An Introduction to Electric Power Plants

Developed for the mPower Ghana Project

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Combined Cycle Power Plant

Outline

- Electromagnetic Principles
- Types of Power Plants
- Power System Components

Principles

- energy = "the ability to do work"

  measured in Joules

- power = rate of energy generation or use

  measured in Watts = Joules / sec

- current = rate of charge flow

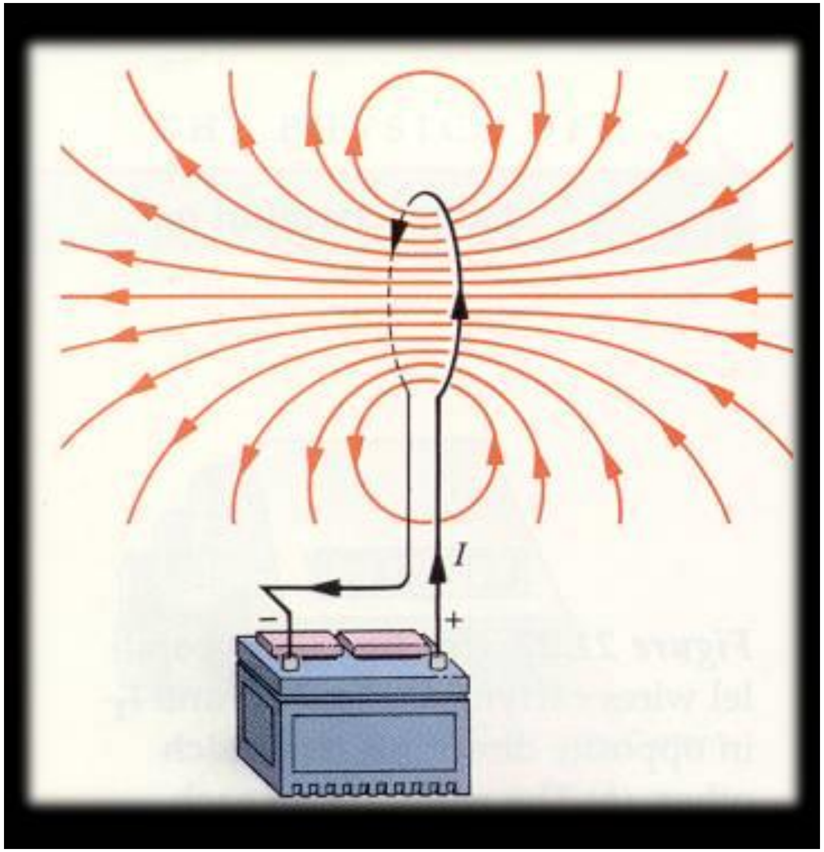
  measured in Amps

