22.351 Systems Analysis of the Nuclear Fuel Cycle
Spring 2003
ProblemSet #1

State the assumptions that you made in order to reach answers to the questions below.

(1) The USEC is currently in the process of gradually integrating some 500 MT of highly enriched uranium (HEU) from Russia as part of the nuclear weapons "Megatons to Megawatts" program. The HEU (at 90% U-235)* is blended down to 5 w/o U-235* in Russia before export by mixing it with natural U*(at 0.711 w/o U-235).

(a) How much net newly-mined U_{NAT} will this displace, assuming an enrichment plant tails of 0.3 w/o U-235*?

(b) How much SWU will this displace?

(c) How many reactor full-power years of energy is represented by the 5 w/o product, assuming:
discharge burnup = 60 MWd/kg
Reactor rating = 1150 MWe; 3411 MWth

(d) Assume that natural uranium costs 35 $/kg and SWU 75 $/kg on today's market. How much is the Russian blended-down product worth? Is it a bargain at the (originally) agreed to price of 12 billion dollars?

(2)

(a) What is the volume of the spent fuel assemblies represented by this deal if the fuel density is 10 g/cc and the fuel is 25% of the fuel volume?

(b) What is the total activity in curies that is associated with the spent fuel at discharge? [see Table 9.1 of the Textbook, attached in the next page]

(c) What is the ore volume that is "saved" by this deal? (See Table 9.1 for info)

(d) What is the total waste saved from conversion and enrichment?

*assume for simplicity

TABLE 9.1
LIFETIME RADIOACTIVE WASTE GENERATION FROM A PWR AND A BWR*

Waste Type	Reference PWR, 1 GW(e)		Reference BWR, 1 GW(e)	
	Volume (m^3)	Radioactivity (Undecayed Curies)	Volume (m^3)	Radioactivity (Undecayed Curies)
Once-through fuel cycle wastes				
Mill tailings	4.353×10^6	3.710×10^4	4.867×10^6	4.149×10^4
LLW from uranium conversion[a]	3.411×10^2	9.813×10^3	3.814×10^2	1.097×10^4
LLW from uranium enrichment[b]	1.328×10^2	9.716×10^3	1.365×10^2	1.080×10^4
LLW from fuel fabrication	3.063×10^3	7.288×10^0	4.110×10^3	9.781×10^0
LLW from reactor power generation	3.032×10^4	2.866×10^4	5.217×10^4	7.956×10^4
Reactor spent fuel	5.213×10^2	3.270×10^{9c}	6.996×10^2	3.342×10^{9c}
Decommissioning wastes				
LLW	1.510×10^4	1.057×10^5	1.640×10^4	2.532×10^5
Greater than Class C	1.130×10^2	4.070×10^6	4.070×10^1	3.300×10^6
TOTALS	4.403×10^6	3.274×10^9	4.941×10^6	3.348×10^9

Source: "Spent Fuel and Radioactive Waste Inventories, Projections and Characteristics," DOE/RW-0006, Rev. 1, U.S. Department of Energy (Dec. 1985).

*Waste generated from 40 yr of reactor operation and 26 GW(e)-yr of electric energy production.

[a] Applies to the fluorination/fractionation process.

[b] Applies to the gaseous diffusion process.

[c] Based on activity levels measured 1 yr after reactor discharge. For the PWR, these levels are based on a burnup of 33,000 MWD/MTIHM. Activity levels reported for the BWR are based on a burnup of 27,500 MWD/MTIHM.