Most of 20 years of dismantling knowhow and experience

Dismantling encompasses all of the stages which follow the shutdown of a nuclear facility at the end of the operating period, including the physical removal of equipment, waste packaging and facility cleanup.
Orano Tricastin has developed know-how in this field since 1999 with the dismantling of the former defense plants for the CEA (Alternative Energies and Atomic Energy Commission).
These activities continue with the dismantling of other site facilities which have been shut down. The next major project will be the dismantling of the Eurodif plant.
The teams are also in charge of monitoring facilities prior to their dismantling.

Key figures EURODIF

Pre-dismantling stage:
350 metric tons of uranium hexafluoride (UF_6) recovered through the PRISME* rinsing operations

* Intensive rinsing project followed by venting at Eurodif (pre-dismantling stage)

Challenges of dismantling:
- **4 buildings** representing a surface area of 120,000 m^2
- **> 1,300 km of piping**
- **> 100,000 valves**
- **150,000 metric tons of steel**

Safety, security and environmental protection: part of our DNA

At every stage in the operation of its plants, the Tricastin site deploys a preventive and corrective maintenance program and applies the highest standards of safety and security.
The site is regularly inspected by the regulatory authorities and is subject to the AREVA group's internal controls.
All of the nuclear facilities are designed, operated and maintained in a manner that minimizes releases and water uptake from the environment, in accordance with limits established for each facility.

Regulated and monitored operations. Some points of reference:

Safety and Security:
1. Dedicated personnel trained in the specific risks involved
2. An average of one inspection per week
3. Regular internal and external drills with local players (fire department, national gendarmerie, Prefecture, etc.)

Environmental monitoring:
- **28,000 analyses performed per year on average** (water, air, sediments, vegetation, fishes, etc.)
- **300 sampling locations** at the site and in its surroundings.

All of the data is available on the public information report (Information about safety and radioprotection at the Orano Tricastin site) and on the website of the National Environmental Radioactivity Measurement Network: **www.mesure-radioactivite.fr**.

Safety, security and environmental training represents close to 50% of all personnel training hours.

2009 Start of construction of COMURHEX II

2011 Startup of Georges Besse II South

2012 Shutdown of Eurodif

2013 Startup of Georges Besse II North
June : Start of the PRISME[1] program
Oct. : Operation of the new HF storage facility at the new COMURHEX II conversion plant

2015 Startup of the REC II support facility[2]

2016 Full production capacity authorized at Georges Besse II
End of the PRISME[1] program

2018 Start-up of Philippe Coste conversion plant

Cleanup operations and removal of waste to the dedicated repository site

Chemistry-Enrichment Business Unit

Orano transforms nuclear materials so that they can be used to support the development of society, first and foremost in the field of energy.

The group offers products and services with high added value throughout the entire nuclear fuel cycle, from raw materials to waste treatment. Its activities, from mining to dismantling, as well as in conversion, enrichment, recycling, logistics and engineering, contribute to the production of low carbon electricity.
Orano and its 16,000 employees bring to bear their expertise and their mastery of cutting-edge technology, as well as their permanent search for innovation and unwavering dedication to safety, to serve their customers in France and abroad.

Orano, giving nuclear energy its full value.

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Energy is our future. Don't waste it!

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Chemistry-Enrichment Business Unit

Orano Tricastin

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Orano Tricastin, a leading industrial platform

Orano Tricastin is a leading industrial platform that draws on 60 years of know-how. All of the operations involved in uranium chemistry – conversion, defluorination and denitration – and in uranium enrichment are performed there. These operations precede the final stage of fuel fabrication for nuclear power generating reactors.

An evolving site meeting the highest safety standards

The Tricastin site has changed considerably in recent years. A number of investments have been made to demanding standards, significantly enhancing the safety of our operations.
Operating in a competitive business environment, the Orano group has built new plants to strengthen security of supply for its customers. Its design standards ensure even better materials containment while meeting the safety requirements of the Supplementary Safety Assessments (SSA) and limiting its operations' environmental footprint.

