REPROCESSED URANIUM RECYCLING: THE IDEAL AND THE FACTS

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ABSTRACT

Commercial reprocessing of Light Water Reactor (LWR) spent fuel provides Reprocessed Uranium (RepU) and Plutonium, both products containing a large amount of energy. As the gap, already quite large, between uranium consumption and production threatens to grow, these materials show today a strong strategic benefit, constituting a substantial and reliable source of supply for nuclear fuel manufacturing.

RepU, which represents about 96% of recycled materials, can be used in all major types of nuclear power reactor currently in operation.

This paper focuses on RepU recycling in LWRs, the feasibility of which is technically well established world-wide**,** and industrially demonstrated through experience gained within the COGEMA Group.

Contrary to a commonly accepted assumption, which probably derives from natural uranium prices remaining for more than a decade at a low level which cannot be sustained into the future, recycling RepU can also bring strong economic benefits to the utilities. It generates savings on uranium procurement that exceed expenditures associated with storing and processing RepU. Thus, the use of this product is an attractive option.

The strategic and economic benefits of recycling RepU will become compelling in the near future. Anticipating these needs, the COGEMA Group has developed capabilities to offer utilities the services covering all steps from reprocessing of spent fuel to fuel fabrication using RepU.

INTRODUCTION

Recycling spent fuel through reprocessing increases substantially the global energy yield of natural uranium and contributes to the conservation of primary resources. Indeed, about 97% of the materials recovered from nuclear spent fuel reprocessing can be recycled, RepU contributing for 96% and plutonium for the other 1%.

Taking into account only the western capacity to reprocess LWR fuel (i.e., La Hague, Thorp and Rokkasho-Mura), as much as 3,600 t per year of RepU as efficient as natural uranium could be recycled in the near future

Who could imagine today not using the potential of such a source of energy and valuable material?

REPROCESSED URANIUM: A RELIABLE SOURCE OF SUPPLY

The supply of natural uranium is quite uncertain:

- western primary production is far lower than consumption and not as well secured as people generally think;
- production from CIS has been steadily shrinking according to a trend that is very difficult to reverse.

RepU appears as an exception as far as reliability in the long term is concerned.

REPROCESSED URANIUM: A SOURCE OF SUPPLY NEEDED TO FILL THE GAP

Other sources of supply will be necessary to fill the gap between primary production and future uranium requirements (Figure 1):

- mobilisation of inventories, whose volume becomes more and more limited;
- material obtained from blending down of nuclear weapon material, commonly referred as HEU feed, a product highly sensitive to political issues;
- plutonium recovered from reprocessing and from inventories;
- uranium recovered from reprocessing.

Market needs in the future the quantities of RepU available for fuel fabrication.

