Nuclear Education & Training in France

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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 programme.”

<table>
<thead>
<tr>
<th>Human Resource Development</th>
<th>Define the human resource roadmap to meet the country’s needs</th>
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<tbody>
<tr>
<td>Education &amp; Training</td>
<td>Provide structured knowledge and skills for individuals at the right time and place</td>
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<tr>
<td>Knowledge Management</td>
<td>Capture, structure and transfer knowledge</td>
</tr>
<tr>
<td>Knowledge Networks</td>
<td>Share knowledge and best practices through networking</td>
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</table>
Human Capacity Building (HCB) is fundamental to develop an electronuclear culture, program, and industry.

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>NPP operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-project</td>
<td>Project development</td>
<td>Construction</td>
<td></td>
</tr>
</tbody>
</table>

| 1 | Government | ![Maximum involvement](white) | ![No involvement](white) | ![Maximum involvement](white) |
| 2 | Safety organizations | ![Maximum involvement](white) | ![Maximum involvement](white) | ![Maximum involvement](white) |
| 3 | Academia & scientific bodies | ![Maximum involvement](white) | ![Maximum involvement](white) | ![Maximum involvement](white) |
| 4 | Industry | ![Maximum involvement](white) | ![Maximum involvement](white) | ![Maximum involvement](white) |
| 5 | Dedicated agencies (e.g. waste) | ![Maximum involvement](white) | ![Maximum involvement](white) | ![Maximum involvement](white) |

No involvement ◀→ Maximum involvement
Human Capacity Building is key to develop a Nuclear culture, programme and industry

1. For over 60 years, France has developed a safe, secure and sustainable electronuclear culture and industry at home…

2. … and has been sharing its knowledge and learning with fellow countries for decades

3. This knowledge sharing contributed to make some newcomers the important nuclear players they are today

4. Nowadays France proposes HCB guidance and training solutions that can enable today’s newcomers to become nuclear players of tomorrow
France has developed a strong and sustainable electronuclear industry at home...

France masters a large nuclear installed capacity at home...

- **58** reactors in operation
  - 1,932 reactor-years of operating experience

- **N° 1** nuclear share in the electricity mix
  - 75% nuclear share of electricity
  - -35% lower electricity price than av. EU-27
  - Among the **lowest CO₂ intensity** electricity mixes globally

**Nuclear installed capacity in France**

- 1,650 MW
- 1,500 MW
- 1,300 MW
- 900 MW

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... for which it has developed a strong industry composed of several hundreds of businesses of all sizes

From mining to nuclear fuel & its management

Building and servicing nuclear components & reactors
... creating nuclear players that are worldwide references...

**World’s leader in nuclear power**
- 346 reactors serviced worldwide
- Unparalleled experience in building reactors
- Integrated solutions in the entire nuclear fuel cycle

**World’s leader in research, development, and expertise**
- Prominent player in international research
- First-class fundamental research
- Close cooperation with industry and academic stakeholders
- 1,500 PhD students and 300 post-docs
- 10 research centres
- Disseminating knowledge with INSTN

**World’s largest nuclear operator**
- 30 reactors serviced worldwide
- Unparalleled experience in building reactors
- Integrated solutions in the entire nuclear fuel cycle

**Sources**: WNN, WNA - 2014
… developing a culture of nuclear safety…

Fostering a culture of safety…

1. Through organization
   - Transparency
   - Safety reference frame
   - Independence of regulator (ASN leads benchmarks between NSAs)

2. Through individual training
   - For everyone
   - From the beginning and continuously
   - From safety fundamentals to expert level

3. Through collective knowledge management

… with everyone successfully contributing to safety during the entire plant lifetime …

... and a readiness for safety response to crisis

Complementary teams of experts for emergency response aligning:

- At all levels:
  - Local, regional, national
  - Government, industry, nuclear institutions (Safety Authority, IRSN, CEA)

- Through all types of actions:
  - Expertise, decision, communication, action

Graph:

- Personal Dosimetry*
- Unplanned automatic scrams**

* Number of people with personal dosimetry between 16 and 20 mSv/year
** Number of events for 7,000 hours critical (average value of the entire fleet)
... creating a complete nuclear education & training infrastructure ...

