FRENCH NUCLEAR EDUCATION AND TRAINING

SUPPORT TO NEWCOMER AND EXPANDING COUNTRIES
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The French electronuclear industry was born in the 1960s. Back then, France had very few domestic resources: neither coal, nor oil, but a strong desire to become energy independent. A whole industry gradually developed to build and then operate nuclear power plants and associated fuel cycle facilities.

The need for individuals who possessed specialized and thorough knowledge, skills and abilities soon became both critical and growing. To meet this need and ensure the safe operation of its newly built facilities, France progressively designed and implemented an exhaustive range of highly specialized programs to train its nuclear workforce. All programs were set up in close relationship with research organizations and industry so as to fully benefit from their latest advances and experience feedbacks.

Thanks to this careful and extensive work, the French nuclear education system now covers the complete spectrum of professions necessary to the development and operation of a fleet of nuclear power plants and fuel cycle facilities: technicians for operation, radiation protection, safety, security, and maintenance; engineers and researchers for design, operation and innovation; experts in all fields, such as materials, safety, radiation protection, nuclear law, and project management; managers; professors, and teachers to transfer the corresponding knowledge and skills.

Over the years, France has established active collaboration with many countries wishing to develop and expand their nuclear programs. Whether for the development of human capacity building roadmaps or the set-up of joint training centers, it has always worked hand-in-hand with fellow countries to help them achieve “safe, secure, and sustainable nuclear power programs”. These partnerships have been established in compliance with IAEA guidelines. At the request of IAEA, French nuclear educational institutions and industrial companies also regularly organize training courses for decision-makers on human capacity building and human resource development.

For countries that intend to develop civilian nuclear power programs, the major challenge is to ensure sufficient and well-trained staff to manage all the stages of their projects. France has been working on human resource development in the nuclear industry for nearly 60 years and has already been actively involved in many international nuclear projects. The high level of expertise of the French nuclear workforce is now a worldwide acknowledged asset of its industry. This expertise has been shared for decades with other countries and will be shared in the future with countries in need of support and assistance in the development of their nuclear power programs.

The International Institute of Nuclear Energy’s (I2EN) mission is to advise newcomer countries on the definition and implementation of their human capacity building plans and to coordinate academic and industrial players to this end. Together with its partners, whose education and training solutions are described in this handbook, I2EN assembles the most suited combination of training solutions adapted to the needs of newcomer and expanding countries.

I invite you to examine our offer in the following pages and wish you a pleasant read.

Yves Fanjas
I2EN Director
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NUCLEAR ENERGY IN FRANCE

58
PWR reactors in operation

63,130 MW
Installed capacity
- 34 PWR (900 MW/unit)
- 20 PWR (1,300 MW/unit)
- 4 PWR (1,500 MW/unit)

I
PWR EPR under construction in Flamanville

I
Reactors under dismantling

1,932
Reactor-years of experience

10
Research reactors,
1 temporary shutdown for refurbishment, 2 under construction
THE NUCLEAR POWER INDUSTRY PLAYS A MAJOR ROLE IN FRANCE’S ECONOMY*

- 1 owner/operator/architect-engineer: EDF, the world’s largest energy utility; operates the largest nuclear capacity in the world.
- 1 reactor vendor: FRAMATOME, with 100 GW nuclear generation capacity built with FRAMATOME’s participation, i.e. 26% of the global nuclear capacity currently in operation.
- 125,000 direct jobs in France, as much as aeronautics, i.e. ~4% of all industrial jobs.
- 220,000 total jobs generated in France by the nuclear power industry, i.e. 1% of total employment in the country.
- 12.3 billion euros in direct value added, i.e. 0.71% of France’s GDP, and 33.5 billion euros in total value added.
- ~440 specialized companies among thousands of suppliers to the industry have developed specific nuclear know-how.

* PricewaterhouseCoopers - The Socio-Economic Impact of the Nuclear Industry in France, PWC, 2011

NUCLEAR POWER REACTORS

1 under construction
58 operational
12 in permanent shutdown

ANNUAL ELECTRICAL POWER GENERATION

550.9 TWh
Total electricity generation (including nuclear)

403.7 TWh
Nuclear electricity generation

ELECTRICITY GENERATION SHARE

73.3%*
Nuclear share

26.7%
Non-nuclear share

* The world’s largest share of nuclear power
The analysis and taxonomy issued by this committee provides France with unequalled tools to assess not only its own needs, but also to help its fellow countries assess theirs. Nowadays, about 220,000 people work for the nuclear industry in France. The sector counts a total of 125,000 direct jobs, and 95,000 indirect jobs. These jobs correspond to a large range of professions, most of which are not specific to the nuclear industry but require absolute professionalism, safety, and security assurance.

To train its nuclear workforce, France has been developing specialized programs since the construction of its first nuclear power reactor 58 years ago. The French nuclear education system now counts about 1,400 graduates each year, one of the world’s highest rates of graduates in nuclear energy science and engineering. According to the latest surveys, around 100 technicians (vocational high school degree), 50 advanced technicians (vocational Associate’s degree), 230 Bachelors (vocational Bachelor’s degree), 800 Masters, and over 200 Doctors specializing in the nuclear field enter the French job market every year. Most of these future professionals received formal classroom, laboratory, and on-the-job training, either through internships, apprenticeship programs or during their PhDs. Some companies complement this training with in-house training for new recruits and all of them offer continuing education for their employees. On average, an employee of the nuclear sector receives 16 days of training per year. This system guarantees not only that the future nuclear workforce is skilled and meets the needs of the industry, but also that the current workforce remains completely up-to-date of new developments in nuclear technologies, safety, security, and good practices.

In 2011, the French Government decided to set up a Nuclear Sector Strategic Committee (CSFN - Comité stratégique de la filière nucléaire) to assess the industry’s future needs in terms of personnel and the adequacy between training programs, skills, and jobs.

![Diagram showing the types of nuclear experts](image-url)

**ONLY 5% OF THE WORKFORCE NEEDS TO BE TRAINED FOR NUCLEAR-SPECIFIC JOBS**

- **Nuclear**
  - Nuclear experts working on primary circuit and core design, safety, and research

- **Nuclearized**
  - Staff with sound nuclear knowledge and know-how, such as plant system engineers, operation managers, and nuclear maintenance personnel

- **Nuclear aware**
  - Staff with no nuclear background but with strong nuclear safety culture, such as manufacturing and non-nuclear maintenance personnel
16 AREAS OF EXPERTISE

Technical professions of the nuclear sector are divided into 16 areas of expertise offering three different types of positions: worker, technician, and engineer. By cross-referencing these categories, a direct link can be established between the current and future needs in skills and the degrees of education that already exist or have to be set up.

- Project management,
- Radiation protection,
- Safety and neutronics,
- Materials and structure (pressurized equipment, metalworking, nondestructive testing),
- Waste management,
- Fluid mechanics,
- Chemistry and environment,
- Processes,
- Tests,
- Mechanics,
- Automation, electronics and industrial data processing (control), and instrumentation,
- Civil engineering and construction,
- Logistics and construction site management,
- Planning, scheduling,
- Pipe work and sheet metal work (welding),
- Electricity.

3 CAREER PATHS

The training offer to maintain and develop skills is very diverse in terms of degrees (university degrees, vocational certificates, specific accreditations, etc.), audiences (students, employees, workers in retraining programs, job seekers, etc.), and training providers (vocational high schools, universities, graduate schools, industrial corporations, certification organizations, etc.). Nuclear education can be divided into three categories:

<table>
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<tr>
<th>Workers</th>
<th>Technicians</th>
<th>Engineers</th>
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<td>Associate’s degrees</td>
<td>Master’s of Engineering degrees</td>
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<td>Vocational certificates (GED*)</td>
<td>Advanced technician degrees (two-year education programs)</td>
<td>Master’s of Science degrees</td>
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<td>One-year undergraduate programs</td>
<td>Vocational certificates</td>
<td>Post-master’s certificates</td>
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<td></td>
<td>Vocational Bachelor’s of Science degrees</td>
<td>PhDs</td>
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* GED: General educational development test

All of these jobs and skills—regardless of the level of education—are necessary to the safe and sustainable development and operation of a nuclear power program. Human capacity building is a collective work that must be undertaken by all the players involved in the development of the nuclear power program: academia, research organizations, safety organizations, and industry.
HUMAN CAPACITY BUILDING AND HUMAN RESOURCE DEVELOPMENT FOR NEWCOMER AND EXPANDING COUNTRIES

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AN INTERNATIONAL NETWORK TO ADVISE YOU ......................... P18
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One of the biggest challenges faced by a country embarking on a new nuclear energy program is human capacity building. Many questions arise when it comes to training personnel: how many technicians, engineers, and doctors do I need? When do I need to start training them? Which institutions do I have to set up in order to have an efficient nuclear education system?

The first step a newcomer country has to take is to develop a reliable and realistic human resource development roadmap, consistent with its national resources. The generic HCB roadmap opposite illustrates all the elements a newcomer country has to take into account when considering developing a civilian nuclear power program. It is based on and compliant with IAEA Milestones. Please keep in mind that it needs to be adapted to each country’s specific needs and resources.

**AIEA’S DEFINITION OF HCB:**
“**A SYSTEMATIC AND INTEGRATED APPROACH TO DEVELOP AND CONTINUOUSLY IMPROVE GOVERNMENTAL, ORGANIZATIONAL AND INDIVIDUAL COMPETENCES AND CAPABILITIES NECESSARY FOR ACHIEVING SAFE, SECURE AND SUSTAINABLE NUCLEAR POWER PROGRAM.**”

**Example of an HCB roadmap for a newcomer country**
Setting up a human capacity building plan and the ensuing education and training system is essential to the development of an electronuclear culture, program, and industry. France has been sharing its knowledge and know-how in the field with fellow countries for decades. Sharing this expertise has contributed to making some then newcomer countries the major nuclear players they are today. At present, French educational institutions, industrial companies, R&D organizations, and safety organizations are more than ever willing to offer HCB guidance and training solutions to make today’s newcomers become nuclear countries of tomorrow.

Together, these players offer comprehensive and customizable solutions to newcomer and expanding countries requesting their support and guidance in the development and set-up of training solutions tailored to their needs. These solutions include a whole range of innovative pedagogical tools such as e-learning platforms, simulators, virtual reality platforms, and full-scale models.

**RELY ON FRANCE FOR ELECTRONUCLEAR HUMAN CAPACITY BUILDING**

**A COMPREHENSIVE OFFER FROM HCB GUIDANCE TO CUSTOMIZED TRAINING PROGRAMS**

- Full-scope analysis of HCB and HRD immediate and long-term needs
- Support in drawing up national HRD master plans
- Support in developing educational and vocational training programs (SAT-based)
- Help in the design of nuclear curricula and implementation of nuclear engineering programs
- Support in developing strong nuclear safety culture
- Advice from France’s best experts in the field
- Networking opportunities through international organizations and bilateral cooperation & partnerships
- Training of senior executives on new nuclear projects management
- Training for different job positions (including instructors)
- Retraining (e.g. for employees from the fossil or hydro sectors)
- Customized and on-demand train-the-trainers programs, study tours, summer schools, seminars, for professionals to enhance and update their nuclear knowledge
- Organization of courses, together with IAEA, to train nuclear professionals from newcomer & expanding countries: Leadership & Management of Nuclear Power Programs, Fellowship Training on Supply Chain Management, etc.
- Support in developing training centers (including material and equipment)
- Transfer of know-how
- Experience feedback and sharing
- Answers to students’ requests for career guidance
- Partnerships between French universities and universities from newcomer and expanding countries
- Welcome of international students in French universities and world-leading nuclear corporations (internships)
- Exchange programs for academics, researchers, and students
- Establishment of partnerships between French universities and universities from newcomer and expanding countries
- Welcome of international students in French universities and world-leading nuclear corporations (internships)
- Exchange programs for academics, researchers, and students
Launched in September 2014 at IAEA Headquarters in Vienna, the Capacity Building Initiative (CBI) aims at understanding the Human Capacity Building (HCB) needs of newcomer, expanding, and nuclear countries. It shall pool together the HCB offers of all Member States and IAEA to produce an exhaustive program directory. The ultimate goal of the Initiative is to identify the gaps between the needs and the offer and to fulfill them by setting up new programs and complementing the global offer.

The CBI is to promote nuclear HCB to all IAEA Member States and to involve all of them to enhance nuclear HCB worldwide.

The Initiative is based on the four pillars identified by IAEA as the cornerstones of HCB: Human Resource Development (HRD), Education & Training (E&T), Knowledge Management (KM), and Knowledge Networks (KN). It includes the following actions:

**HUMAN RESOURCE DEVELOPMENT**

Developing human resource roadmaps that meet countries’ needs.
- Improving the definition of HRD roadmaps,
- Strengthening HRD roadmaps in newcomer, expanding, and nuclear countries,
- Preparing the 3rd IAEA Conference on HRD (2018).

**KNOWLEDGE MANAGEMENT**

Capturing, structuring, and transferring knowledge to future generations.
- Promoting e-learning tools,
- Promoting the use of IAEA’s platforms,
- Sharing & promoting public acceptance tools, such as the American “Amazing Atoms” App or the “Energy Days” organized by EDF.

**EDUCATION & TRAINING**

Providing the current and future nuclear workforce with structured knowledge and skills at the right time.
- Producing a World Nuclear Capacity Building Inventory,
- Helping newcomer and expanding countries carry out their self-assessments,
- Developing local training centers and training curricula in regions in need.

**KNOWLEDGE NETWORKS**

Sharing knowledge and best practices through networking
- Helping identify ICERR (International CEnter based on Research Reactor) needs,
- Assisting new ICERR candidates,
- Estimating a target number of ICERR trainees/year,
- Creating regional & global knowledge networks.
AN INITIATIVE FOR CONCRETE AND SHORT TERMS ACTIONS

WORLD CAPACITY BUILDING INVENTORY
- A database for IAEA to list reference HCB contact points in all Member States,
- A directory of all existing HCB offers dedicated to nuclear,
- A tool to help IAEA find the right answer when a need is identified.

PROMOTING HRD & HCB

BRINGING ASSISTANCE TO ICERR CANDIDATES
- The Jules Horowitz Research reactor was the first to apply for ICERR candidacy,
- France has designed templates for the candidacy report and inspection mission and is willing to help any country that would like to propose its own research reactor for ICERR candidacy.
France supports the development of civilian nuclear power worldwide and promotes the guiding principles that ensure the responsible and sustainable use of nuclear energy.

France developed bilateral relations with many countries on the peaceful use of nuclear power. Intergovernmental agreements on nuclear cooperation have been signed with over 30 countries:

**Nuclear energy countries**
The United Kingdom, the United States, Russia, China, India, Japan, Finland, South Africa, Brazil, Morocco, Tunisia, Vietnam, Korea, etc.

**Newcomer and expanding countries**
The Kingdom of Saudi Arabia, Turkey, the United Arab Emirates, Jordan, Poland, etc.

Several contact points have been set up to help and guide newcomer and expanding countries develop their own civilian nuclear power programs:

**INSTITUTIONS**

**CEA, THE FRENCH ATOMIC ENERGY AND ALTERNATIVE ENERGIES COMMISSION**
CEA is the French government representative for institutional relations with countries wishing to turn to nuclear power. French nuclear representation worldwide is ensured by a network of nuclear advisors from CEA within French embassies abroad. Nuclear advisors act as intermediaries between major nuclear players of the countries they are posted in, and French players: government departments, industrial companies and research organizations. Thanks to their knowledge of the local issues and needs with regards to CEA’s fields of expertise, nuclear advisors help develop strategic partnerships, promote CEA’s offer abroad and encourage mobility of both people and knowledge.

Nuclear advisors are present in countries that play major roles in the field of nuclear science and technology and in countries that are actively looking to acquire nuclear equipment.

**AFNI, THE FRENCH INTERNATIONAL NUCLEAR ENERGY AGENCY**
As a Government agency, AFNI’s mission is to organize and coordinate the actions of all French public authorities and institutions involved in collaboration with countries embarking or re-embarking on nuclear power programs. AFNI’s action covers all such countries which have intergovernmental agreements with France. In the earlier stages of nuclear power programs and through constant dialogue with local authorities and stakeholders, AFNI’s work focuses on raising decision makers’ awareness on major topics such as legal frameworks, safety organizations and regulation schemes, public information and stakeholders’ involvement, radioactive waste policy, and academic involvement. As projects develop, AFNI extends its activity up to the establishment of peer-to-peer collaborations between French public entities and their local counterparts. AFNI’s activities rely on the expertise of French government authorities and public institutions specializing in nuclear power such as the Atomic Energy and Alternative Energies Commission (CEA, see p. 54), the Institute for Radiation Protection and Nuclear Safety (IRSN, see p. 58), and the French National Agency for Radioactive Waste Management (Andra, see p. 52). The agency also draws on the non nuclear-specific expertise of some organizations which competences are necessary to the safe development of a nuclear build program (e.g. geology and site studies). In the field of education and training, AFNI calls upon I2EN.
CEA’S NETWORK OF NUCLEAR ADVISORS ACROSS THE WORLD

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FRANCE HAS BEEN SHARING ITS KNOWLEDGE AND EXPERTISE WITH ITS INTERNATIONAL PARTNERS FOR DECADES.

• OVER 40 YEARS OF SUCCESSFUL HCB GUIDANCE AND COOPERATION WITH FELLOW COUNTRIES SINCE THE 1970s.

• OVER 55 PARTNERHIPS WITH TOP UNIVERSITIES WORLDWIDE. SET UP OF JOINT TRAINING CENTERS.

• OVER 850 TRAINEES FROM FOREIGN NNP OPERATORS TRAINED OVER THE PAST 30 YEARS.

• 346 REACTORS SUPPORTED, OUT OF THE 435 IN OPERATION (I.E. 80% OF NUCLEAR GLOBAL FLEET), WITH PRODUCTS AND SERVICES.

