Example: the efficiency of a car engine

Combustion at about $2,000^{\circ}\text{K}$

Exhaust gas is about 500°K

$^{\circ}\text{K}$, or Kelvin, is the absolute scale, 0°K is as cold as it gets, $273^{\circ}\text{K} = 0^{\circ}\text{C}$

Efficiency = $1,500/2,000 = 0.75$ or 75%

Efficiency

This is the maximum possible efficiency in this case, everything else works to lower this, such as friction of tires on road, heating the engine instead of turning the wheels, etc.

The overall efficiency of cars is more like 30% due to these problems.

In other words, only about $\frac{1}{3}$ of the energy in gasoline goes to useful work such as moving you to where you want to go.

Efficiency and pollution

Note that we get better efficiency when we burn fuel at higher temperatures.

But since we get the oxygen for combustion from air, we pay a price for high temperature combustion. Why?

Examples:

nitrogen oxides from nitrogen in air
sulfur oxides from coal

Moral: you can't get something for nothing! More efficient engines will generally pollute more!

Generating electricity

To get electricity, we convert mechanical energy to electrical energy

the mechanical energy comes from chemical, like fossil fuels, or from solar, or some other form

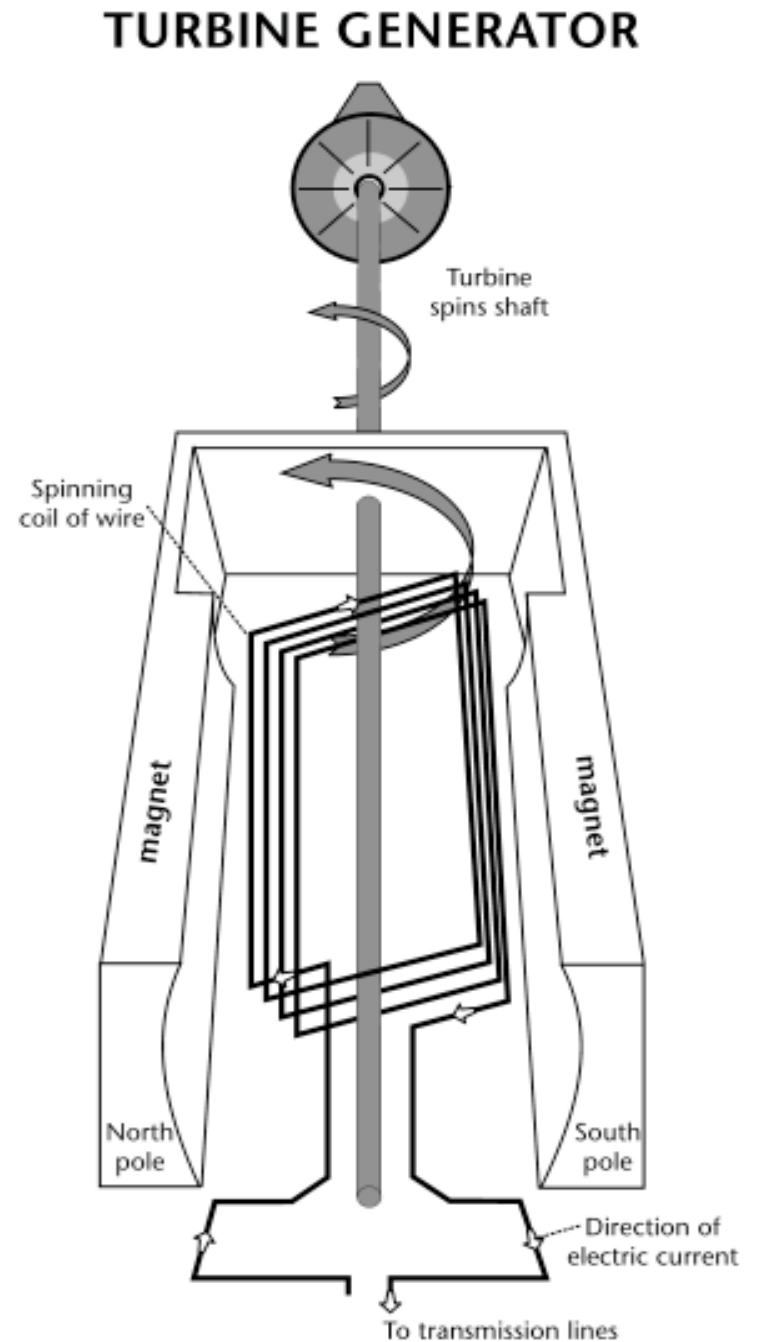
Converting mechanical energy to electricity is done by **electromagnetic induction**

Simple, but fundamental principle discovered by **Michael Faraday** in 1831.



