6. Energy Concepts
3. Conversions and Efficiency

Prepared for EGY 105

Energy in Our World

Kenneth M. Klemow, Ph.D.
Wilkes University

“Conversion” and “conservation” two important concepts

- Both have two meanings
  - Conversion
    - Translating between different units of measure
      - Joule <-> Calorie <-> BTU
    - Changing from one form to another
      - Chemical energy -> Thermal energy
  - Conservation
    - First law of thermodynamics
      - Energy cannot be created or destroyed, only converted
    - Reduce wasteful energy consumption
      - Switch from incandescent to light-emitting diode (LED)

Some conversion factors

(See Table 4.4 on pp. 84 – 85 for more complete list)

- 1 kilowatt hour = 3.60×10^6 J
- 1 barrel oil equivalent = 6.119×10^9 J
- 1 ton wood equivalent = 9.83×10^9 J
- 1 ton coal equivalent = 29.31×10^9 J
- 1 ton oil equivalent = 41.87×10^9 J
- 1 quad (PBtu) = 1.055×10^{18} J

Energy conversions
(From Table 2.2 on p. 28 in text)

Conversion From:	To Chemical	To Electric	To Heat	To Light	To Mechanical
Chemical	Food Plants	Battery Fuel cell	Fire Food	Candle Phosphorescence	Rocket Animal muscle
Electrical	Electrolysis Electroplating	Transistor Transformer	Toaster Heat Lamp Spark plug	Fluorescent lamp Light-emitting diode (LED)	Electric motor Relay
Heat	Gasification Vaporization	Thermocouple	Heat pump Heat exchanger	Fire	Turbine Gas engine Steam engine
Light	Plant photosynthesis Camera film	Solar cell	Heat lamp Radiant solar	Laser	Photoelectric door opener
Mechanical	Heat cell (crystallization)	Generator Alternator	Friction brake	Flint Spark	Flywheel Pendulum Water wheel

Laws of Thermodyamics

- First law: Energy cannot be created nor destroyed, can only be converted (conservation of energy)
  - In an isolated system, total energy will always remain constant
- Second law: No energy conversion is perfect; always get some loss as heat.
  - Gives direction to a reaction
  - Get increase in disorder (entropy).

Consequences of Second Law

- In system involving movement, always get loss as friction
- Thus perpetual motion machines are impossible (yet people still try to invent them)
- Waste heat given off to environment
  - Ultimately go off to space

Efficiency an important measure

$$\text{Efficiency} = \frac{\text{energy (work) output}}{\text{total energy input}} \times 100$$

- Efficiencies can vary from 5% - 95%
- In multistep processes, efficiency is the product of efficiency of each step.
- Comparative assessments of energy processes / devices typically take great pains to accurately measure efficiency

Efficiencies of energy conversion devices and systems

Electric generators	70–99%
Electric motor	50–90%
Gas furnace	70–90%
Wind turbine	35–50%
Fossil fuel power plant	35–40%
Nuclear power plant	30–35%
Automobile engine	20–30%
LED lamp	25–30%
Fluorescent lamp	20%
Incandescent lamp	5%