- voltage = "pressure" pushing current

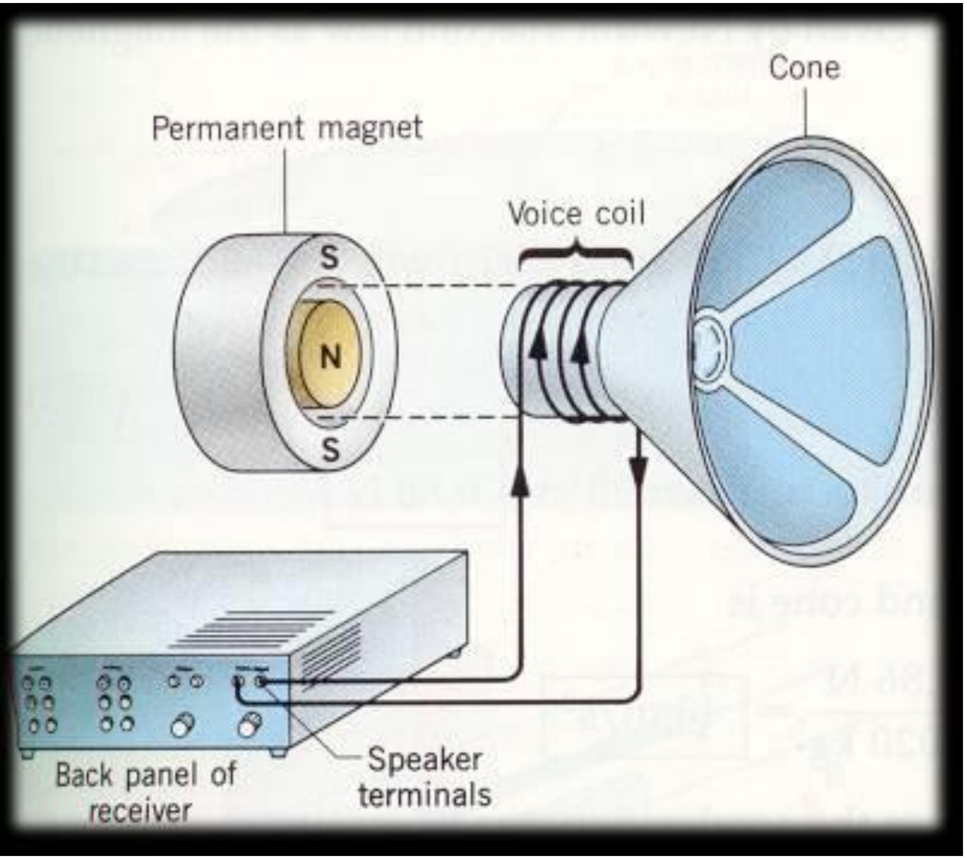
  measured in Volts

Electrical Currents Create Magnetic Fields

- electromagnets



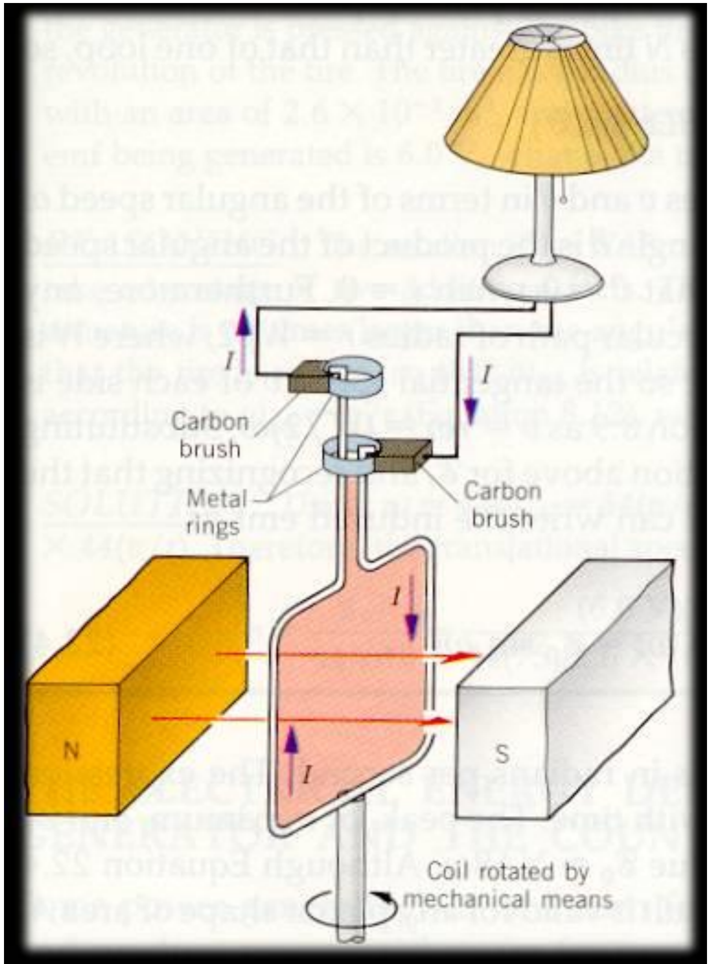
Magnetic Fields Push on Moving Electrons



DEMO: force on current apparatus
DEMO: make current with magnet & coil

Power Plant Provide Turning Power

- Why do we need "mechanical means"?
  - It takes a force to push a conductor through a magnetic field — inertia won't due.



