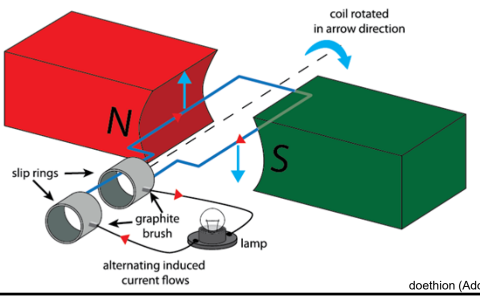
Generators

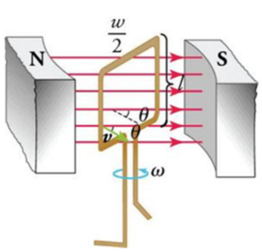
Nothing Ahead (Pexels)

- The most important application of the laws of electromagnetic induction was the development of the electric generator.
  - A coil of wire rotating in a magnetic field.



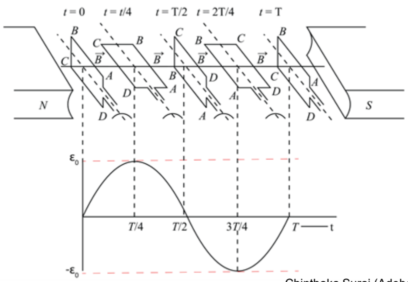
doethion (Adobe Stock)

- The magnetic flux in the coil varies with time.
  - It oscillates between the maximum (when the coil is perpendicular) to zero (when the coil is parallel).

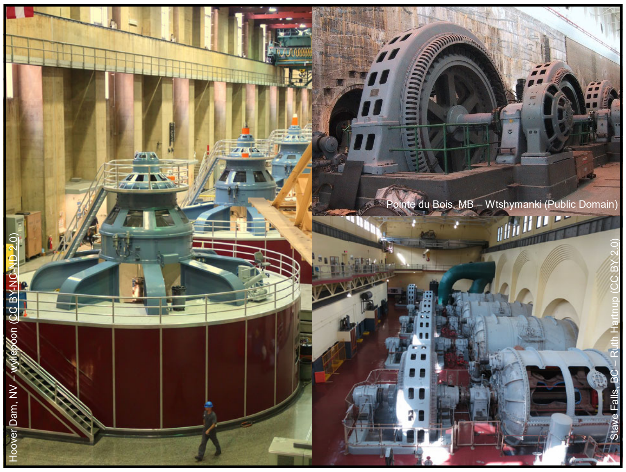


OpenStax, Rice University (CC BY 4.0)

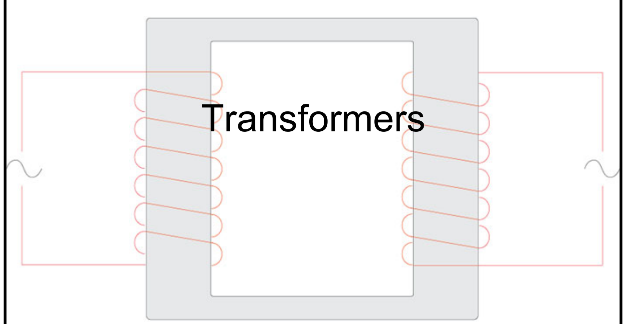
- The emf generated oscillates between ε_0 and $-\varepsilon_0$.
  - It increases as flux decreases and decreases as flux increases.



Chinthaka Suraj (Adobe Stock) - modified



Transformers

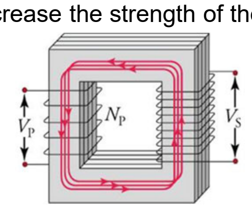


yeTis (Pixabay)

- A transformer is a practical application of electromagnetic induction that can be used for increasing or decreasing AC voltages.

Images: ds_30; Connie Montoya; Eric Westendarp (Pixabay)

- Transformers consist of two coils of wire connected by a laminated soft iron core.
  - The two wire coils are called the primary and secondary coils.
  - The laminated soft iron core reduces eddy currents (increases efficiency).
  - The core is enclosed on top and bottom to increase the strength of the magnetic field.



- When a current flows in the primary coil, a magnetic field is produced.
- It grows and “cuts” the secondary coil inducing a current.
- The size of the voltage input/output depends on the number of turns of wire in each coil.

$$\boxed{\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s}}$$

Example

- A transformer has 50 turns in its primary coil and 1000 turns in its secondary coil. If the input voltage is 110 V, what is the output voltage?

