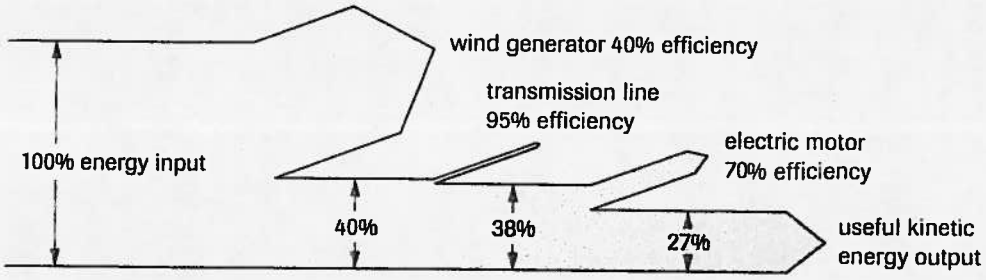
Energy Flow Diagrams—Additional Practice

The overall efficiency of a chain of energy transformations is nicely illustrated by energy flow diagrams. For example, this energy flow diagram shows the energy transformations in operating an electric motor (70% efficiency) using electricity that has been generated by a wind generator (40% efficiency) and transmitted over low-voltage transmission lines (95% efficiency).



The overall efficiency is (0.40)(0.95)(0.70) = 0.27 or 27%.

Provide energy flow diagrams for each of the following energy-transformation chains, and calculate the overall efficiency for each.

1. A geothermal generator (20% efficient) produces electricity that is transmitted (95% efficient) and used to operate an electric hair dryer (95% efficient).

2. Uranium is mined and refined (85% efficient) and used to generate electricity in a nuclear fission reactor (30% efficient). The electricity is transmitted (95% efficient) and used to operate a fluorescent light (20% efficient).

3. Trees are harvested and transported (90% efficient) to a biomass generator (5% efficient). The electricity is transmitted (95% efficient) and used to operate a television (90% efficient).

Calculating Efficiencies—Additional Practice

In many cases, when you look at the efficiency of an energy-transformation technology, you are looking at the efficiency of only one energy transformation. In reality, there exists a chain of energy-transformation technologies, each of which has its own efficiency. The longer the chain, the more inefficient the overall energy transformation becomes. The overall efficiency is the product of the individual efficiencies of the energy transformations that make up the chain.

$$eff_{overall} = (eff_1)(eff_2)(eff_3) \ldots$$

Sample Problem

A wind generator (50% efficiency) generates electricity that is used to charge batteries (85% efficiency). The batteries are used to operate a fluorescent lamp (20% efficiency). What is the overall efficiency of the three energy transformations?

Solution

$$\begin{aligned} eff_{overall} &= (eff_1)(eff_2)(eff_3) \\ &= (0.50)(0.85)(0.20) \\ &= 0.085 \end{aligned}$$

The overall efficiency is 0.085, or 8.5%.

Solve each of the following problems in the space provided.

1. What is the overall efficiency of a chain of four energy-transformation technologies that have individual efficiencies of 0.95, 0.80, 0.65, and 0.15?

2. Using the energy-efficiency percentages from **Table 1** in section 4.4 on page 193 of your textbook, calculate the energy efficiency of the following. Determine which one has the greatest efficiency:
   (a) Electricity from a hydraulic generating station is used to power an incandescent lamp.

   (b) Electricity from a wind generator is used to power a large electric motor.

   (c) Electricity from a nuclear fission reactor is used to power a fluorescent lamp.

3. Two energy-transformation technologies each have an efficiency of 0.60. What is the efficiency of a third energy-transformation technology if the overall efficiency of the chain is 0.18?

4. Two energy-transformation technologies have the same efficiency, and the overall percentage efficiency of the two operating together is 49%. What are their individual efficiencies?

5. Do you support or oppose each of the following arguments? State your reasons.
   (a) Over one-half of the energy available in fossil fuels is wasted when the fuels are used in the generation of electricity. Canada should immediately replace fossil-fuel generating stations with higher efficiency sources.

   (b) Electric heaters are 100% efficient. To use electrical energy more efficiently, households should switch to electric heat.

   (c) Solar cells are typically 10% to 15% efficient. Because solar cells have such low efficiencies, there is no point in using them.