- From Table 4.1 on p. 76 of text

Example of multistep efficiency

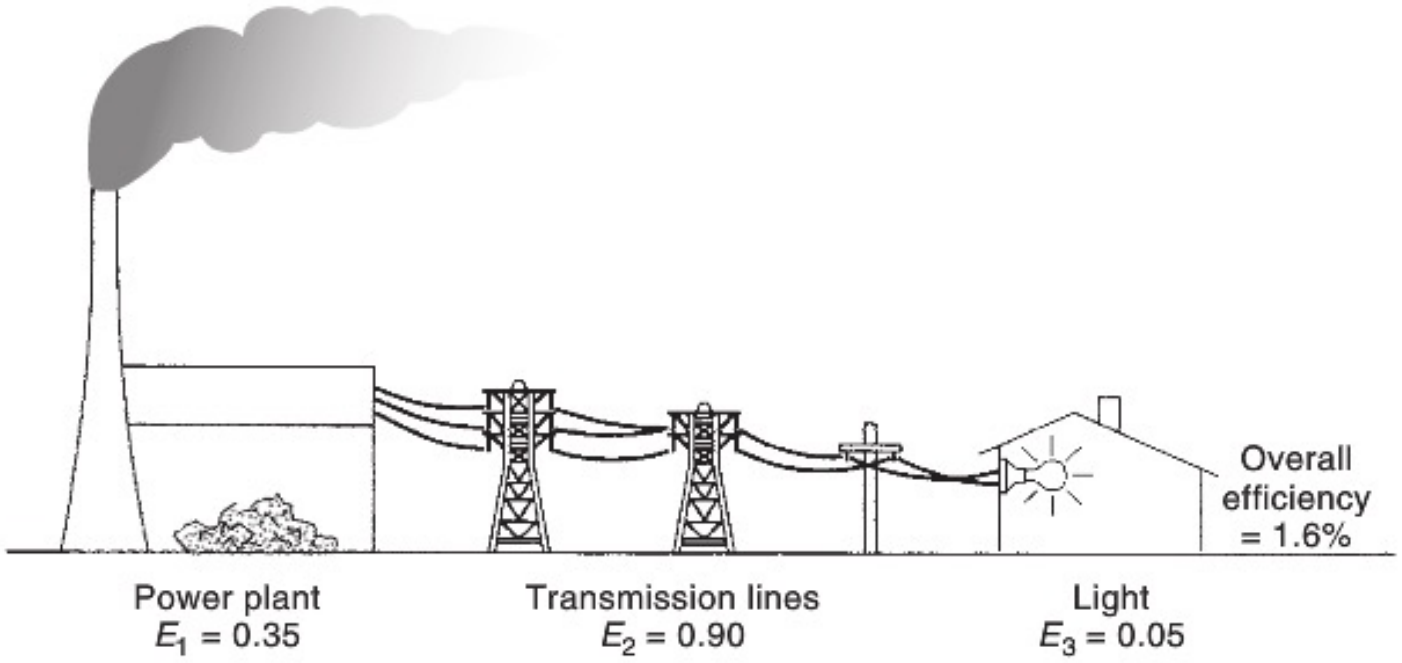
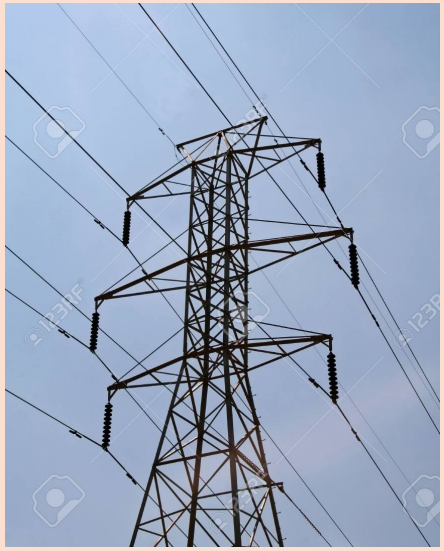


Figure 3.4 Calculation of the overall efficiency for a multistep process involves multiplying the efficiencies of the individual steps.

Note: This is Figure 4.4 on p. 77 of your text.

What would be the efficiency of the following process?

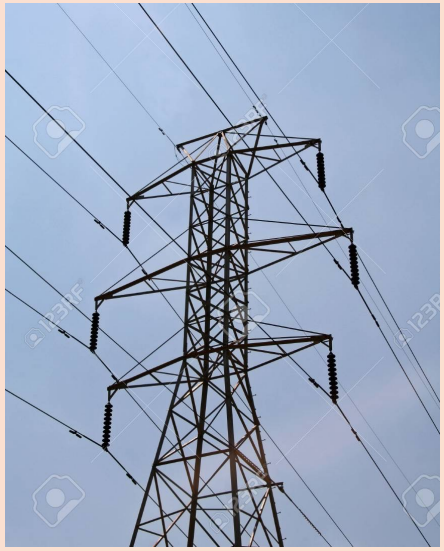
- Nuclear power plant -> Wires -> LED bulb



What would be the efficiency of the following process?

- Nuclear power plant -> Wires -> LED bulb

0.35

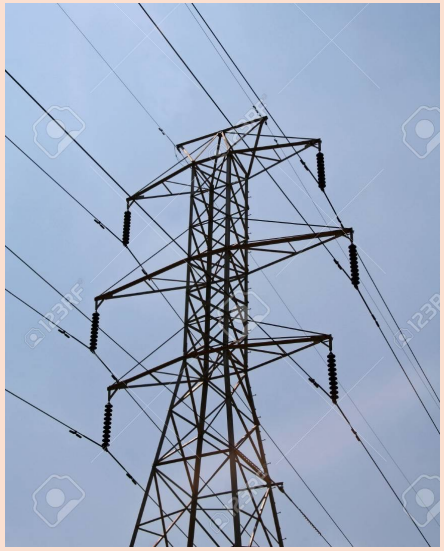


0.90

0.30

What would be the efficiency of the following process?

- Nuclear power plant -> Wires -> LED bulb



0.35 0.90 0.30

Efficiency = 9.45%