Civilian Nuclear

(1) Intensive rinsing program followed by venting at Eurodif
(2) Receiving-Sampling-Packaging Facility, a support facility for the Georges Besse II plants

1961 Startup of the first conversion plant (COMURHEX)

1978 Startup of the Eurodif enrichment plant

1984 Operation of the defluorination facility (W)

1996 Startup of the denitration facility (TU5)

2006 Start of construction of the Georges Besse II plant

1958 Construction of the gaseous diffusion plants (GDP)

Uranium enrichment for Defense purposes

1962-64 Startup of the GDPs

1996 Shutdown of the GDPs

Dismantling operations

2008

Nuclear for national defense

Uranium conversion

An essential stage of the fuel cycle

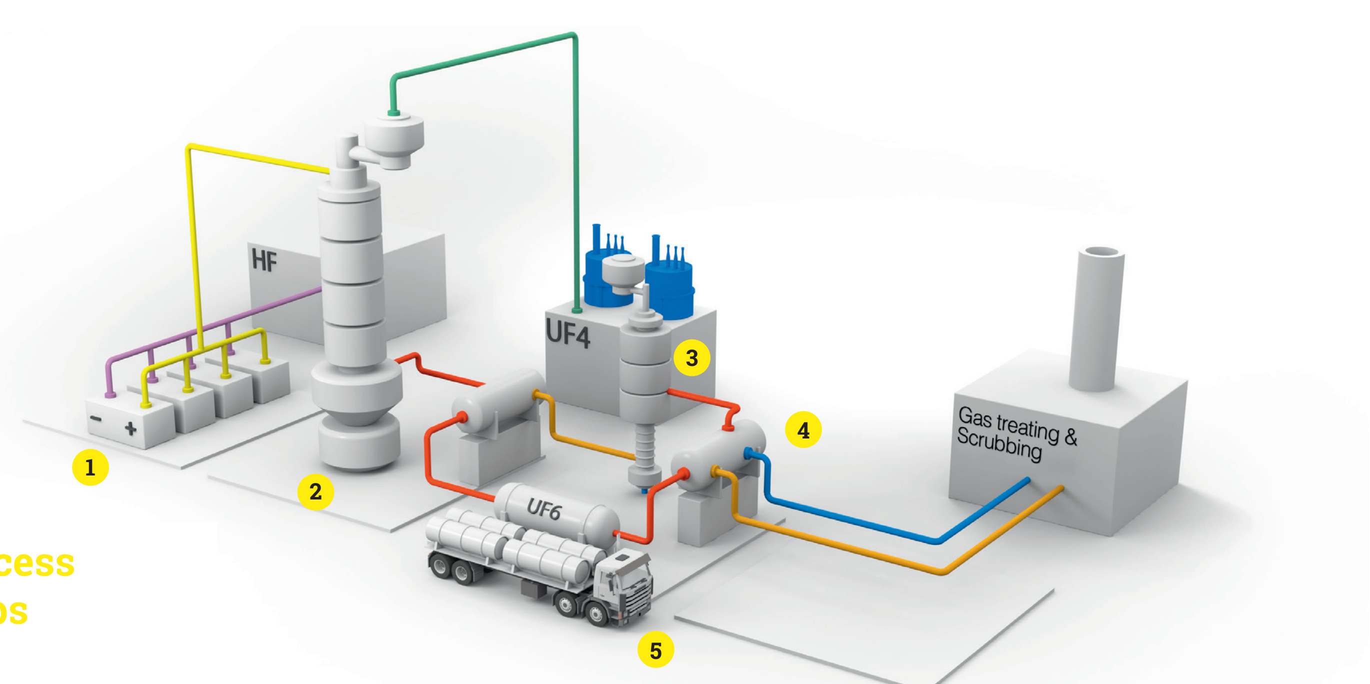
Conversion is conducted after the natural uranium ore is mined and before uranium enrichment. It produces the form of uranium most suited to enrichment operations: uranium hexafluoride (UF_6).

