FROM RESEARCH TO INDUSTRY

cea den

# NUCLEAR ENERGY DIVISION

# Nuclear Energy Division

**Within the CEA, the Nuclear Energy Division (DEN) provides the French government and industry with technical expertise and innovation in nuclear power generation systems to develop sustainable nuclear energy that is both safe and economically competitive.**

To meet these objectives, the DEN is engaged in three main areas of investigation:

- Optimising the current nuclear industry;
- Developing nuclear systems of the future – dubbed "4th generation" reactors – and their fuel cycles;
- Developing and operating large experimentation and simulation tools needed for its research programmes.

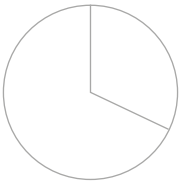
As nuclear operator, the DEN also has to manage and upgrade its own fleet of nuclear facilities. It carries out numerous construction and refurbishment programmes on its facilities, together with clean-up and dismantling programmes for those that have reached the end of their service life.

# Key Figures*

**4 208**
**employees**

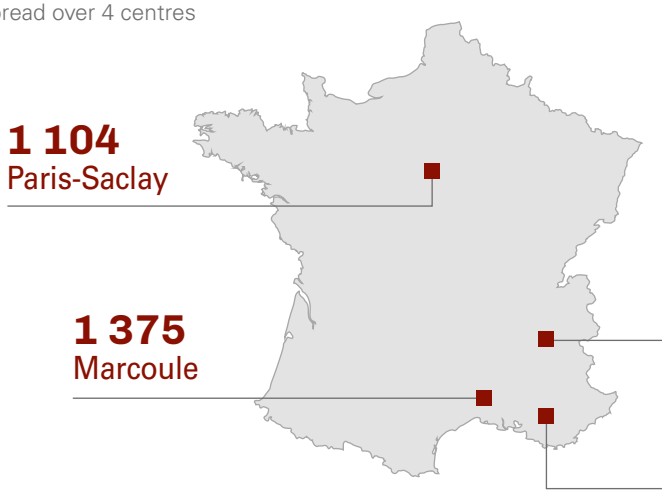
including...

**2 811**
men



**1 397**
women

spread over 4 centres




**485**
**scientific publications**

**25**
**post-doctoral researchers**

**301**
**doctoral candidates**

**43**
**patents filed**

* 2017-2018

Irradiated materials laboratory.

# Optimising the current nuclear industry

**The DEN is conducting research to address the challenges facing its industrial partners. The first objective is to support EDF and Framatome in increasing the competitiveness of the French fleet currently in operation. The second objective, in collaboration with Orano and Andra is to optimise or adapt the front-end and back-end facilities of the nuclear fuel cycle.**

## Front-end of the fuel cycle

The front-end of the fuel cycle includes the industrial operations associated with preparing uranium for use in reactors, from mining through to enrichment. The DEN is therefore working not only to improve the performance of the selective extraction, purification and conversion of uranium but also to reduce the environmental impact of these processes.

## Back-end of the current fuel cycle

Programmes are being conducted to support Orano in optimising or adapting the processes used to treat spent fuel at the La Hague plant and to manufacture MOX[1] fuel at the Melox plant. They are also designed to support Andra so as to provide the scientific and technical information needed for the acceptance files for future waste disposal sites. Lastly, such programmes set out to guide EDF in its management of certain types of waste.

## 2nd and 3rd generation reactors

The DEN is conducting research to support the current 2nd generation of French pressurised water reactors (PWRs) and the deployment of 3rd generation reactors. Research is mainly led in collaboration with EDF, Framatome and IRSN. It addresses industrial issues such as improving reactor performance levels, extending reactor service life and increasing the safety level of power plants.

Lab-scale studies on selective uranium extraction processes.

### The DEN on the international stage

The DEN cooperates with most major nuclear powers. Such cooperation can concern issues of national interest when requested by the Government wanting to foster strategic partnerships with other countries that have nuclear power. It can also concern scientific and technical issues when the DEN needs to develop its expertise in complementary fields by signing collaboration agreements with foreign partners. And it can cover economic issues when the DEN is offering its services to foreign industrial partners or looking for foreign investment in its research infrastructures.

(1) Mixture of uranium and plutonium oxide

Modelling to support 4th-generation fast reactor design.