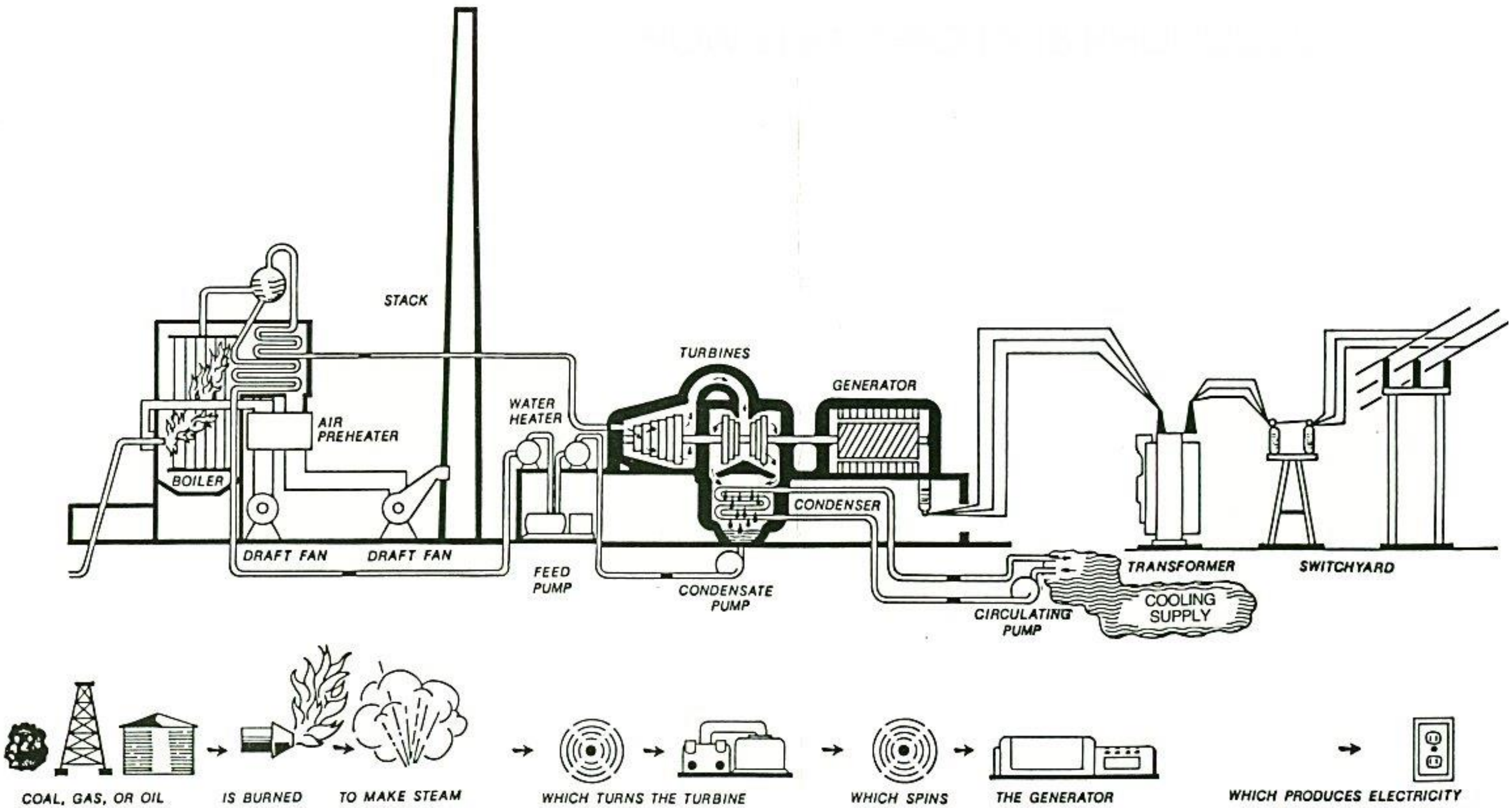
Powerhouse @ Hoover Dam

Types of Power Plants

Classification by the "mechanical means" used to turn the generator...