• 100% SUSTAINABLE DEVELOPMENT POTENTIAL OF LOCAL NUCLEAR INDUSTRIES – BOTH NPP AND FUEL CYCLE – THROUGH TECHNOLOGY TRANSFER AND SKILLS DEVELOPMENT, INCLUDING R&D SUPPORT.

### INTERNATIONAL REFERENCES

#### ORANO & FRAMATOME

**CHINA**
- Taishan EPR: 166 training courses on nuclear islands’ EPR technology. 1,284 Chinese engineers trained in Europe and China,
- Contract signed with CNPE (CNNC Group): training of 40 top executives in project management.

**SOUTH AFRICA**
- Training of AREVA local supply chain partners,
- Master’s degree in project management and tailored-made training for 40 high-potential future project leaders,
- Study tour for a South African delegation from the National Empowerment Fund.

**POLAND**
Initial training for 37 Polish university professors organized by AFNI, I2EN, AREVA, EDF, CEA/INSTN, IRSN, ANDRA
- Technology training,
- Site visits,
- Experience sharing,
- Networking with French academic partners.

**SAUDI ARABIA**
- French cooperation (AREVA, EDF, CEA/INSTN, MINES NANTES, I2EN) to propose a skill development roadmap,
- On-going project to set up a training center and build a regional network of academic and industrial partners,
- Study tour for 19 Saudi academics and nuclear professionals,
- Suppliers excellence training.
CORYS

In the past 25 years, CORYS has installed 120 simulators in over 15 countries:

- **USA**
  - Constellation (Calvert Cliffs, Ginna, Nine Mile 1, Nine Mile 2).
- **CHINA**
  - CGNPC (Ling AoII),
  - TNPJVC (Taishan),
  - State Universities (SWU, NUAA, NJIT, HIT, NEDU, TT).
- **RUSSIA**
  - BELOYARSK.
- **INDIA**
  - BHEL.
- **AUSTRALIA**
  - Royal Australian Navy.
  
And in Armenia, Bulgaria, Greece, the Republic of Kazakhstan, the Slovak Republic, the United Kingdom, Belgium, the Czech Republic, Lithuania, the Republic of Sudan, and Ukraine.

EDF

Over the years, EDF has provided training support to several countries:

- **CHINA — DAYA BAY AND LING AO NUCLEAR POWER PLANTS**
  - Initial training in France of 170 engineers, followed by on-the-job training and coaching in China during the first years of operation,
  - Support for the implementation of a local maintenance training centre with training advisors,
  - Training of fuel handling operators, followed by the support for the development of a local fuel handling training center,
  - Post-accident operations training of more than 50 operators and managers using the State-Oriented Approach.

- **CHINA — TAISHAN EPR NUCLEAR POWER PLANT**
  - Shadow training of about 70 operators, shift managers and safety engineers,
  - Secondment of EDF instructors.

- **SOUTH AFRICA — KOEBERG NUCLEAR POWER PLANT**
  - Initial training of engineers for start-up and commissioning,
  - Full training, including shadow training of 100 engineers and technicians.

- **UNITED KINGDOM — HINKLEY POINT C NUCLEAR POWER PLANT**
  - Initial training of 120 new graduates,
  - EPR initial training delivered to more than 170 new staff members,
  - Mentoring of trainees as a key success factor, with continuous assessment and coaching.

CEA/INSTN

- Founding Member of ENEN and Chair of ENEN from 2003 to 2013,
- Tailor-made courses (nuclear safety, radiation protection, etc.) at the request of IAEA for 40 years,
- Participation in various European FP7 projects aiming at building nuclear training schemes in engineering (ENEN III), safety culture (NUSHARE), and radiation protection (ENETRAP III and PETRUS III).

ECOLE DES MINES DE NANTES

- 10 double-degrees in the nuclear fields with educational institutions around the world (Europe, North America, and Asia),
- Participation in I2EN’s actions in Saudi Arabia.
NUCLEAR EDUCATION AND TRAINING IN FRANCE

I2EN ........................................................................................................................................................................... P24
ORGANIZATION ........................................................................................................................................................ P26
A FULLY COMPREHENSIVE NUCLEAR EDUCATION AND TRAINING SYSTEM .................................................. P27
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NUCLEAR EDUCATION & TRAINING IN FRANCE

I2EN
International Institute of Nuclear Energy

Our mission: coordinating the French offer in nuclear human capacity building.

THE INTERNATIONAL INSTITUTE OF NUCLEAR ENERGY
The International Institute of Nuclear Energy (I2EN) represents and coordinates France’s nuclear industry, R&D, and academia abroad to support and foster the export of French nuclear technologies. By bringing together all the players of French industry, R&D, and academia, I2EN serves as a unified voice for countries wishing to develop nuclear curricula and to benefit from the French expertise in the field.
The mission of the Institute is to provide newcomer and expanding countries with the best training solutions for human resource development in nuclear energy and to help and guide them in the development of their own nuclear education & training systems. I2EN is here to share best practices in human capacity building so as to contribute to the safe and reliable implementation of civilian nuclear power programs in newcomer and expanding countries.
I2EN also reviews French nuclear educational programs with regards to the needs of the industry and accredits them through its independent Committee of Experts.

I2EN’S TOOLS FOR NEWCOMER AND EXPANDING COUNTRIES
I2EN conducts an annual survey on nuclear education and training programs in universities and engineering schools. This survey consists of listing nuclear-specific curricula and analyzing their contents. Since 2010, I2EN has been collecting data on over 80 French Master’s degrees and 47 undergraduate degrees (from high school diplomas to Bachelor’s degrees) in nuclear energy.

THE MISSION OF THE INSTITUTE IS TO PROVIDE NEWCOMER AND EXPANDING COUNTRIES WITH THE BEST TRAINING SOLUTIONS FOR HUMAN RESOURCE DEVELOPMENT IN NUCLEAR ENERGY.
The outcome of this survey is summarized in the I2EN handbook on nuclear education & training in France. The handbook offers a selection of first-class Master’s programs in the field and gives key information to understanding the French academic system. You will also find a list of institutions awarding vocational high school diplomas, advanced technician degrees, Associate’s degrees, and vocational Bachelor’s degrees in nuclear environment and maintenance. Check it out online at www.i2en.fr or ask for your own hard copy at contact@i2en.fr.
Under specific agreements with industrial companies, academic institutions, and Government organizations from France’s partner countries, I2EN and its partners
• assess your immediate and long-term needs,
• support and guide you in the design of your nuclear workforce development plan,
• develop academic programs in the universities of your country (BS, MS, and PhD programs),
• register students and interns in existing academic and internship programs in France,
• implement vocational training solutions and set up vocational training institutions,
• develop on-the-job training programs directly related to your current nuclear projects.
I2EN’S PARTNERS AND ASSOCIATE MEMBERS

* ParisTech, the Paris Institute of Technology, is a consortium of 12 Graduate Schools of Science and Technology among which 6 offer programs in electronuclear science, engineering, and chemistry: ARTS ET MÉTIERS ParisTech, CHIMIE ParisTech, ÉCOLE POLYTECHNIQUE ParisTech, ENSTA ParisTech, MINES ParisTech, PONTS ET CHAUSSÉES ParisTech.
NUCLEAR EDUCATION & TRAINING IN FRANCE

ORGANIZATION

YOUR CONTACT POINT
Providing France’s international partners with the best nuclear E&T solutions for human capacity building

EDUCATIONAL INSTITUTIONS

Players
- Specialized institutes
- High schools
- Graduate Schools of Engineering
- Universities
- Continuing education institutes

Assets
- From high school to university
- Focus on professional and research skills
- Welcome international students
- PhDs

INDUSTRY

Players

Assets
- Teach to operate NPP in a safe and competitive way
- On-site operation-like experience using simulators
- Full-scale NPP models allowing to train the entire supply chain staff
- Provide internships for students
- PhDs

R&D WASTE MANAGEMENT
NUCLEAR SAFETY

Players

Assets
- Active collaboration with the industry
- State-of-the-art experimental facilities & simulation tools
- Provide internships for students
- PhDs

Academic education

Hands-on training

Vocational training and research training

All these players are at your service to support you and share their expertise in nuclear education and training.
NUCLEAR EDUCATION & TRAINING IN FRANCE

A FULLY COMPREHENSIVE NUCLEAR EDUCATION AND TRAINING SYSTEM

Assets and added-value of the French system

In 60 years, France has not only acquired invaluable expertise but has also had time to develop a fully comprehensive system. The French nuclear education and training system...

... covers all stages of the nuclear cycle
- Uranium mining
- Fuel manufacturing
- NPP engineering
- Construction
- R&D
- NPP operation
- Fuel reprocessing
- Maintenance
- Radiation protection
- Transports and logistics
- Waste management, processing, and storage
- Decommissioning and dismantling

... is provided by all types of players
- Educational institutions
- Industrial companies
- R&D organizations
- Safety organizations
To enjoy the latest technologies & experience feedback, to offer real-conditions internships, to raise safety awareness, and to benefit from the experience of the best teachers in the field.

... offers all levels of education
- Vocational high school diplomas
- One-year undergraduate programs
- Vocational certificates
- Associate’s degrees
- Advanced technician degrees
- Vocational Bachelor’s of Science degrees
- Master’s of Science degrees
- Master’s of Engineering degrees
- Post-master’s certificates
- PhDs

... covers all topics and infrastructures described in IAEA Guidelines
- Project management
- Nuclear law
- Finance
- Localization of the nuclear supply chain

... enjoys outstanding facilities and tools
- National nuclear campus
- NPP simulators
- Training centers with full-scale models of NPP components
- Training facilities and courses in safety, construction, operation, emergency planning, supply chain, etc.
- Innovative pedagogical tools: virtual reality platforms, serious games, simulators, etc.
- Distance education: MOOCs, remotely supervised lab work, e-Learning, etc.

... is acknowledged worldwide by international organizations
- IAEA
- OECD/NEA
France has an extensive network of training facilities dedicated to nuclear energy.

EDF VOCATIONAL NUCLEAR TRAINING UNITS
EDF vocational nuclear training units deliver initial, continuing and advanced nuclear training at all 22 training centers. More than 760 skilled and recognized professional instructors design training courses to address all the training needs. They deliver initial, continuing and just-in-time training. Hands-on training complements the theoretical training with full scope simulators, mock-ups and O&M workshops with equipment at each local training center. Saclay training center is dedicated to training for new nuclear projects. To this end it is equipped with a PWR simulator and an EPR simulator operated in English. Other equipments are available such as flow loop simulators, part task and post accidental physical phenomena study simulators, and valves workshops. In addition, Bugey national training center is dedicated to maintenance and technical support personnel training.

GLOBAL TRAINING CENTER INNOVATION AND KNOWLEDGE TRANSFER
From 2016 onwards, the EDF Saclay campus (near Paris) will become the largest European energy professional training center. The 25,000 m² center will offer the latest training tools, its proximity with the EDF R&D center, the top universities, and EDF partners R&D centers, enhancing cross-learning opportunities.

EDF ENERGY TRAINING FACILITIES
Cannington Court training center offers innovation, inspiration, inclusiveness and a chance to engage with new ways of thinking, learning and cutting edge technologies in fabulously restored listed buildings. It is a place in which people can experience the digital future using innovative tools to discover new ways of learning that will appeal to all different styles of learning.

Portsmouth is the place of a residential apprentice training facility in which 60 new technical apprentices are trained per year.

EDF – AREVA

NPP TRAINING CENTER WITH FULL SCALE MODELS
Founded by AREVA and EDF, the CETIC training center is dedicated to the qualification of personnel and the preparation of outage operations on pressurized water reactors (PWRs). This 4,000 m² facility offers unique hands-on training using full-size components of a PWR complemented by standard training rooms, delivering an outstanding learning experience, with a focus on fuel handling for both initial qualification and just-in-time training.
ORANO & FRAMATOME
INTERNATIONAL TRAINING FACILITIES CLOSE TO CUSTOMERS

AREVA LEARNING SOLUTIONS FOR THE NUCLEAR INDUSTRY
A variety of teaching tools
• E-learning,
• Learning tours and visits of operating nuclear facilities,
• Training courses with instructors,
• High-level conferences.

Exceptional training facilities
• Simulator training,
• Experimental reactor training,
• AREVA plants under operation,
• Reactor commissioning: both a pilot & a training facility.

CEA/INSTN
A UNIQUE RANGE OF TRAINING FACILITIES
As support for a full range of courses, INSTN has cutting-edge teaching tools that add real value to the courses by placing learners in practical situations close to reality:
• ISIS, a 700 kW pool type training reactor,
• PWR simulators for normal and accidental conditions,
• Laboratories: radiation protection, physics, radiation chemistry and biology, nuclear measurements, materials characterization,
• Full-scale mock-up facilities for hands-on training in maintenance or decontamination techniques in hostile environments,
• IT equipment: R&D and radiation protection computation codes, serious games for E&T in radiation protection, virtual environments for decommissioning and radiotherapy training.

CORYS (AREVA GROUP)
THE WORLD EXPERT IN POWER SIMULATOR DEVELOPMENT
Corys delivers training courses to the Nuclear Industry in its Grenoble Training center since 1989.
• Over a hundred nuclear simulators around the world,
• Computer-based training,
• Reactor simulators for basic principle and accident initial PWR training,
• In conjunction with EDF, CORYS is currently developing the world’s first EPRTM full-scope reactor simulator.
* Please note that these do not represent all French nuclear industrial companies but only those who provide and offer a significant amount of in-house nuclear training for their own personnel and for external customers.
EDF is the world’s largest producer of electricity, covering all aspects, from engineering and generation to transmission, distribution, and delivery. Among the ten greatest energy companies, the EDF group has the lowest CO2 emitting fleet per kilowatt-hour produced thanks to the share of nuclear power, hydraulics and other renewable energies in its production mix.

EDF’S NUCLEAR ASSETS IN THE WORLD
We own and operate 78 nuclear reactors worldwide. Of these, 58 are in France, 15 are in the UK and 5 are in the USA that we hold 50/50 jointly with Exelon. Due to its heavy investment in nuclear power, France is the smallest emitter of carbon dioxide among the seven most industrialized countries in the world.

A NEW SERIES WITH EPRs
We are investing heavily in new-generation EPR reactors. The Flamanville-3 reactor in France is under construction as are the two units at Taishan in China and at Hinkley Point in the UK. Two other units are under development in the UK.

EDF’S NUCLEAR EXPERTISE
Our expertise in the nuclear field is very broad with more than 30,000 employees in the nuclear sector in France. Of these 23,000 are in operations, 6,000 in engineering and 1,000 in R&D.

KEY FIGURES
• €69.6 B sales in 2017
• 35.1 million customers
• 152,033 employees
• 87% CO2-free energy
• €662 million R&D budget
TRAINING

EDF NUCLEAR ACADEMY
As an owner/operator, EDF has set up a comprehensive training system for those employed in the engineering and generation sectors so that its NPPs are safely designed, built and operated.

IN-HOUSE TRAINING
EDF Nuclear Academy’s introductory and continuous training programs cover the whole set of skills required for the pre-project, project development, design, construction and operation, and decommissioning stages of a nuclear power plant’s life. We have implemented the “Systematic Approach to Training” methodology to make sure our staff reaches the highest level of safety and performance. We ensure that those trained with us first acquire common knowledge and fundamentals by completing core modules, and then acquire the specific knowledge they need for their professions and improve their skills by completing a variety of advanced modules. In-house training capabilities deliver the best preparation across a broad range of disciplines, for both EDF and EDF’s partners.

INNOVATIVE LEARNING
EDF uses the latest and most appropriate innovative tools to enhance the learning experience. Teaching and learning methods include e-assessment, e-learning, interactive videos, serious games, on-site visits, simulators and learn-by-doing.

CONTINUOUSLY IMPROVING TRAINING PROGRAMS
Training programs are constantly evaluated and revised to include new requirements and to incorporate lessons learned using our unique professional network of experts and cross-training relationships with universities, industry and institutional partners, and R&D.

TRAINING FACILITIES
EDF has a large number of training centers covering a broad range of skills (see p. 28).
Framatome is a major international player in the nuclear energy market recognized for its innovative solutions and value-added technologies for designing, building, maintaining, and advancing the global nuclear fleet. The company designs, manufactures and installs components, fuel and instrumentation and control systems for nuclear power plants and offers a full range of reactor services.

With 14,000 employees worldwide, every day Framatome’s expertise helps its customers improve the safety and performance of their nuclear plants and achieve their economic and societal goals.

Framatome is owned by the EDF Group (75.5%), Mitsubishi Heavy Industries (MHI – 19.5%) and Assystem (5%).

KEY FIGURES

- 14,000 employees
- Experience on over 250 reactors worldwide
- 3,500 patents covering about 680 inventions
- 750 open positions in 2018
- 320 apprentices per year
Our industry is going through a time of transition with a generation of plant personnel retiring and new professionals entering the workforce.

With Framatome’s training portfolio, we are working to foster operational excellence, to facilitate knowledge transfer and to provide utility employees with the information and skills they need to continue operating nuclear energy facilities safely and at optimal performance.

Our training offer covers several introductory courses and also a number of up to date Framatome technology courses. Our trainers are specialists and will share with you their technical experience. Our pedagogy is active. Many courses are illustrated by on real time simulator exercises. Our catalogue includes a range of standard courses. With our experience we can also offer individual programs specific to your company.

A WORLD LEADER IN POWER PLANT SIMULATORS

We are particularly experienced in the development of simulators for under-construction plants, such as the simulators developed for Flamanville 3 and Taishan EPR units. Our integrated system developed by CORYS aims at enhancing pedagogy for better understanding of the physical phenomena, plant processes and cycle events of a PWR nuclear plant. It combines simulators and training content, and alternates between periods of tuition, tutorials, and practical exercises. Our training suite covers most of the needs of an academic nuclear engineering or NPP design program. These tools can also serve to train engineers working in the nuclear industry in order to improve general knowledge of power plant design and operation. The training suite comprises 3 off-the-shelf set of simulation tools which, used together, are the first integrated training center available worldwide. It enables to train people for all kinds of situations: from normal operations to severe accidents and I&C regulation design:

- PWR C1300 is dedicated to physics principles, normal operations and PWR concepts.
- PWR X1300 is a more advanced version and enables trainees to focus on and become familiar with abnormal procedures and accident handling,
- The PWR M series is a set of modules that provides dedicated self-training on precise topics (systems and regulation) typical of a large set of PWRs.

