RECYCLING REVISITED & GEOLOGICAL DISPOSAL BURIED

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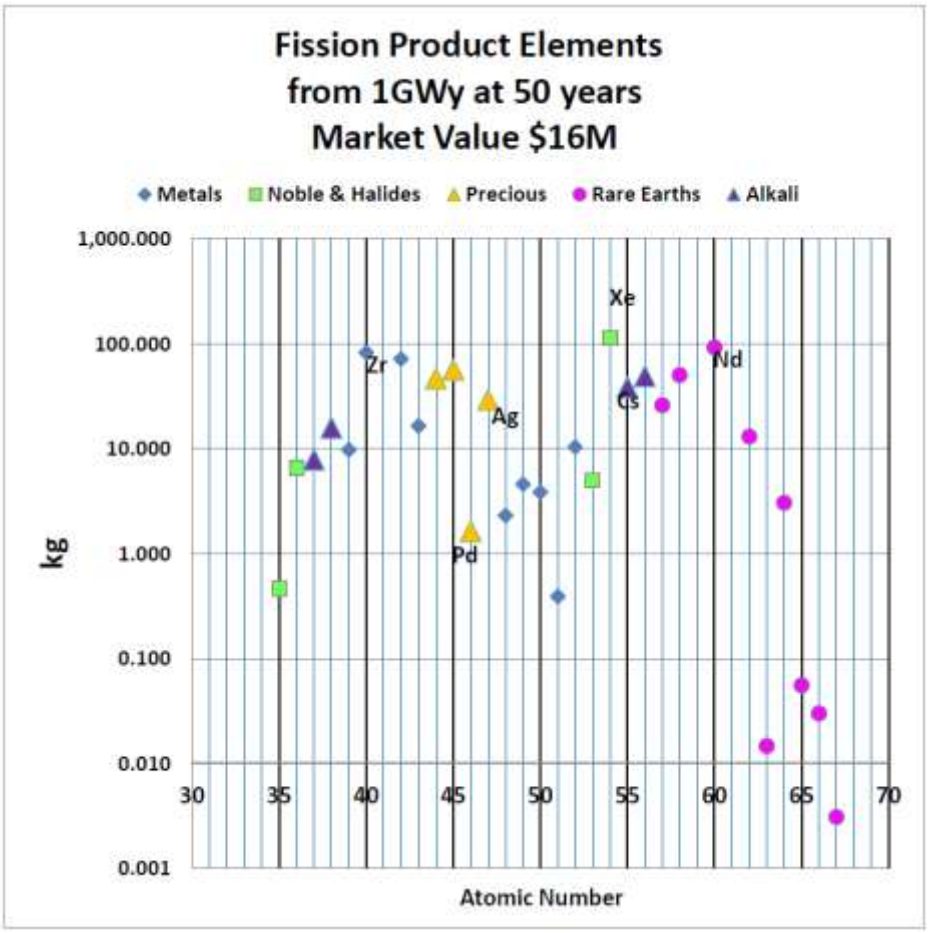
The 20t of nuclear fuel spent annually in a 1000MWe PWR reactor is enormously valuable, mainly because each tonne is 95% reactor fuel with a value of £1.3Bn at 15p/kWh. The remaining 5% consists of fission product fragments which, in 50 years cool off to mainly precious metals, rare earths, and other stable elements worth about £10M when separated out. A fraction remains radioactive and needs to be stored, or used as a heat source, for no more than 500 years.

