22.351 Systems Analysis of the Nuclear Fuel Cycle
Spring 2003
Problem Set #6

(1) (a) What is the waste fee of 1 mill per kWhr of electricity (that utilities pay DOE for disposal of spent fuel) equivalent to in $/kg U when the thermal efficiency of a nuclear plant is 32% and the average fuel burnup at discharge is 33,000 MWd/TU?

(b) What is the effect of the rise in average burnup of discharge fuel to 50,000 MWd/TU on the disposal fees per kg U?

(c) What is the annual fees paid into the waste funds from the 99GWe of nuclear plants operating at 90% capacity?

(d) In a thorium-uranium seed-blanket cycle, 50% of the core is of blanket assemblies that stay in the core for three times as many cycles as the seed assemblies do. The seed assemblies produce 60% of the power while the blanket produce 40% of the power. Relatie to all uranium core, how much would a 1000MWe power plant operating with the Th-U core pay in waste fees if it operates for 30 years at a capacity factor of 90% under the 1 mill per kWhr formula?

(e) What would the Th-U plant fees be relative to the all U core if the waste fees formula was $350/Kg of discharged heavy metal? Assume that a seed assembly stays in the core for a total of 4.5 years and there are 192 assemblies in the core.

(2) Compare the decay heat from discharged fuel of a 1000 MWe plant after 18 months of continuous operation at full load to the decay heat of discharged fuel from a plant that operated 1.0 yr before it shutdown for 0.5 yr then re-operated for 0.5 yr before the fuel was discharged.

Compare the decay heats at (i) one month after discharge, (ii) 1 yr after discharge and (iii) 100 years after discharge.

Based on these results, how does the intermittent operation affect: (i) the required cooling of a storage pool? and (ii) the amount of heat to be deposited in the repository?

The decay heat power P can be given by:

$P/P_o = 0.0592 [t^{-0.2} - (t + T)^{-0.2}]$

Where P_o = operating power,

t = time after shutdown in seconds, and

T = operating time at P_o in seconds