22.351 Systems Analysis of the Nuclear Fuel Cycle
Spring 2003
Problem Set #5

Starting with the attached illustrative fuel cycle cost calculation for a PWR from our class notes, determine the savings in Mills/kWhre for each of the following.

(a) A decrease in SWU costs to 20 $/kg SWU due to a breakthrough in separations technology.

(b) Zero cost government loans to purchase fuel as a greenhouse gas reduction incentive.

(c) Changing to a fixed waste disposal fee of 200 $/kg, payable as of the start of irradiation, to encourage high burnup.

(d) A CO_2 avoidance credit of 50$/Ton C, assuming that the nuclear unit displaces coal combustion producing 0.18 MWd e/MT Carbon.

(e) Adopting a future "sustainable energy" mode exploiting the virtually infinite resource of natural uranium in seawater, recoverable at 200$/kg.

(f) Use of vibratory compaction of UO_2 powder instead of pelletizing, at a saving of 50 $/kgHM.

(g) For each of the above indicated what changes in fuel cycle and fuel management practices would be likely consequences of the postulated change.

LWR Fuel Cycle Cost Estimate

Basis: 1 kg of fuel, n = 193/72 = 2.68, 18 calendar month cycle, enrichment = 4.51 w/o

Transaction	Cl Unit Cost ($/kg)	Ml Mass Flow (kg/kg fuel)	Lead time to Irradiation (yr)	Δt Time to Midpoint of Irradiation (yr)	Cl*Ml Direct Cost ($/kg)	Cl*Ml*φ*Δt Carrying Charges ($/kg)	Total per Process Step ($/kg)
Ore Purchase $/kg U_{out}	50	9.398	2	4.25	469.90	199.71	669.61
Conversion $/kg U_{out}	8	9.351	1.5	3.75	74.81	28.05	102.86
Enrichment ($/kg SWU)	110	6.908	1	3.25	759.88	246.96	1006.84
Fabrication ($/kg U)	275	1	0.5	2.75	275.00	75.63	350.63
				TOTAL ($/kg)			2129.93
				TOTAL (Mills/kwhre)			5.326
				Federal Waste disposal fee (Mills/kwhre)			1
				TOTAL FUEL COST (Mills/kwhre)			6.326

Notes:

1) Annual carrying charge rate = 0.1 / yr (Φ)
2) Plant Thermo Efficiency = (1150 MWe/3411 MWt) = 0.3371
3) Transportation costs are included in each major cost center
4) Mass flow rates have processing losses included
5) Fabrication costs do NOT include the extra cost for poisoned assemblies (big assumption)
6) Numbers for unit cost and time to midpoint of irradiation obtained from IECD report “The Economics of the Nuclear Fuel Cycle”
7) Discharge Burnup = 49.4 MWd / kg

$$\{\text{Mills/kwhre}\} = \frac{\{\text{Fuel Cost in \$/kg}\} * \{1000 \text{ mills}/1\$\}}{\{\text{Discharge Burnup in MWD/MTU}\} * \{1 \text{MTU}/1000 \text{kg}\} * \{24 \text{h}/1 \text{d}\} * \{\text{Plant Thermoefficiency in MWe/MWth}\} * \{1000 \text{kW}/1 \text{MW}\}}$$