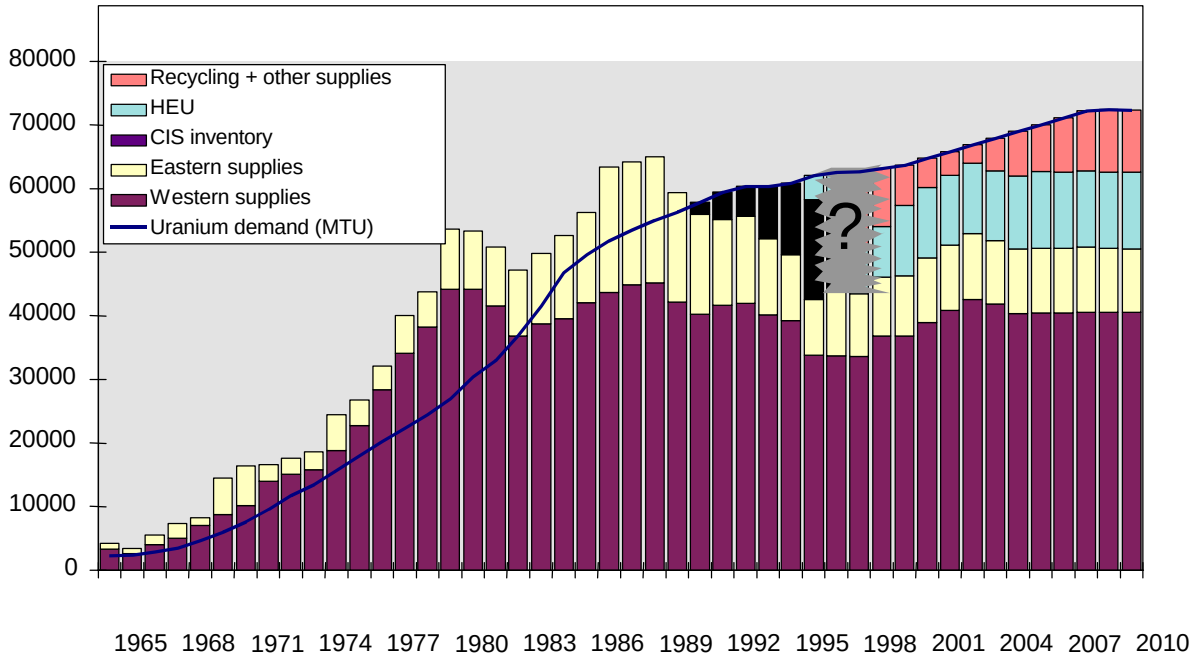

Figure 1 Uranium Supply & Demand (Civil)

RECYCLING REPROCESSED URANIUM: A MASTERED PROCESS

The RepU recovered from world-wide reprocessing facilities comes mainly from LWR fuel. Although it can be re-used in virtually any type of reactor (LWRs, CANDU, Magnox, RBMK) or serve other

purposes-such as support matrix for MOX LWR fuel assemblies or fertile coating of FBR fuel assemblies-we will focus on the re-use of RepU in LWRs, which we feel represents its most promising future utilisation.

To date, several reactors have been loaded with fuel made out of re-enriched RepU (ERU) in France, Belgium, Japan and Germany.

Two of the EDF reactors, Cruas 3 and 4, are devoted entirely to ERU fuel; as is Doel 1 in Belgium. Several others reactors have received ERU reloads.

All these experiences have been very positive with in core performances totally satisfactory:

- Loading ERU fuel assemblies does not affect in core management (no additional boron consumption).
- ERU fuel achieves the same fuel performance (cycle length, burn up) as enriched natural uranium (ENU) fuel. It also allows similar operation.
- The fuel behaviour is highly satisfactory (no leaking rods).

Using ERU fuel is not a technical challenge.

RECYCLING REPROCESSED URANIUM: A PROFITABLE OPTION

In principle, the economy realised in replacing natural uranium by RepU at least compensates for extra expenditures related to storage and added costs for conversion, enrichment and fabrication. The competitiveness of RepU is thus strongly related to the cost of natural uranium supply.

However, the economics of RepU recycling cannot be appraised on a general basis. The isotopic characteristics (residual ^{235}U enrichment and minor isotopes content) vary from one batch to the other, and influence recycling cost.

The curves on Figure 2 show, as a function of the price of natural uranium, the percentage of saving that can be expected in using ERU fuel assemblies.

As an example, considering the natural uranium price at 15 $/lb. U_3O_8 and RepU with 0.85 wt/% U^{235}, 0.025 wt/% U^{234} and 0.35 wt/% U^{236}, the overall cost of ERU fuel with 4.4 wt/% U^{235} equivalent is 14% below ENU fuel.

These economic calculations do not take into account other long term benefits for the environment, such as the saving of natural uranium resources and the reduction of ultimate waste quantities.

Recycling RepU *is definitively a profitable option, as far as economics and environment are concerned, on the short as on the long term.*