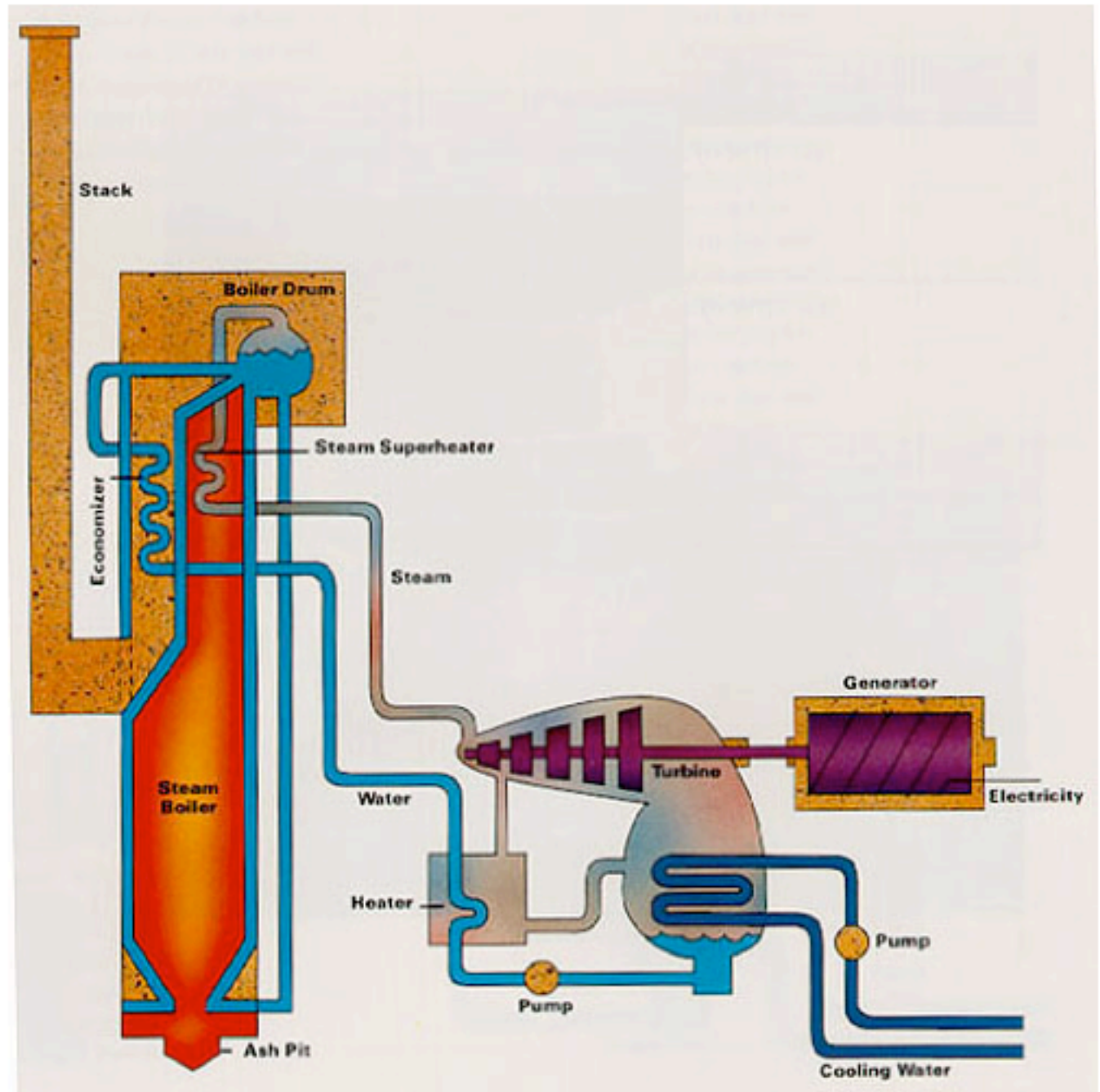
Generating electricity

Spinning wires inside a magnetic field, or vice versa, causes electrons to move in the wire, and moving electrons is called electricity



