Calculating the amount of nuclear waste generated per person, per year.

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This explains how we calculated the amount of nuclear waste each person in the USA would generate if all electricity came from nuclear power. First, we need to know how much nuclear waste is generated for each bit of electricity created from nuclear power. To do this, we check the EIA for yearly waste discharge data[1].

	Discharge (MT)	Avg. Burnup (GWd/MT)	Energy Released (GWd-thermal)
PWR	1667.6	45.7	76209
BWR	739.6	40	29584
Total	2407.2		105793

Now we need to know the average thermal efficiency of the US nuclear fleet so we can convert the thermal power into electrical power. Usually, nuclear power plants run at an efficiency of around 33%, but we want more than an estimate here. Using data from the NRC, we summed up the thermal rated powers of all the reactors in the USA and the net electrical output of the same reactors[2]. The ratio, $\epsilon = \frac{P_{electric}}{P_{thermal}}$ gives the efficiency. We found $\epsilon = 32.14\%$. Now we calculate nuclear waste produced per Joule of electricity generated.

$$\frac{\text{grams of waste}}{\text{Joule}} = \frac{2407.2\text{MT} \cdot 1 \times 10^9 \frac{\text{g}}{\text{MT}}}{105793\text{GWd-th} \cdot \epsilon \frac{\text{GWd-e}}{\text{GWd-th}} \cdot 1 \times 10^9 \frac{\text{W}}{\text{GW}} \cdot 24 \frac{\text{hr}}{\text{day}} \cdot 3600 \frac{\text{s}}{\text{hr}} \cdot 1 \frac{\text{J}}{\text{W}\cdot\text{s}}}$$

This evaluates to $8.193 \cdot 10^{-10}$ grams/J.

US energy use Now we have to figure out how much energy we use in the US per capita. This is a simple calculation. Since we have data from 2002 above, we'll use the 2002 data from the census bureau. In 2002, there were 288,125,973 people living in the USA[3]. Also in 2002, according to the EIA, the US used 3,858.5 billion kWh of electricity[4]. To convert billion kWh to Joules, we simply use dimensional analysis.

$$\text{Joules used} = \text{billion kWh used} \times 1 \cdot 10^9 \frac{\text{kWh}}{\text{billion kWh}} \times 3600 \frac{\text{s}}{\text{hr}} \times 1000 \frac{\text{J}}{\text{kW} \cdot \text{s}}$$

This comes out to $4.821 \cdot 10^{10}$J/yr/person. Finally, we divide grams/J by J/yr/person to find grams/yr/person. This evaluates to 39.5 g/yr/person. That means each person would produce about 40 grams of nuclear waste each year if we used only nuclear power.

References

[1] Energy Information Administration, Form RW-859, "Nuclear Fuel Data" (2002).
http://www.eia.doe.gov/cneaf/nuclear/spent_fuel/ussnftab3.html

[2] Information Digest, 2007-2008 (NUREG-1350, Vol. 19), Nuclear Regulatory Commission http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/

[3] US Census Bureau, Population Estimates Program
http://factfinder.census.gov/servlet/DTTable?_bm=y&-geo_id=01000US&-ds_name=PEP_2006_EST&-mt_name=PEP_2006_EST_G2006_T001

[4] EIA Net Generation by Energy Source by Type of Producer Energy Information Administration, Form EIA-906, "Power Plant Report;"
http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html