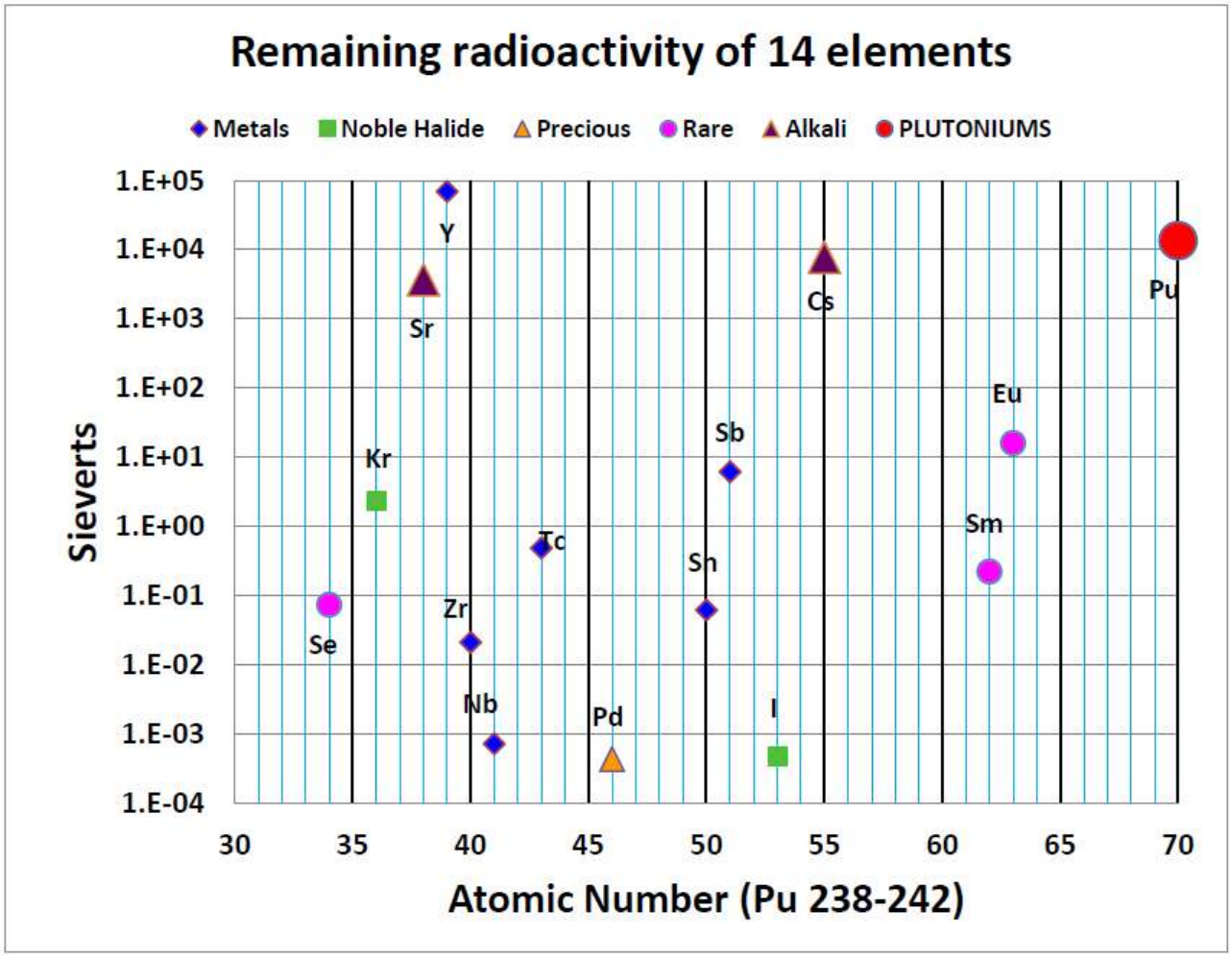
More advanced reactors, with molten salt fuels, will be able to consume all existing spent fuel by the end of the century. These will be the world's safest reactors which will never melt down or go on fire, will not release radioactive materials into the environment and will breed their own fuels. Spent fuel should not be a million year problem.

With these advanced reactors there is no need for Fast reactors or disposal facilities good for geological timescales.



The first chart shows the Fission Product contents of 50 year old spent fuel (E. Sayre). There are some 33 elements, mostly with several isotopes, in the middle of the periodic table. The top three are Xenon, Zirconium, and Neodymium. Note the log scale for the elements. The chart indicates the wide range of chemistry needed for efficient separation.

The second chart shows the radiation outputs in watts, equivalent to Sieverts here, from the fraction of radioactive isotopes for each element. There are several others omitted whose decay times approach the age of the universe and so are not a hazard anywhere. For the sake of comparison the radiation from all the Plutonium isotopes in the spent fuel is shown at the edge of the chart. The few grams of Yttrium-90 decay hotly into Zirconium-90 with a half life of 2.7 days. They would effectively vanish during processing. It is clear that only the top two elements, Strontium, and Caesium need be stored or used for nuclear batteries. Recycling need not wait 50 years and, in liquid fuelled reactors, can be done online. Steady removal of Sr and Cs would reduce the heat load of the bulk of recycled ouput.



With sensible safety measures, the isotopes with radiation at or below that from technetium can well be used in industrial applications. Almost all the radiation is in the form of beta particles – fast electrons – which can be shielded by a sheet of paper. Even the most active actinide fuels, like Americium 241, can be used in minute quantities in devices such as a domestic smoke alarm. Other isotopes, like an excited Tc-99m or a paramagnetic Gadolinium, have medical uses due to their high and therefore brief activity.

Recycling is necessary as a matter of responsibility to future generations and as a matter of energy economics today. Nuclear energy from fission and fusion will run the planet for hundreds of millennia. Liquid fuelled reactors will be demonstrated over the next 20 years.

Sayre,E. commercial_value_used_nuclear_fuel_reprocessed. http://www.nist.gov/tip/wp/pswp/upload . 2006