Press kit

Philippe Coste conversion plant

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EDITORIAL

The Philippe Coste plant is a major industrial investment for Orano, for the French nuclear industry and for the industry of our country.

With the Georges Besse II enrichment plant on the same site, it is probably the largest industrial investment made in France in recent years. The Comurhex II project was launched to give France an industrial facility offering cutting-edge safety, security, and environmental and industrial performance. A facility that gives us a global competitive advantage and guarantees an uninterrupted electricity supply for our markets. A tool integrating technological innovations in terms of safety, environment, and improvement of industrial performance: recycling of chemical reagents, reduction by 90% of water consumption, automated control-command system to improve the process control.

It is an exceptional project that has required the best of our expertise from the teams of Orano Chemistry and Enrichment as well as Orano Projets, and throughout our group alongside our industrial partners. The project successfully completed at the same time as our group was reinventing itself to create a new flagship technology business to give nuclear materials all their value.

The investment we have made in the Tricastin site and its plants shows the confidence we have in the future of nuclear energy.

Nuclear power is also an energy that allows France to not only have electricity that is more than 95% carbon-free but it also secures a continuous electricity supply, 7 days a week and 365 days a year. The equation for 2050 is simple: production of electricity, the predominant energy of the 21st century, will have to double, and CO2 emissions will need to be halved to combat climate change.

Comurhex II was the name of the project and our plant is known as the Philippe Coste Plant. He was the first founding CEO of Comurhex, one of the instigators of the Comurhex I plant, and also responsible for technical advances, most notably in the field of electrolysis. Like Georges Besse, Philippe Coste was a great industrialist who commissioned multiple facilities, and as we open our 21st century plant today, we felt it was essential to honor him, and through him, all the pioneering men and women of our industry, and without whom we would not be here today.

Thanks to the Philippe Coste Plant, both the great industrial story of our group and of French nuclear power will live on and is guaranteed a bright future. It is now up to all of us to write the new chapters of this story.

Par **Philippe Knoche**
Orano CEO

I . The COMURHEX II project : an industrial reality

Orano has invested €1.15 billion in a new uranium conversion plant, the COMURHEX II project at its Narbonne and Tricastin sites. This investment will maintain its position in the conversion market thanks to the most modern and efficient industrial facility in the world.

This new plant is part of the strategy to upgrade the industrial facilities of the Orano Tricastin site, where the group has invested more than €5 billion over the past 10 years.

- **What is uranium conversion ?**

Uranium ore extracted from mines cannot be used in nuclear reactors in its untreated form. Conversion is an essential step in the fuel cycle between mining and enrichment.
Through conversion, uranium concentrate acquires the purity essential for manufacturing nuclear fuel and consists of transforming mining concentrates into uranium hexafluoride (UF6) for the next step in the fuel cycle, known as enrichment. This uranium can then be used to produce the fuel necessary for operating power plants all over the world.

In the Orano group, conversion is carried out on two industrial sites in the South of France with the necessary expertise in fluoride chemistry and uranium transformation. The first stage is carried out at the Orano Malvési site (Narbonne – Aude), and the second stage of the industrial process takes place on the Orano Tricastin site.

- **Orano, the first industrial group in the world to open a new conversion plant**

The COMURHEX II project incorporates technological innovations from major research and development programs, as well as exploiting 55 years of process experience. The highest possible level of safety and a reduction in environmental footprint have been major priorities in the design of this project.

Launched in 2006, the COMURHEX II project consisted of upgrading three workshops on the Orano Malvési site where new facilities have been fully operational since June 2016, and building a new plant on the Tricastin site to replace the historic COMURHEX I plant where production was stopped in December 2017. More than 450,000 tons of UF6, or the energy equivalent of 24,000 TWh, were produced over 55 years (equivalent to one year of worldwide electricity consumption from all energy sources – base year 2015, all sources of electricity production, WEO 2017).

An exceptional « Made in France » investment

The COMURHEX II project represents an investment of €1.15 billion, of which €850 million was spent on the Tricastin plant.

More than 240 partner companies were involved in construction of the new conversion plant on the Tricastin site, 99% of which were French companies, and 70% of which were local to the region.