# Future industrial nuclear systems

**The Nuclear Energy Division (DEN) is currently working on the 4th generation of fast reactor systems for the future. Their development is needed to better meet requirements with respect to secure energy supplies and energy independence.**

These systems can optimise the material management process thanks to the possibility of better exploiting uranium resources, while enabling the multiple recycling of plutonium and minimising radwaste production.

## 4th generation reactors

The French government has tasked the CEA with conducting research on innovative "4th generation" nuclear reactor systems. The CEA is therefore leading the design studies for an integrated technology demonstrator of a sodium-cooled fast reactor (SFR) called Astrid, whilst continuing its technology watch and R&D activities on other relevant technologies for this 4th generation.

## Back-end of the future fuel cycle

The research on the fuel cycle for the future aims to assess all the options available for managing nuclear materials for the future reactor fleet, as well as the technologies for recycling these materials. This is being done in accordance with the Act dated 28 June 2006 on the sustainable management of radioactive materials and waste.

## Basic scientific and technological research

Basic scientific and technological research focuses on activities that are upstream of applied research, by resolving cross-functional issues through other fields covered by the DEN. Driven by dynamic collaborations, this research helps improve the foundations and the scientific quality of knowledge needed to establish the relevance of solutions recommended to solve the main issues of nuclear energy in three different areas: materials, fuels and separation chemistry.

Jules Horowitz Reactor currently under construction.

# Major tools for developing nuclear energy

**Research on current or future nuclear systems requires specific experimental and simulation tools. For this reason, the DEN is developing and making use of a comprehensive, coherent fleet of experimental facilities. In the field of simulation, the DEN is developing codes in all the main fields of nuclear science in order to model the phenomena involved in a reactor.**

## Numerical simulation

The DEN is developing software platforms and simulation codes in all the main fields of nuclear energy (neutronics, thermal-hydraulics, thermal-mechanics, fuels, fuel cycle chemistry and materials) to model the complex phenomena that occur in normal or accident operation of a reactor or nuclear facility. Most of the codes developed by the DEN are used by the French nuclear industry. They have been distributed to international R&D organisations, mainly accompanying collaborations, under a large number of licensing agreements.

## Major facilities supporting the programmes

The research conducted by the DEN on reactor physics, nuclear safety and the fuel cycle rely on experimental facilities such as research reactors, hot labs and technology platforms. This fleet of facilities is undergoing a major refurbishment and optimisation programme to meet the evolving regulatory and research programme requirements.

## Jules Horowitz Reactor (JHR)

The construction of the JHR at Cadarache is a major project for the CEA. The JHR is the only reactor of its type being built in Europe. It will provide a unique tool for studying materials and fuels under irradiation to support current and future nuclear reactors. It will also be used to produce a sizeable fraction of the radioisotopes needed for medical purposes. The JHR project is funded via the French future investments programme and is being built within the scope of an international consortium, with the CEA as project owner, nuclear operator and contracting authority of the facility.

Clean-up and dismantling activities in a shutdown nuclear facility.

# Nuclear clean-up and dismantling

**Facilities having reached the end of their service life require the implementation of dismantling programmes. This includes all the activities carried out after final shutdown in order to reach a predefined end state for the facility. Other than clean-up and dismantling, such programmes also cover the retrieval and conditioning of legacy waste, including the deployment of cross-functional activities on all sites to support or coordinate the projects on a global level.**

These clean-up and dismantling programmes are supported by R&D activities to reduce the cost and duration of dismantling work, the doses incurred and the waste produced, while improving the working conditions at the sites.

## Dismantling sites

There are currently 28 regulated nuclear facilities (INB) or individual facilities undergoing dismantling at the DEN. The broad range of facilities to be dismantled - test reactors, laboratories, fuel cycle workshops and plants, waste treatment and storage facilities, etc. - means that the CEA cannot benefit from standardised or reproducible operations. Over the years, the CEA has gained significant experience, both in project ownership and in the methodologies and expertise required for the implementation of such dismantling projects.

Using the Maestro tele-operated arm to dismantle nuclear facilities.

## Cross-disciplinary programmes for clean-up and dismantling

To be able to make progress in clean-up and dismantling operations and the retrieval and conditioning of waste, cross-disciplinary programmes are needed to coordinate and support the different activities involved with such operations. These activities range from transportation and transport casks, waste and material flow management, operation of nuclear service facilities and the transfer of waste to existing and future waste outlets, as well as the R&D needed to support these worksites. These cross-disciplinary programmes are not just specific to clean-up and dismantling projects, however; they apply across all CEA activities, including research.

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