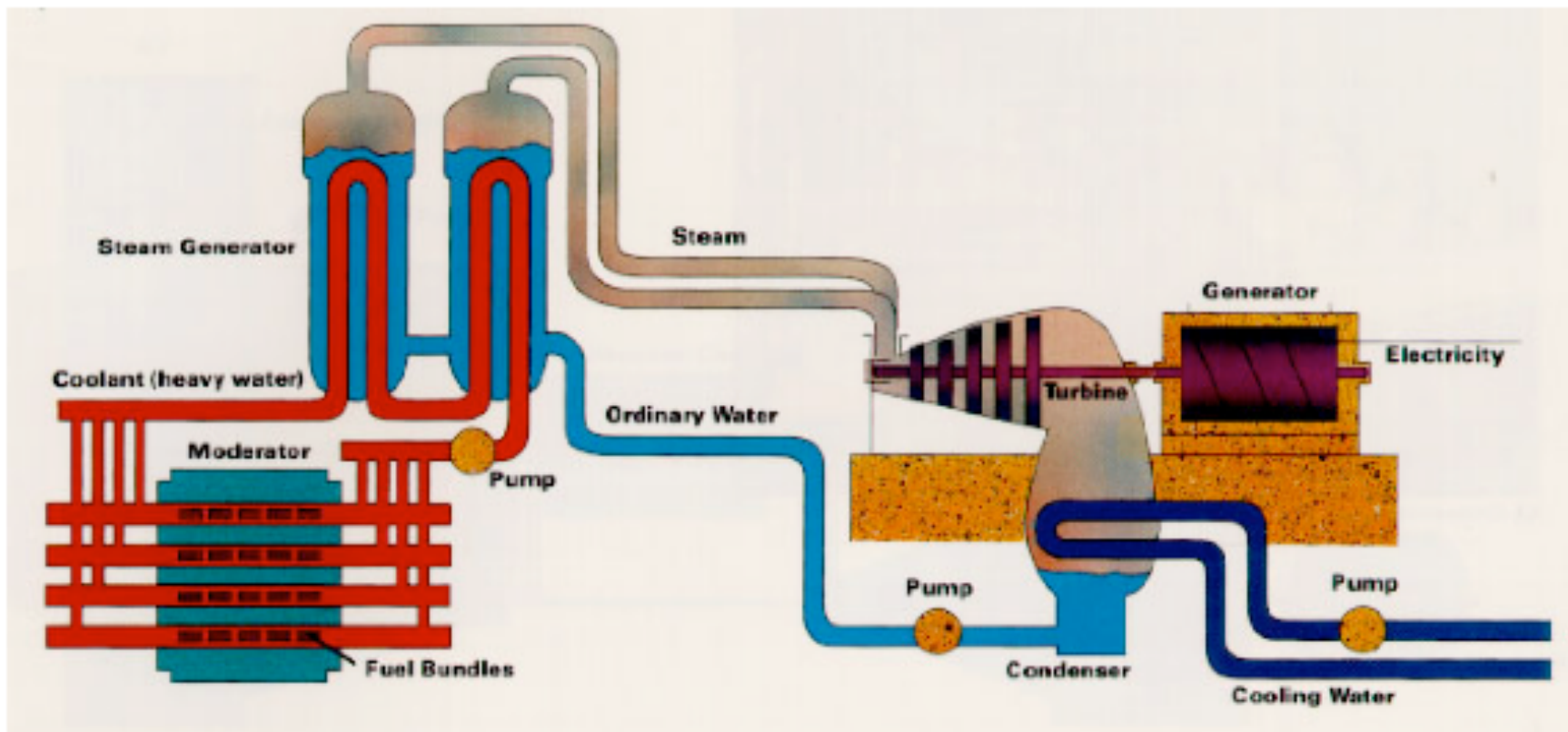
Electricity

Fossil fuels to
steam to
spinning
turbine to
electricity to...