In the Orano group, conversion is carried out at two sites in southern France:

- 1st stage: the natural uranium is purified at the Malvési plant (Aude Department) and converted into uranium tetrafluoride (UF_4)
- 2nd stage: the uranium's conversion into uranium hexafluoride (UF6) is completed at the Tricastin plant (Drôme Department).

Backed by more than 50 years of experience and with a capacity of 15,000 metric tons of uranium per year, the Orano group's conversion plants prepare the natural uranium for the nuclear fuel of its utility customers all over the world.

The uranium hexafluoride (UF_6) production process



Process steps

At the Tricastin site, two atoms of fluorine (F_2) are added to the UF_4 from Malvési to form UF_6.

1 Fluorine manufacturing
Fluorine molecules (F_2) and hydrogen molecules (H_2) are released from electrolyzers containing hydrofluoric acid (HF). As it is manufactured, the gaseous fluorine is routed to the next stage.

2 Primary fluorination
The fluorine is injected into a flame reactor, where it reacts with the UF_4. The reaction between the UF_4 and the fluorine is instantaneous and exothermic (approximately 1,000°C). Gaseous UF_6 is formed.

3 Secondary fluorination
This stage consists in having the unburnt remains of the primary fluorination react in a multi-plate reactor in motion, where they recombine with the UF4 and excess fluorine. Once again, this forms gaseous UF_6.

4 UF_6 trapping
L'UF_6 gazeux est piégé dans des cristallisoirs froids où il se solidifie.

5 UF_6 packaging
The crystallizers are heated to liquefy the UF6 and fill by gravity a container (48Y cylinder) located in a leak-proof packaging chamber. The full cylinders are placed in the building's cooling contained zone until the UF_6 crystallizes, and are then transferred to the storage area.

The resulting natural UF_6 will be enriched, the next stage before nuclear fuel fabrication.