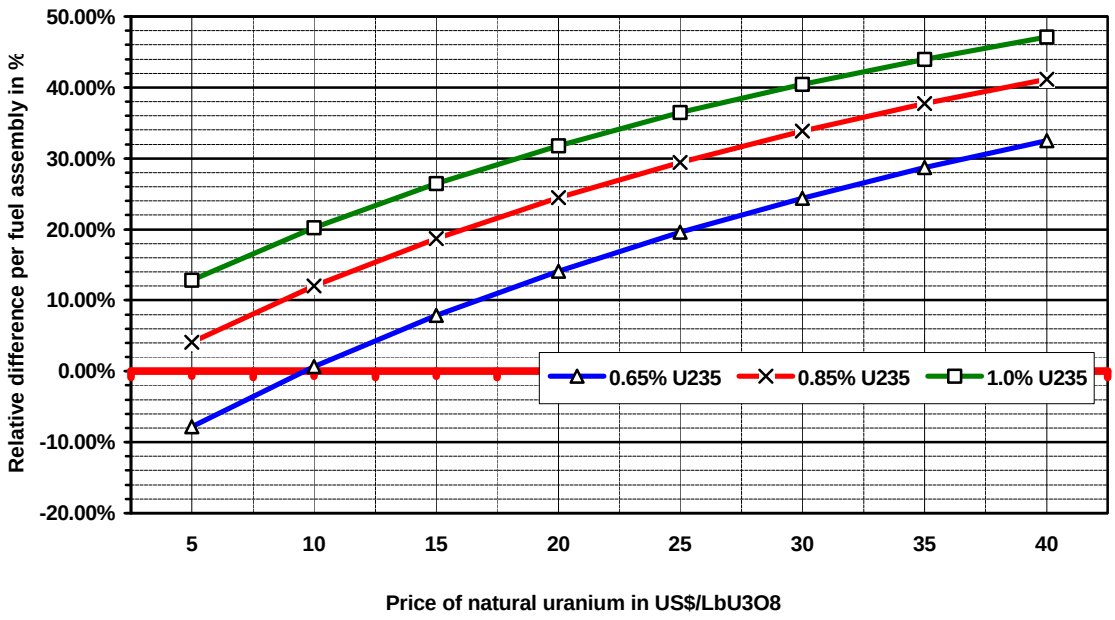

Figure 2 Savings generated by recycling RepU

RECYCLING REPROCESSED URANIUM: AN INDUSTRIAL REALITY

The COGEMA Group is today in a position to provide utilities with a complete service to recycle RepU from the reprocessing plant up to the LWR fuel:

- COMHUREX, a 100% COGEMA subsidiary, operates two conversion facilities in Pierrelatte (France) known as Structure 2000 and Structure 2450. They convert RepU Uranyl Nitrate (UNH), U_3O_8 or UO_3 into UF_6. Their capacity **is** 350 t RepU/year and could be extended as needed.
- The COGEMA Group provides enrichment services in partnership with enrichers using centrifugation process, such as Russia. In the future, laser enrichment should enable U^{235} enrichment of RepU.
- The French fuel manufacturer FBFC, 49% subsidiary of COGEMA, has equipped its plant in Romans with a pelletising line capable of producing 180 t /year of ERU fuel.
- All the ancillary services, as conditioning, transport, storage... are also provided by COGEMA.

Figure 3 illustrates the process from UNH to fuel fabrication in the COGEMA Group.