- **The key stage of the project :**

  - **2006 :** Launch of the Comurhex II project and basic design carried out by the group's engineering division (Orano Projets)
  - **2009 :** Approval of the building design, public inquiry and start of civil engineering works
  - **2013 :** Commissioning of the hydrofluoric acid storage building (first building of the plant)
  - **2014 - 2018 :** Finalization of other buildings (UF6 production unit, utilities, UF4 storage unit, effluent treatment unit)
  - **September 2016 :** start of qualification tests on industrial equipment (without uranium materials)
  - **Mars 2018 :** Orano Projets hands over all the Comurhex II Tricastin project facilities to the operator
  - **Avril 2018 :** Start of hot testing of process buildings - introduction of first uranium materials
  - **September 10th, 2018 :** inauguration the Philippe Coste plant with introduction of the first cylinder in the presence of our customers, employees and institutional stakeholders
  - **December 12th, 2018 :** industrial commissioning of the plant

- **A plant contributing to production of low-carbon electricity**

Industrial commissioning of the new plant started in December 12th 2018, with capacity increasing from 7,500 tons to 15,000 tons of installed capacity by 2021, after the commissioning of a new fluorine production facility (delivery of which is scheduled for the end of 2020).
With this new plant and the Georges Besse II enrichment plant, the Tricastin site will contribute to production of low-carbon electricity for more than 90 million homes, or the equivalent of France, Germany and England combined.

- **A pre-emptive and planed transition : the challenges of maintaining skills and securing customer deliveries**

In order to control the costs involved in building a new plant in a weakened market and in view of market demand, Orano reassessed the schedule of the COMURHEX II construction site in 2012. This resulted in production at the COMURHEX I plant being extended from 2015 to 2017, after approval by the French Nuclear Safety Authority.

- The first challenge was to maintain the skillsets of teams during the transition phase between the two plants. A major training program was devised in 2016 and deployed in 2017 and 2018. Operators of the COMURHEX I plant were included in the COMURHEX II project team from 2017 to facilitate appropriation of the new industrial facility and contribute to qualification tests. In February 2018, all teams joined the start-up teams of the new conversion plant

- The second challenge consisted of securing the deliveries of our customers during the transition and production ramp-up period of the new conversion plant. Before production of the COMURHEX I plant was shut down, sufficient stocks were built up to meet the needs of our customers over the period 2018 to 2021.

Two questions for Jacques Peythieu,

Senior Executive Vice President of the Chemistry / Enrichment Business Unit

- **What does the new plant contribute to the French nuclear industry?**

The investments made allow us to meet the needs of our utility customers and significantly enhance the safety of industrial operations. Orano is the first industrial group in the world to renew and modernize its industrial conversion facility. It's a "Made in France" investment with an international component that we are very proud of, allowing us to involve more than 240 partner companies, 99% of which were French, to complete the project.

- **How will it benefit the local area ?**

With a world-class center of expertise in the birthplace of the nuclear industry, the local labor market is superbly qualified. The many subcontracting companies in our industry are also setting up in an area which is favorable to development and economic growth. Our industrial platform will be here for the next 50 years, making a significant contribution to the attractiveness of the area.

Key figures

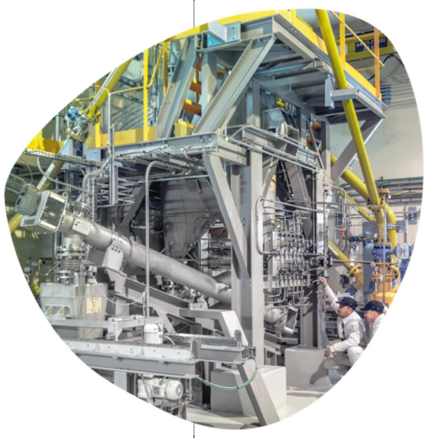
- **3,000,000** Orano Projets engineering hours
- **110** linear kilometers of pipes laid
- **2,300** items of equipment installed and connected
- **450** kilometers of electrical / instrumentation and control cables
- **14,000** m3 of concrete
- **3,000** tons of reinforcement structures
- **60,000** welds
- **7** kilometers of ventilation, air conditioning and sanitation systems
- Up to **700** people on the construction site

- **Orano Projets, project management from design to hot testing**

As part of the Orano group with its new focus on fuel cycle activities, Orano Projets is one of the group's six business units and provides expert engineering services for all activities related to the nuclear fuel cycle. The scope of its activities range from support engineering for operators to complete EPCM missions (Engineering, Procurement, Construction, Management).