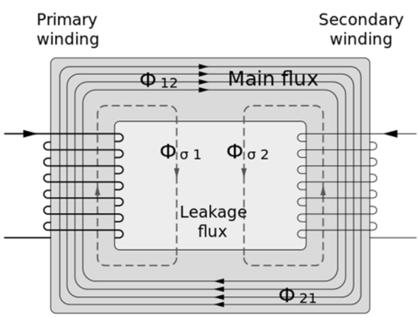
$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

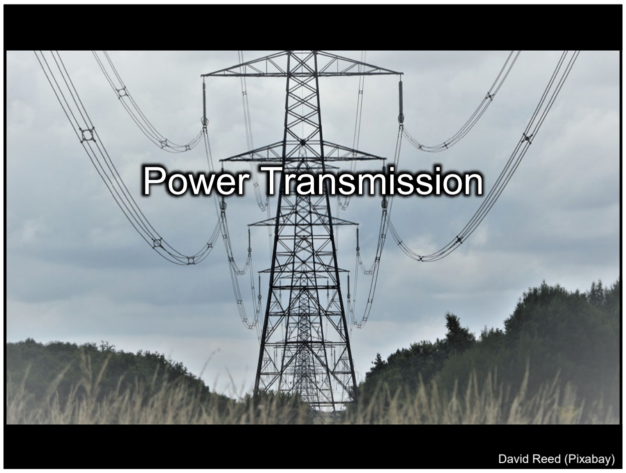
$$V_s = \frac{V_p N_s}{N_p} = \frac{(110)(1000)}{(50)} = 2200 \text{ V}$$

- If a transformer is 100% efficient, the power produced in the secondary coil should equal the power input of the primary coil.

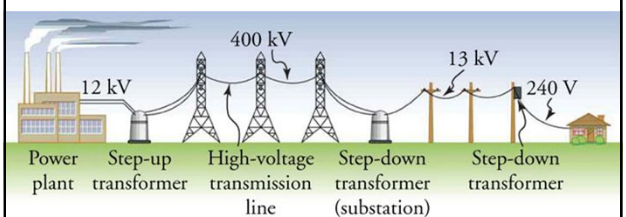
$$P_p = P_s$$
$$I_p V_p = I_s V_s$$

- In practice, power is lost due to flux leakage (eddy currents) decreasing the maximum possible efficiency.





- Electric power is transmitted over high voltage (high tension) power lines.
  - Low current (high voltage) transmission minimizes the energy loss due the resistance of the wire.



Example

- An average of 120 kW is delivered to a suburb 10 km away. The transmission lines have a total resistance of 0.40 Ω. Calculate the power loss if the transmission voltage is:
  - 240 V
  - 24 000 V

240 V

$$P = IV$$

$$I = \frac{P}{V} = \frac{120\text{x}10^3\ \text{W}}{240\ \text{V}} = 500\ \text{A}$$

Power loss:

$$P = I^2R = (500\ \text{A})^2(0.40\ \Omega) = 100\ \text{kW}$$

24 000 V

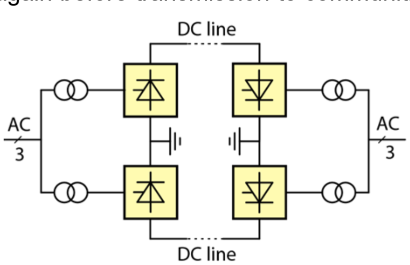
$$P = IV$$

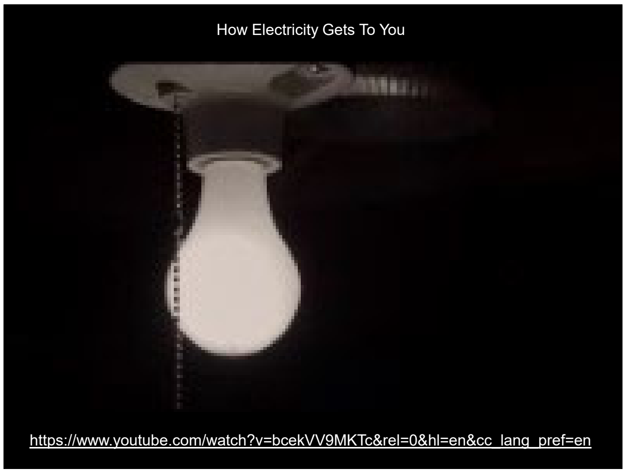
$$I = \frac{P}{V} = \frac{120\text{x}10^3\ \text{W}}{24\,000\ \text{V}} = 5\ \text{A}$$

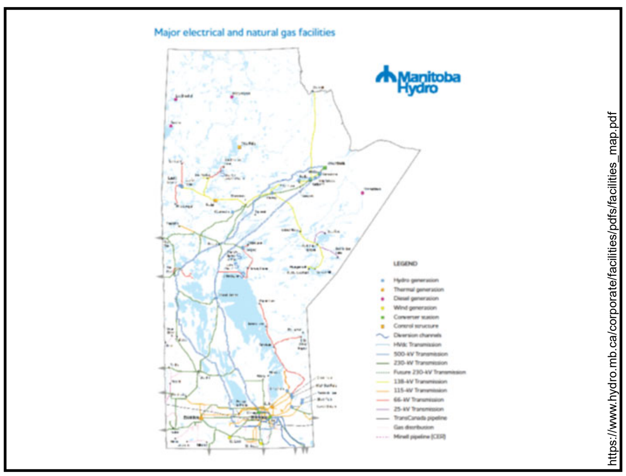
Power loss:

$$P = I^2R = (5\ \text{A})^2(0.40\ \Omega) = 10\ \text{W}$$

- In Manitoba, AC power is converted to DC for transmission from the North.
  - This further reduces loss due to resistance.
  - The DC current must be converted to AC again before transmission to communities.




How Electricity Gets To You
https://www.youtube.com/watch?v=bcekVV9MKTc&rel=0&hl=en&cc_lang_pref=en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