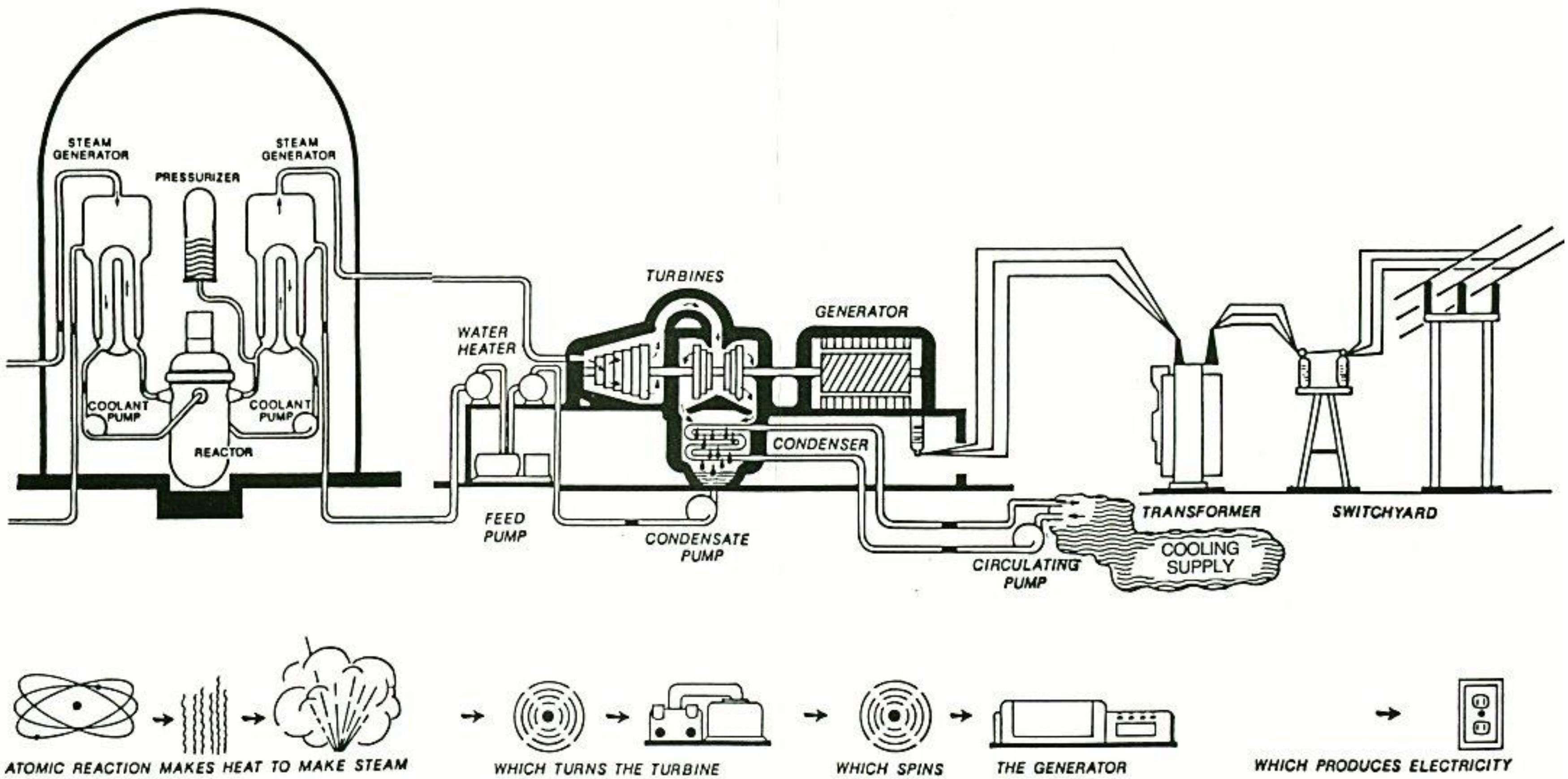
- Thermal (water steam by burning Coal, Oil, NG)
- Nuclear (water steam or gas cooled and fueled by Uranium or Plutonium fission)
- Hydroelectric (falling water)
- Geothermal
- Wind
- Solar