With 40 years' experience in the design and execution of complex projects in France and abroad, Orano Projets was responsible for producing engineering studies, project managing the entire process and coordinating cold testing of the COMURHEX II project on the Orano Malvési and Orano Tricastin sites.

II. Innovative industrial processes to improve our performance and reduce our environment



The COMURHEX II project incorporates technological innovations from major research and development programs, as well as exploiting 55 years of industrial process experience. The highest possible level of safety and a reduction in environmental footprint have been major priorities in the design of this project.

- **The Philippe Coste conversion plant is :**

  - application of the best available technologies;
  - a facility compliant with seismic standards (Safe Shutdown Earthquake or SSE);
  - a new hydrofluoric acid storage building with augmented containment and safety features;
  - new electrolysis-generated fluorine production facilities incorporating the latest improvements in electrolyzers;
  - a new UF4 to UF6 conversion unit associated with a uranium tetrafluoride storage building and a contained unit for storage of UF6 containers during cooling;
  - a liquid effluent treatment unit generating less waste and reducing the plant's environmental footprint.

Research and development in chemistry and enrichment activities: for improved processes and technological innovation

- Average annual budget: around €5 million
- Workforce: 20 people
- Skills: molten salt electrolysis, uranium and fluorine chemistry, wet chemistry, gas/solid reactions, process engineering, process modeling/simulation
- Resources: dedicated R&D laboratory at Tricastin (HRP laboratory), collaboration with numerous university laboratories (Lille, Toulouse, Nancy, Strasbourg, Bordeaux, Le Mans, Clermont-Ferrand, Saint-Etienne, Lyon)
- 10 to 15 development initiatives undertaken each year
- Intellectual property: 72 patents in force

- **Facilities compliant with the highest safety standards**

The Philippe Coste plant significantly enhances the safety of industrial operations and is compliant with the most stringent safety and security standards.

The new plant is classified as an upper tier establishment under the SEVESO directive (ICPE – Classified Facility for Environmental Protection), and was built to the latest nuclear standards ensuring in particular reinforced containment of materials:

- Concrete process buildings with independent ventilation.
- Compartmentalization of the main building into 200 rooms.
- The process buildings are designed with increased resistance to safe shutdown earthquakes (corresponding to a once-in-a-millennium earthquake weighted by +30%).
- Piping for transferring chemical and uranium materials (racks) was designed with a double casing.
- Flood risk prevention: equipment containing UF6 is either sited beyond the reach of water or waterproof.

- **A new plant with a smaller environmental footprint**

The Philippe Coste plant is the first plant of its generation to incorporate all the technologies capable of reducing its environmental footprint right from the design stage, in particular by making the principle of recycling an integral part of the industrial process.

Innovations implemented have therefore resulted in reduced consumption of chemical reagents (-75% ammonia, -50% nitric acid, -60% potash), 10 times less water consumption and lower greenhouse gas emissions.

Orano met its CLIMAT commitment two years ahead of time, with an 80% reduction in CO_2 emissions and a 50% reduction in energy consumption (reference year 2004). For a plant on the scale of Orano Tricastin, this means a 96% reduction in energy consumption and an 80% reduction in greenhouse gas emissions.

III. The Philippe Coste plant, the best of Orano's expertise to serve the energy of the future

With this new conversion plant, Orano opens a new chapter in the history of Tricastin and continues its role as a benchmark industrial platform benefiting from more than 55 years of expertise in all activities related to uranium chemistry (conversion, defluorination and denitration) and uranium enrichment.

With the Philippe Coste plant, Orano is the first company in the market to renew and modernize its industrial conversion facility, thus guaranteeing a reliable and predictable supply for its customers in compliance with safety and environmental requirements.

The success of this project was made possible through the know-how of the Orano Chemistry / Enrichment and Orano Projet teams, working together to fulfil the ambitions of the Orano Group: give nuclear energy all its value, the energy of the future.

- **Orano Chemistry / Enrichment**

  - Contributing to the supply of low-carbon energy

The Front End nuclear fuel cycle activities take place after natural uranium ore has been extracted and processed. They include uranium conversion and enrichment services, which will then be used for fabrication of fuel assemblies for nuclear reactors.

With the industrial commissioning of the Georges Besse II plant and now Philippe Coste plant, the Enrichment / Chemistry Business Unit offers its worldwide customers the most modern and efficient industrial facility on the planet.