**Academia**
- From high school to higher education (up to PhD)
- Focus on professional skills and researchers’ competencies
- Response to international education and training requests
  - 1,400 graduates / year
  - 20% foreign students (MS, PhD)

**Research**
- Research entities and academic laboratories
- Research hand-in-hand with industry
- State-of-the-art experimental facilities / simulation tools
- Systematic internships of students

**Industry**
- Learn 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
- Systematic internships of students

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**Paris-Saclay campus**

**CEA, research laboratory**

**CETIC center, founded by EDF & AREVA**

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**Job-ready for nuclear (industry and research)**

**Sharing of cutting-edge nuclear expertise**

**Real-life conditions preparing for ever safer operations**

This infrastructure constitutes exceptional training facilities
... and has been sharing its knowledge and learning with other countries for decades

<table>
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<tr>
<th>Areas of support</th>
<th>Knowledge and learning sharing</th>
<th>Examples</th>
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<tr>
<td>HCB</td>
<td>40+ years of successful HCB guidance and cooperation with fellow countries since 1970’s.</td>
<td></td>
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<tr>
<td>Education and training</td>
<td>55+ partnerships with top universities worldwide.</td>
<td></td>
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<tr>
<td>(all types)</td>
<td>Set up of joint training centers.</td>
<td></td>
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<tr>
<td>NPP operation</td>
<td>850+ trainees from foreign operators trained over the last 30 years.</td>
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<tr>
<td></td>
<td>346 reactors supported, out of the 435 in operation (i.e. 80% of nuclear global fleet), with products and services.</td>
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<tr>
<td>Localization</td>
<td>100% (up to) sustainable development potential of local nuclear industries – both NPP and fuel cycle – through technology transfer and skills development, including R&amp;D support.</td>
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</table>
France: Decommissioning competences Gap Analysis / Capitalizing on and sharing engineering knowledge and know-how

Brazil: Organization change management

Poland: Train the trainers program / University master courses.

Ukraine: Nuclear safety competence mapping and senior management training

China: Nuclear project management competence development / Chinese French nuclear engineering school

South Africa: University Masters in Project Management

Korea: training of KORAD teams on waste management

Saudi Arabia: Summer Schools for students from KSA universities

Poland: Train the trainers program / University master courses.

A long track record with our partners around the world
I2EN: the entry point to the French Nuclear E&T
Global coordination of E&T players’ network in France

### Academic Education

**Academic Institutions**
- Engineering and master degree level
- Operator in nuclear education & training
- Technician level and vocational training
  - Ministry of Education (Prof. High schools)
  - IRI/ AFPI, etc…

### Hands-on Training

**Industry**
- Leading companies in the nuclear industry
  - AREVA
  - EDF
  - GDF Suez
  - GIIN

**Research, Safety, etc…**
- Safety Authorities
- Technological Research
- Waste management

**French State departments**
Higher education and research, Industry, Environment and Energy, Defense, and Foreign Affairs
I2EN: a gateway to the French E&T system

- **Response to international education and training requests** originating from government agreements, international initiatives (IAEA, AEN ...)

- **Information entry point for foreign students and professional trainees in the framework of bilateral agreements:** orientation to the most appropriate French curricula. Advise them during the selection, admission and installation processes

- **Comprehensive panorama of French E&T offer** at each level of the nuclear energy high education system (Technician, Bachelor, Master, PhD)

www.i2en.fr
Regional Training Centers / Supply Chain

Types of training

- **Fundamentals training**
  - General information on nuclear energy
  - Radiation protection
  - NPP systems and equipment
  - Safety culture
  - Quality

- **Technical basic training**
  - Mechanics, chemistry, electricity, electronics and I&C…
  - Manufacturing
  - Monitoring, Non Destructive Examination

- **Construction training**
  - Excavation training
  - Civil works training
  - Nuclear Island, Conventional island, Balance Of Plant training

- **WHO ?**
  - Technicians
  - Workers
  - Trainers
Operation and Maintenance Training Centre

Types of training

► **Nuclear fundamentals training**
  ▪ Radiation protection.
  ▪ NPP systems and equipment,
  ▪ Safety culture,
  ▪ Quality
  ▪ Knowledge management & experience feedback

► **WHO ?**
  ▪ Main Control Room engineers
  ▪ Safety engineers
  ▪ Operation engineers / technicians
  ▪ Maintenance engineers / technicians
  ▪ O&M trainers

► **Operation training**
  ▪ EPR courses
  ▪ Engineering simulator courses
  ▪ Full Scope Simulator course
  ▪ Fuel loading, storage and removal training
  ▪ …

► **Maintenance training**
  ▪ EPR systems and equipment
  ▪ Detailed system courses
  ▪ Diagnostic & maintenance courses
  ▪ Maintenance on primary components
National Nuclear Excellence Centre

Types of training

- **Nuclear management and Leadership**
  - Energy strategy.
  - Finances and insurances,
  - Risk management
  - Nuclear projects management,
  - ....