Thermal Power Plant



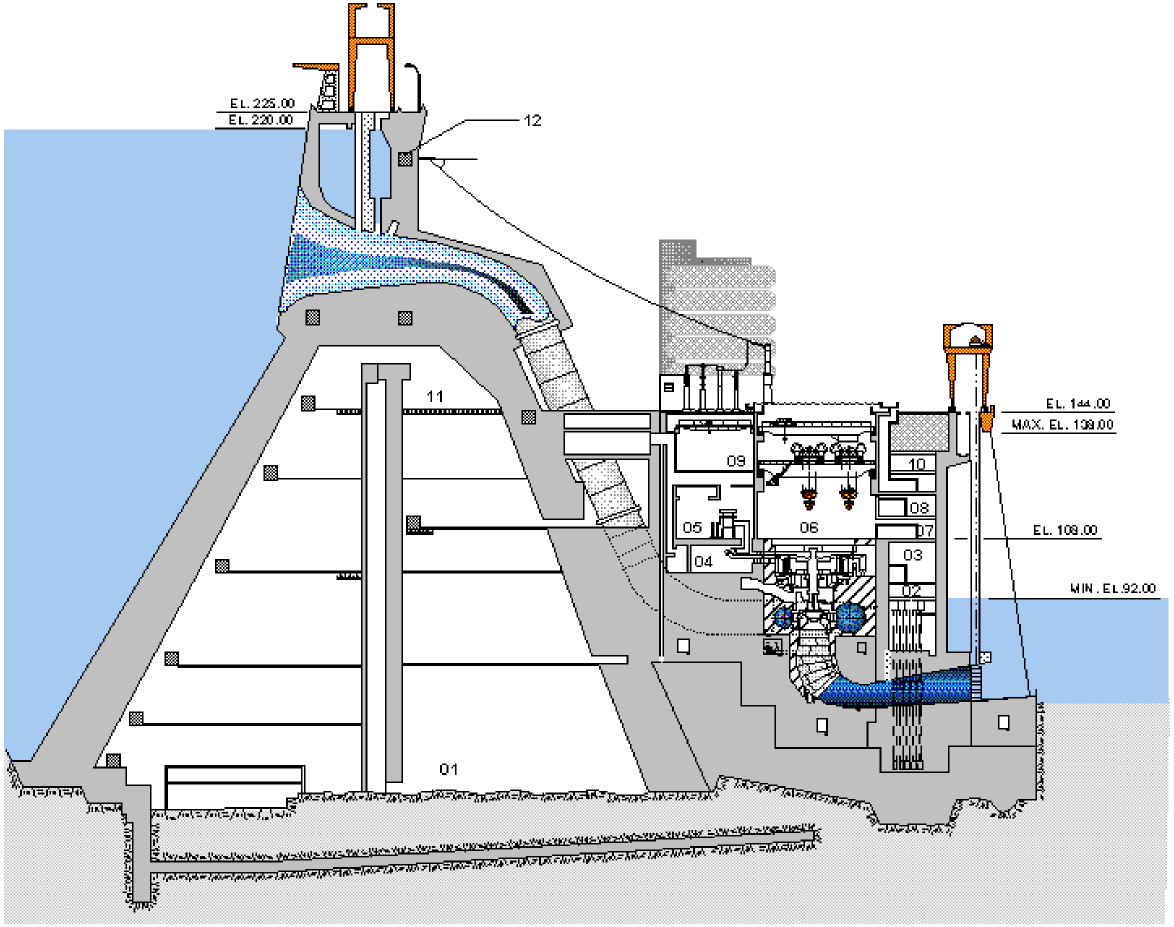
Coal-fired Power Plant

Nuclear Power Plant

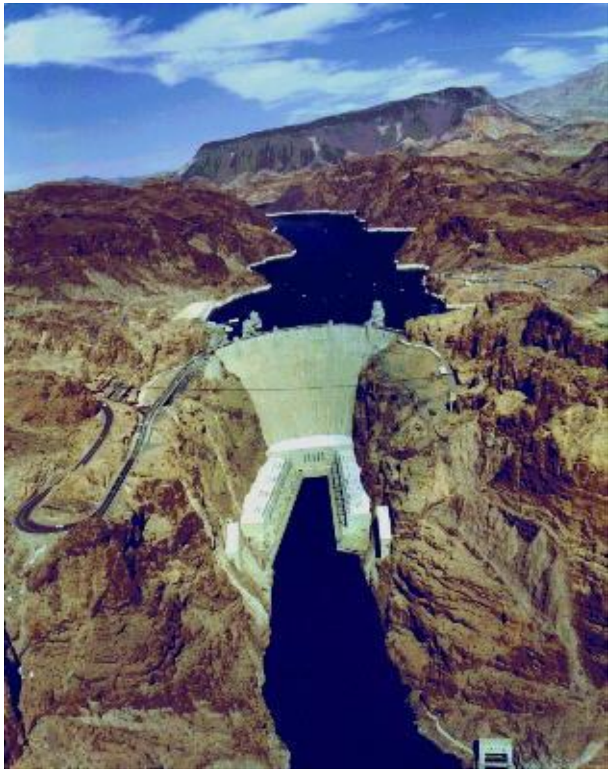


Nuclear Power Plant

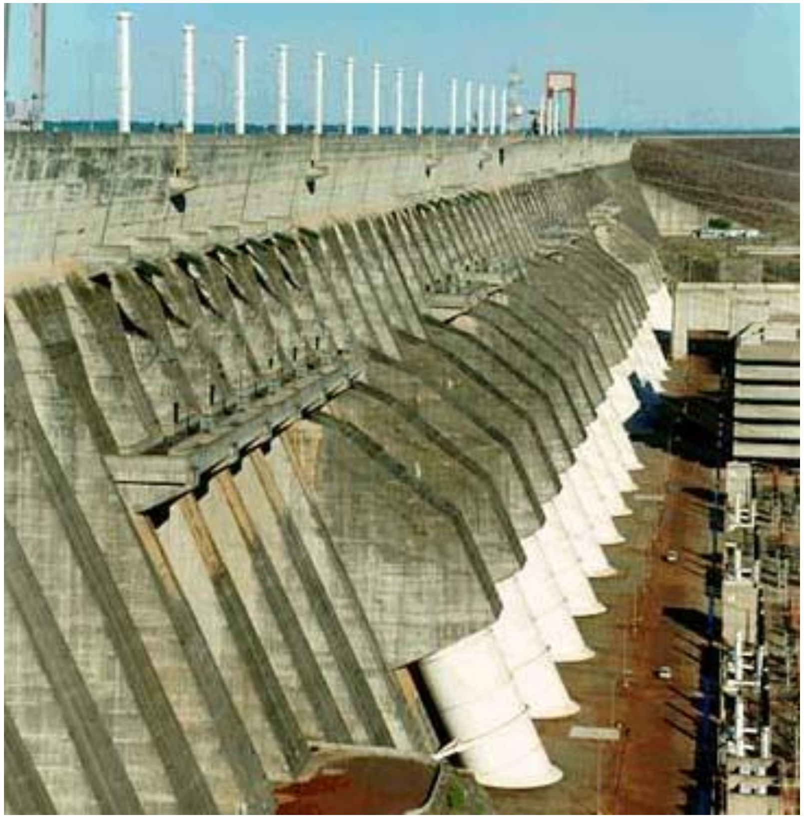
Hydroelectric Power Plant: Part One



Hydroelectric Power Plant: Part Two



Hoover



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Power Plant Components

ELECTRICAL

- Generators & Turbines