Key figures
UF_6 Conversion Production Capacity at Tricastin

4,000 metric tons of fluorine per year

15,000 metric tons of uranium in the form of UF_6 per year

Uranium enrichment by centrifugation

A proven, effective technology

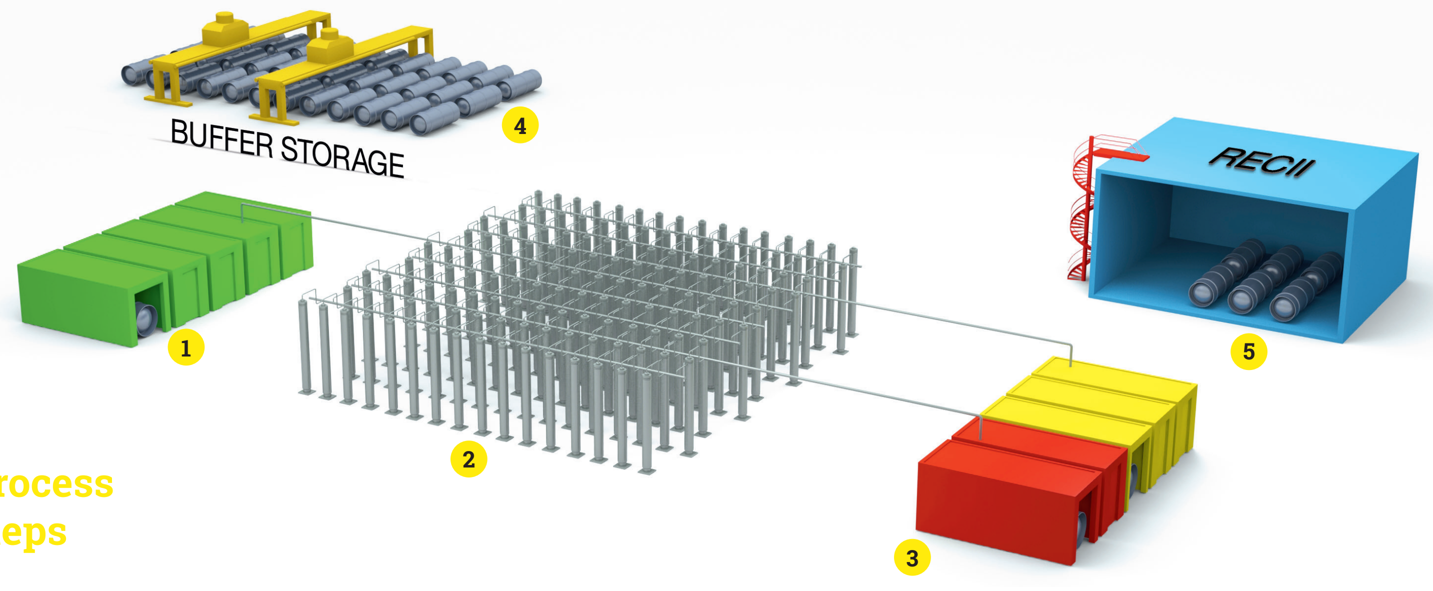
Enrichment consists in rendering uranium capable of supplying enough energy to generate electricity in nuclear power plants. In its natural state, uranium consists mainly of two isotopes*: uranium-235 (0.7%) and uranium-238. For uranium to be used in a reactor, its proportion of uranium-235 must be raised to between 3 and 5%.

* Isotopes: atoms of the same element, but with a different number of neutrons contained in the nucleus

After 50 years of operating experience in gaseous diffusion enrichment, Tricastin continues to provide enrichment in the two new Georges Besse II plants based on centrifugation technology. These utilities can enrich natural uranium, depleted uranium, and recycled uranium.

The centrifugation process

Centrifugation consists in separating uranium-235 from uranium-238 by making use of the uranium molecules' masses and the rotation speed of the centrifuges, which are shaped like a cylindrical bowl.



Process steps

1 Feeding
A cylinder of natural UF6 (produced by the conversion plant) is heated in a workstation. The UF6 is sublimated* and fed via collectors into centrifuges spinning at very high speed.

* sublimation = direct change from the solid state to the gaseous state (without passing through the liquid phase)

2 Isotopic separation
The centrifugal force throws the heavier molecules (U_{238}-F^6) to the cylinder walls, while the lighter molecules (U_{235}-F_6) migrate to the center. This individual stage of isotopic separation is repeated in a series of connected centrifuges called a cascade.

3 UF_6 extraction
The enriched UF_6 is withdrawn from the cascade directly into a suitable cylinder awaiting in a dedicated station, cooled to bring it to the solid state. The depleted UF_6 is extracted into another cylinder, which is also waiting in a cooled dedicated station.

4 Buffer storage
The cylinders are weighed and placed in the buffer storage area adjoining the plant pending transfer to the following stage.

5 Quality control and packaging for shipment
The enriched UF_6 production is sampled in the RECII* facility (quality control) and packaged in 30B cylinders for shipment to the fuel fabricator.

