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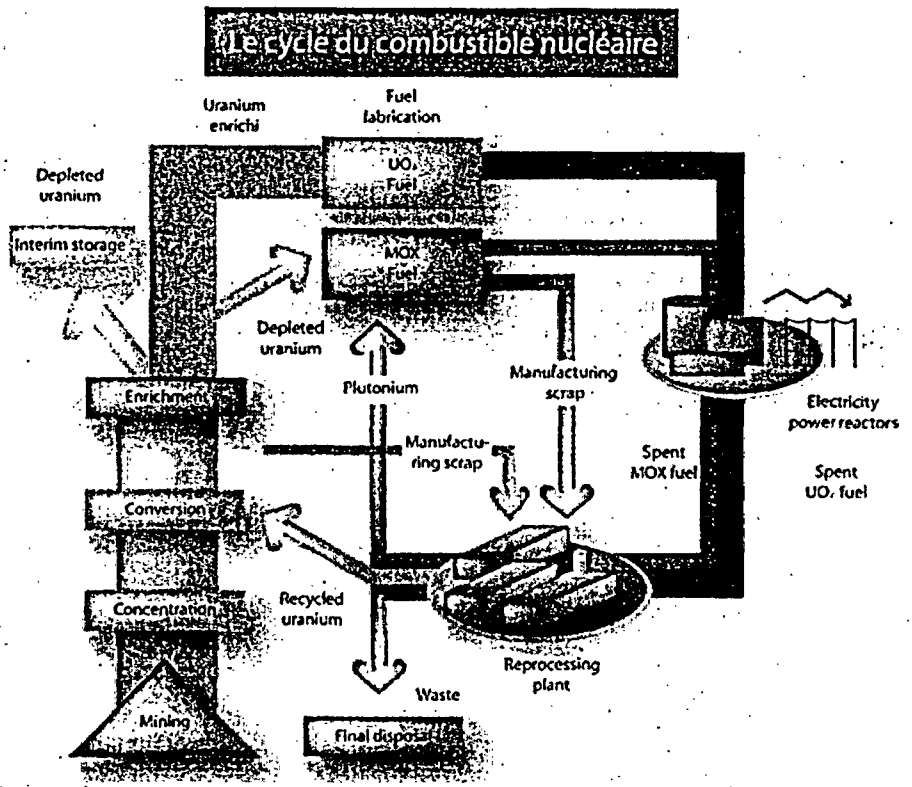
NUCLEAR FUEL CYCLE INSTALLATIONS

CHAPTER 13

The fuel cycle



Manufacture of the fuel and its subsequent reprocessing after it has passed through the nuclear reactors constitute the fuel cycle. The cycle begins with the extraction of uranium ore and ends with storage of a variety of radioactive waste originating from the irradiated fuel or from the industrial operations involved and utilising radioactive materials.

The uranium ore is mined, purified and concentrated into yellow-cake on the mining site. The installations involved use natural uranium, where the uranium 235 content is about 0.7%. They are not subject to BNI regulations.

Most of the world's reactors use uranium which is slightly enriched with uranium 235. For example, the pressurised water reactor (PWR) series requires uranium enriched to between 3 and 4%. Prior to enrichment, the solid yellow-cake is converted into uranium hexafluoride gas during the conversion operation. This is done in the Comurhex facilities in Malvési (Aude department) and Pierrelatte (Drôme department).

In the Eurodif plant at Tricastin, the uranium hexafluoride is separated into two streams using a gaseous diffusion process, one relatively rich in uranium 235 and the other depleted.

The enriched uranium hexafluoride is then converted into uranium oxide to allow manufacture of fuel assemblies in the FBFC plants at Romans-sur-Isère. The assemblies are then placed in the reactor core where they release power by fission of the uranium 235 nuclei.

After about three years, the spent fuel is removed from the reactor and cooled in a pit, first of all on the plant site and then in the COGEMA reprocessing plant at La Hague.

In this plant, the uranium and plutonium from the spent fuels are separated from the fission products and the other actinides. The uranium and plutonium are packaged for interim storage before

subsequent reuse. The radioactive waste is placed in a surface repository if low-level, or in interim storage pending an appropriate disposal solution.

The plutonium produced by reprocessing can be used to make fuel for fast neutron reactors (as was the case in the ATPu at Cadarache), or MOX fuel (uranium and plutonium mixed oxide), used in French 900 MWe PWRs, in the ATPu shop or in the Marcoule MELOX plant.

The vast majority of the plants in the cycle belong to the AREVA group, which primarily consists of the COGEMA and Framatome-ANP groups. The uranium-based fuel manufacturing plants are operated by FBFC, a wholly-owned subsidiary of Framatome-ANP. The COGEMA group organisation comprises an executive committee and four activity areas (Mines-chemistry, Enrichment, Processing-recycling-engineering, Services) grouping 11 business units (operational result centres), corporate functions and an operational committee. Fuel cycle BNIs depend on the business units covering Chemistry (Comurhex, TU5, W, COGEMA Miramas), Enrichment (Eurodif), Processing (COGEMA La Hague) and Recycling (ATPu, MELOX).

Fuel cycle industry throughput (2003)

Facility	Material processed	Tonnage	Product obtained	Tonnage
Comurhex Pierrelatte	Uranyl nitrate (based on reprocessed uranium)		UF_6 UF_4 U_3O_8	0 0 672
COGEMA Pierrelatte TU5 shop	Uranyl nitrate (based on reprocessed uranium)	5035	U_3O_8	1518
COGEMA Pierrelatte W shop	UF_6 (based on depleted uranium)	12 137,8	U_3O_8 produced U_3O_8 stored	13 647
Eurodif Pierrelatte	UF_6 (based on natural uranium)	23 839,7	UF_6 (depleted uranium) UF_6 (enriched uranium)	21 383 3039
FBFC Romans	UF_6 (based on enriched natural uranium) UF_6 (based on enriched reprocessed uranium)	1681 60,8	UO_2 (powder) UO_2 (fuel elements) UO_2 (URE fuel elements)	551 811,9 51,4
ATPu Cadarache	UO_2 (based on depleted uranium) PuO_2	19 15	MOX (fuel rods) Scrap	16,8 5,1
MELOX Marcoule	UO_2 (based on depleted uranium) PuO_2	123,2 9,15	MOX (fuel elements)	113,82
COGEMA La Hague	Reprocessed irradiated fuel elements UP3 UP2 800 UP2 400 Irradiated fuel elements unloaded into pit	407,8 707,3 0 1439,2	Vitrified waste packages produced UP3 (number of containers) UP2 800 (number of containers) NU produced PuO_2 produced	289 318 1115 11,06