Our reactors training center in France offers over 35 training courses in the following fields:

- Introduction courses for PWRs
- Advanced courses for PWRs
- PWR operation

Our specific courses handle topics such as the discovery of the ASME, RCC-E, RCC-M, RCC-MRx or RSEM codes. Our courses are provided on demand and can be delivered in our training center in Paris or at other locations upon request.
The nuclear sector is an industry of the future, one that creates value and jobs. It is its capacity to provide powerful, safe, low carbon and competitively priced electricity that fully gives it its place among the energies of tomorrow. It is an energy source that is essential to meet the challenges our world is facing: to double the production of electricity whilst halving the production of greenhouse gases.

Our expertise at Orano: to supply high-tech products and services right across the nuclear fuel cycle, from mining to dismantling, as well as in conversion, enrichment, recycling, logistics, engineering and nuclear medicine. It is this internationally-recognized expertise that provides the foundation for the relationship of trust that we have built up over time with our customers.

Our priorities: creating value for our customers, innovation and operational excellence.

Our values: responsibility and safety, customer satisfaction, continuous improvement, respect and people development, cohesion and team spirit, leading by example, and integrity.
MULTIDECADAL EXPERIENCE IN SKILLS DEVELOPMENT FOR THE NUCLEAR INDUSTRY
• Vocational and regulatory training,
• Training centers close to industrial and nuclear sites (Mining college, “Ecole des métiers” at La Hague, Trichom…),
• Design of training modules, learning solutions, tailored-made training and career-specific programs for nuclear professions,
• Innovative educational means: e-learning, serious game, virtual reality, simulators, study tours including site visits, interactive classroom modules…

A UNIQUE MASTERY OF THE NUCLEAR CYCLE AND OF A DEEPLY RENEWED INDUSTRIAL TOOL OVER THE LAST TEN YEARS (CONVERSION/ENRICHMENT/RECYCLING)
Thanks to its wide range of professions—from mining to dismantling, and by relying on teams experienced in sharing and transferring knowledge, on high-quality pedagogical contents, on distinctive industrial and engineering tools, on the experience of its deep transformation over the past few years, Orano’s training offer is both large

and well-integrated in the global French training offer coordinated by I2EN. Our offer includes the following:
• Introduction to nuclear Cycle,
• Nuclear project management,
• Nuclear Safety skills,
• Design, operation, maintenance and decommissioning of nuclear facilities,
• Support for the definition of partners’Human Resource Development roadmap,
• Transformation and Excellence programs for managers,
• Leadership programs and learning solutions for Executives.

We are able to partner with all French nuclear energy players to address the needs in Human Capacity building of newcomer and expanding countries.

NUCLEAR CYCLE TRAINING 2.0
We are also able to develop and customize innovative solutions to train and develop people faster and deeper. By leveraging up-to-date technologies such as virtual or augmented reality, we deliver programs able to constantly improve nuclear safety and operational performance while reducing workers’ exposure to radioactive environment.
The global energy landscape has changed significantly in recent years. Faced with global warming, the increasing scarcity of raw materials and the inequality in sources of supply, the energy transition has gradually become a necessity to reduce the energy-related environmental impact while at the same time supporting growing energy needs.

ENGIE is committed to addressing these energy challenges of the coming decades by putting responsible growth of its businesses to rise to the challenges of the energy transition towards a low-carbon economy. For the Group, nuclear energy, as a low carbon source of electricity with high availability factors and easy access to fuel, is a significant contributor, in countries that have made this choice, to the energy transition.

ENGIE is one of the few European groups with more than 50 years of nuclear-related expertise all along the nuclear value chain, developing expert skills in engineering, procurement, construction and installation, operations and maintenance, nuclear fuel cycle, radioactive waste management, decommissioning. Besides ENGIE’s extensive experience as a leading European nuclear operator, the Group’s ambitions in nuclear services activities can be summarized as follows:

- Strengthening construction and installation activities for Nuclear New Build projects including large nuclear research installations worldwide;
- Developing offerings in connection with spent fuel & radioactive waste management and decommissioning & dismantling of nuclear facilities;
- Developing the existing competences in project development and operational readiness type of services, addressed to developers, vendors, state-owned or private utilities, regulators or governments.

Nuclear safety is the essential guiding thread and the key consideration at every stage of ENGIE’s nuclear activities.

**KEY FIGURES**

- 50 years of expertise in nuclear power
- 7 reactors in operation in Belgium
- 6,134 MW of nuclear capacity
- 16 subsidiaries expert in all areas of nuclear power
- More than 9,000 employees specialized in nuclear power
AN HR TOOL FOR THE GROUP’S NUCLEAR STRATEGY
To roll out our strategy and achieve our nuclear ambitions, we need the very best talent. ENGIE currently employs over 6,000 individuals with specific nuclear competencies. These specialists’ skills are built around an advanced level of technical knowledge and exacting standards in terms of approach and nuclear safety culture.
In the years ahead, over 2,000 engineers and technicians are set to join one of our nuclear entities to replace current staff who will be retiring and to ensure continuity and the further development of our ongoing projects.
Attracting and retaining talent is a top priority in terms of the Group’s nuclear strategy. With this in mind, in 2006 the Nuclear Development Division (NDD) launched the Nuclear Trainees Program—Junior (NTP—J).

NUCLEAR TRAINEES PROGRAM—JUNIOR
In 2006, ENGIE launched the Nuclear Trainees Program – Junior (NTP-J). This original recruitment and training program, the NTP-J is geared towards young engineers either nearing the end of their degree courses, who have recently graduated, or who have less than three years’ professional experience. Whilst being employed by one of the ENGIE’s nuclear entities, the trainees follow a course lasting approximately 400 hours in France and Belgium, alongside their professional work.
The NTP—J enables these junior engineers joining ENGIE to become nuclear ‘generalists’ whilst at the same time building up a solid network of contacts within the Group.

NTP seeks to achieve the following:
• Give trainees an insight into and general overview of all aspects of the Group’s nuclear activities and business,
• Enable trainees to meet nuclear actors within the Group (to build up a network of contacts, share best practices, promote mobility and synergy between all the Group’s entities worldwide),
• Offer a tailor-made course combining both theoretical knowledge and practical projects.
The training modules, to which trainees devote one week per month, are designed to develop three core competencies: technical (the business itself), behavioral and cross-functional as Project Management. Technical tests at the beginning and end of each training program assess how the young engineers’ knowledge is developing. Combining practical training with day-to-day operational constraints gives trainees a thorough overview of the Group’s nuclear businesses.

THE NTP-J IN A NUTSHELL:
• 400 hours of training
• One week of training per month over a period of one year
• Technical modules: safety, nuclear security, radiation protection, the basics of nuclear technology, fuel cycle, pressurized water reactors, management of spent fuel and decommissioning, maintenance of nuclear power stations, etc.
• Non-technical modules to develop the core competencies required of all nuclear managers: Project Management, communication, leadership, managerial behavior, etc.
• Trainees recruited on open-ended contracts and to an operational function within one of the Group’s 11 nuclear entities
Bureau Veritas, created in 1828, is a global leader in Testing, Inspection and Certification (TIC). Bureau Veritas delivers high quality services to help clients meet the growing challenges of quality, safety, environmental protection and social responsibility. As a trusted partner, Bureau Veritas offers solutions that go beyond simple compliance with regulations and standards, reducing risk, improving performance and promoting sustainable development.

Bureau Veritas offers services to nuclear industry stakeholders around the world throughout all the nuclear lifecycle, from construction to operation, and to de-commissioning. We develop innovative solutions to support the demonstration of compliance of nuclear equipment with regulations, codes and standards.

With an extensive presence in 140 countries, we offer our customers a rapid response capability around the world, combined with a perfect knowledge of local contexts (regulations, language, culture ...). We are active on large nuclear projects in Europe (France, United Kingdom, and Finland) and worldwide (China, Japan, Argentina, and South Africa).

Our strong experience in the nuclear field relies on:
- 10 years of NPE conformity assessment practice,
- accreditations from the French and Finnish safety authorities (respectively French Nuclear Safety Authority – Autorité de Sûreté Nucléaire [ASN] and Radiation and Nuclear Safety Authority – Säteilyturvakeskuksen [STUK]),
- top-level skills in design / calculation,
- a global network of qualified inspectors and experts in the areas of materials, metallurgy, welding and Non-Destructive Testing.

Our in-depth knowledge of the specific expectations of our different interlocutors (Nuclear Operators, Safety authorities...) is a guarantee of reliability and quality of our services. Moreover, our strong nuclear technical and practical experience combined with the systematic implementation of good practices will contribute to control your project’s risks.

**KEY FIGURES**
- 69,000 employees
- 1,400 offices and laboratories in 140 countries
- 400,000 clients
- 2016 revenue 4.55 billions euros
OUR TRAINING OFFER

For over 30 years, Bureau Veritas has accompanied its customers in their risk management approaches by sharing with them its training know-how. We develop programs, methods, and innovative pedagogical tools specific to each profession of the nuclear sector. Our training offer includes construction codes & standards (RCC-M and ASME III), pressurized equipment regulation (French Order of 7 February 2012 setting the general rules relative to basic nuclear installations, French Order of 30 December 2015 on nuclear pressurized equipment, ASN Guides, STUK’s Regulatory Guides on nuclear safety—Ydinturvallisuusohjeet [YVL]), and the nuclear quality management system (NSQ 100). Bureau Veritas has a partnership with the French Association for Codes & Standards, AFCEN, and provides RCC-M and RCC-MRx accredited training courses in French and English.

Bureau Veritas offers a wide and comprehensive range of training courses available for both public and in-company presentation in France and worldwide. Our courses always take into account the latest regulatory requirements.

MORE INFORMATION ABOUT OUR TRAINING PROGRAMS

http://formation.bureauveritas.fr/formation/9_nucleaire.html
Set up in 1959, GIIN - French Nuclear Suppliers Association is an independent and non-governmental organization acting to support the French supply chain in its development in the civilian nuclear sector. GIIN – French Nuclear Suppliers Association represents over 450 SMEs and mid-caps companies which, together, offer a wide range of expertise and solutions. With a long track record in new build, plant operation, fuel cycle, dismantling & decommissioning, and research reactors, these solutions will bring value to your current and upcoming projects.

BUSINESS ACCELERATOR
Present at many trade shows internationally, GIIN - French Nuclear Suppliers Association showcases its affiliated companies and contributes to accelerating business opportunities between French and international players.

FIND YOUR FRENCH PARTNER TO BOOST YOUR DEVELOPMENT
GIIN – French Nuclear Suppliers Association helps international players find French partners for their projects and future development.

- **Get to know:** French suppliers technologies, solutions and references.
- **Promote:** Your company and solutions to French suppliers.
- **Connect:** With French nuclear expertise.

SUPPORTING I2EN
We are a founding partner of I2EN and support the institute:
- To make sure that students acquire the skills necessary to the industry and thus ensure a skilled recruiting ground for our corporate members.
- To foster the export of our members’ technologies and services by complementing their technical offers with training offers adapted to the needs of their potential customers.

THESE COMPANIES PROVIDE SOLUTIONS IN THE FIELDS OF:
GIIN: OUR MISSIONS AND ACTIONS

A UNIFIED VOICE FOR THE NUCLEAR SECTOR’S INDUSTRIAL COMPANIES AND THEIR FEDERATIONS
- We represent federations at the Nuclear Sector Strategic Committee (CSFN, see p.08) and influence its strategic orientations in regard to market access conditions, training, exports, innovation, and communications.
- We express the needs of SMEs and midmarket companies of the nuclear sector and contribute to the actions they conduct together with EDF, Framatome, Government Departments, and trade unions:
  - Participation in working groups run by EDF to prepare for the NPP life-extension plan (as a member of the nuclear contractors’ charter supervisory committee, with professional organizations, and within the “employment, training, and attractiveness” working group).
  - Participation in the French Nuclear Safety Authority (ASN) Commission on the comprehension of social, organizational, and human risk factors (COFSOH).
- We promote the nuclear industry and speak out its positions on current energy and industry issues.

A SOURCE OF EXPERTISE AND INFORMATION
- We provide our experts’ contributions at regional, national and international conferences, such as:
  - The European Nuclear Society’s conference “Preparing for nuclear new build: is there a danger of supply chain bottlenecks emerging if the UK, Finland, Bulgaria, Poland and Turkey are all constructing new plants at the same time?”.
  - The French Nuclear Energy Society’s round-table on the EDF NPP life-extension plan.
- We organize conferences to inform our member companies on diverse topics such as:
  - Insurances: “Insurance within the context of contractual liability on nuclear contracts”.
  - Financing: “Presentation of financial investment tools by BPI France and CMGH”.
  - Energy policy: “Challenges of the European energy policy and FORATOM activities”.
- We hold quarterly congresses on:
  - Foreign trade: financing for export, Framatome’s vision of the world’s nuclear market, Chinese market prospects, etc.
  - Economy and industry: supplier/customer relationships, reforms on radiation protection regulations, etc.
- We publish a bimonthly market watch newsletter and an international press review on the global nuclear market.

ENHANCED VISIBILITY AND PROMOTION OF COMPANIES FOR EXPORT PURPOSES
- We participate in many trade exhibitions in France and abroad:
  - Member of the organizing committee of the World Nuclear Exhibition—WNE (Paris-Nord Villepinte, France) and support for the participation of our member companies.
- Collective pavilions coordination: Atomexpo & Atomex (Moscow, Russia), NIC & CIENPI (Beijing, China), INE (Mumbai, India), INPPS (Istanbul, Turkey).
- Collaboration with Business France, the French agency for the international development of French companies, and contribution to their actions such as welcoming international delegations.
- We distribute the official French nuclear industry directory to Government Departments, ASN, IRSN (see p. 58), the Chambers of Commerce and Industry, large corporations, etc.
- We maintain strong representation in Beijing and Moscow to support companies that want to expand into those markets.

KEY FIGURES OF THE FRENCH NUCLEAR INDUSTRY
- €15 B turnover
- 20% of which acquired through exports
- 2,500 companies
- 115,000 highly-skilled workers and executives
- Over 450 SMEs and mid-cap companies with a variety of expertise and solutions

Scope: companies of the nuclear industry except for operators
ASSYSTEM

ADDRESSING THE ENTIRE NUCLEAR LIFECYCLE, FROM DESIGN TO DECOMMISSIONING

With 50 years of experience in nuclear engineering, Assystem is now the 3rd nuclear engineering leader in the world. Being independent, Assystem can work with any technology provider in the world. We have a long track record of addressing the entire nuclear fuel cycle. We have the capacity to field 2,500 engineers worldwide to serve the challenges of nuclear power production in a world that is more than ever focused on seeking alternative sources of energy.

Leveraging our unrivalled expertise in designing, building, commissioning, maintaining, and decommissioning a wide range of nuclear plants, we have developed the capacity to provide a full range of services to governments and industrial players currently examining the options of developing a nuclear power program. These services go beyond standard engineering requirements and focus on the entire range of technical, economic and long-term risk issues that are inherent to the nuclear power business, including the sensitive issue of gaining public acceptance on this technology. Our comprehensive range of services include Project Management & Engineering, Digital & Performance and Security & Safety. Assystem is a leading engineering and innovation consultancy, located in 13 countries with more than 5,000 employees.

KEY FIGURES
• 2017 turnover: over €400 M
• 2,500 nuclear experts worldwide
• 3rd nuclear engineering company in the world
• 10,000 training hours & 600 trainees per year at the Assystem Nuclear Institute
Assystem established its Assystem Nuclear Institute in 2008 as a place of transfer of knowledge between senior nuclear experts and junior engineers. We share, train, and teach younger colleagues who will be addressing the technology challenges of the coming decades. We bring our experts together with those who will be called to become. We help new recruits join the inner circle of nuclear engineers. This vital facility draws on our multiple fields of expertise to train our people in all relevant theoretical and practical concerns involved in supporting our clients. We see this commitment to technical knowledge as part of our responsibility towards our clients.

Assystem relies on its nuclear institute to:
- Develop its employees’ knowledge,
- Ensure adaptation to technical evolutions,
- Maintain cutting-edge expertise.

Training modules include "Operation & Maintenance", "Technologies in nuclear plants", "Facility operating security", "Main systems and equipment". We also provide specific modules, for example on safety and security issues, for clients wishing to train their own employees to the highest standards.
ONET Technologies is a major player in the civilian nuclear industry. We intervene at all stages of the nuclear cycle, tailoring all-inclusive solutions to meet the specific needs of each client. We offer our proven capabilities in integrated engineering and lead-contracting in new build and nuclear services. ONET Technologies draws from 40 years' experience in the building, maintenance and replacement of major components in power reactors and other nuclear facilities, in decontamination, in radioactive waste treatment and storage, and in decommissioning.

We are resolutely turned towards the future and play an expert role in innovative projects such as the International Thermonuclear Experimental Reactor (ITER), research reactors and Generation IV reactors. ONET Technologies’ international expansion has been remarkable, supported by the activities of its partners all over the world and its subsidiaries in Bulgaria and India.

ONET Technologies is a brand belonging to the ONET group. Techman Industrie is a subsidiary of ONET Technologies. It is the French leader in the fields of nuclear logistics and radiological protection for nuclear plants in operation or to be dismantled. Techman Industrie is recognized as a specialist in training courses for the nuclear and construction sectors.