- Transformers
- Switches
- Busses
- Circuit Breakers
- Capacitor Banks

MECHANICAL

- Conveyors
- Silos
- Boilers
- Scrubbers & Stacks
- Pumps
- Cooling Towers

Auxiliary Equipment

- Conveyors
- Boilers
- Scrubbers and Stacks
- Pumps
- Cooling Towers

Generators

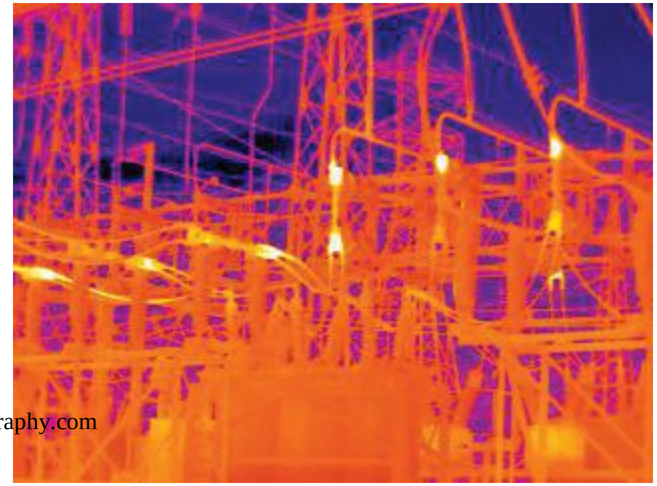
- The whole point of the power plant is to turn the generators to produce electrical energy.