- Key Chemistry / Enrichment figures

    - **2,000** employees
    - **10-year** order backlog
    - **1/4** of Orano revenues
    - The leading Western company in conversion activity
    - **Third-ranked** company for enrichment activity
    - **60** customers and 40 partners worldwide
    - **2** benchmark industrial sites: Orano Tricastin (Drôme & Vaucluse), Orano Malvési (Narbonne – Aude)

- Orano Tricastin figures :

    - **2,500** Orano employees (activities: Chemistry / Enrichment, Dismantling and Services and Orano Projets)
    - **2,000** employees of partner companies
    - **€200** million for the purchase of supplies and services, two thirds locally

- **Orano Projets**

Orano Projets is one of the group's six business units and provides expert engineering services for all activities related to the nuclear fuel cycle. The scope of its activities range from support engineering for operators to complete EPCM missions (Engineering, Procurement, Construction, Management). Orano Projets offers its customers a wide range of solutions: consultancy, engineering studies, construction and testing, turnkey projects, etc.

Orano Projets supports all other business units in the group, as well as external customers both in France and internationally (Spain, United Kingdom, Asia, etc.).

Orano Projets is located in France (Saint-Quentin-en-Yvelines, Équeurdreville in the department of Manche and Bagnols-sur-Cèze in Gard) and the United Kingdom, through its subsidiary Orano Projects Ltd. Engineering activities also have a process development and qualification center, the Beaumont Research Center (HRB).

In the South of France, engineering supports renewal of the Orano group's industrial equipment, whether at Tricastin (Georges Besse II, Comurhex II) or Malvési (Comurhex II); it is also involved in maintenance and in-service support operations, as well as carrying out post-Fukushima complementary safety assessments.

Key engineering figures :

- **1,452** employees
- **42** trades
- **300** projects each year with budgets from €10k to €1bn
- **90%** of projects delivered on time
- **40** years' experience
- **Optimal safety:** an accident frequency rate of less than 1

Two questions for Patrick Jacq

Senior Executive Vice President of Orano engineering activity

- **What role did Orano Projets play in COMURHEX II ?**

As project manager, our engineering teams worked on all stages of the project, from the detailed basic design in 2006, completion of civil engineering works between 2009 and 2011, handover of the plant's first building in 2013, to the construction phase of the other buildings between 2014 and March 2018. In total, the COMURHEX II project represents 3 million engineering hours for Orano Projets.

- **How were your employees involved?**

The exceptional scale of the COMURHEX II project has required the expertise of our teams from its design to the present day - an average of 100 people representing the various engineering professions. In addition to our employees, we also involved more than 240 companies who supported us in the different phases of the project. We are all very proud of the work accomplished which is contributing to the renewal of the French nuclear industry. I would also like to thank each and every one of them for their involvement, which has allowed us to achieve an exemplary safety record.

IV. The Orano Group

Orano benefits from a buoyant global market with a long-term future.

A major challenge post-COP21: between 2014 and 2040, the IEA forecasts a 64% increase in global electricity production and a 54% decrease in carbon intensity (from 515 g CO2/kWh to 335 g CO2/kWh).

The IEA predicts that by 2040, installed nuclear capacity will increase by 52%, up from 398 GWe to 606 GWe. 60 nuclear units are currently under construction worldwide. At the same time, the stock of used reactor fuel will increase by 70% by 2040 and more than 150 reactors will have to be dismantled.

Growth in the nuclear market is driven by Asia (Japanese reactors are being restarted and the Chinese program is accelerating). The Chinese market will account for over half of worldwide growth in the installed nuclear fleet over the next 20 years.

France can take advantage of this market and increase the positive contribution of nuclear energy to the country's balance of trade (€6 billion per year).

Orano, a group entirely dedicated to fuel cycle activities

The restructuring plan of the AREVA group has given rise to three distinct entities, each refocused on specific missions: AREVA SA, in charge of the EPR reactor project in Finland, AREVA NP – now Framatome, for reactor activities and associated services – and Orano.

Orano activities include mining, uranium conversion and enrichment, used fuel recycling, nuclear logistics, dismantling and services, and engineering.

We have high ambitions for Orano, namely to become the market leader in the production and recycling of nuclear materials, waste management and dismantling over the next ten years.

