

# THE CIVIL NUCLEAR INDUSTRY

2009

According to figures provided by the IAEA, France has the second largest national nuclear power industry after the United States, with 58 reactors distributed over 19 sites throughout the country. France is the second largest producer of nuclear electricity in the world (78% of the total electricity produced), and this fact enables it to figure amongst the countries producing the lowest quantities of greenhouse gases (27<sup>th</sup> of the 30 countries in the OECD in terms of CO<sub>2</sub> production in relation to GDP). As a consequence, the French experience constitutes a reference in all of the sectors affecting the civil nuclear industry, namely research and development, construction and maintenance of the installations, and training of the staff (technicians, engineers and researchers, lawyers, etc.).

The Atomic Energy Commission (AEC), created in 1945, has been entrusted with the task of performing research and development, up to the industrial stage, regarding all of the processes and methods that are necessary for the production of nuclear electricity. The nuclear sector in France is expert in all of these stages, from upstream extraction of uranium and the manufacture of fuel to downstream management of the fuels used and of the waste materials produced.

The main participants in the industrial sector AREVA for the supply of nuclear components and services in the cycle, both upstream and downstream, namely EDF and GDF SUEZ for plant operation, ALSTOM for the conventional parts of the power plants (the turbines), as well as the network of small and medium sized companies and industries in the sector, providing opportunities of high-status employment for any engineers who are interested in the nuclear sector. Organisation of the public sector (apart from the AEC, the ASN and the IRSN for nuclear safety, and the ANDRA for management of the waste products) also supplies employment opportunities.

## THE NETWORK OF PRINCIPAL TRAINING ENTITIES IN FRANCE

In order to improve the availability of training in relation to the demand by staff in the nuclear sector, a committee for the coordination of training in nuclear science and techniques was created in 2008.

### • Paris and Ile de France

- Launch of a Master of Science degree in “Nuclear Energy” (September 2009), programmed over 2 years and taught through English, in a partnership between Université Paris-Sud, ParisTech (Ecole Polytechnique, ENSTA, Chimie Paris, Mines Paris, Ponts et Chaussées, and Arts et Métiers), Ecole Centrale Paris – Supelec, INSTN (Institut des Sciences et Techniques Nucléaires/AEC) and with the support of EDF, AEC, AREVA, and GDF-Suez
- a virtual doubling of the course capacities (100 student engineers) in “Atomic Engineering” of the INSTN. Engineers with more general qualifications are able to specialise here by obtaining an engineering diploma in Atomic Engineering in 1 year.

- Several new programmes on energy in the most renowned engineering colleges of the region (Mines, ENSTA, Ponts, Centrale, Supelec, etc.)
- Creation of complementary training in “Atomic Engineering”, at doctorate level, in the form of an international summer school, the first edition of which, in 2007, was a resounding success (70 participants).

### • Region Ouest (western region) around the Nantes-Caen-Cherbourg axis

- Nuclear instrumentation (ENSI Caen)
- Nuclear engineering and management of the nuclear waste products at the Nantes Ecole des Mines (start-up in September 2009 of 9 months of courses followed by industrial internship).

### • Region Sud-Est (south-east region) covering Grenoble, Montpellier, Aix-Marseille and Valence

- Chemistry for the nuclear industry: Master’s degree in CSMP (Separative Chemistry, Materials and Methods - Application to the nuclear fuel cycle) Université Montpellier 2 - Sciences et Techniques du Languedoc
- The physics of reactors: Phelma Grenoble
- Radioprotection: Université Joseph Fourier-Grenoble
- The science of materials: Grenoble INP - Phelma
- Engineering of nuclear power plants: Grenoble INP - Ense3
- Plant dismantling and waste products: Université Joseph Fourier-Grenoble
- Instrumentation: Université de Provence (Marseille)
- Nuclear safety: ENSAM Aix-en-Provence
- Nuclear engineering and civil engineering: INSA Lyon

Other higher education establishments in France also provide training courses in response to the needs of the nuclear sector, at Bac+5 level, in the form of options in engineering colleges, which can be taken after a preparatory class in higher or special mathematics, or a masters degree in one of the universities.

## RESEARCH THEMES

The strategic positioning of the AEC is structured around three research axes, namely:

- energy generation that does not emit greenhouse gases, including nuclear, this being its historical role,
- the information and health technologies,
- general defence and security

In these three areas which are essential to the country, the AEC plays a key role by ensuring a good collaboration between research, innovation and industry, which represent a generator economic development and a creator of jobs.

Alongside these three main axes, and the fundamental research base that supports them, the AEC also very often performs, jointly with the CNRS and the Universities, a mission of design, construction and operation of very large installations for the benefit of the national, European, and international scientific community (such as Synchrotron Soleil, Institut de Chimie Separative de Marcoule, ITER Cadarache site for controlled fusion and Neurospin on the Saclay site for cerebral imaging by magnetic resonance).

## INTERNATIONAL STANDING

The following are some examples:

-The European Union, the United States, Russia, Japan, China, South Korea and India are all collaborating in the ITER project, which is a long-term programme designed to study controlled nuclear fusion. Its objective is the construction and experimental operation of a magnetic containment chamber that is intended to control a plasma in order to study the possibility of energy production by nuclear fusion. The installation will be built at Cadarache in France.

- The countries to which France exports nuclear products, namely China, South Korea, Brazil, South Africa, and Europe. The industrial contracts in this type of export market are always accompanied by an offer of training for the construction and operating phases.

## Websites

- Training in nuclear engineering at the ONISEP site  
<http://www.onisep.fr>
- The Atomic Energy Commission - AEC  
<http://www.cea.fr/>
- The Nuclear Energy Agency of the Organisation for Economic Co-operation and Development - OECD  
<http://www.nea.fr/>
- The site of the International Atomic Energy Agency - IAEA  
<http://www.iaea.org/>
- The French Nuclear Energy Society:  
<http://www.sfen.org/>
- The INSTN ( Institut National des Sciences et Techniques Nucléaires)  
<http://www-instn.cea.fr/>
- The AREVA company  
<http://www.aveva.com/>
- The EDF company – Foundation for the Energies of the Future  
<http://www.energiesdedemain.com>

## Key words

IAEA - AREVA - sanitation/disposal in nuclear installations - astrophysics - AEC - nuclear power plants - separative chemistry - containment - nuclear waste products - civil engineering in nuclear installations - EDF - electricity - nuclear energy - environment - fission - fusion - neuroscience - optics - physics - plutonium - radioactivity - radiobiology - radiopathology - radiation - nuclear reactors - reprocessing of waste products - SFEN - nuclear safety - toxicology - uranium