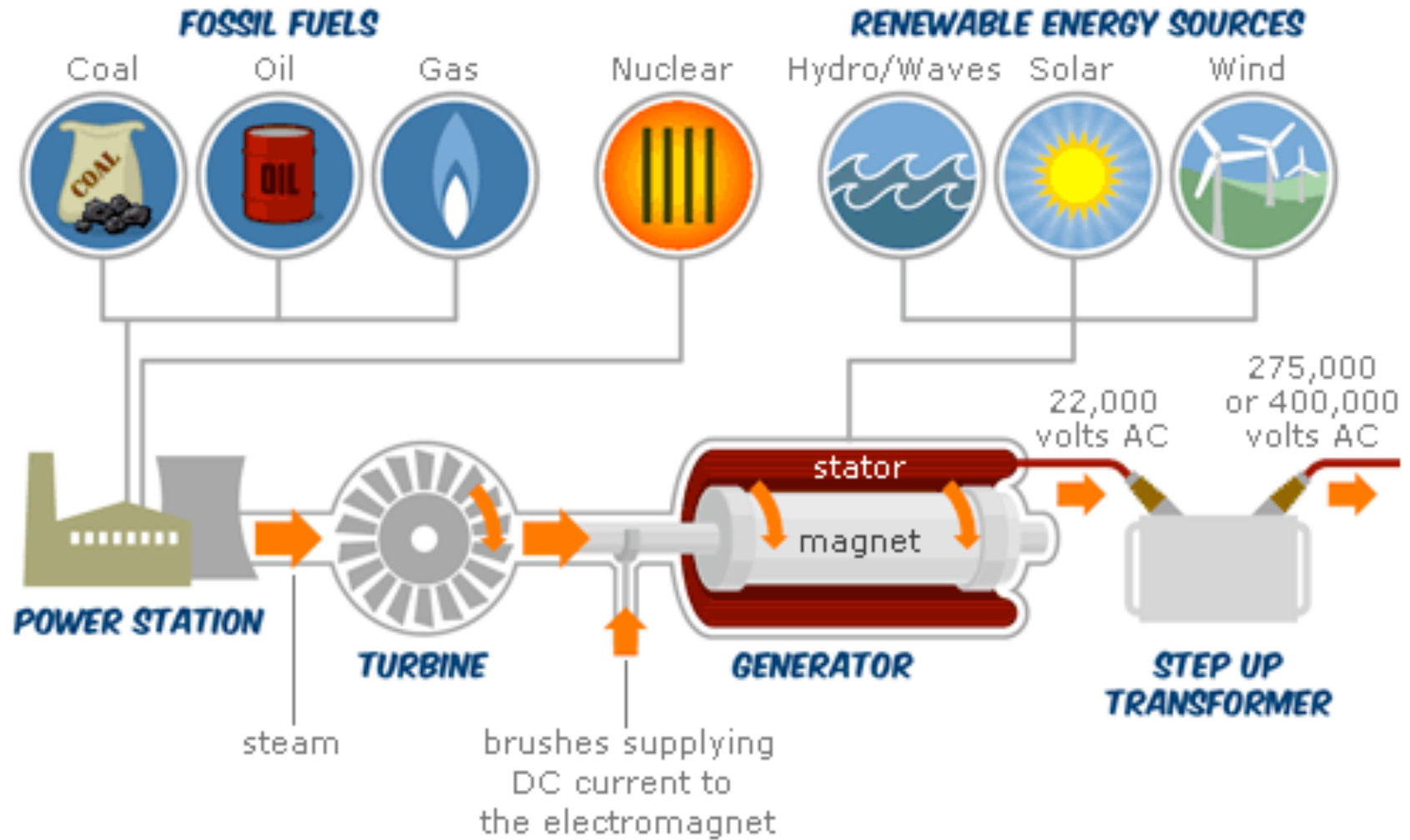


Electricity

The heat source can be any fuel... nuclear (below), solar, wind, biomass...



Electricity



Efficiency and electricity

Efficiency of electric power plants are usually about 30% (chemical energy to electricity); rest is wasted heat

Best technology can get about 40%, not much better.

Ever wonder why the ponds next to the Arapahoe power plant never freeze?

