EXERCISES

1. Seawater desalination in a large-scale reverse osmosis plant requires about 6 kWh of electricity to produce 1 m$^3$ of fresh water. How much fresh water can be produced by the electricity that can be generated by using the uranium contained in one m$^3$ of seawater? Assume that the uranium is enriched to 3.75% after extraction from seawater and then used in a LWR reactor with a thermal efficiency of 32% and a burnup rate of 40 GWd/t. About 0.7% of naturally found uranium is U-235 (Ans: 30.6 l).

2. The known U-238 reserves economically recoverable for U-238 prices around $200/kg amount to 20 million metric tonnes. Based on energy conversion parameters as in the preceding example, estimate the thermal energy in these reserves in Quad, Mtoe, and million tonnes of coal (based on a coal heating value of 30 MJ/kg). Assume a normal isotope distribution of 99.3% U-238 and 0.7% U-235 in naturally-found uranium (Ans: 12170 Q, 308000 Mtoe, 430000 million tonnes of coal).

3. How much energy needs to be spent to enrich one kg of naturally-found uranium (0.7% U-235) to an enrichment level of 3.75% using
   a. Gaseous diffusion
   b. Gaseous centrifuge
   Ans: 1730 kWh and 34 kWh.

4. How much energy is needed to bring the enriched uranium (3.75% U-235) of the preceding exercise to weapon-grade uranium (95% U-235) (Ans: 910 kWh or 18 kWh depending on the enrichment process).

5. How much enriched uranium (3.75% U-235) is needed to fuel a 700-MWe nuclear plant for one day, if the thermal efficiency is 35% and the burnup rate is given as 38 GWd/tonne. Ans: 52 kg/day.

6. A water pump considered for a nuclear plant is used in other industries under similar conditions and has the following failure data:
   The number of pumps in continuous service = 300000
   The number of failures in a typical year in that population = 2
   If one pump has enough power to pump the required amount of coolant, how many pumps in parallel need to be installed to achieve a coolant pumping failure probability of better than 1 in $10^7$ reactor-years?
   Ans: $N > \frac{7}{\log_{10} 6.67 \times 10^{-6}}$ therefore, choose $N=2$. 

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