**KEY FIGURES**

- 40 years of experience
- 2,700 employees
- 700 engineers and experts
- Business volume: €250 M
- 25,000 training internships offered each year
TRAINING

TECHMAN INDUSTRIE: SPECIALIZED IN NUCLEAR LOGISTICS & TRAINING
Techman Industrie has 10 training centers throughout France and offers a wide range of regulatory and qualifying training programs. Our programs are aimed at target audiences from the nuclear and construction sectors. Our training team puts all its experience and methodology at the disposal of our clients to provide their employees with life-long-training and enable them to acquire the necessary skills to fulfill their role safely and with professionalism. Our ambition is to enhance knowledge and stimulate life skills to create know-how.

DESIGN ENGINEERING FOR TAILOR-MADE TRAINING COURSES
Techman Industrie is committed to providing its customers with the most adapted training programs. To do so, we work hand-in-hand with them to set the ultimate goals of their programs, determine trainees’ profiles, and develop appropriate training contents and schedules. We always collect experience feedback to keep on improving our customers’ experience.

REGULATORY AND QUALIFYING TRAINING PROGRAMS
Techman Industrie offers over 150 training programs. Our two fields of expertise are the nuclear industry and the construction industry.

Nuclear-specific training
- Radiological protection,
- Safety,
- Quality,
- Stars (technical support training in security/radiological protection),
- Wearing of SCBA personal protective equipment, helmet, wind…

Construction-industry-specific training
- CACES® (Certificate of Competency in Secure Driving,
- Lifting and handling,
- Asbestos risks,
- Risk prevention,
- Security with regards to electrical and mechanical risks,
- Scaffolding and thermal insulation.

HUMAN AND TRAINING RESOURCES
Our team, composed of experienced industry professionals, has been training our clients’ staff for over 10 years. We have 110 trainers and a number of training worksites: 10 where we deliver radiological risk prevention instruction, 10 where we deliver instruction in quality, nuclear safety and the environment, 3 specific to asbestos training and one specific to valves. In addition, we have 45 training rooms distributed among five sites in France. Training courses can be delivered in different languages.

CERTIFICATIONS
We hold the following certifications:
- CACES® (certificate n° STC/033-e),
- All categories carriage - R389,
- PEMPE 1A, 1B, 3A et 3B - R386,
- CEFRI 15F,
- SCN-CSQ 41,
- ISO 9001, ISO 14001 and OHSAS 18001 2006041560-2C,

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- Illange site: +33 (0)3 82 54 48 17

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ONET SA - RCS B 059 801 324 Marseille
The international Standard Developing Organization, AFCEN groups together; through its member companies, technicians, engineers and scientists from industry and research centers. Founded in 1980, it plays an active role in nuclear safety and quality, aiming to promote accurate and practical rules covering all the technical fields relevant to the design, construction and operation of nuclear facilities. AFCEN codes, training and special learning programs, conferences and user groups offer an international reference framework for those involved in the construction of nuclear power plants.

Results don’t lie: in total, more than 100 nuclear power plants (in operation or under construction) worldwide are covered by AFCEN codes. The use of AFCEN codes is both a factor for operational efficiency and a source of progress in relation to competitiveness and safety, in particular through the integration of the best operating feedback.

Based on this success, AFCEN has striven to go even further by fully reviewing its approach: in 2010, AFCEN began an in-depth reform of its statutes to open up more to international membership and develop synergies.

In order to promote AFCEN Codes and their appropriation, the Training Committee ensures that certified training is available to users of AFCEN codes. AFCEN does not personally run training courses, so that its experts can remain focused on drafting codes. As such, the Training Committee outsources training to external providers and consequently assesses their ability to provide such training.

The attribution of this certificate relies on the prior control of the training organization: its tools, the content of training materials, the professionalism of teachers in charge of trainings, effective conditions of achieving trainings and monitoring. The certificate ensures that the highest quality of service is made available to users to enable them to acquire knowledge, understanding, ownership and control requirements and codes use practices.

To do so, the Training Committee relies on the relevant Subcommittees wherever possible. It establishes partnership agreements with training organizations and manages all the aforementioned aspects. AFCEN has signed partnership agreements with 13 organizations that are qualified in the field of nuclear pressure equipment: APAVE - FRAMATOME - CETIM - PONTS FORMATION CONSEIL - EFECTIS - IS GROUPE - INSTN - SICA nucléaire - NUCLEXPERT - BUREAU VERITAS - VINCOTTE ACADEMY - SNCT - SNPI (GROUPE CGN). Each training course delivered by a partner organization must have its dedicated certificate.

• 13 partner training organizations
• 18 partnership agreements
• 25 certified training courses
• 76 training courses ran
• 495 trainees trained
WHO ARE WE?

- A French company, spin-off from EDF, founded in 2002 by independent experts. 70% of our activities occur outside of France. 140 multidisciplinary consultants based in a number of locations around the world.
- ISO 55000, 31000, 15288 specialists, experts in risk and life-cycle management of large assets. Our experience totals over €1,200 billion worth of analysed assets.
- Experts in simulating ageing and developing solutions to increase the lifecycle of assets at the optimal cost.
- Developers and exclusive providers of the Simeo™ platform.

WHAT IS OXAND ACADEMY?

- We share our vision on asset, ageing and risk management in order to educate your employees about the way of looking at and working with complex assets or systems.
- It is our conviction that there is more than enough knowledge, experience and data available within your team to optimise asset, ageing and risk management.
- We compose with you a training program, aimed to bridge the gap between the current understanding and capabilities of your team and the desired ones.
- Oxand Academy owns a Business Game portfolio of 13 games, which covers the tangible subjects of asset, ageing and risk management, as well as related tacit subjects like team composition and project, and group dynamics.

KEY FIGURES

- 90 nuclear reactors
- 6 storage centers for radioactive waste
- 12 decommissioned nuclear reactors
- 55 classified military bases
- 40 million m² of real estate
## R&D

### WASTE MANAGEMENT

### NUCLEAR SAFETY

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Andra, the French National Radioactive Waste Management Agency, is supervised by the French Government Departments of Energy, Research, and the Environment. The agency is completely independent from radioactive waste producers. We are in charge of developing, implementing and operating safe solutions for the management of all types of radioactive waste in France in order to protect current and future generations from the hazards posed by such waste.

RESEARCH AND DEVELOPMENT
Within this framework we undertake scientific research and develop technologies to design and implement sustainable solutions for the management of high-level waste (HLW), intermediate level long-lived waste (ILW-LL) and low-level long-lived waste (LLW-LL) placed in temporary storage. We also perform all R&D in support to existing disposal facilities for low-level and intermediate-level short-lived waste (LIL-SL) and very low level waste (VLL).

INDUSTRIAL ACTIVITIES
We have industrial activities disposing of radioactive waste produced by the nuclear sector, the non-nuclear power industry, national defense operations, research and the healthcare sector on our sites; operations include the monitoring of radioactive waste disposal facilities so as to protect people and the environment.

PUBLIC SERVICE AND INFORMATION
Our public service activities include retrieving radioactive objects from private individuals and local authorities; cleaning up and remediating radioactive orphan sites; drawing up and publishing a national inventory of radioactive waste and materials in France; providing clear and verifiable information on the management of radioactive waste; promoting meetings and dialogue with all stakeholders.

PROMOTING THE FRENCH EXPERTISE IN FRANCE AND ABROAD
We also develop scientific collaboration throughout France and the world; promote Andra’s entire range of services throughout France and the world; and disseminate experience, scientific knowledge and technical know-how as widely as possible.
TRAINING

ANDRA’S TRAINING SOLUTIONS AND CAPABILITIES

Andra has developed various training programs in the field of radioactive waste management and welcomes trainees who wish to complete their initial theoretical training with practical training in various fields, including operations and R&D.

Over the past years, Andra has provided training to professionals at the request of IAEA, institutional organizations, and companies in the radioactive waste management sector. Benefiting from our experience, trainees gain helpful means enabling them to reduce costs and delivery times whilst minimizing risks for their own projects.

CUSTOMIZED TRAINING LECTURES AND OPERATIONAL TRAINING

Andra can supply specific and generic waste management courses designed for specific customers. We have training programs on safety, repository design, operation, capping and closure. Our trainees have operational use of Andra facilities and R&D resources.

SERVICES IN ANDRA’S FIELD OF SCIENTIFIC AND TECHNICAL EXPERTISE

We offer to help our customers develop and implement their radioactive waste management plans. Our wide range of services includes:

- Project definition, program & management;
- Establishing detailed inventories for existing as well as for future radioactive waste;
- Defining plans and strategies for your radioactive waste management;
- Site investigation, processing and databases;
- Disposal concept development;
- Specification of waste & packaging (Waste Acceptance Criteria);
- Waste tracking;
- Design, construction, operation, capping and closure of your waste repositories;
- Safety assessments and safety cases;
- Expertise and consultancy, including on economic aspects;
- Facility and environment monitoring;
- Communication and public information;
- Relationship with stakeholders.

RESEARCH TRAINING

As part of our mission, we conduct extensive research and first-rate studies to design disposal facilities for radioactive waste, especially for the most radioactive and long-lived waste. Andra provides an opportunity for PhD students to contribute to the research undertaken in our laboratories.

Each year, research laboratories and academic institutions – such as universities – are invited to submit proposals for PhD projects. At the end of the call for proposals, Andra awards 3-year PhD fellowships to the selected candidates. PhD students can then start their research in their host laboratories.

In early 2016, 14 French and international PhD students were undergoing their research theses under Andra supervision. The subjects of their theses are varied, ranging from the study of the behavior of radionuclides, to optical fiber measurements, to the study of hydro-mechanical properties of storage materials, and corrosion in clay-rich environments.
CEA, the Atomic Energy and Alternative Energies Commission, is a French public research organization. We conduct research in low carbon energies (nuclear and renewable energies), defense and global security, information technologies, and health technologies. In each of these four fields, CEA’s work relies on first-class fundamental research. The Commission also participates in the design and operation of very large international research facilities such as the LHC, ITER, and the ESRF. Through our strong relationships with university and industry partners, we support industrial companies, the set-up of innovative technology start-up companies, and exports of French nuclear technologies.

SECURING COMPETITIVE, SAFE, AND CO2-FREE ENERGY TO MAINTAIN FRANCE’S ENERGY INDEPENDENCE AND FIGHT GLOBAL WARMING

Research on nuclear energy at CEA is carried out by the Nuclear Energy Division and focuses on 7 areas of expertise:

- the design of future nuclear systems—referred to as Generation IV nuclear systems—and the associated reactors and fuel cycle. They aim at optimizing the use of uranium resources and reducing waste production. CEA plays a key role in the Generation IV International Forum.
- the optimization of current French nuclear reactors and the related fuel cycle,
- the development and operation of large simulation and experimental tools,
- research on radioactive waste management and control of the impact of nuclear activities,
- the cleanup and dismantling of nuclear facilities,
- safety and security,
- and nuclear materials & mechanics.

As a nuclear operator, the Nuclear Energy Division is also in charge of managing and enhancing CEA’s nuclear facilities. It carries out construction, renovation, decommissioning, and dismantling programs.

Our outstanding research equipment features some unique facilities (see opposite page).

KEY FIGURES

- 9 research centers
- 19,738 technicians, engineers, researchers and support staff
- 762 priority patents filed
- 204 spin-offs since 1972 in the innovative technologies sector
- €5 B overall resources
TRAINING

ACADEMIC EDUCATION AND VOCATIONAL TRAINING
Academic education (from Bachelor’s degrees to Master’s degrees) and vocational training at CEA are managed by INSTN (see p. 62). Research training is managed by labs themselves together with our Office for Research Training & Career Development.

RESEARCH TRAINING
PhD students at CEA join research teams and complete their doctoral research under the guidance of the lab supervisor and/or an academic supervisor. They also receive professional training in different settings inasmuch as they are encouraged to do internships in academia, government organizations, and industry.
Together with INSTN, the Office for Research Training & Career Development also organizes seminars and workshops to help PhD students manage their studies, enlarge their knowledge of the business world, and prepare their careers. These include but are not limited to:
• conducting your thesis and determining your career project
• managing a scientific project
• technology transfer and innovation in the industry
• supervising a PhD student, for lab supervisors.

UNEQUALLED RESEARCH FACILITIES, TOOLS AND EQUIPMENT
We have cutting-edge nuclear research facilities, some of which are unique in the world. They are constantly updated and enhanced so as to maintain their exceptional experimental capabilities. Our PhD students have access to our 27 Equipex (Facilities of Excellence) and 33 Labex (Laboratories of Excellence), as well as to all our other facilities:
• research reactors (ORPHEE, JHR in construction—start of operation scheduled in 2017) and critical models (EOLE, MINERVE),
• hot laboratories to carry out studies on radioactive substances (ATALANTE, LECI),
• experimental platforms for thermal-hydraulic, earthquake, severe accident, and corrosion studies.
They also have access to the biggest library resource of doctoral and post-doctoral level in France dedicated to nuclear science and technology, with over 1,000,000 books, magazine collections, technical reports, and dissertations.

INTERNATIONAL SCHOOL IN NUCLEAR ENGINEERING
INSTN and the Nuclear Energy Division organize each year an international school in nuclear engineering for PhD students, post-docs, young professionals, and established engineers. The school consists of 6 one-week courses:
• thermal hydraulics and safety
• materials for nuclear reactor, fuel and structures
• reactor core physics: deterministic and Monte Carlo methods
• nuclear fuels for LWRs and FRs
• nuclear fuel cycle and reprocessing
• nuclear waste management.

INTERNATIONAL COURSE ON GENERATION IV NUCLEAR REACTORS
ENEN, INSTN, and CEA have set up an annual international course on future nuclear reactor systems. It is meant for professionals, researchers, and students, and taught entirely in English by international experts in the field. It includes lectures and tutorials on SFRs, HTRs and VHTRs, GFRs, LFRs, SCWRs, MSRs, and the fuel cycle.

SUPPORT TO NEWCOMER AND EXPANDING COUNTRIES
We are a founding member of I2EN. Together with INSTN and other industry partners, we often take part in I2EN’s missions abroad to help newcomer and expanding countries develop their HCB plans. We also put our experts at the disposal of AFNI (see p. 18) for advice on regulation, safety, waste management, public information, etc.

KEY FIGURES
• 1,183 PhD students, 280 at the Nuclear Energy Division in 2017
• 160 postdoctoral fellows, 40 at the Nuclear Energy Division in 2017
• 700 labs
• 4,914 publications in peer-reviewed journals in 2017, and 500 at the Nuclear Energy Division in 2017
• 64 framework agreements with universities and graduate schools
CNRS, the French National Center for Scientific Research, is a public organization supervised by the French Government Department of Higher Education and Research. We cover all scientific fields: human and social sciences, biology, nuclear and particle physics, computer science, engineering and systems, physics, mathematics, chemistry, earth sciences, ecology and the environment. We encourage exchanges between disciplines to always take research to a new level. Our numerous laboratories are spread not only throughout France but also abroad.

CNRS is involved in upstream research on nuclear energy, by studying innovative cycles and systems (hybrid systems and dedicated accelerators, molten salt reactors, thorium cycle, transmutation of waste...), modeling and multi-physics coupling, innovative materials for Generation IV reactors and waste confinement, nuclear instrumentation, the behavior of radionuclides in the environment, new methods for separation chemistry, and also by involving the human sciences community on risk issues and decision-making processes (reactors, waste storage). We collaborate with major players of the nuclear sector of France and abroad, notably thanks to the NEEDS project, and European programs, platforms, and networks.

KEY FIGURES
• 33,000 researchers, engineers and technicians
• 30,000 PhD students and postdoctoral fellows
• 10 institutes
• 1,144 laboratories
• A budget of €3.4 B
TRAINING

INITIAL EDUCATION
CNRS researchers are heavily involved in all university Bachelor’s and Master’s degrees offered in France in the nuclear energy sector and participate actively in majors offered by Graduate Schools of Engineering. CNRS laboratories, generally research establishments jointly run with Universities or Graduate Schools of Engineering, welcome many students at both Bachelor’s and Master’s levels for short-term internships.

RESEARCH TRAINING
Our doctoral and post-doctoral fellows are aiming to work either in public or industrial research, or in nuclear engineering in France and abroad. Research grants are awarded either by public authorities, companies, regions, or other research organizations. Undertaking a PhD or a post-doctoral fellowship at CNRS is the best opportunity to benefit from our international network of very high level research laboratories and to participate in international research collaboration.

APPRENTICESHIP
We offer apprenticeship programs for students at Bachelor’s and Master’s levels. Students enrolled in BS, MS or MEng programs can thus receive both academic education and on-the-job training concurrently.

CONTINUING EDUCATION
CNRS provides continuous training programs in nuclear technology to its own employees, but also to partner companies and people in retraining.

B-TO-B TRAINING
We offer two types of training for companies and other research organizations:
- Qualifying training programs in radiation protection for industrial and research companies, and for the healthcare sector. The certificates delivered at the end of these programs are valid 5 years. We offer programs for both the first certificate, and the certificate renewal.
- Training in the use of radiation portal monitors. This program teaches how to carry out measurements and the protocol to follow in the event of an alert caused by a high-level of radiation.
We also tailor-make courses for the National Radiation Measurement and Analysis Platform, referred to as the Becquerel Network. This network is entirely dedicated to measuring radioactivity in the environment.
ENHANCING NUCLEAR SAFETY

IRSN, the French Institute for Radiation Protection and Nuclear Safety, is the national public expert on nuclear and radiological risks. IRSN contributes to public policies in the fields of nuclear safety and ionizing radiation protection for public health and environment. As a research and scientific institution it acts in consultation with all stakeholders concerned by these policies, while preserving its independence of judgment.

IRSN is a public institution with industrial and commercial activities (EPIC) and it is placed under the joint authority of the Ministers of environment, research, energy, health and defense.

AREAS OF EXPERTISE

Our areas of specialization include environment and radiological emergency response, human radiation protection in both a medical and professional capacity, and in both normal and post-accident situations, the prevention of major accidents, nuclear reactor safety, as well as safety in nuclear plants and laboratories, transport and waste management, and nuclear defense and security expertise.

