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Nuclear-Power Waste and the Thorium-Fuel Option

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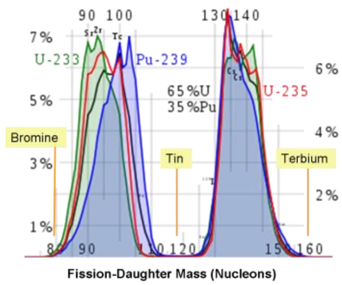
Thorium is an abundant heavy metal, commonly associated with Rare-Earth containing minerals such as Monazite. It's about 4 times as abundant as Uranium and can fully be converted to fissile fuel (^{233}Uranium) via neutron capture, as in a standard fission reactor. Easily-fissioned isotopes (fissiles) have odd-numbered masses: 233, 235, 237, 239 and 241. ^{235}U constitutes the fission-energy source in common, water moderated and cooled, reactors (LWRs). Its thermal energy release is about 5GWHrs per mole.

Waste in a fission-reactor fuel cycle is constituted of three types of isotopes: a) fission products of masses from about 80 to 160, bimodally distributed:

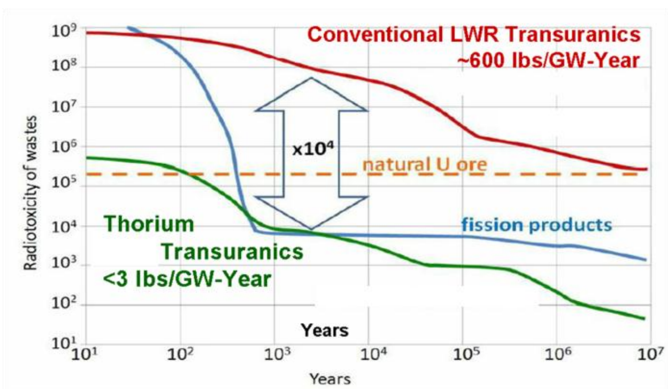


b) dilutant atoms, such as ^{238}U; and c) heavier isotopes formed via neutron capture by ^{238}U and/or any other isotopes which failed to fission. These heavier isotopes are "transuranics" and include primarily Plutonium, Americium, Curium. Typically, ^{239}Pu is the most abundant, while ^{240}Pu and ^{241}Pu follow in lower concentrations.

Used ('spent') nuclear fuel (removed after several years) from LWRs consists of about 95% the original ^{238}U dilutant, about 4% fission products (that are decayed or rapidly decaying), about 1% unfissioned fissile (^{235}U), about 1% transuranics, and traces of intermediates such as ^{236}U and heavier transuranics – all the result of neutron capture on the fuel's isotopes without a resulting fission.

Fission products are dominant in generating radioactive emissions and heat, which is why used fuel must be cooled (for a few years) and safely stored. But their high radioactivity means fission products need hundreds, not thousands of years in safe storage. Transuranics are much less radioactive, but longer lived – this is the source of both weapons-diversion and long-term-storage worries.

Fortunately, use of ^{232}Thorium to generate fissile fuel within a reactor itself, greatly improves reactors' waste profiles. Thorium, upon neutron capture, creates ^{233}Protactinium, which decays into ^{233}U. It not only fissions more easily than ^{235}U, but is more non-fission neutron-captures away from transuranics, creating far fewer of them. Thorium fuel reduces waste radioactivity and half lives to those of fission products and lower.



Keywords: fission products, neutron capture, transuranics, fissile, isotope.