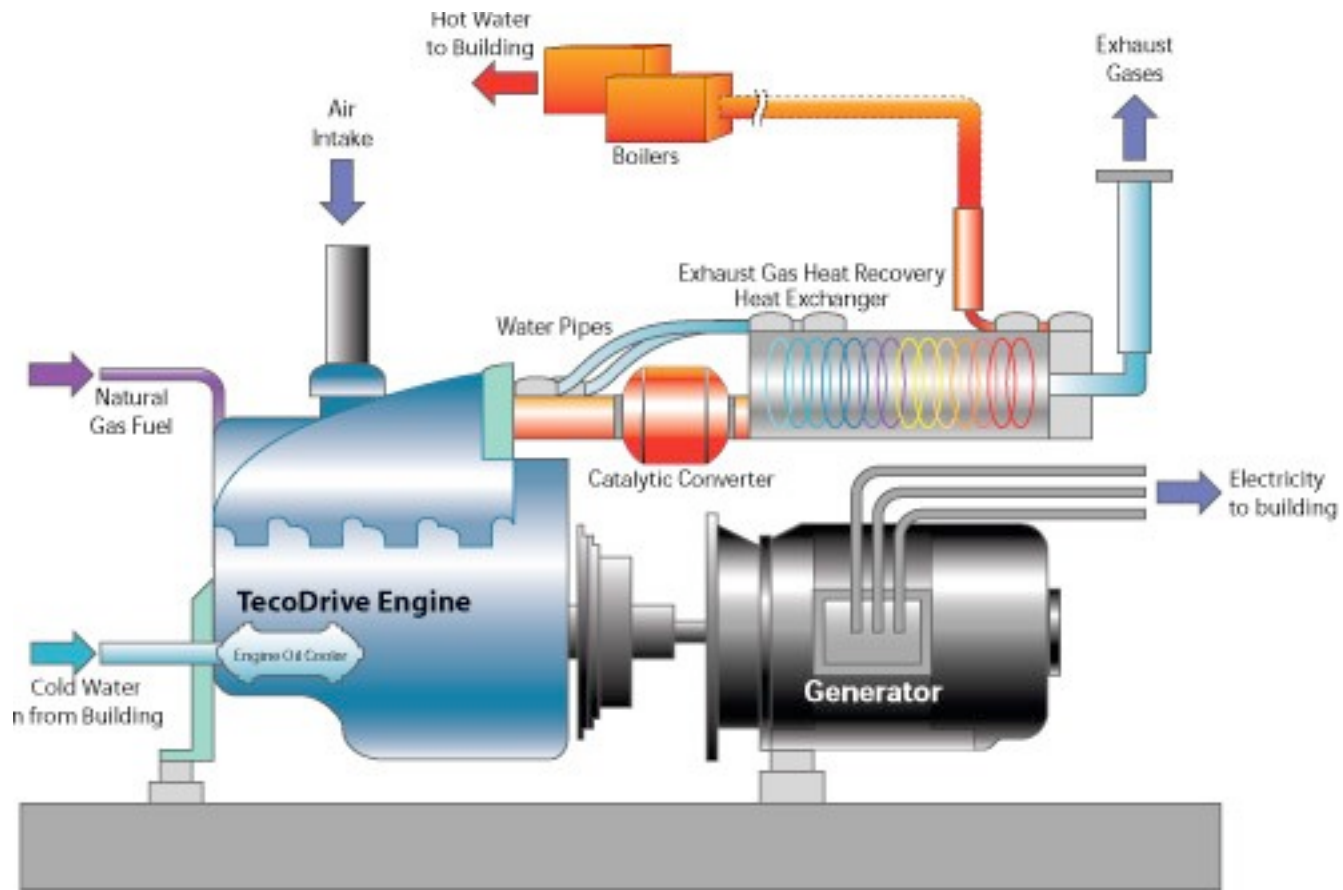
Cogeneration

How do get more out of the fuel we burn?