IRSN interacts with all parties concerned by these risks (public authorities, especially nuclear safety and security authorities, local authorities, companies, research organizations, stakeholders’ associations, etc.) to contribute to public policy issues related to nuclear safety, human and environmental protection against ionizing radiation, and the protection of nuclear materials, facilities, and transport against the risk of malicious acts.

KEY FIGURES

- 1,800 employees in 2017
- 39.8% of IRSN’s annual €280 M budget spent on research in 2017
- 43,109 hours of training given to maintain the skill levels of engineers and experts in 2017
- 3,020 hours of teaching given outside the Institute (Universities, engineering schools, INSTN, etc.) and at ENSTTI in 2017
- 54 international projects in 2017
- €20.36 M from commercial services revenues, including €10.89 M for dosimetry services, in 2017

RESEARCH, ASSESSMENT, OPENNESS TO SOCIETY

Research, assessment and openness to society are three key issues of IRSN’s strategy for enhancing global nuclear safety. In all these strategic areas, it has developed initiatives with its counterparts, coordinated or contributed to targeted scientific projects, e.g. IRSN is involved in ETSON (European TSO Network) development and Euratom Horizon 2020 work program.

IRSN also defines and conducts research programs aimed at maintaining and developing the skills necessary for expert assessments in its areas of expertise. It either carries out the programs itself or, in a European or international context, may entrust them to other French or foreign research organizations.
TRAINING

RESEARCH TRAINING
IRSN is deeply involved in research training resulting in an increasing number of young researchers joining IRSN laboratories each year, with several tens doctoral students and about twenty post-doctoral fellows per year. Concurrently, IRSN is encouraging its senior researchers to apply for Accreditations to Supervise Research, aiming at 50 certified research directors.

Like most research organizations, we consider research training one of our core missions to transfer the knowledge and skills acquired in our laboratories. At IRSN, research is conducted with a purpose: beyond the quest for knowledge, it aims to reinforce the quality and pertinence of its expertise in nuclear and radiation risks in order to provide support to public authorities and the relevant players in society. In this context, research training provides an ideal intellectual environment, offering high-quality joint supervision, and access to state-of-the-art equipment, aiming not only to impart the methods, but also to nurture an aptitude for anticipating the societal issues raised at the Institute.

COLLABORATION WITH ACADEMIC AND RESEARCH ORGANIZATIONS
Research training is also an integral part of the general policy implemented by IRSN to reinforce its relationships with universities, institutes of higher education, and eminent scientific organizations. These collaborative projects are fundamental, since they contribute to the reinforcement of fundamental research, which in turn supports applied research. They provide an influx of new skills that complement the in-house competencies of the Institute.

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Collaborative projects allow IRSN experts to participate in training programs offered by its partners, thus encouraging its researchers to push investigations forward in their own discipline, furthering their action within the Institute.

KEY FIGURES
- 209 publications in 2017
- 81 PhD students employed by IRSN in 2017
- 6 postdoctoral fellows in 2017
- 47 researchers accredited to supervise research in 2017
The French Government Department of Education, Higher Education, and Research now offers a comprehensive range of training and education programs dedicated to nuclear skills, trades, and professions.

Top-level education programs have been complemented with modern training programs created to train technicians, advanced technicians, and intermediate-level technical executives.

In 2006, industrial companies of the nuclear sector asked the Department of Education to set up a vocational high school program in nuclear environment. A few years later, we granted them a second request and set up an advanced technician program—a two-year vocational undergraduate degree referred to as BTS—in nuclear environment. The first class of advanced technicians in nuclear environment graduated in 2013. These degrees cover a wide range of activities. Nuclear maintenance, equipment installation, dismantling, radiation protection, security, and safety are at the heart of their curricula. The close relationship between educational institutions and companies ensures the operational viability of curricula and pedagogical materials, and enables us to develop and maintain apprenticeship programs.

We constantly update and enhance education programs to best meet the needs of the industry. The review of the vocational high school program in nuclear environment has borne fruit and recently given way to a vocational high school program for nuclear operation technicians. The first class of nuclear operation technicians will graduate in 2015. These programs are designed to best meet the international needs in nuclear energy education & training.

Jean-Michel Schmitt
Inspector General, French Department of Education
EDUCATIONAL INSTITUTIONS

SPECIALIZED INSTITUTES

INSTITUTES

ENSTTI
IRUP-ISTP CENTER FOR NUCLEAR EDUCATION AND TRAINING

HIGH SCHOOLS

GRADUATE SCHOOLS

ARTS ET MÉTIERS ParisTech
CHIMIE ParisTech
ÉCOLE POLYTECHNIQUE ParisTech
ENSTA ParisTech
CentraleSupélec
IMT Atlantique
ENSCL
ENSCM
ENSICAEN
ESIX Normandy
Grenoble INP
Le Cnam

UNIVERSITIES

Aix-Marseille University
Université Grenoble Alpes
Lille 1 University
Claude Bernard Lyon 1 University
Montpellier University
Paris-Diderot University
Paris-Sud University
Pierre and Marie Curie University

CONTINUING EDUCATION

AFPA
For over 60 years, INSTN has been supporting nuclear development with academic and professional training programs in the field of nuclear technologies and their industrial and radiopharmaceutical applications. Through our expertise, we continue to demonstrate INSTN’s role as the French education and training institute for nuclear applications.

Administered by CEA (the French Atomic Energy and Alternative Energies Commission, see p. 54), INSTN supports the scientific and industrial development of the French nuclear sector by transferring knowledge and competences. At INSTN, we provide highly specialized education and training courses in nuclear science and technology applied to energy and health, at all levels of qualification - from operator, to engineer or researcher.

ACADEMIC AND CONTINUING EDUCATION
We have developed a complete and coherent offer ranging from initial to continuing education and life-long training covering all applications of nuclear physics, from energy production to the use of radioisotopes in biology and medicine. These courses are aimed at both French and international students, advanced technicians, engineers, scientists, etc.

A UNIQUE FACULTY
At INSTN, we impart cutting-edge know-how and skills thanks to our privileged access to the scientific and technological potential of CEA and our network of partners. Our programs are taught by researchers and experts from industrial companies and safety organizations, university professors, and medical professionals.

INTERNATIONAL COOPERATION
For several years now, we have been further developing INSTN’s international program. In 2016, INSTN was designated as an IAEA ‘Collaborating Centre’, the first in Europe. This accreditation has further strengthened our international development in 2016 and 2017, with agreements signed with European, African, and Middle Eastern partners. In support of CEA’s International Relations Division and key players of the French nuclear industry, INSTN develops tailor-made solutions which meet the challenges of developing competences for the nuclear energy and nuclear applications in human health sectors.

INSTN also participates in various European H2020 projects aiming at building nuclear training schemes in engineering (ENEN+), safety culture (NUSHARE), and radiation protection (ENETRAP III and PETRUS III). We are a founding member of the European Nuclear Education Network (ENEN) that we chaired from 2003-2013.

KEY FIGURES
•  112 in-house staff
•  1,500 trainers and experts (75% from CEA)
•  1,100 students per year in academic programs
•  7,400 trainees per year in continuing vocational training
•  1,500 PhD students working at CEA
TRAINING

ACADEMIC DEGREES
We award over 41 academic degrees, including Bachelor’s and Master’s degrees, as well as specialized technician degrees (undergraduate vocational degrees) generally taught in partnership with universities and Graduate Schools of Engineering. National and international academic courses cover nuclear engineering, material sciences, radiation protection, waste management, clean-up and decommissioning, health technologies, alternative energies, energy economics, technology & innovation, etc. Our courses are offered as regular classroom training or as apprenticeship programs for on-the-job training.

For over 60 years, INSTN has been training engineers specialized in nuclear engineering in advanced technologies in nuclear reactor physics, design, operation, facilities optimization, and broader topics of the nuclear field. The engineering course Génie Atomique (Nuclear Engineering, Advanced Graduate Engineering Degree) awards the title of Engineer specialized in Nuclear Engineering, which is accredited by the French Commission for Engineering Degrees and Certifications (CTI) and listed in the French Government’s National Directory of Professional Qualifications (RNCP and EUR-ACE).

CONTINUING VOCATIONAL EDUCATION
Engineers, researchers, and experienced technicians can attend some of our 250 training courses, lasting a few days to several weeks, all-year-around. They cover nuclear engineering, nuclear fuel cycle, nuclear safety, radiation protection, imaging in nuclear medicine, radiotherapy, energy system and carbon-free energy sources, micro and nanotechnologies, etc. These courses can serve to update knowledge, to adapt to a new job, to move ahead in one’s professional sector, to become initiated to a new scientific or technical field, to undergo retraining, etc.

INSTN also designs training programs in French and English, tailor-made for the specific needs and expectations of companies and laboratories. These courses can be held at the customer venue.

INSTN AT THE SERVICE OF E&T IN NEWCOMER AND EXPANDING COUNTRIES
With its industrial and research partners, INSTN supports newcomer and expanding countries at every stage of the implementation of their nuclear power programs by offering its Human Capacity Building services. For example, we:

• help students acquire a solid background in nuclear science, at Master’s or PhD levels,
• provide professionals with vocational training,
• train trainers,
• provide assistance for the local implementation of training platforms, from skill and attitude development to the set-up of facilities,
• tutor decision-makers to address energy-related issues.

In previous years, we have designed many courses for a number of countries including the United Arab Emirates, China, Finland, Italy, Japan, Morocco, Poland, Saudi Arabia, Sweden, Tunisia, Vietnam, etc.
Enstti is the professional training and tutoring Institute to transfer the knowledge and know-how of the European nuclear safety organizations. The ENSTTI initiative was set up in 2010 to meet the growing need for trained experts, prompting the major European technical safety organizations for the nuclear industry, which are members of the ETSON network, to pool their resources. ENSTTI transfers the knowledge and know-how of over 2,000 experts with operational responsibilities in a wide range of activities in the fields of nuclear safety, nuclear security and radiation protection from the assessment of nuclear power plant safety to the analysis of the effects of interventional radiology on health. Ours founding members are BELV (Belgium), IRSN (France) and LEI (Lithuania). ENSTTI’s ultimate goal is to provide initial training and continuous qualification programs to ensure that personnel at European Nuclear Regulatory Authorities and Technical Safety Organizations can maintain skills in their current positions and remain prepared to take on emerging tasks or advancements. ENSTTI has set up a high-quality training mechanism to tackle the training needs of experts at NRAs and TSOs, ensure the continuous development of qualified experts in this area, and foster harmonization of technical practices in nuclear safety, nuclear security and radiation protection. This is achieved through regular vocational training and tutoring, delivered exclusively by senior professionals from European TSOs who take the latest technical developments into consideration. The training program is continuously updated and improved through a systematic approach to training. Both their field experience and their pedagogical qualities provide a guarantee of quality for the training courses. ENSTTI training can be supported through IAEA and European Union fellowship programs. ENSTTI has earned recognition and backing from the European Commission and international organizations, starting with the IAEA. It is commissioned more and more to provide training and tutoring outside the European Union, under initiatives such as the EC’s Instrument for Nuclear Safety Cooperation. ENSTTI successfully adapts its approaches and organization to meet the specific needs of “newcomer” countries, for instance in Asia. In this spirit, the Institute seeks to foster closer ties with all other regional associations. Every year, more than one thousand participants attend its training and tutoring program.

**KEY FIGURES**
- 869 trainees attending ENSTTI activities
- 188 lecturers from the TSO member organizations
- 63 training sessions
- 34 months of tutoring
- Training courses dispensed in 12 countries in the EU, Africa, Asia and Latin America
TRAINING & TUTORING

ENSTTI offers both intercompany training courses and customized intracompany training courses each year. Tailor-made training can be developed with you or adapted from existing trainings, it best meet your needs. In 2018, 42 courses are offered, including 2 news ones. ENSTTI offers a large catalog of training courses in the following fields:

EMERGENCY PREPAREDNESS
Training on Emergency Preparedness and Response in case of a nuclear or radiological accident situation discusses the radiation hazards associated to this situation and the way to get prepared for providing the appropriate response to it. It addresses the international and European requirements, the effects of ionizing radiation, the exposure pathways, the strategy for managing the protection of the population both during the emergency and post-accidental phases, the corresponding needs for planning, tools, equipment, and training. Emergency situations in a Nuclear Power Plant, during a nuclear fuel transportation or with a damaged source are used to illustrate EPR.

NUCLEAR SAFETY
Fully understanding the physical and chemical phenomena at work during the operation of nuclear reactors, laboratories, and plants such as waste disposal facilities, enables a more effective assessment of the safety of these facilities. Contributing to the safety of existing and future nuclear facilities is done through a wide range of activities: drafting or reviewing the safety files of facilities in operation or under construction; supporting inspection teams from the safety authorities; contributing to the process of updating national and international regulations; developing research programs regarding the prevention of accidents and the management of the consequences of major accidents…

NUCLEAR SECURITY
Understanding of nuclear security and safeguards relates to knowledge on issues such as physical protection of nuclear facility, transport of nuclear material, cybersecurity at nuclear facilities, nuclear material accounting and control, and international safeguards. ENSTTI courses cover several angles which present these different concepts, explaining existing synergies as well as differences.

RADIATION PROTECTION:
Using ionising radiation for beneficial purposes requires appropriate protection of workers, patients, the public and the environment. Knowing and implementing safety standards for radiation protection, radioactive waste and transport of radioactive material is of utmost importance for any stakeholder of a national regulatory system.

FIVE GOOD REASONS TO TRAIN WITH ENSTTI:
- Guarantee of training effectiveness
- Active teaching methods
- Team of experienced and dependable trainers
- Practical arrangements as close as possible to your needs
- One-year post-training hotline service offered
The IRUP - ISTP Center for Nuclear Education and Training has been working with companies of the nuclear sector for over 20 years in fields as varied as maintenance, dismantling, construction, and services, for nuclear power plants and fuel cycle facilities. Around 1,600 students attended courses over the past two decades. This long experience has enabled us to develop a wide range of training programs.

Our programs train skilled workers, advanced technicians, and engineers. Our technicians receive training in construction site management, mechanics, I&C, non-destructive testing, valve operation and can access intermediary management positions such as general foreman, integrated service supervisor, and radiation protection manager.

Our commitments in terms of quality assurance and sustainable development, as well as our ISO 9001, CEFRI-F, and CIN (EDF) certifications, testify for our dedication to customer satisfaction and innovation. Companies—whether they are large corporations or SMEs, are involved both in training design for their employees’ continuing education—and in the definition of certification criteria for the degrees awarded by IRUP and Saint-Etienne Graduate School of Engineering.

This constitutes the trademark of lifelong learning programs at IRUP-ISTP Center for Nuclear Education and Training. Our collaboration with and commitment to companies also translate into tangible support actions. Our engineers work together with companies to improve quality, safety, efficiency, and productivity.

**KEY FIGURES**

- 1,600 students trained since 1997
- 1,339 graduates since 1997
- 200 partner companies
- 70% of our students are employed in the company where they did their apprenticeships after graduating
- 12 training programs from high school diplomas to Master’s of Engineering and certificates
- 100% professional integration
TRAINING

NUCLEAR TRAINING FACILITIES
The IRUP-ISTP Center for Nuclear Education and Training trains students at two nuclear training facilities designed to provide today's nuclear industry professionals with the required skills: radiation, protection, quality, safety, pressurized water reactor, work within controlled area. With the Campus Industriel where they are located in Saint-Etienne (France), IRUP and ISTP have access to 75,350 sq ft dedicated to training including 13,000 sq ft of workshops (welding, valves, robotics, operational excellence, etc.).

AWARDS
In 2013, the IRUP-ISTP Center for Nuclear Education and Training was awarded the Yves Chellet Prize for its commitment to nuclear education and training. The Master’s of Engineering in Nuclear Facilities Engineering was awarded the Nuclear Training Award for on-the-job training and many other of our programs were nominated in the apprenticeship category.

In the past 5 years, students from IRUP and ISTP were awarded the Fem’Energia prize, from EDF, WIN France, and WIN Europe for their training paths in the nuclear field and recently, students from ISTP won the French INNOVATOME and I4N (Innovation for Nuclear) International contest with their SyMon project.

NETWORKS
The IRUP-ISTP Center for Nuclear Education and Training is involved in several networks, among which IFARE, COPSAR and SFEN, VIN, Nuclear Valley, ENEN (European Nuclear Education Network) and I2EN. It is also linked to Birmingham and Cork universities for European mobility.

TRAINING PATHS
Our vocational preparation to nuclear professions program trains job-seekers who wish to undergo retraining and turn to the nuclear industry. It is a preparatory qualifying program.
Accreditations: SCN1 (Common nuclear knowledge - level 1), RP1 (radiation protection - level 1) and CSQ (safety and quality).

Our maintenance and nuclear logistics technician program trains young high school graduates in one year to become technicians in maintenance, civil engineering, logistics, and dismantling. It is a qualifying program.
Accreditations: SCN1, RP1, CSQ, crane operator and electrician certifications.

Our maintenance technician specialized in nuclear sites program offers 3 specializations: valves, electrical mechanics, and pipes. It trains young high school graduates in two years to become operations supervisor. The program leads to a vocational certificate delivered by IRUP.

Our maintenance supervisor in nuclear environment program offers 2 career paths: general engineering or civil engineering. It trains in one year Associate’s degree holders for team supervision and to coordinate maintenance, dismantling, and decommissioning works. They can also aim at technical assistant positions. The program leads to a vocational certificate.
Accreditations: SCN 1 and 2, RP 1 and 2, crane operator, electrician, and occupational first-aid certifications.

Our operations supervisor in nuclear environment program offers 2 career paths: general engineering or civil engineering. It trains in one year Associate’s degree holders to become chemistry technicians, account officers, or intervention specialists. The program leads to a vocational certificate.
Accreditation : HN3.