- **Nuclear sciences and technology**
  - Reactor physics,
  - Radiations and matter interaction, shielding,
  - Severe accidents phenomena,
  - Nuclear fuel chemistry.
  - Decommissioning....

- **Nuclear engineering**
  - Thermal-hydraulics, mechanics, chemistry, electricity, electronics and I&C engineering,
  - Design and manufacturing codes and standards,
  - Nuclear fuel cycle engineering,
  - Engineering simulator courses
  - ....

WHO ?
- PhDs
- Engineers
- Trainers
Education & Training offer

- **Covering all levels**, from workers to engineers and top managers

- **For Reactor Operation**: Trainers of the future operators and first shifts

- **For mass training (workers, technicians)**: a “Train the Trainers’ strategy”
  1. Train the trainers, in English language, in France, in a nuclear environment
  2. Jointly design and develop the training methodology and training programme tailor-made
  3. Support as necessary the Deployment of training

- Through a combination of classic trainings and specific programs

  Anticipation will be key for the success of this « Train the Trainer » approach
A wide range of solutions dedicated to Operators
From simulators to « on-the-job training »

INITIAL FUNDAMENTAL TRAINING

PROCESS ADVANCED TRAINING

FULL SCOPE SIMULATOR TRAINING

ON THE JOB TRAINING

JOB ACADEMY

SPECIFIC KNOWLEDGE

FIELD OPERATOR SPECIALISATION
• Systems training

ON THE JOB TRAINING

Reactor Operators

SPECIALISATION

ADVANCED TRAINING

1 YEAR

2 YEARS

3 YEARS

Control Room personnels, Safety Engineers, Instructors

Field operator

And after Initial Training, for all the job positions Refresher Training

Senior Reactor Operators

Blocking Managers

Nuclear Safety Engineers

Shift Managers

Full Scope Simulator Instructors
A wide range of supporting tools and facilities of the French Team

► A variety of teaching tools
  ◆ e-learning
  ◆ Learning tours and visits to operating nuclear facilities
  ◆ Training courses with instructors
  ◆ High-level conferences

► Some exceptional training facilities
  ◆ Simulator training
  ◆ Experimental reactor training
  ◆ Nuclear plants under operation
  ◆ Reactor commissioning:
    both a pilot & a training facility
A Training strategy based on innovative training tools

**Serious game**

**Interactive video**

**Micro simulation**

**FOROB**
Our innovative approach using video conference

**CEA - INSTN Internet Reactor Laboratory (1/2)**

- Since March 2014, the INSTN and ISIS reactor proposes Internet Reactor Laboratories (IRL)
- Using video conference equipment, trainees in a remote location are able to interact with a lecturer and the operators in the reactor control room
Our innovative approach using video conference

CEA - INSTN Internet Reactor Laboratory (2/2)

- They are able to “conduct experiments” by asking the reactor operators to change the reactor settings and by following in real-time displays showing the evolution of the reactor parameters.

- This type of training courses is an alternative to the actual face-to-face training courses.
Assessment of the French nuclear sector needs

Industry and Research

- Recruitment needs analysis per specialty

Gap analysis

E&T network

- Listing of existing E&T and Number of students graduating

Continue their studies to higher degree

Go to other industry

Available for nuclear industry
The electronuclear industry needs numerous nuclear specialists... 
... and a much larger number of specialists in conventional domains.

- **Nuclear specialists working on the process** (research, core design, safety experts)
- **Staff having to deal with interfaces with the process** (plant systems engineering, operation managers)
- **Staff having no contact with the process** (manufacturing, non-nuclear maintenance)

Resource categories:
- **Nuclear**
- **Nuclearized**
- **Nuclear aware**
Number of students graduating from the French Nuclear education network

Every year, ~1,400 students graduate from one of the following programs:

- PhD’s – Over 200 doctors
- Master’s – Over 800 graduates / year from the 50 Master’s programs with internships and hands-on work in CEA, ANDRA, IRSN, EDF, AREVA, etc. (1 or 2 years – graduate)
- Bachelor’s – 230 students / year from 16 Bachelor’s programs (3 years – undergraduate)
- Advanced technician – 50 vocational associate’s degree from 16 technician programs (2 years – undergraduate)
- Technician – 100 vocational high-school degree / year from 15 technician programs

Over 800 masters and 200 doctors graduate in nuclear energy every year in France, 20% of these come from abroad
Skills and employment in the French Nuclear Industry

Nuclear in France

Non-nuclear in France

Nuclear abroad

Non-nuclear abroad

In France

Outside France
Please visit I2EN at WNE 2016
Thank you for your attention!