Turbines

- Difficult to replace
- A spare is often kept

Busses

- uninsulated electrical conductors
- large cross-section = low resistance
- must be far from ground and other components to avoid arcing



flirthermography.com

Switches & Switchyards

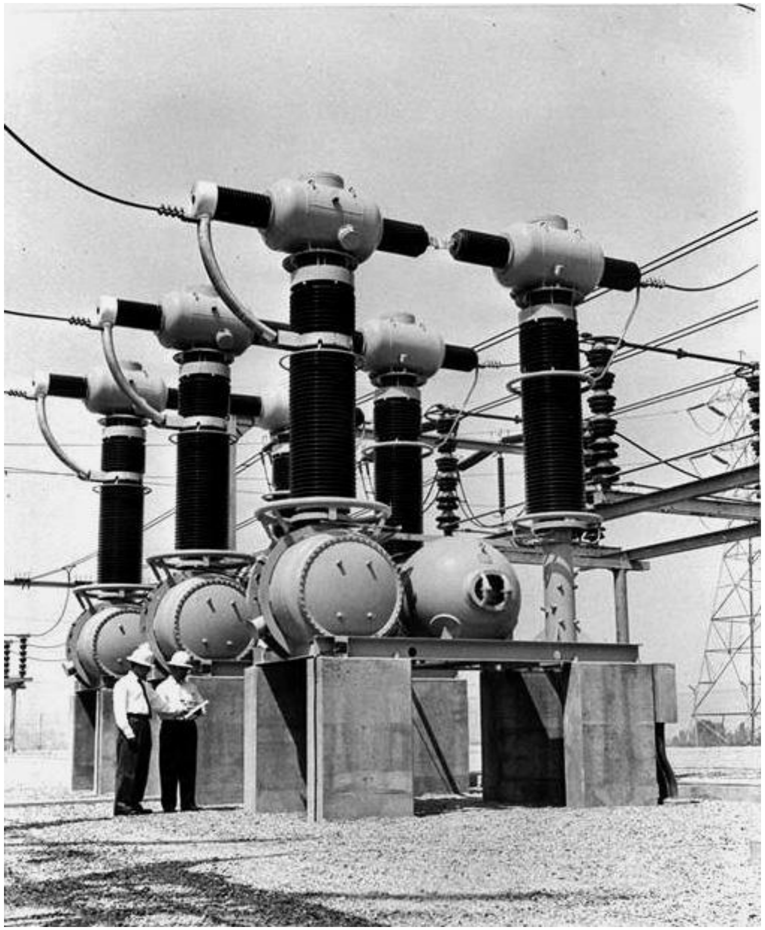
http://www.learnz.org.nz/trips06/images/big/b-switchyard.jpg

Transformers

- PURPOSE: to change the voltage
  - increase = “step-up”
  - decrease = “step-down”
- Often run hot, must be cooled, prone to explode.
  - oil inside
  - cooling fins and fans
  - blast walls

Circuit Breakers

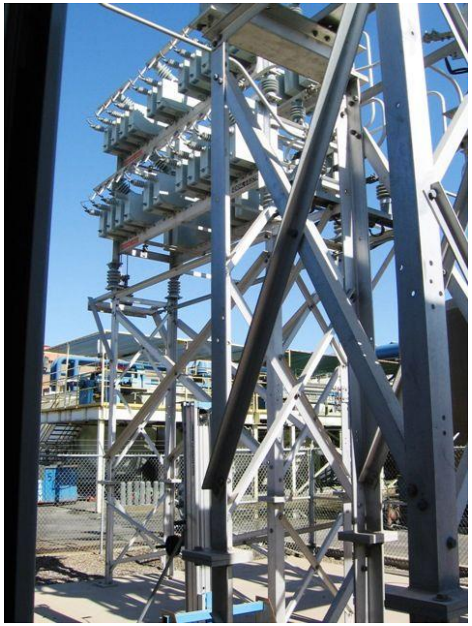
- PURPOSE: stop the flow of current if too much flows (due to short circuit or excess demand)



