Due: Sept. 15, 2005

22.251 Systems Analysis of the Nuclear Fuel Cycle
Fall 2005
PROBLEM SET #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).

(1.a) How much net newly-mined UNAT will this displace, assuming an enrichment plant tails of 0.3 w/o U-235*?

(1.b) How much SWU will this displace?

(1.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

(1.d) Assume that natural uranium costs 40 $/kg and SWU 100 $/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) (2.a) How many 1000MWe LWR-years can the world reserves of uranium service? Use the reserves information in Table 2.7 in the Text book of Cochran and Tsoulfanidis, and add all the categories for world resources.

(2.b) If the current capacity of the World nuclear fleet is 350GWe, and that capacity grows at 2% per year, how many years can be served by these resources?

(2.c) If advanced reactors are introduced in 2025 that have a plant efficiency of 45% instead of 33%, how long will the reserves last?

(3) The following was reported by the Reuters news agency on Sept. 1 2004:
"The International Atomic Energy Agency (IAEA) said in the confidential report circulated to diplomats and obtained by Reuters that Iran planned a "larger test" of a uranium conversion facility "involving 37 tons of yellowcake."

David Albright, a former U.N. weapons inspector and currently president of the Institute for Science and International Security (ISIS) said this could theoretically result in 100 kg of weapons-grade highly-enriched uranium."

(3.a) Do you agree with this (implied) calculation? What tails enrichment is required to make the calculation correct?
(Assume "weapons-grade" is 93 w/o)

(3.b) How many SWU are required to produce the 100kg weapon grade HEU?

(3.c) Twenty percent is the U235 enrichment considered as the boundary between "proliferative" and "non-proliferative". (More on this in a later lecture.) How many kilograms of 20 w/o enriched uranium are require to produce 100 kg of weapons-grade uranium, (that is, you use the 20 w/o material as feed to the enrichment process)? How many SWU are required?

TABLE 2.7
WESTERN WORLD* URANIUM RESOURCES
AS OF JANUARY 1987

Resource Category	Tons Uranium
RAR (<$80/kg U)	1,555,000
EAR-I (<$80/kg U)	891,000
RAR (<$80 to $130/kg U)	678,000
EAR-I (<$80 to $130/kg U)	425,000

*WOCA = world outside centrally planned economic areas.