Our Master’s of Engineering in nuclear facilities engineering is jointly run by Mines Saint-Etienne (Saint-Etienne Graduate School of Engineering) and INSTN (see p. 62). It is a three-year program for future engineers. It leads to a Master’s of Engineering degree delivered by Mines Saint-Etienne.
Accreditations: SCN1, RP1, CSQ.
Vocational high school programs are three-year programs, from 10th to 12th grade. There are several possible options to prepare vocational high school diplomas: full-time programs, apprenticeship programs, continuing vocational education, and PLAR (Prior Learning Assessment & Recognition). For PLAR, applicants must have at least three years’ prior experience as skilled workers or equivalent in a position consistent with the targeted degree.

**VOCATIONAL HIGH SCHOOL DIPLOMAS IN NUCLEAR ENVIRONMENT**
- CFA André Voisin
  > Apprenticeship Dieppe
- Lycée professionnel Emulation Dieppoise
  > Full-time program Dieppe
- CFA de l’industrie de Haute-Marne (CFAI)
  > Apprenticeship Saint-Dizier
- CFA des industries du nucléaire
  > Apprenticeship Thionville
- CFA de l’académie de Reims (lycée Vauban)
  > Apprenticeship Givet
- Lycée Léon Blum
  > Full-time program Le Creusot
- Lycée Paul Emile Victor
  > Full-time program Obernai
- Lycée professionnel Alexis de Tocqueville
  > Full-time program Cherbourg-Octeville
- Lycée professionnel Blaise Pascal
  > Full-time program Saint-Dizier
- Lycée professionnel du l’Estuaire
  > Full-time program Blaye
- Lycée professionnel Catalins
  > Full-time program Montélimar
- Lycée des métiers Marguerite Audoux
  > Full-time program Gien

**POST-SECONDARY PROFESSIONAL CERTIFICATIONS IN RADIATION PROTECTION FOR TECHNICIANS**
- INSTN
  > Apprenticeship or continuing vocational education Cadarache
  > INSTN
  > Full-time program Cherbourg-Octeville
Based in the greater Paris area, the nuclear maintenance training center offers a coherent range of courses for technicians working on facilities and particularly at EDF nuclear power plants. The center can boast two strong points: a 100% pass-rate in examinations and, above all, 100% integration into the nuclear industry.

The center gathers several academic institutions covering different levels of higher education and offers both initial and continuing education fully in line with industry requirements. In over two decades, more than 2,800 people have been trained at the various institutions. Their organization as a pool has increased total activity by 35%, particularly in apprenticeship programs.

In cooperation with EDF, the center works closely with the main operators and R&D players, five regional service provider associations, industry, trade unions, the French Nuclear Energy Society, and government authorities. To fully respond to changing needs in the industry, each year the center hosts a one-day national professional event which brings together all the players and delivers valuable insight to tailor the training offer.

**THE TRAINING CENTER’S ACADEMIC INSTITUTIONS**

- André Malraux school (Montereau) specializing in maintenance and valves,
- Gustave Eiffel school (Varennes-sur-Seine) specializing in metal structures and electrical engineering professions,
- IUT (university technical institute) in Sénart for vocational degree courses,
- ENS (teacher training college) in Cachan for skills, jobs analysis, and characterization.

**AVAILABLE COURSES**

- advanced technology diploma (DNTS) and vocational degree (three years’ higher education)
- valves and nuclear maintenance (one year higher education)
- certificate of qualification (CQP) or certificate of qualification in metallurgy (CQPM)
- two-year vocational course in industrial sheet metal work, design, and manufacturing (BTS – advanced technician diploma)
- two-year vocational course in electrical engineering (BTS)
- two-year vocational course in industrial maintenance (BTS)
- vocational high school diploma in industrial equipment maintenance
- sheet metal, pipes, and welding workers (ICTS)
- vocational undergraduate training (CAP) in industrial sheet metal work & valves (RCI)
- course intended solely for professionals (available by accreditation of prior learning and through apprenticeship): valves and fittings, QSP (supplier safety quality) and PR1 (level-1 risk prevention), biological protection fitting.
GRADUATE SCHOOLS OF ENGINEERING

ARTS ET MÉTIERS ParisTech

EDUCATION PROGRAMS
The school offers an extensive education offer in technology from Bachelor’s degree to PhD:
• 1 Bachelor’s of Technology
• 1 Master’s of Engineering
• 8 Master’s of Engineering through apprenticeship
• 20 Master’s of Science
• 17 Post-master’s certificates & MBAs
• PhDs

Arts et Métiers has developed multiple education programs in nuclear energy to meet the increasing demand in skilled nuclear personnel of industrial corporations.

MASTERS OF ENGINEERING
The MEng major in Engineering for the nuclear industry is offered to students in their third year at Arts & Métiers ParisTech and is taught at our Paris Campus. A double-degree with INSTN (see p.62) is also available to students enrolled in this major.

We also offer a Master’s of Engineering specializing in energy engineering at our Paris Campus. In partnership with the Ingénieurs 2000 Apprentice Training Center, this program is available through apprenticeship only. It lasts three years and offers two possible majors, including one in nuclear engineering.

POST-MASTER’S CERTIFICATE IN NUCLEAR SAFETY
In partnership with INSTN (see p.62) and IRSN (see p.58), the Arts et Métiers Campus at Aix-en-Provence offers a one-year post-master’s certificate in nuclear safety.

KEY FIGURES
• 14 Arts et Métiers campuses
• 6,200 students and interns
• 9 engineering programs
• 17 post-master’s certificates & MBAs
• 15 research laboratories
**GRADUATE SCHOOLS OF ENGINEERING**

**CHIMIE ParisTech**

Chimie ParisTech, also known as the Paris Graduate School of Chemical Engineering, is the best Graduate School of Engineering specializing in chemistry in France. We provide education programs that cover all fields of chemistry from organic chemistry, to materials chemistry, physical chemistry, analytical chemistry, process engineering, and energy. Students are also enrolled in a wide range of classes in human and social sciences such as management and entrepreneurship.

They benefit from our numerous assets, i.e. a cutting-edge research center in line with the education programs we offer, small classes, over 20 student organizations, and an ideal location at the very heart of the Latin Quarter in Paris, France. To graduate, students must do at least 12 months of internship, including 5 months abroad. They have the possibility to go on exchange programs as we have many double-degrees with educational institutions abroad but also with other graduate schools in Paris.

Education at Chimie ParisTech is based on the following principles: thorough knowledge of physical and chemical properties of matter and its transformations; complementary skills in mathematics and computer science; solid skills in business management; development of innovation spirit; consideration of sustainable development and social responsibility; learning of two foreign languages and discovery of cross-culturality (international students and professors, cross-cultural conference in sophomore year, mandatory international mobility during the degree for an internship or an exchange program in a university abroad); permanent concern of students’ personal development and their professional projects; close cooperation with the industry.

**MASTER OF SCIENCE IN NUCLEAR ENERGY SPECIALIZING IN FUEL CYCLE**

The Master of Science in Nuclear Energy is jointly run with 2 other ParisTech schools, Paris Sud University, Centrale-Supélec, and INSTN.

The major in “fuel cycle” aims at providing students with the physics and chemistry knowledge necessary to understand and master the different stages of the cycle. Special emphasis is given to separation and transmutation—a field in which recent advances are leading to a new cycle-reactor approach. This new approach includes the notion of recycling and even of “mutlirecycling”, for a complete incineration of long-lived minor actinides within the reactor.

The originality of this Master’s degree is that its program covers all fields related to nuclear energy.

In their first year, students learn the fundamentals of:
- Nuclear physics
- Material sciences
- Energy industries
- Project management
- Mathematics
- Process Engineering
- Continuum mechanics
- Languages and cultures
- Fluid mechanics and heat transfers
- Solution chemistry
- Economics of the energy sector
- Thermodynamics
- Material sciences.

In their second year, students must choose one of the following five majors:
- Physics and engineering of nuclear reactors
- Nuclear power plant design
- Operation
- Fuel cycle (engineering or radiation chemistry)
- or Dismantling and waste management.

This Master’s degree also aims at preparing students to teaching and research for those who want to pursue their studies with a PhD. The very large number of labs supporting this Master’s degree enables quite many students to follow this path.

**KEY FIGURES**

- 100% professional integration
- 90 PhD students
- 6 to 10 patents a year
- 50% female students
- 20% international students
GRADUATE SCHOOLS OF ENGINEERING

ÉCOLE POLYTECHNIQUE
ParisTech

This 4-year curriculum provides our students with both:
• Multidisciplinary courses which give them a solid scientific background (fundamental science, engineering science, economics and social sciences)
• Specialized courses with advanced scientific concentrations that rival the top engineering schools worldwide.

General studies are offered during the first two years of the program, where students acquire a solid scientific foundation in subjects such as mathematics, physics, chemistry, biology, mechanics, economics and computer science.

Specialized studies are offered during the third and fourth years of the program:
• In their 3rd year, students choose a major. One of them is dedicated to Energies of the 21st century and provides students with a global overview of energy and environment issues, with relevant courses from the fields of applied mathematics, materials sciences, mechanical engineering, physics and economics, and with more specialized courses such as thermal-hydraulics, neutronics, nuclear reactor physics, or nuclear fuel cycle. At the end of this year, students complete a 4- to 6-month full-time research internship in an academic institution or a company. Students who have completed a Bachelor’s of Science in other institutions may also join this program and validate it as the first-year of a Master’s degree.
• 4th-year students may further specialize in the field of Nuclear Engineering (and obtain a Master’s degree) by entering either the joint Master of Science in Nuclear Energy or one of the 2nd year master-level courses offered by I2EN’s partners such as ENSTA and INSTN.

KEY FIGURES
• 3,000 students
• 850 international students (30% of the student body)
• 27 international double-degrees
• 670 full-time professors
• 23% international faculty
ENSTA ParisTech, the National School of Advanced Sciences and Technologies, belongs to the foremost Graduate Schools of Engineering in France. We provide our students with a broad education in engineering to train them to design, carry out, and manage complex technical projects. We constantly update our programs to keep pace with advances in cutting-edge technologies. At ENSTA, students also receive training in languages and humanities and all the skills needed in business life such as law, communications, economics, accounting, and management.

MASTER OF ENGINEERING
Our Master’s of Engineering offers three majors: Energy and environment, Transports, and Systems engineering. The major in Energy and environment covers energetic systems, offshore energies engineering, energy and environment management, and electronuclear energy. The course in electronuclear energy provides our students with both scientific and technological education in advanced fields such as nuclear fission, reactor physics, fuel cycle, heat transfer and finite element modeling of flow, structures mechanics, and interactions. The main goal is not to train specialists in reactor physics and calculations but to give students a precise and correct understanding of nuclear power plant operation. They are also trained to understand the policy, economy, and strategy of the energy market. Students are in direct contact with specialized players, often French decision-makers from major industrial companies such as EDF, AREVA, and ENGIE, as well as public and private research organizations (CEA, CNRS, ANDRA, IRSN, etc.). Considering the current context and given the high level of training at ENSTA ParisTech, young graduates in nuclear engineering have numerous opportunities on the job market (around 1,000 open positions per year) and easily find jobs in the nuclear sector.

MASTER OF SCIENCE IN NUCLEAR ENERGY (MNE)
ENSTA ParisTech is not only partner of a prestigious consortium of 12 Graduate Schools of Engineering, namely ParisTech, but also a founding member of the recently inaugurated Paris-Saclay University. In this context, ENSTA ParisTech is teaching a large number of Master’s degrees, including the Master of Science in Nuclear Energy. Its major in Nuclear plant design gives students thorough knowledge in design and construction of nuclear facilities, particularly with regards to safety monitoring, general operation, structures and infrastructures, as well as systems and equipment. This master gives students the necessary fundamentals to understand the physical phenomena which underlay the operation of nuclear reactors. It allows students to become familiar with the main calculation codes for structures and nuclear reactor operation. The major in Nuclear plant design also gives insights into radiation protection and the protection of people and the environment. This major aims to give students a complete and large overview of the nuclear energy sector, including of its economic and organizational issues.

KEY FIGURES
- 708 students
- 98 PhD students
- 30.4% international students
- 70 partnership agreements with international universities
- 80 tenured professors and 650 speakers from the industry
or from countries where French industrial companies are developing nuclear activities.

The program was introduced in 2008 in the context of an ever increasing global demand in nuclear power. In France alone, nuclear corporations are planning on hiring about 1,000 new engineers and executives per year over the next ten years.

The MS in Nuclear Energy concentrates in engineering and research, and is jointly run by Paris-Sud University (see p.88), ParisTech Graduate Schools of Engineering, and INSTN (see p.62). Its goal is to provide students with solid multidisciplinary methodology in all areas related to nuclear energy, to get them acquainted with research methods and approaches, and to prepare them to work in large industrial corporations. Five majors are offered:

- **Nuclear Engineering**: in-depth knowledge of reactor physics • use of existing tools • development and installation of Generation III reactors • design and development of Generation IV reactors,
- **Nuclear Plant Design**: in-depth knowledge of design and construction of nuclear reactor facilities, systems, and equipment,
- **Fuel Cycle**: in-depth knowledge of chemistry in order to understand and master the different stages of the cycle. Special emphasis is given to separation and transmutation,
- **Operation**: operation and maintenance of nuclear power plants,
- **Decommissioning and Waste Management**: in-depth knowledge of the dismantling of nuclear power plants and waste management • protection of people and the environment.

**MASTER OF ENGINEERING IN ENERGY SYSTEMS**
The MENg in Energy Systems offers a class in nuclear energy. Its aim is to provide students with the technical fundamentals to understand nuclear energy production as a whole. It gives them a solid background in the major scientific fields covered by nuclear energy, i.e. neutronics, thermal hydraulics, electricity, chemistry, radiation chemistry, and materials engineering. The class shows how all these fields are related and can be applied to nuclear energy (nuclear fuel cycle, electricity production, life-span of materials, etc.). It is divided into three chapters: nuclear reactors, material irradiation, and fuel cycle.

The idea is to regard students as future project managers in the nuclear industry and to make them capable of discussing with specialists from any technical field (e.g.: experts in neutronics, thermal hydraulics, electricity, chemistry, environment, etc.). After completing the class, students have the sufficient background to pursue—if they wish to—other classes specializing in the nuclear field of the MENg in Energy Systems (e.g.: thermal hydraulics engineering, nuclear engineering, nuclear fuel cycle, etc.).

**MASTER OF SCIENCE IN NUCLEAR ENERGY**
The Master in Nuclear Energy is mostly designed for international students from countries in need of nuclear training which have signed contracts or agreements with France,
IMT Atlantique, is an institute of higher education and research, grounded through the fusion of École des Mines Nantes and Telecom Bretagne in January 2017. IMT Atlantique Technological University, is a member of Institut Mines Telecom. The research potential ranks IMT Atlantique among the top 10 in France. We have built our reputation both on high-level research and on innovative teaching methods. We offer three degrees: MEngs—including through apprenticeship, MS’ and PhDs. We prepare our future engineers and researchers to a globalized world upheld on a network of 180 partners across the world, offering 51 double-degrees and three international MS’ We offer three programs which cover all fields in the nuclear sector, from the most fundamental to applied.

MASTERS OF ENGINEERING
For MEng students interested in careers within major corporations and institutions in the nuclear sector, three majors are available:
- Nuclear: technology, safety and environment (NTSE);
- Systems and technologies applied to nuclear reactors (STAR);
- Research and development, instrumentation (RDI).

INTERNATIONAL MASTER OF SCIENCE
We offer an international MS in Sustainable Nuclear Energy -Applications and Management (SNEAM), taught in English. Students acquire solid scientific, technical and industrial knowledge in each off the three majors:
- Advanced Nuclear Waste Management (ANWM) focuses on the back-end of the nuclear fuel cycle, waste management, long-term safety, and environmental impact assessment, and provides strong insights on dismantling and decommissioning issues;
- Nuclear Energy Production & Industrial Applications (NEPIA) specializes in nuclear reactors and industrial applications (particles beams technology, instrumentation, etc.). A particular focus is put on safety and radiation protection;
- Nuclear Technologies for Medical Applications (NUTMA; partly in French) focuses on the different nuclear technologies used in the medical field.

MASTER OF SCIENCE IN FUNDAMENTAL PHYSICS AND APPLICATIONS (PFA)
This MS, managed jointly with Nantes University, offers three different majors: Ionizing radiation and medical application (RIA); Research into Sub-atomic Physics (RPS); Dismantling and Nuclear Modeling (DMN).

INTERNATIONAL COOPERATION
IMT Atlantique is a founding member of IFCEN, the Sino-French Institute of Nuclear Engineering & Technology, at Guangzhou’s Sun-Yat-Sen University in southern China. It is an engineering school modeled on the French system.

RESEARCH
IMT Atlantique participates in many joint research units with CNRS, Nantes University, University of South Brittany, University of Rennes 1, other graduate schools, INSERM and INRIA. We have created two research and teaching chairs in the nuclear and high-risk industry sectors in partnership with major corporations such as ANDRA, ORANO, EDF, NAVAL Group, and IRSN:
- Stocking and storage of radioactive waste,
- RESOH, Research into Human Safety Organization.

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- Research and development, instrumentation (RDI).

INTERNATIONAL MASTER OF SCIENCE
We offer an international MS in Sustainable Nuclear Energy -Applications and Management (SNEAM), taught in English. Students acquire solid scientific, technical and industrial knowledge in each off the three majors:
- Advanced Nuclear Waste Management (ANWM) focuses on the back-end of the nuclear fuel cycle, waste management, long-term safety, and environmental impact assessment, and provides strong insights on dismantling and decommissioning issues;
- Nuclear Energy Production & Industrial Applications (NEPIA) specializes in nuclear reactors and industrial applications (particles beams technology, instrumentation, etc.). A particular focus is put on safety and radiation protection;
- Nuclear Technologies for Medical Applications (NUTMA; partly in French) focuses on the different nuclear technologies used in the medical field.

MASTER OF SCIENCE IN FUNDAMENTAL PHYSICS AND APPLICATIONS (PFA)
This MS, managed jointly with Nantes University, offers three different majors: Ionizing radiation and medical application (RIA); Research into Sub-atomic Physics (RPS); Dismantling and Nuclear Modeling (DMN).