** RECII = Receiving-Sampling-Packaging facility

Key figures
Tricastin centrifugation

2 plants

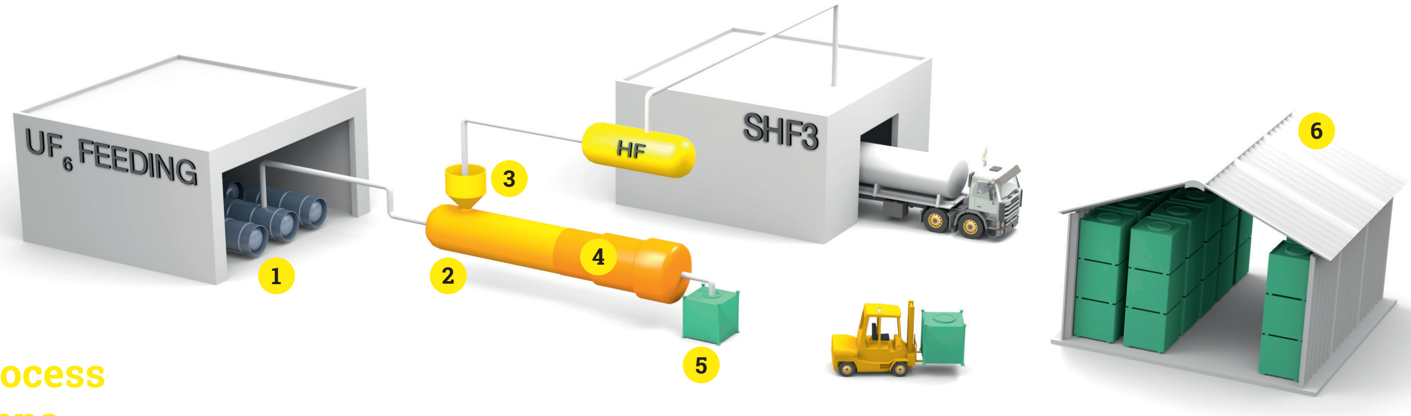
Production capacity **7.5 MSWU*** per year

* Millions of Separative Work Units

Defluorination and denitration: chemical processes for uranium transformation

The defluorination process

During uranium enrichment, part of the uranium becomes depleted; depleted uranium contains three times less 235 isotope than natural uranium. This reusable material is sent to the defluorination plant (W plant) for conversion into uranium oxide (U_3O_8). U_3O_8 is incombustible, insoluble in water, non-corrosive and completely stable, allowing it to be safely stored pending later reuse.



Process steps

1 UF_6 feeding
A cylinder of depleted UF_6 is heated in a chamber in order to sublimate the UF_6*.

* sublimation = direct change from the solid state to the gaseous state (without passing through the liquid phase)

2 Hydrolysis
The gaseous UF6 is injected into an furnace heated to 300°C at the same time as steam ➔ hydrolysis, an instantaneous reaction which releases hydrofluoric acid (HF) and uranium oxyfluoride (UO_2F_2).

3 HF extraction and treatment
Gaseous HF is immediately released, escaping to the top of the furnace: it is filtered, routed to a condenser, liquefied and transferred into a storage tank for removal by our chemical-industry customers.

4 Pyrohydrolysis
Following the reaction in the furnace, the UO_2F_2 is brought into contact with the superheated steam (counter current flow) and additional hydrogen ➔ pyrohydrolysis and formation of HF and U_3O_8 oxide.

Key figures
Defluorination production capacity at Tricastin

13,000 metric tons of uranium in the form of U_3O_8 per year

9,000 metric tons of hydrofluoric acid

5 $U_3 0_8$ packaging
The U_3O_8 exits the furnace through a series of isolating valves and is routed pneumatically to the container filling area (DV 70 containers). A DV 70 contains 12 metric tons of oxide.

