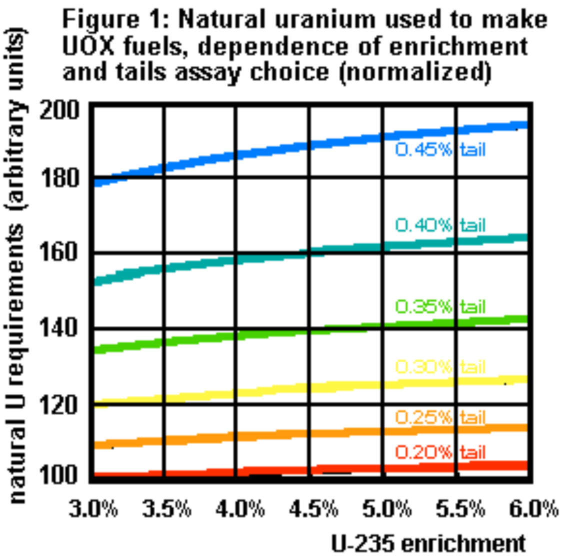
Uranium use and savings by MOX use

One of the usual claims of the MOX lobby is that MOX use saves precious uranium and cuts enrichment costs. Since part of the reactor core is loaded with MOX fuel instead of UOX, this seems quite obvious. The real question however is "Compared to what?" The aim of this section is to examine not only how much can be saved, but also to answer that question. We have to understand that uranium conservation and costs savings are not synonyms, which can be shown from enrichment practices. One needs to have a more general view of enrichment parameters in order to correctly evaluate the uranium conservation story.

Natural uranium requirements

Since the enrichment process involves numerous cascade steps in which the U-235 to U-238 ratio is increased a little bit in every progressive step, it is easy to understand that higher enrichment requires more of these steps and thus requires more energy input per unit of enriched product. One should always compare energetic equivalent fuels, with the same initial amounts of U-235. It does not make much sense to compare two products of equal weight with different enrichment levels (as is often done), since these do not hold the same amount of energy. To be more accurate: I have made sure that the U-235 fission *potential* is the same in any case, so the real objective is actually the *power output* which has to be the same "always" and thus so does the initial power for a specific reactor, no matter what the enrichment is. Hence 100 kg uranium enriched to 3% can be considered equivalent with 75 kg uranium enriched to 4% (although the latter may achieve a burn-up higher than expected by linear extrapolation).

It will be clear that the natural uranium feed equals the output of the enriched product (only some 1/10 to 1/6) plus the depleted uranium. There are two enrichment parameters that have to be chosen. The product's **enrichment** obviously is the first. This is the relative amount of U-235 in the product. But what about the relative amount of U-235 in the depleted uranium? This is called the **tails assay**, or simply tail, which tells us how much U-235 extracted from nature remains unused. Since about 5/6 to 9/10 of the natural uranium feed becomes depleted, the tail's choice is in fact much more decisive for the extend of natural uranium usage, both qualitatively and quantitatively.



In figure 1 you can see the relation between the natural uranium requirements and both the U-235 enrichment and the U-235 tail. I have set the 3% enrichment and 0.20% tail combination to 100. These parameters were often used in calculations at the beginning of the nuclear era, and they were indeed representing real practices then. Today this has changed (yes, you might be tricked by reports still using these values which are not very realistic anymore). During the first half of the eighties **the tails have been raised to an average of some 0.35%**. The reasons why are easy to understand. First of all, the expected growth of the nuclear sector had been overestimated, which resulted in relatively low uranium prices (as is still the case). Fresh fuel costs are obviously determined by enrichment costs and natural uranium prices. Since industrial enrichment agreements are usually settled in long term contracts, enrichment prices are not really "spot" prices (which would depend heavily on ever changing conventional energy costs). So there isn't that much movement in price levels. With natural uranium turning out to be less scarce than expected, utilities could save money on enrichment by exploiting the natural uranium in a less efficient fashion by raising the tails and I wouldn't be surprised if the current drive towards higher burn-ups (requiring higher enrichment) would push the tails up a little more. This illustrates why there is a big difference between uranium savings and costs savings.

In figure 1, you can also see that an enrichment increase does not make much difference for the natural uranium requirements (because one is able to use less enriched fuel then). On the whole, if we compare current realistic parameters like an **enrichment of some 4% and a 0.35% tail, almost 40% more natural uranium is needed** compared to our reference! This side of the story usually remains untold when the plutonium lobby promises us "significant uranium savings" when using MOX fuels. They should say "Look, we've got nowhere to go with our plutonium, we can't sell it unless we're the ones paying and think of all the trouble that would cause, we're faced with storage costs, so we'd rather do something with it", since that's the *real* story.

Does MOX cuts costs then?

But of course, one can at least have **lower front-end** costs since the MOX part of the fuel does not need enrichment, right? I honestly doubt that, because **the costs of MOX fuels are much higher compared to UOX fuels**, even when reprocessing costs are not included in any way -- which is incorrect, but **making the reprocessed plutonium costless** on paper is exactly what they do.

In fact, what they are saying is that reprocessing costs have been made in the past and therefore they are considered *front-end* costs. This means that the reprocessing costs are added to the costs of conventional UOX fuels. They are not considered "waste costs" as they should be. Of course, this provides a very welcome "scientific" base for those pushing the MOX plan, since MOX costs can be lowered by leaving the costs of its most important component -- plutonium -- out of the picture, even adding them to the conventional front-end costs instead. This is voodoo economics if you ask me. The funny thing is that MOX fuels then turn out to be still more expensive then conventional UOX fuels, figures from the nuclear society themselves still show at least an optimistic 60% difference. It is very hard to come up with an estimate of my own, and it would be incomparable to "official" figures, so I'd rather not.

Even in terms of burn-up MOX fuels lag behind, which was foreseeable since the fissile plutonium isotopes do not "burn" nor breed enough to compete with U-235 because physics says that there is relatively more capture instead of fission. But a lot of it also has to do with legal limits, like in France. This is important, though, to have some notice whether there eventually is more or less energy extracted from the fuels.

Uranium savings

In figure 2, I have put the tail on the horizontal axis, and you can see three "iso-enrichment" curves for UOX only, and for UOX with 20, 30 and 50% MOX. Once again you can see how the tail's choice is much more important than the enrichment level. If one uses 30% MOX in the reactor core with a 0.35% tail, the uranium savings nearly equal the savings which could be achieved by lowering the tail back to 0.20%. **This shows that uranium conservation is not really as important for the nuclear sector as the plutonium lobby would like us to believe.** Anyone willing to go through the trouble of analyzing uranium use in the enrichment stage, must agree that this argument in favor of MOX use is really not very persuasive.

Figure 2: Uranium savings with MOX use, depending on tails and enrichment choice