INTERNATIONAL COOPERATION
IMT Atlantique is a founding member of IFCEN, the Sino-French Institute of Nuclear Engineering & Technology, at Guangzhou’s Sun-Yat-Sen University in southern China. It is an engineering school modeled on the French system.

RESEARCH
IMT Atlantique participates in many joint research units with CNRS, Nantes University, University of South Brittany, University of Rennes 1, other graduate schools, INSERM and INRIA. We have created two research and teaching chairs in the nuclear and high-risk industry sectors in partnership with major corporations such as ANDRA, ORANO, EDF, NAVAL Group, and IRSN:
- Stocking and storage of radioactive waste,
- RESOH, Research into Human Safety Organization.

IMT Atlantique is an institute of higher education and research, grounded through the fusion of École des Mines Nantes and Telecom Bretagne in January 2017. IMT Atlantique Technological University, is a member of Institut Mines Telecom. The research potential ranks IMT Atlantique among the top 10 in France. We have built our reputation both on high-level research and on innovative teaching methods. We offer three degrees: MEngs—including through apprenticeship, MS’ and PhDs. We prepare our future engineers and researchers to a globalized world upheld on a network of 180 partners across the world, offering 51 double-degrees and three international MS’ We offer three programs which cover all fields in the nuclear sector, from the most fundamental to applied.

MASTERS OF ENGINEERING
For MEng students interested in careers within major corporations and institutions in the nuclear sector, three majors are available:
- Nuclear: technology, safety and environment (NTSE);
- Systems and technologies applied to nuclear reactors (STAR);
- Research and development, instrumentation (RDI).

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multiple career paths in various industries such as cosmetics, paints, lubricants, etc. The *Materials optimization and reliability* major focuses on mechanics, damage of materials, and structural materials. With this program, ENSCL offers a more comprehensive and innovative program to differentiate itself from more traditional majors offered in other schools such as "materials chemistry" and "materials recycling". The major in *Sustainable chemistry and processes* for the industry was launched in 2012 to prepare future chemists to develop a sustainable industry. This goal can only be achieved by using alternative and renewable resources from biomass, by adapting processes, and by developing industrial and research reactors integrated into clean processes and complying with environmental regulations in force in the chemical and industrial waste management industry.

**MASTER OF SCIENCE**

We also offer 6 Master’s degrees jointly run with partner universities such as Lille 1 University. About twenty of our students enroll in these programs each year. The goal is not necessarily to prepare them for a PhD but to provide them with complementary training. Students registered in the major *Materials optimization and reliability* can thus be awarded both the MEng and the MS in Chemistry, Energy, and Environment awarded jointly by Lille 1 University and ENSCL. The aim of this MS is to provide graduate students with specialized education in the field of nuclear energy, and most especially in the fields of research explored in our labs and by our industrial partners. The three main topics are fuel cycle, materials resistance, and nuclear safety.

**RESEARCH**

ENSCL maintains strong links with the business and research world to remain always up-to-date on scientific advances. Our tenured professors carry out research in three joint laboratories: the Catalysis and Solid-state Chemistry Unit (joint research unit with CNRS UCCS - 8181), the Transformation and Materials Unit (joint research unit with CNRS UMET - 8207), and the Formulation and Molecular Chemistry Laboratory (CMF EA 4778).

**MASTER OF ENGINEERING**

We offer students one MEng with three possible majors: *Formulation chemistry*, *Materials optimization and reliability*, and *Sustainable chemistry and processes for the industry*. ENSCL was one of the first schools to develop a specialized program in *Formulation chemistry*. After graduating, our students can chose between 2,600 alumni active worldwide
360 students
47 tenured professors and teachers
3 renowned research laboratories
300 industrial partners

**KEY FIGURES**
ENSCM, Montpellier Graduate School of Chemistry, is the heir to a long and rich tradition of chemistry studies and research in Montpellier. We train top-level chemistry engineers for various jobs in production, research, and management in fields as varied as fine and health chemistry, materials chemistry, environment, and sustainable development.

SCIENTIFIC FIELDS
The programs we offer aim at providing students with background knowledge on the main reactors currently in operation, on radioactivity and advances in fuel cycle chemistry, on fuel materials, on radwaste matrices, on f-block elements, on liquid-liquid extraction processes, on waste treatment and packaging processes, and on regulation related to the decommissioning and dismantling of nuclear facilities. Both theoretical and practical aspects of these issues are developed as we also teach students about environmental and economic issues related to energy. Students also gain insight into industry issues classes and conferences taught by speakers from the private sector.

MASTER OF ENGINEERING
About 40 engineers specialized in fuel cycle chemistry and materials have already graduated from the major in Nuclear chemistry & environment (CNE) set up in 2009 with CEA/INSTN (see p. 62) and Montpellier University (see p. 86). The major was launched simultaneously as the opening of the Marcoule Institute of Separation Chemistry (joint research unit with CEA, CNRS, ENSCM, and Montpellier University). Nuclear-specific classes are taught by engineers, researchers, and tenured professors working at the CEA-Marcoule Center.

MASTERS OF SCIENCE
Our students can also enroll in a double-degree program thanks to the partnership we set up with Montpellier University. Students who successfully complete the program are awarded both the MEng and the MS in Separation chemistry, materials, and processes (CSMP) taught at Montpellier University.

PROFESSIONAL OUTCOMES
The two degrees were designed so as to be both close to the corporate world and enable students to carry on with positions in the industry (mostly at AREVA, EDF, and their contractors) and the research world to enable them to carry on their training with a PhD (mainly at Andra, CEA, and EDF).

At the end of their studies, all students have to conduct an industrial project in the framework of a 5-6-month internship. Their projects are supervised by teachers or researchers from our partner research laboratories. Working partnerships with companies and research organizations enable students to intern at CEA, AREVA, and EDF in France, or at Oak Ridge National Laboratory, Iowa National Laboratory, and Washington State University abroad.

After graduating, students can go for jobs in any field where the technical know-how and knowledge of chemistry engineers are required. This means R&D where innovation and creativity are strategic features for companies, but also production, analysis, quality assessment, regulations, environment, decommissioning, dismantling, etc.

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ENSICAEN, a Graduate School of Engineering based in Caen, provides first-class scientific and technical training to future engineers. Our training offer is supported by a cutting-edge research center with seven laboratories, six of which are jointly run with CEA, CNRS, and Université de Caen Normandie, the seventh one with NXP France and Presto Engineering.

MASTERS OF ENGINEERING
We train engineers in Electronics and applied physics, Computer science, and Materials chemistry. We also have two apprenticeship programs in computer science, electronic banking, and system security, and in Mechanical and materials engineering.

CONTINUING EDUCATION
We offer four continuing education programs: an MEng in Industrial engineering in partnership with ITII, a post-master’s certificate in Electronic banking and secured transactions (MTS) and a qualifying program in Economic intelligence.

RESEARCH
ENSICAEN is an internationally recognized multidisciplinary research center. The fields of research of our 7 joint research units are nuclear, atomic, molecular and condensed matter physics, chemistry, materials, catalysis, organic chemistry computer science and communications technologies.

NUCLEAR TRAINING AT ENSICAEN
The lower part of Normandy is renowned for its expertise in nuclear energy and medical applications. It is a reference player in the Normandy nuclear cluster. This sector employs about 14,000 people in the region.

The Master of Engineering in Electronics and Applied Physics of ENSICAEN offers two nuclear-specific programs. In their 2nd year, students choose a major:

- Nuclear and energy engineering: Since 2004, more than 250 students have graduated, and most of them now work in the nuclear industry. The major prepares future engineers for careers in the nuclear industry by providing scientific and technological knowledge in design and operation of nuclear facilities, reactor operation, neutronics, thermal hydraulics, computer modeling, nuclear safety and instrumentation. It also deals with the different sources of energy and energy conversion techniques and offers an overview of the energy mix. The program includes industrial presentation from major companies in the field (ORANO, EDF, CEA, ASSYSTEM...) and site visits (La Hague nuclear fuel reprocessing plant, nuclear power plants).
- Advanced instrumentation: The major aims to develop scientific and technological knowledge in R&D for instrumentation and measurement systems: photonic applications, optics, LASERs and optoelectronics, industrial and medical applications of radiation, imaging, radiation protection, design and implementation of sensing applications, control-command. A focus on biomedical engineering is proposed in the 3rd year.

ENSICAEN is also a member of the Normandy Nuclear Science and Nuclear Applications Cluster, NUCLEOPOLIS.

KEY FIGURES
- 700 students
- 5,200 alumni
- 177 PhD students
- 650 researchers, tenured professors, technicians, and support staff
- 14 MEngs, MS' and post-master's certificates
- 7 research laboratories
ESIX Normandy

ESIX Normandy is the Graduate School of Engineering of Caen-Basse-Normandie University. Our belonging to the University of Caen-Basse-Normandie enables us to benefit from its first-class pedagogic and scientific environment and our engineering programs provide us with a close relationship with industry.

ESIX Normandy is located over three campuses — Caen, Saint Lô, and Cherbourg — all in Western France.

MASTERS OF ENGINEERING
Our three-year program trains future engineers to become knowledgeable about industrial technologies, readily operational, and capable of adapting to technological innovation thanks to their scientific and project management skills. Curricula are developed in partnership with industrial companies such as AREVA, DCNS, Andra, SALVAREM, SPIE and EAMEA — the School for Military Applications of Nuclear Power.

The specialization in Nuclear operations can be pursued either as an initial or continuing education program. It trains engineers to work in nuclear facilities throughout all the stages of their lives — from construction to upgrade, maintenance, and dismantling.

The program focuses on nuclear technology and is meant to develop significant safety culture. Students learn to:
• Ensure the technical quality of nuclear feasibility studies and construction sites: physics, chemistry, materials, and mechanics;
• Guarantee the operating safety of nuclear facilities, construction sites, and equipment, the security of people, and the quality of the environment: risk management, occupational health and security, radiation protection, safety;
• Manage projects: project management, accounting;
• Evolve in a nuclear, industrial, and international environment: foreign languages, management, and ethics;
• Perform professional activity: project methodology, initiation to research, site visits, mandatory 6-month internship with a possibility to do it abroad;
• Be operational in a nuclear environment: students have to take and pass the PRI certificate (Risk Prevention — level 1).

KEY FIGURES
• 26% international students
• 2 years of specialization in nuclear operations
• 7 months of internship over two years
• 9 partner universities abroad in Austria, Finland, Slovakia, Spain, and Argentina
• 1 laboratory dedicated to ceramic materials and components, and electrical energy systems, flows, and transfers.
Grenoble INP, The Grenoble Institute of Technology, is one of Europe’s leading technology universities. We have been training engineers for 100 years in 11 high-tech areas at our schools specialized in the nuclear sector: Phelma (physics, applied physics, electronics and materials science) and Ense3 (energy, water and environmental sciences). We offer 6 different education programs in nuclear energy and award 100 BS, MEng and MS degrees every year in this field. With more than 40 years of experience, Grenoble INP has the oldest nuclear engineering training and research program in France together with INSTN (see p.62). Grenoble INP is one of the key founders and supports of the Sino-French Institute of Nuclear Engineering & Technology, IFCEN, at Sun-Yat-Sen University, Zhuhai.

NUCLEAR ENERGY PROGRAMS AT PHELMA
The GEN MS (Reactor physics and nuclear engineering, 3 years, FR) prepares future engineers for a career in the nuclear industry. GEN’s main objectives are to provide in-depth understanding and practice in: (a) reactor physics, thermal-hydraulics, material and nuclear physics, and nuclear instrumentation; (b) modeling and simulation; (c) engineering sciences and (d) reactor operation, safety and design.
respgen@phelma.grenoble-inp.fr

MaNuEn (Materials science for Nuclear Energy, 2 years, EN) is an international Master’s program, developed in close cooperation with EDF, CEA, and INSTN for students seeking a career in the nuclear industry or R&D. It covers the specificities of materials used in a nuclear environment from nuclear fuels to structural materials of nuclear reactor components. Special focus is given to material durability under irradiation.
respmanuen@phelma.grenoble-inp.fr

EMINE, the European Master’s In Nuclear Energy (2 years, EN) provides the high-level technical education required to master the engineering complexities of nuclear power generation, as well as business training related to innovation and energy management. The program is supported by Europe’s leading companies in nuclear energy and research organizations (EDF, CEA, FRAMATOME, Orano and ENDESA). EMINE involves 6 academic partners: KTH and UPC for the first year; and ENSTA ParisTech, CentraleSupélec, Chimie ParisTech, and Grenoble INP for the second year:
emine@kic-innoenergy.com

The EP MS (Physics for Energetics, 2 years, FR) provides students with a strong education in physics for energy systems such as nuclear power plants and solar energy applications. Special emphasis is given to: (a) energetics, nuclear and reactor physics; (b) material physics and nanotechnologies; (c) thermal sciences, (d) solar energy and positive energy building.
M2EP@phelma.grenoble-inp.fr

NCEPU (International Bachelor in Nuclear Engineering, 1 year, EN) is designed for undergraduates who want to do their last year of BS in a highly specialized environment dedicated to nuclear engineering.
in-coming@phelma.grenoble-inp.fr

NUCLEAR ENERGY PROGRAM AT ENSE3
IEN (Engineering of Nuclear Energy, 3 years, FR) is an MEng focused on providing expertise in the full energy conversion chain as well as in advanced modeling and numerical simulation to give students the scientific and technical skills required for the operation, modeling, building and decommissioning of present and future nuclear energy systems.

KEY FIGURES
• 5,500 students
• 1,300 Master’s degrees & 200 PhDs awarded each year
• 800 researchers and tenured professors
• 40,000 Alumni
• 37 research laboratories - 11 of which are international labs
• 6 graduate schools of engineering
CNAM, the National Institute for Crafts & Trades is the French reference for providing professional training to adults, awarding 450 different degrees and certificates from high school diplomas to PhDs. As over half our teachers come from the worlds of business and industry, our students benefit from both academic and professional knowledge and know-how. The CNAM engineering school (EICnam) is present in 29 regions throughout metropolitan and overseas France and in a number of countries abroad ranging from China to Lebanon. The school graduates 1,000 engineers a year in majors as varied as chemistry, mechanics, computer science, and nuclear power.

TRAINING IN THE NUCLEAR FIELD AT CNAM
Training in the nuclear field has been available at CNAM since 1948; it includes two options: nuclear reactor technology and radiation protection. Four different diplomas are delivered: a CNAM certificate and three universally recognized degrees: a Bachelor’s degree, an advanced technician degree, and a Master’s of Engineering. The training courses were developed in close collaboration with professionals to ensure they provide the required skills. Professional experience is totally integrated in the programs as credits are awarded for it.

Training for professionals
Each student can learn at his own pace and construct an individual tailor-made training program by validating complementary units in chemistry, materials technology, metrology, occupational health, etc. All nuclear theoretical units are available in e-learning mode to fit in with the busy schedule of professionals. CNAM has developed an internet platform—Plei@df—translated into a number of languages such as English, Arabic, Spanish, etc. The Plei@df platform offers many services such as chat, video-conference, mail, and an open forum. We have used this website for nuclear training to both teach theory and make exercises available to students. They can download videos of their classes, handouts, and every three or four lessons an MCQ is proposed to help students make sure they have understood the theory. A brief overview of all lessons is also given. Once a month, a meeting with all students is held. It can be attended either in person or online, in real time, or delayed. The final written test is always held in one of CNAM’s centers in France. The only training course which is not in e-learning is the practical one. It is held either on Saturdays, or on occasional days over a longer period, or concentrated into a single week.

Training engineers through apprenticeship
For over 20 years, CNAM has trained engineers through apprenticeship. Excellent courses combining theoretical knowledge and operational know-how are put together and taught by tenured professors and professionals from the nuclear sector enabling apprentices to acquire the necessary skills to exercise the main professions in the nuclear sector.
AIX-MARSEILLE UNIVERSITÉ

AMU, Aix-Marseille University, is the largest French-speaking University. It gathers 72,000 students pursuing initial education or vocational training, 10,000 of our students come from abroad. We teach all disciplines: arts, humanities, languages and human sciences, law and political sciences, economics and management, healthcare, science and technology, education, etc. We award Bachelor’s degrees, Associate’s, Master’s of Science, Master’s of Engineering and PhD degrees but also technical university diplomas and healthcare diplomas.

Aix-Marseille University counts 130 research laboratories, most of which are run jointly with national research organizations. Our five major fields of expertise are energy, environmental and universe sciences, life and health sciences, advanced science and technology, and human and social sciences.

Transdisciplinarity and technology transfer are the major development areas to achieve both our international and national ambitions.

RESEARCH
Aix-Marseille is recognized for the excellence of its research. The funding agreement of A*Midex (Aix-Marseille Initiative of Excellence) was approved by the French Government on April 5, 2012. This ranks us among the eight French Clusters of Excellence recognized by an international panel of experts.

AIX-MARSEILLE UNIVERSITY CAMPUS: CAMPUSES RENOVATED TO MEET INTERNATIONAL STANDARDS
The Campus Program is a government-funded project which aims at supporting 12 world-class university clusters in France with exceptional grants. Aix-Marseille University was one of the prize-winners of this program and was awarded €500M by the French government itself, €34M for immediate operations, and €300M from local authorities and organizations. These grants enable us to renovate and revitalize the Aix-Marseille and Luminy campuses, among others.

NUCLEAR ENERGY TRAINING AT AIX-MARSEILLE UNIVERSITY
The MS in Nuclear energy at Aix-Marseille University aims at meeting the needs in highly-skilled personnel for the international development of civilian nuclear power. The program covers several scientific disciplines and various fields of activity applied to nuclear fission and fusion: physics, mechanics, and materials and process engineering. We focus on the acquisition of skills with modern modeling and experimentation techniques so that our students can choose between several career paths such as design engineering, research, or project management. Potential employers are companies such as EDF, AREVA, ENGIE, CEA, IRSN, and engineering and services companies in the field of energy. We offer six second-year majors:
- Nuclear physics and neutronics,
- Thermal mechanics and thermal hydraulics for nuclear systems,
- Materials for nuclear applications,
- Process engineering applied to nuclear power,
- International projects engineering for nuclear instrumentation,
- Fusion sciences.