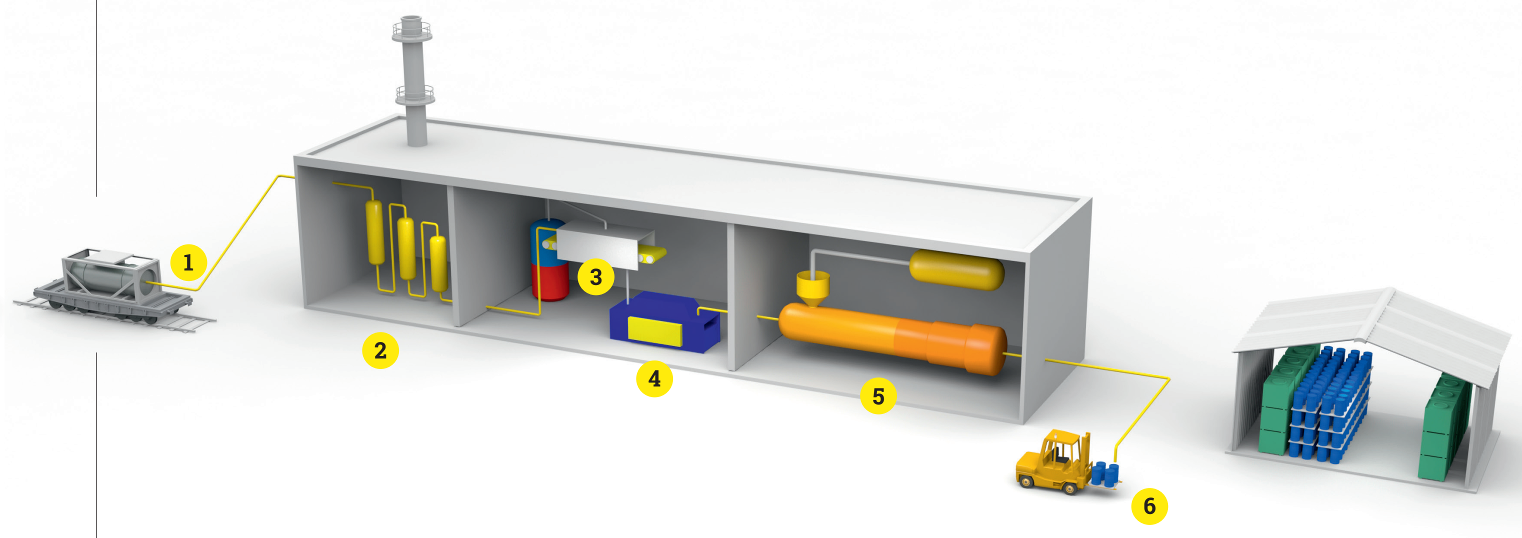
6 Storage area
The DV 70 containers are stored pending later reuse.

New facilities to meet the highest safety standards

SHF3: in operation since February 2015, this new facility is used to store hydrofluoric acid (HF) produced during the defluorination process in W plant. Following on from SHF3, a UF_6 feeding workshop was built, it's the EM3 project.
Expected to start operation in 2018, this facility will prepare gaseous UF_6 and feed it to the defluorination furnaces of W plant. Both these new facilities meet strengthened safety standards (seismic resistance, containment, severe weather conditions, etc.).

The denitration process

After 3 to 4 years in the reactor, the used fuel is treated at the Orano la Hague plant. The operations performed there allow the reusable materials (96%) to be recycled. The uranium is recovered in the form of uranyl nitrate, poured in LR65 tankers and routed to the TU5 denitration plant at Tricastin. There, it is reconditioned in the form of uranium oxide (U_3O_8). Once again, the oxide form allows for safe storage pending later reuse.



Process steps

1 Facility feeding
The uranyl nitrate (UN) from an LR65 tanker is transferred to a feed preparation tank.

2 Precipitation
The UN is precipitated into uranium pulp with oxygenated water.

3 Filtration
The pulp is washed and filtered on a band filter, where the mother liquors are recycled to the head of the process. The recovered UN joins the process downstream (thermal denitration) for conversion into UO_3..

4 Drying
The uranium paste is dried to produce a UO_4 powder.

Key figures
Denitration production capacity at Tricastin

1,400 metric tons of uranium in the form of U_3O_8 per year

5 Calcination
The UO_4 powder (and the UO_3 from the filtration step) is fed to a calcining furnace for conversion into U_3O_8 (uranium oxide). The powder is homogenized and sampled before it is placed in drums.

6 The drums are transferred to the dedicated storage area pending later reuse.