Chapter 38 Problem 68 [†]

Given
$P = 1.2\ GW = 1.2 \times 10^9\ W$
$m = 1311\ kg$

Solution
a) Find the thermal power output.

According to Appendix C the energy content of uranium-235 is $8.2 \times 10^{13}\ J/kg$. The uranium-235 used during one year is then

$$E = (1311\ kg)\left(\frac{8.2 \times 10^{13}\ J}{1\ kg}\right) = 1.08 \times 10^{17}\ J$$

This energy is released over the course of a year. This corresponds to

$$t = (1\ yr)\left(\frac{365.25\ days}{1\ yr}\right)\left(\frac{24\ hr}{1\ day}\right)\left(\frac{3600\ s}{1\ hr}\right) = 3.16 \times 10^7\ s$$

The thermal power output is then

$$P = \frac{E}{t} = \frac{1.08 \times 10^17\ J}{3.16 \times 10^7\ s} = 3.42 \times 10^9\ W = 3.42\ GW$$

b) Find the efficiency.

Efficiency is

$$\varepsilon = \left(\frac{electric\ power}{thermal\ power}\right) \times 100\%$$

$$\varepsilon = \left(\frac{1.2\ GW}{3.42\ GW}\right) \times 100\% = 35\%$$

[†]Problem from Essential University Physics, Wolfson