Classes directly or indirectly related to nuclear power are also proposed in other Master’s degrees offered at the university such as the MS’ in Materials, Process engineering, Instrumentation, and Energy law and governance.

KEY FIGURES
- 72,000 students
- 19 university departments
- 130 research laboratories
- 4,600 tenured professors, teachers, and researchers
- 3,650 PhD students
UGA, Université Grenoble Alpes, is a major player in higher education and research in France. Our 80 laboratories and six research departments allow us to enjoy great cross-disciplinarity and to be at the forefront of innovation. Our courses cover all academic disciplines and we feature in the top 100 and top 200 universities in major international rankings (Reuters, Shanghai, Times Higher Education and QS) in many of our scientific fields. We conduct research in conjunction with major French scientific organizations using the international large research equipment we have on-site such as the European Synchrotron Radiation Facility at Institute Laue Langevin.

MASTER OF SCIENCE IN NUCLEAR ENGINEERING

Amongst our numerous vocational curricula, we developed a Master of Science in Nuclear Engineering which is especially designed to meet the needs of the industry. This 2-year program was set up to meet the needs of industrial companies and train top-level specialists in radioactive waste management, nuclear facility dismantling, and safety. The main characteristic of the Master in Nuclear Engineering program is its very strong relationship with the industrial world, with 10 months of internship in an industrial company, a large share of industrial speakers, and many partnership agreements. The program relies both on the scientific potential of UJF and on the skills of the major French nuclear industrial players.

Since 2001, 618 students have graduated from the Master in Nuclear Engineering, most of which now work in the nuclear industry. During their first year, our students mainly learn about nuclear physics, fuel cycle chemistry, and mechanical engineering to prepare for one of the three majors available in second year. The program also includes a 4- to 6-month internship during which students get to know the industrial world and apply the lessons learned during the year. We encourage them to do their internships in industrial companies (EDF, Orano, Framatome, CEA, etc.) so that they get a conclusive first professional experience and can find an apprenticeship in second year.

The second year alternates between classroom training and on-the-job training with 18 weeks at the University and 34 in the company. Three majors are offered, taught in conjunction with INSTN (see p. 62):

• Scientific and technological management of radioactive waste (GDRA)
• Decommissioning and Dismantling of Nuclear Facilities (ADIN)
• Nuclear Safety (SN).

Most classes are taught by speakers from the industry (CEA, Orano, Framatome, IRSN, EDF, etc.) with on-site lab work at CEA-Marcoule, CEA-Cadarache, and the Nuclear Physics and Modeling experimental platform at LPSC Grenoble and visits of major industrial sites of the French nuclear industry. The professional integration rate of graduates is outstanding. The MS' Steering Committee manages apprenticeship contracts and the Council defines its strategic guidelines to make sure the curriculum matches the needs of the industry. The average duration between graduation day and the beginning of the first job (80% permanent positions and 20% short-term contracts) in the nuclear industry was below one week over the past three years.
Lille 1 University of Science and Technology, is a world-class scientific and technology cluster. We have 39 laboratories, most of which are shared with national research organizations such as CNRS (see p. 56), INRIA, INSERM, and INRA. Our laboratories gather about 1,500 tenured professors and researchers and over 1,000 PhD students. 30% of our PhD students come from abroad. Thanks to our numerous partnerships, we make up a top-level scientific and technological cluster of national and international renown.

RESEARCH FIELDS
Lille 1 University of Science and Technology contributes to facing the challenges of the future. We conduct research in 8 research fields:
- information and communications science and technology,
- biology and biotechnology,
- chemistry and materials,
- environment,
- human and social sciences,
- mechanics,
- physics,
- mathematics.

MASTER OF SCIENCE
The Master’s of Science in Chemistry, Energy, and Environment – Nuclear Energy taught at Lille 1 University is a one-year program focused on chemistry and materials for nuclear energy applications. The program addresses the issue of sustainable technological development by taking into account the preservation of the environment in the development of new energy technologies. Our students study both the front-end of the cycle by examining the use and transformation of raw materials, and the back-end by studying wastes, their recycling, valorization, and destruction processes.

The program is meant for students who have completed a first year of MS in chemistry and wish to specialize in nuclear energy to both get strong theoretical background and have an opportunity to do lots of lab work. Our classes are taught by tenured professors, researchers, and experts from Lille 1 laboratories (UCCS, MET, PC2A, etc.) and nuclear industrial companies and research organizations such as AREVA, CEA, and IRSN. The first semester is dedicated to lectures and lab work at school and the second semester is a full-time internship in either an industrial company or research organization. A large selection of research projects in the laboratories are offered. Teaching language is French.

The curriculum offers insights into the following disciplines: reactor services; front-end and back-end; neutronics; thermal-hydraulics; computing codes and simulation; operation of nuclear facilities; reactor safety and regulations; fuel cycle processes; dismantling; environmental impact; political economy of the energy sector; definition, properties, and manufacturing of materials (structure, fuel, matrices, and containers); and English or other foreign languages.
Claude Bernard Lyon 1 University trains students in the fields of science and technology, health and sport. With a strong intellectual reputation both in France and abroad, Claude Bernard Lyon 1 University is continuously pushing the boundaries of knowledge, promoting education through research, and encouraging dialogue between science and society.

MASTER OF SCIENCE
SYVIC Master’s degree - Synthesis, aging, and characterization of nuclear materials

Our objective is to train key employees for the nuclear industry of the future. This course was created to respond to private and public research requirements and industrial R&D needs. The course emphasis is on the issues and challenges faced when using materials in the electronuclear cycle in terms of sustainable development. The following topics are studied: materials used in nuclear fission and fusion reactors, materials associated with the management of nuclear waste. A basic study of materials used for energy complements this course. The SYVIC Master’s degree is meant for students who have completed a first year of Master’s in physics, chemical physics, or material sciences as well as for engineering students who have completed four years of higher education.

Skills and know-how acquired
• Durability and aging of materials
• Radiation protection
• Physical-chemical characterization of surfaces and interfaces
• Radioelements behavior modeling
• Radiolysis and irradiation

In which companies?
• Large nuclear corporations and R&D organizations (Andra, AREVA, CEA, EDF, ONET, etc.)
• Nuclear contractors
Montpellier University was created in 1808 by Napoleon Bonaparte. The first College to be inaugurated was the College of Science. Our training offer is diversified and comprehensive as we award 230 different degrees, most of which can be taken through apprenticeship or as continuing education programs. We welcome international students from 115 countries.

RESEARCH
We conduct research in 8 scientific and technical fields:
• biology applied to health sciences and agronomics,
• biodiversity and ecology,
• evolution and environment,
• chemistry, earth, and water sciences,
• engineering,
• physics,
• mathematics and computer sciences,
• education management and science.
Montpellier University counts about 2,000 researchers and tenured professors working in 40 research units jointly run with large research organizations.

BACHELOR OF SCIENCE
We offer a vocational BS in Chemistry & processes applied to the nuclear fuel cycle. This 1-year program comes after two years of college in chemistry. It is jointly run with CEA/INSTN (see p. 62) and especially the Marcoule Institute of Partitioning Chemistry. We train students to work in various industrial sectors such as the chemical, energy (nuclear and conventional), and environmental industries (treatment and confinement of industrial wastes, industrial site redevelopment).

MASTER OF SCIENCE
The MS in partitioning chemistry, materials and processes is a 2-year program jointly run with CEA/INSTN. It focuses on:
• the evolution of global needs in energy and the place for nuclear energy in an energy mix to meet these needs;
• nuclear reactors, recycling, and waste confinement processes;
• partitioning chemistry and actinide separation processes;
• confinement materials and alteration mechanisms for the long-term storage of nuclear waste;
• the latest advances in nanostructured materials.

This unique and multidisciplinary program provides our students with unique expertise in solution chemistry, chemical analysis, and materials and process sciences. It meets the needs of many industrial sectors—even beyond nuclear energy—such as the chemical, material, environmental, pharmaceutical, and food-processing industries. The CEA-Marcoule center contributes actively to this MS. Its belonging to the Actinet European network of excellence enables our students to do internships in many laboratories in France and abroad. 9 to 10 months of internship are included in the program with 12 to 16 weeks in first year, and 24 weeks in second year.

After graduating, students can choose between completing a second MS to acquire skills in a complementary field, going for a diploma in industrial technological research, starting a PhD, or finding a job in their field of expertise.

KEY FIGURES
• 17,477 students
• 1,173 PhD students
• 1,501 tenured professors, associate professors, and teachers
• 2,178 publications in peer-reviewed journals in 2013
• €221 M budget
The first four months are common to all students, after which they must choose two of the following five electives:
• Nuclear Energy 1: reactor operation, from fission to electricity generation
• Nuclear Energy 2: Evolution of an NPP, from installation to dismantling
• Technology and management of wind turbines
• Photovoltaic and concentrated solar power
• Energy management in buildings.

The electives in nuclear energy include lab work on the ISIS Reactor at INSTN/CEA-Saclay (see p.62).

This program is meant to make student readily operational when they enter the job market after graduating. Potential employers are companies such as AREVA, BOUYGUES, CEA, EDF, and ENGIE.

MASTER OF SCIENCE
The goal of the MS in Nuclei, Particle and Astroparticle Physics, and Cosmology is to prepare students to pursue their studies with a PhD in nuclear physics, elementary particle physics, astroparticle physics, or cosmology. It ensures a smooth transition between the academic and research world by mixing theory, modeling, and instrumentation. Students learn how to design experiments, to choose the right instruments, and develop them. They also learn about data mining and processing, how to publish experiment results and to explain them. The academic year finishes with a three-month internship, preferably in the lab where students are planning on conducting their PhD. All classes are taught in English. This degree is jointly run with Pierre and Marie Curie University (see p.89), Paris-Sud University (see p.88), CNRS (see p.56), and CEA/INSTN (see p.62).

KEY FIGURES
• 29,772 students
• 89 research teams
• 1,800 tenured professors
• 280 international cooperation agreements
UNIVERSITIES

PARIS-SUD UNIVERSITY

A MAJOR PLAYER IN HIGHER-EDUCATION AND RESEARCH
Paris-Sud University is a prestigious and multidisciplinary university with a central science and health science feature. We enjoy outstanding international reputation thanks to the exceptional quality of our research, the appeal of our programs, our fulfilling student life, our multiple partnerships, and the knowledge and skills of our staff. Paris-Sud University counts nine schools among which a School of Science, three Institutes of Technology, and a School of Engineering.

THE EXCELLENCE OF PARIS-SUD RESEARCH: AN INVALUABLE ASSET
In 2011, we came out first amongst French universities in the Shanghai ranking. In 40 years, we have earned many prestigious awards and honors, including two Nobel Prizes in Physics and four Fields Medals. We maintain close relationship with high-level research organizations to provide our students with state-of-the-art knowledge, multidisciplinary and transdisciplinary programs, innovative pedagogy making full use of the latest technology, and career-oriented training at Bachelor’s, Master’s, and PhD levels.

INTERNATIONAL COOPERATION
Paris-Sud has a long established tradition of international exposure and connections with foreign universities and research centers, through its laboratories, research teams and faculty.

MASTER OF SCIENCE IN NUCLEAR ENERGY
The MS in Nuclear energy is a 2-year program open to both French and international students. Set up in 2009, the Master in Nuclear Energy gathers 8 institutions—Paris-Sud University, Ecole Polytechnique, Chimie ParisTech, Ecole des Ponts ParisTech, ENSTA ParisTech, Mines ParisTech, Centrale Supélec, and CEA/INSTN—and was founded with active support from EDF. Delivered by Paris-Saclay University, the degree is one of the national and international reference training programs in the field of nuclear energy. 5 Majors are offered in second year, which cover all nuclear engineering professions: reactor physics, design of nuclear facilities, fuel cycle, operation, dismantling and waste management. All programs are taught in English by professors from our founding members, researchers from CEA and CNRS, and speakers from our industrial partners such as Andra, EDF, Framatome and Orano.

VOCATIONAL BACHELOR DEGREE IN PHYSICS OF ENERGY
This Bachelor’s degree is meant for students who wish to specialize in energy production, consumption, and control processes. 6 main topics are taught: electricity production, transport and storage; thermal science and related technologies; applied thermal dynamics; materials, properties, and applications; fluids: flows and energy transfer; nuclear energy and radiation protection. This Bachelor’s degree is an apprenticeship program: students alternate between weeks in class and weeks at work in a company. Classes on nuclear power are taught by professionals from AREVA, EDF, CEA, and IRSN. These companies also employ students for their apprenticeships. Numerous site visits are organized throughout the school year. Career paths open to students after this program are advanced technician positions in radi- nation, risk prevention, nuclear fuel, and nuclear logistics.

KEY FIGURES
• 31,400 students (5,000 international students)
• 4,300 researchers and tenured professors
• 6,000 scientific publications in peer-reviewed journals/year
• Over 2,600 PhD students
UPMC, Pierre & Marie Curie University, is France's largest scientific and medical campus with 33,900 students (including 6,900 international students). We benefit from the largest library network in France. UPMC features among the best French Universities and is ranked 6th in Europe and 35th in the world. We teach a wide range of hard sciences such as math (4th in the world), chemistry, physics, electronics, computer science, engineering, mechanics, environmental and earth sciences, life sciences, and medicine. With €430 million allocated to research and 8,000 publications every year, UPMC is one of the major players on the global knowledge and innovation market, as shown by the many Prizes and international medals we have been awarded. With 6,900 researchers and senior lecturers within 100 laboratories, UPMC files each year over 20 patents and signs many cooperation agreements with renowned universities around the world.

**MASTER OF SCIENCE**

UPMC is committed to taking up the new challenges faced by the nuclear industry (development of new reactors, dismantling, increased safety requirements) and contributes significantly to the education and training of a large number of Master’s students in its fields of excellence: resource management, safety and criticality, and chemical physics of certain stages of the nuclear cycle.

The Master’s degree in Science and Technology (Physics, Chemistry, and Engineering Sciences) offers a second-year major in Nuclear Engineering, and nuclear safety, together with energy policy and the socioeconomic challenges of the nuclear industry. Certain classes are taught by external lecturers from IRSN, CEA, and EDF (3 months).

- Elective courses. Student must choose one of the two following electives: Resources, cycle, and waste or Safety, criticality, and radiation protection. These courses are partly taught by professionals and experts from the industry: AREVA, EDF, CEA, IRSN, etc. (3 months).
- Internship (6 months).

**PROFESSIONAL PREPARATION**

The program includes industrial on-the-job training, site visits, and meetings with HR staff.

- 3-day on-the-job training at an EDF NPP to learn about NPP operation.
- Tour of the AREVA La Hague storage facility.
- 3-day on-the-job training at the CEA-Marcoule research center.
- Site visits of CEA-Saclay's research facilities.

**CAREERS**

After completing their degrees, students are readily operational to work in the nuclear industry: A critical asset since the need for highly-skilled personnel is bound to expand in the coming years due to 1. the upcoming retirement wave among the French nuclear workforce and 2. the development of new types of reactors, fuel treatment and recycling, the planned decommissioning of the first NPPs. Students can also pursue their careers in the field of medical radiology.
AFPA

TRAINING TO FOSTER COMPETITIVENESS AND EMPLOYMENT
AFPA, the agency for adult vocational training, trains over 150,000 people each year. We have been the major training organization for employees and job-seekers for 65 years. As a social economy company, we offer a wide range of qualifying and certifying training programs adapted to the needs of the workforce, companies, and public authorities. Guided by its economic and social role, AFPA supports technical and economic progress by anticipating on emerging skills. We also support the international development of companies by offering our expertise to governments, most especially in the framework of French cooperation agreements.

AFPA’s offer is both customized and customizable. It includes life-long training for the workforce, either for professional integration, retraining, or acquisition of further qualification. Thanks to our pedagogy focused on professional behavior and our various teaching tools, employees get to understand what skills they lack and can acquire them to improve their professional performance.

A NATIONAL CENTER SPECIFICALLY DEDICATED TO NUCLEAR POWER ACTIVITIES
With over 25 years of expertise, the AFPA center in Cherbourg-en-Cotentin is certified “national center” for nuclear energy and renewable marine energies. We offer several technical platforms developed in partnership with companies such as:

- A technical platform for the operation of automated facilities developed together with ORANO la Hague during the construction of the 3rd Unit of the fuel elements reprocessing plant.

- A 4,300 sq ft model of a construction site developed together with EDF for the EPR. This model offers multiple pedagogical tools and about twenty models of valves, pumps, pipes, mechanical seals, and 5 virtual models specific to the nuclear industry.

THREE FIELDS OF TRAINING
- Construction—to train industrial insulation, pipe, and welding workers for the EPR;
- Maintenance—to train technicians specialized in valve and pressurized rotating machinery maintenance for EDF’s nuclear reactor life extension program;
- Dismantling—to train nuclear workers to work in nuclear and fuel treatment plants. These programs give access to pre-qualification diplomas and to certificate of qualification in metallurgy for nuclear dismantling workers.

Trainees can also prepare a vocational certificate in nuclear environment.

EXAMPLES OF TAILOR-MADE TRAINING COURSES FOR ORANO
- Training in PLC, control room operations, instrumentation, and regulation
- Training in chemistry and chemical physics
- Training in flow transfer technologies and hydraulics
- Training in breakdown diagnosis
- Training in mechanical and chemical risks
- Training in ventilation
- Training in utilities, water-air-steam-electricity
- Training for new recruits

KEY FIGURES
- Over 150,000 people trained each year
- 4,400 trainers from the field trained to adult pedagogy
- 220 engineers
- A national nuclear training center in Cherbourg-en-Cotentin
- 110 training centers in France, covering over 200 sites
NOTES