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Ministère de l'économie, des finances et de l'industrie
Ministère de la santé et des solidarités
Ministère de l'écologie et du développement durable

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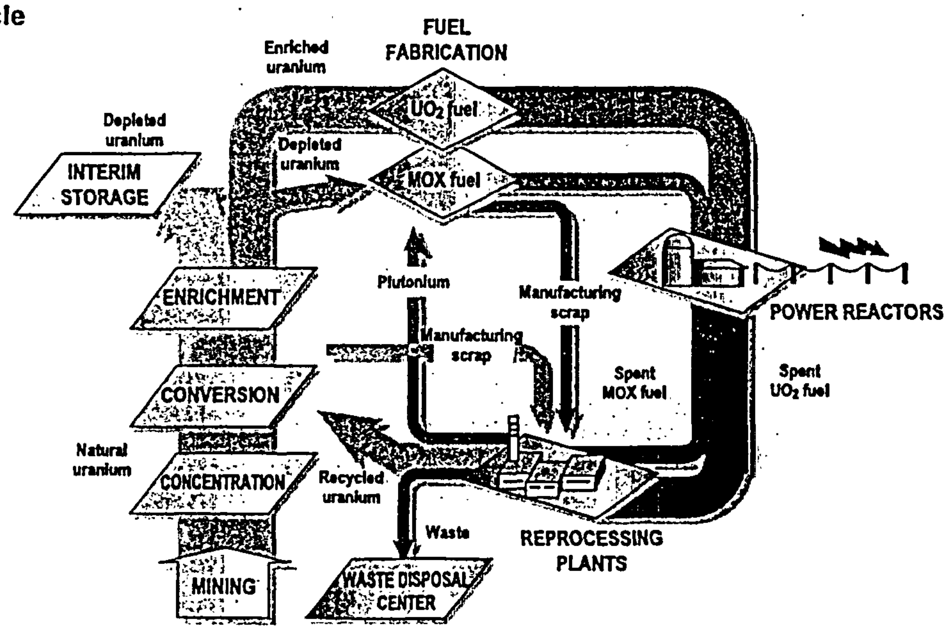
The fuel cycle



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 wastes originating from the irradiated fuel or from the industrial operations involved utilizing 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 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 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 COGEMA group. It should however be noted that the uranium-based fuel manufacturing plants are operated by FBFC, a 100% subsidiary of Framatome-ANP. The COGEMA group is a subsidiary of AREVA. Its organization comprises an executive committee, 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), Recycling (ATPu, MELOX), Mechanical engineering (SICN).

Fuel cycle industry throughputs

Facility	Material processed	Product obtained
Comurhex (Pierrelatte)	uranyl nitrate (reprocessed uranium)	UF_4: 41 tons UF_6: 40 tons U_3O_8: 153 tons
COGEMA (Pierrelatte) TU5 shop W plant	 uranyl nitrate (reprocessed uranium) UF_6 (depleted uranium)	 U_3O_8: 1,458 tons U_3O_8: 15,491 tons Total U_3O_8 in interim storage U_3O_8: 110,855 tons
Eurodif (Pierrelatte)	UF_6 (natural uranium): 18,194 tons	UF_6 (depleted uranium): 16,715 tons UF_6 (enriched uranium): 2,165 tons
FBFC (Romans)	UF_6 (enriched uranium): 1,167 tons UF_6 (enriched reprocessed uranium): 33 tons	UO_2 (fuel elements): 733 tons UO_2 (reprocessed uranium fuel elements): 18 tons
ATPu (Cadarache)	UO_2 (depleted uranium): 50 tons PuO_2: 3 tons	MOX (fuel rods): 44.2 tons
MELOX (Marcoule)	UO_2 (depleted uranium): 108.8 tons PuO_2: 7.55 tons	MOX (fuel elements): 110.5 tons
COGEMA (La Hague)	Spent fuel elements Quantities processed UP3: 217.1 tons UP2 800: 733.5 tons UP2 400: 0 ton Spent fuel elements offloaded to the spent fuel pits: 1,050.5 tons	 Vitrified waste packages produced UP3: 254 containers UP2 800: 461 containers PuO_2: 8.8 tons Uranyl nitrate: 962.3 tons

1 MAIN TOPICS COMMON TO ALL INSTALLATIONS

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Fuel cycle consistency

With a view to upgrading the performances of reactors in service, EDF implements new fuel management systems, requiring prior DSIN authorization.