[1] World Energy Outlook 2016 – New Policies Scenario
[2] World Energy Outlook 2016 – New Policies Scenario
[3] WNA

An ambitious strategic action plan

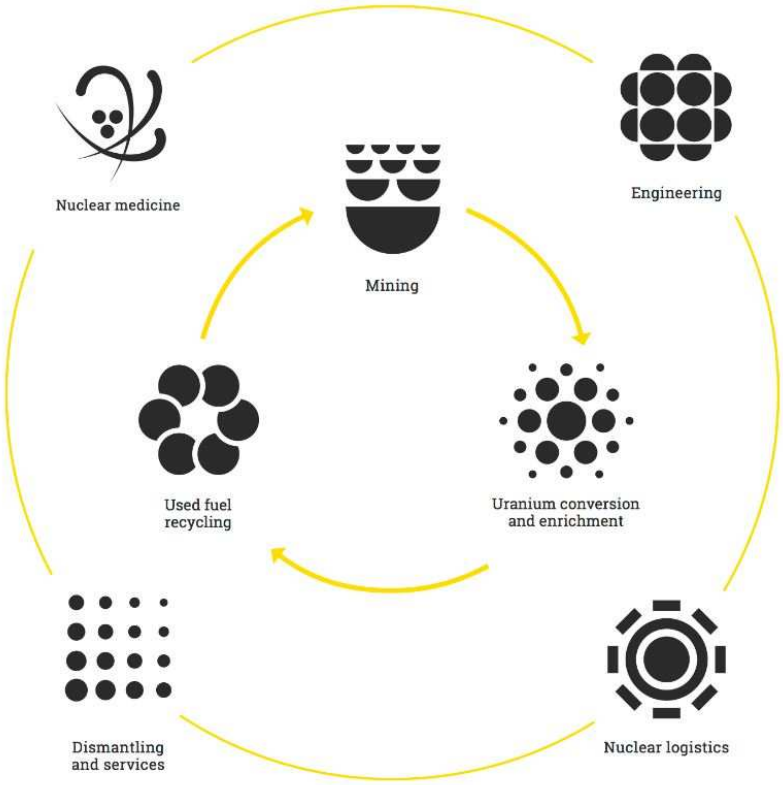
The strategic action plan of our group is based around three ambitious objectives:

1. More than 30% of our revenues generated in Asia by 2020 (versus 20% today)
2. Positive net cash flow from 2018
2. More than 50% of our workforce in service activities from 2020

To achieve these targets we will continue to:

- Invest in our plants (€1.8 billion allocated to their modernization from now to 2025) and our skills (training programs covering changes in our businesses and new technologies),
- Work on our competitiveness (performance plan),
- Further our efforts to develop customer relationships and strategic partnerships in France (EDF, CEA) but also abroad (China, Japan, etc.) which already accounts for 55% of our revenues,
- Develop new products and innovative solutions (waste treatment, research on cancer treatment solutions, etc.).

V. Our activities



- **Mining**

As the first link in the nuclear fuel cycle, Orano's mining activities encompass the exploration, production (Canada, Kazakhstan, Niger) and commercialization of uranium throughout the world as well as the remediation of former mining sites. The group is one of the world's leading producers of uranium.

- **Uranium conversion and enrichment**

With a unique integrated industrial platform and the most up-to-date facilities in the world, thanks to the new conversion and Georges Besse II enrichment plants, Orano is recognized by the market for its technical skills and cutting-edge processes.

- **Recycling used nuclear fuel**

Thanks to the performance of its La Hague and MELOX plants, the only facilities operating on an industrial scale, Orano is positioning itself as an international leader in used fuel processing and recycling.

- **Nuclear logistics**

Throughout the fuel cycle, Orano brings its unique expertise to the design, approval and manufacture of containers, and organizes land, sea or rail transport compliant with the highest level of risk control.

- **Dismantling and services**

With 50 years' experience, Orano is a benchmark supplier providing support for operation of nuclear sites (site logistics, specialized maintenance, radiological safety), management of radioactive waste and dismantling of end-of-life equipment and facilities.

- **Engineering**

Engineering activities are grouped together in the Orano Projets entity and include engineering consultancy contracts, project owner or project management assistance, design and execution engineering, and start-up and operational support for plants. Customers are the business units of the group as well as external customers in France and abroad.

Orano is also developing its medical activities to create innovative cancer treatments.

Orano, in the world’s top 3 for each of its activities