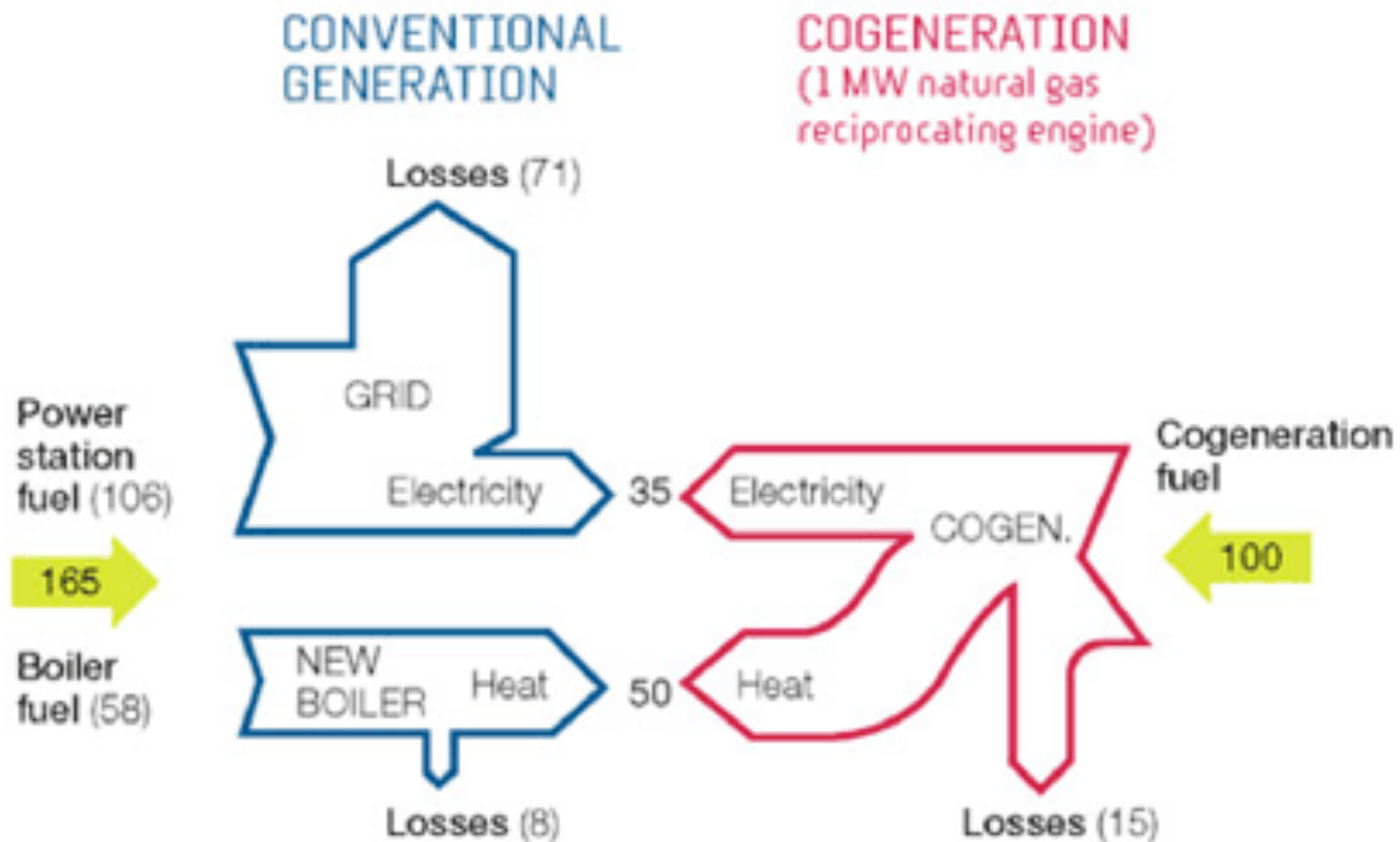
Cogeneration: this uses the waste heat from combustion to heat buildings, for example

Cogeneration can achieve up to 85% efficiency.

Cogeneration



Cogeneration vs. Conventional generation



Cogeneration

Note that you can use any fuel source that generates “waste heat” for cogeneration

- Fossil fuels
- Biomass
- Nuclear
- Geothermal
- etc

Cogeneration

Cogeneration: Old CU power plant example

Overall efficiency: 70%

Efficiency for electricity production: 35%

Excess heat used to heat buildings around campus (steam heating)

Shut down in 2004 due to rising natural gas prices

Cogeneration

Why don't we use cogeneration everywhere?

Need close proximity of power plants and heating needs

Problem of central versus local power plants, we have stressed large, central power plants far from homes and businesses

NIMBYism