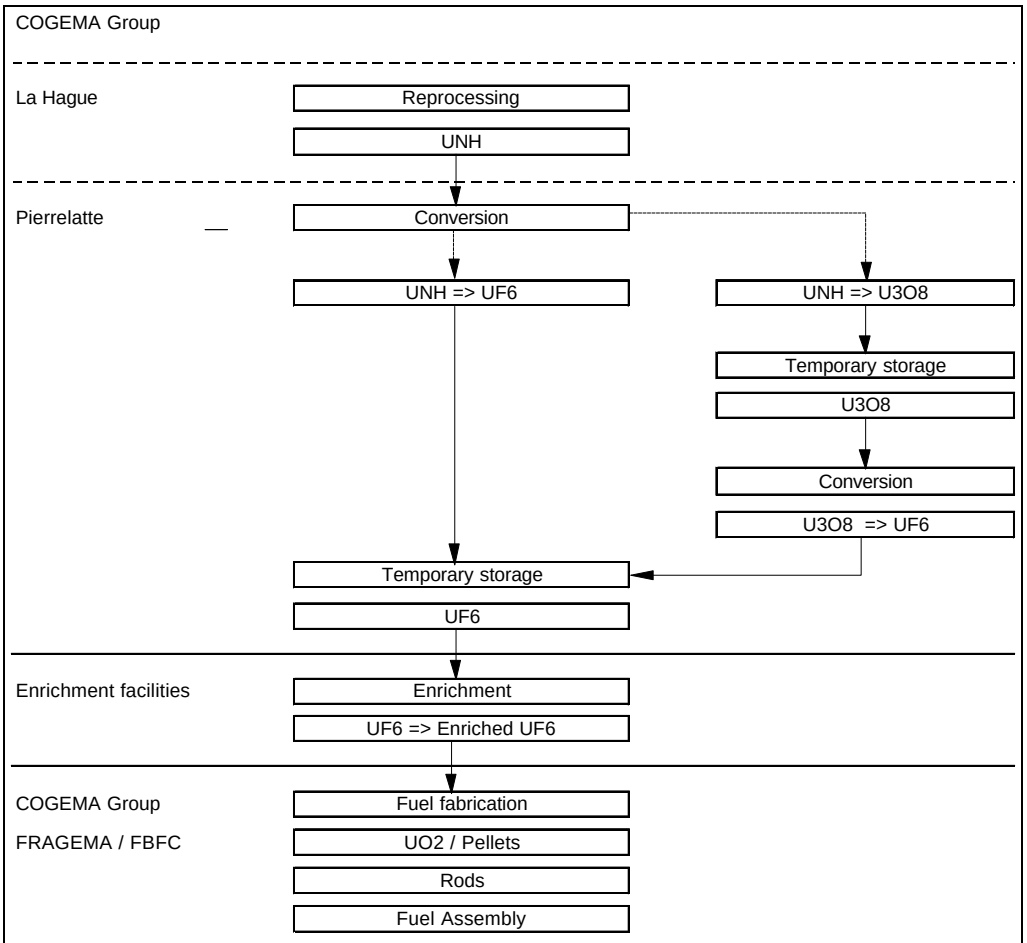

Figure 3 Recycling RepU: from UNH to fuel fabrication

As one can see on this figure, two routes can be taken for the conversion and storage of the RepU before recycling:

- direct conversion into UF_6; or
- intermediate conversion to U_3O_8, which is a more stable form, for an interim storage prior to conversion to UF_6.

The choice of one option or the other depends on the policy of recycling and the time schedule of such recycling.

One can consider that recycling within a reasonably short time after reprocessing (i.e. 7 to 10 years) should lead to a direct conversion into UF_6 whereas greater delay is conducive to an interim storage as U_3O_8. The decision made by the utility is essentially related to economic (interest rate level) and strategic considerations.

After 10 years of successful operation at the TU2 facility in Pierrelatte, COGEMA has adjusted its capacity to the needs and has been operating, since 1996, the TU5 facility for conversion of UNH into U_3O_8 with an annual capacity of 1,600 Te.

The existing industrial facilities have demonstrated their ability to perform consistently. They provide today a fair capacity permitting present demand to be met. Should this demand increase, the COGEMA

Group is prepared to adjust (as was already done with TU5 facility), its capacities to recycle on a larger scale.

COGEMA Group offers today a full set of services for recycling RepU. *Tailor made package offers can be proposed to the utilities, with full or partial service from reprocessing to ERU fuel delivery.*

PAST CONSTRAINTS

Up to now, the development of RepU recycling was somewhat limited due to a number of factors that lessened economic, strategic and environmental benefits of such recycling. They are now being overridden:

- For the last 20 years, natural uranium prices have been quite low. Natural uranium acquisition from inventories (CIS or others) was a very attractive source of supply which was favoured by utilities for their procurement. However stocks are diminishing and should come to an end in the very short term, strengthening the market prices.
- Pressing non-proliferation objectives, among other reasons, provided incentive for utilities and fuel cycle industrial participants to focus primarily on Plutonium recycling as first priority. Today, Plutonium recycling in standard LWRs using MOX fuel is well underway. Fuel performance matches standard uranium oxide fuel and the MOX industry is a mature industry.
- Utilities which need a new license for loading ERU fuel can now benefit from the experience of French, Belgian, Japanese and German utilities which all together loaded more than 350 fuel assemblies in their reactors. Obtaining new licenses remains the only major brake to RepU recycling development.

CONCLUSION

In the early 2000s, as alternative uranium sources of supply will be needed, RepU recycling will become a key factor to secure fuel supply contributing to some **extent** to the regulation of the market.

Recycling RepU is a mastered process already largely experienced by several utilities throughout the world: its feasibility has been demonstrated through many programmes in France, Belgium, Germany, and tomorrow Japan and others.

The savings it generates can be very substantial.

Aware of the strategic, economic and environmental benefits of recycling RepU, the COGEMA Group proposes a complete service from spent fuel reprocessing to ERU fuel fabrication, and is prepared to increase its capacities when needed to match utilities' demand.

However, RepU recycling option should not be evaluated solely on the minimization of short term fuel cost. A reasoned decision needs to be made in a long term framework, taking into account as well strategic and environmental considerations in saving natural uranium resources and reducing ultimate waste quantities.