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'THE NUCLEAR FUEL CYCLE IN 2040: THE CHALLENGES AND SOLUTIONS TO ACHIEVE SUSTAINABLE NUCLEAR GENERATION IN EUROPE'

Chavagnat, Florian and Duperray, Romain
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Recycling valuable materials produced by light water reactors

Nuclear waste management is a current core issue of the nuclear fuel cycle and will remain as such in the future. A question worth posing is: how might one take benefit from this waste? Valuable elements can be found in among the fission products, and extracting them could be a proper way to enhance the fuel cycle efficiency.
The aim of this article is to investigate these fission products, which ones can be found in significant amounts and the profits that can be obtained from the materials extraction.

Methods Calculations were made for a typical Pressurized Water Reactor with a burn-up of 45 GWd/t and a fresh fuel enrichment of 3.7% in uranium-235.
Then the economical interest of each elements was evaluated by comparing on one hand the available mass within the spent fuel and on the other hand the corresponding market prices. Evaluations were based on the current French fuel recycling industry, which processes 1,000 tonnes of Heavy Metal fuel per year.

Results Most interesting materials in terms of available mass and market price are Platinum group elements and to a lesser extent, Lanthanides. All of these elements can be usable after a short-time storage process. Then, highly radioactive isotopes are avoided. Figure 1 shows the available mass of several elements per ton of heavy metal fuel, computed with MatLab.
Platinum Group Metals are interesting in catalysts manufacturing, Lanthanides are used in high yield permanent magnets for electrical motors. Both are also used in the electronics industry. Plus, Americium is an excellent alternative to Plutonium to manufacture radioisotope thermoelectric generators for spacecrafts. Following that two main advantages can be considered. Direct profits come from the sales of these resources, we estimate the total sale revenue at about 300,000$ per tHM considering Lanthanides, Platinum Group Metals and Molybdenum. Cost avoidance can also be reached in long term nuclear waste storage, recycling elements in waste means less volumes to store. Plus, our thermal calculations show that the heat removal coming from the recycling of Americium allow to reduce the interleaf between storage packages by about 40%.

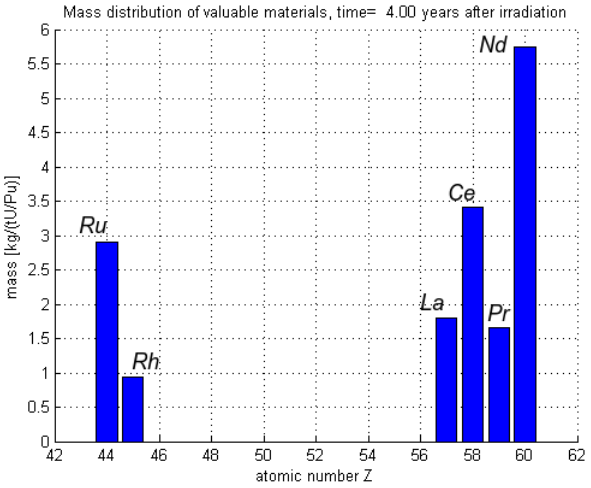

Figure 1: Mass distribution of valuable materials in kg per tonne of heavy metal fuel

The extraction process for the Lanthanide elements could be based on the existing PUREX liquid-liquid extraction process at the La Hague plant (AREVA), which is used to recover and purify Uranium and Plutonium. Several studies and experimental demonstrations have been performed by the CEA at Marcoule (France) to build upon this process in order to further separate out the lanthanides and the minor actinides. These processes are at an advanced stage of development. In addition, Ion Exchange Chromatography combined with Catalytic Electrolytic Extraction provides a complete process to separate Platinum Group Metals.

Extracting valuable elements from nuclear waste could be a good way to increase the nuclear fuel efficiency. Precious elements could be sold for a great profit and the total amount of waste to be stored could be reduced. Moreover, it allows to increase the public acceptance of the Nuclear Industry by going deeper with the ability to recycle, a trendy topic and an essential issue for sustainable development.