LETTERS TO THE EDITOR

COMMENTS ON "TOTAL ENERGY INVESTMENT IN NUCLEAR POWER PLANTS"

I would like to thank Rombough and Koen[1] for their very useful contribution on this topic. However, there appears to be an unfortunate inconsistency in the way they report their results. For construction energy, they compare thermal energy input with electricity produced; for the fuel cycle, they compare electrical energy input with electricity produced. In the case of coal, they revert to thermal input against electricity produced. Thus, their results are unfair to coal. Also, they have neglected the construction energy investment required for enrichment plants.

Each separative work unit (SWU) consumes 2582 kWh(e) or ~8600 kWh(th) of process energy. In addition, a 9 million SWU/a plant will cost ~\$4 billion, including the power stations needed to supply it, and this will contribute an additional 240 kWh(th)/SWU. Thus, pressurized water reactor (PWR) fuel requires

$$4.31\ \frac{\text{SWU}}{\text{kg}} \times \frac{8840\ \text{kWh(th)}}{\text{SWU}} = 38\ 100\ \text{kWh(th)/kg} \quad .$$

The PWR fuel burnup is 792 000 kWh(th)/kg or ~237 000 kWh(e)/kg. Thus, the thermal energy expended on the fuel is ~16% of the electricity produced. By comparison, the total thermal energy investment required for natural uranium CANDU-PHW fuel is <2% of the electricity produced.

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REFERENCE

1. CHARLES T. ROMBOUGH and BILLY V. KOEN, "Total Energy Investment in Nuclear Power Plants," *Nucl. Technol.*, **26**, 5 (1975).

REBUTTAL TO "COMMENTS ON 'TOTAL ENERGY INVESTMENT IN NUCLEAR POWER PLANTS' "

We thank Bradley[1] for his interest and observations regarding our analysis. The current debate[2] surrounding energy analysis has centered on the point raised by Bradley—how we are to handle different forms of energy in the calculation.

Basically, there are four ways to solve this problem.

1. Convert all input energy to electricity and compare with the electrical output energy. This assumes that the thermal input energy could have been used to generate electricity. In this case, the energy ratio (ER) (in/out) becomes 5.8% for nuclear and 2.6% for coal.

2. Convert all input energy to thermal and compare with the electrical output energy. In this case, ER becomes 17.5% for nuclear and 7.8% for coal.

3. Assume that the output electricity can be substituted directly for all forms of input energy in which case no conversions from electricity to thermal or vice versa are made. The ER then becomes 7.1% for nuclear and 7.8% for coal.

4. Convert all energy forms to some other unit representing the amount of equivalent useful work available from the energy. This last case would account for the differences in efficiencies between electricity and thermal energy. For example, a natural-gas water heater may be 62% efficient compared to a 95% efficient electric water heater. Using these values, let our unit be the equivalent number of pounds of water that can be heated 1°F for each energy form:

$$\begin{aligned}
\text{Nuclear:}\quad & 1.38\times10^{13}\ \text{Btu(th)}\times0.62 = 0.86\times10^{13}\ \text{lb}\\
& 3.71\times10^{13}\ \text{Btu(e)}\ \times0.95 = 3.52\times10^{13}\ \text{lb}\\
& \qquad\qquad\qquad\qquad \text{Total: } 4.38\times10^{13}\ \text{lb}\\
\text{Coal:}\quad & 5.63\times10^{13}\ \text{Btu(th)}\times0.62 = 3.49\times10^{13}\ \text{lb}\\
\text{Output:}\quad & 71.7\ \times10^{13}\ \text{Btu(e)}\ \times0.95 = 68.12\times10^{13}\ \text{lb}
\end{aligned}$$

$$\text{Nuclear ER} = 6.4\%$$

$$\text{Coal ER} = 5.1\%.$$

As noted in our paper,[3] we chose method 3 for simplicity, although method 4 is probably the most realistic. The assumption that the thermal input "could have been" used to generate electricity, used in method 1, is purely hypothetical, while the assumption that electricity from the plant could be used for any input energy directly (method 3) is not hypothetical at all. For example, it is realistic to assume that a 1000-MW(e) nuclear plant could be used to supply the energy requirements for a large enrichment facility. Since