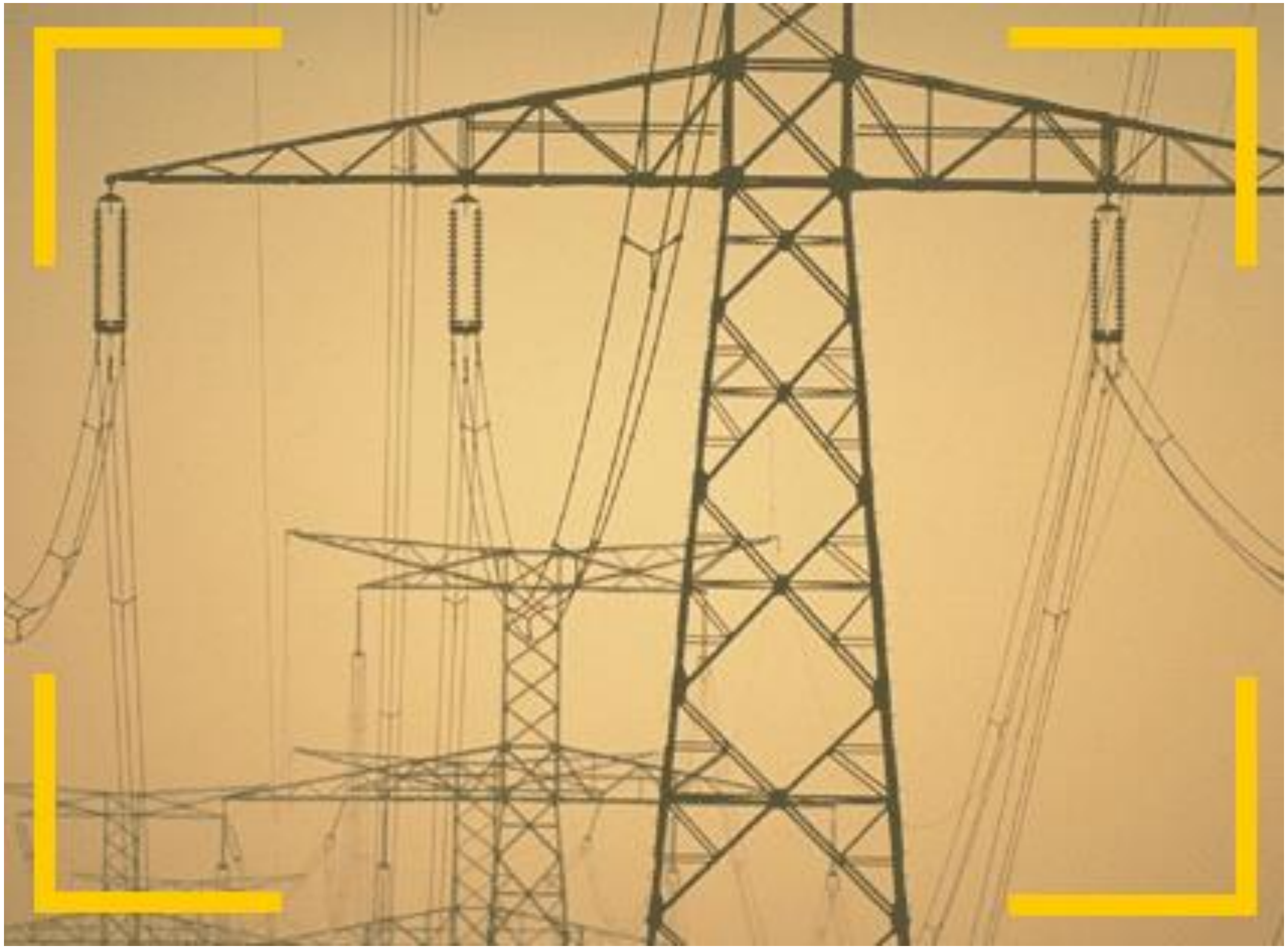
230 kV breaker

Capacitor Banks

- Purpose: to smooth out spikes in the line voltage.



Transmission Lines



Why are High Voltages Used?

- Transmission lines typically carry voltages of 110 kV, 230 kV, or even higher. The wires are not insulated, so they are kept high off the ground and well separated from each other, to prevent arcing (sparks) and injury or people or animals.
- Why use such high voltages? Using very high voltages on the transmission lines reduces the amount of energy wasted heating up the wires.

Why are High Voltages Used?

- And why is that so? Transformers cannot add energy, so if the voltage is increased, the current (in amps) must decrease. The charges flowing through the wires constantly collide with the atoms, losing energy and heating the wire. We call this resistance. Recall that the power (energy per time) lost to that heating is given by the equation $P=I^2R$. If the current is reduced, the power used in heating the wire is reduced.

Transformer Sub-Station

- to reduce the very high voltages from the transmission lines (>100kV) to intermediate voltages used to serve an individual town or section of a city (typically 66 kV or 33 kV)

To the house: Part One

smaller transformers: pedestal mounted, green boxes on the ground) reduce the voltage further to the 240V delivered to individual homes

To your house: Part Two

smaller transformers on power line poles reduce the voltage further to the 240V delivered to individual homes