Collaboration between Technology Developers, Users, and Universities for Training Programmes related to GEN IV Nuclear Energy Systems

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COLLABORATION STRUCTURES

EUROPEAN NUCLEAR EDUCATION NETWORK ASSOCIATION

CONSORTIUM
ENEN III Fission Training Schemes

- EFTS Non-Nuclear Engineers
- EFTS Construction Engineers GEN III
- EFTS GEN III Design Engineers
- EFTS Research Engineers GEN IV
EUROPEAN NUCLEAR EDUCATION NETWORK ASSOCIATION (Long Term)

**Legal Entity:** established in France in September 2003

**Members:** Universities, Research Centers, TSOs, Industry in the European Union, South Africa, Japan, Russia, Ukraine

**Objectives**
European Master in Nuclear Sciences Reference Curricula and Certification

**Activities**
- **Academia:** Student exchanges, Courses, Publications, Multimedia
- **Research:** Master, PhD and Postdoctoral support, PhD Prize
- **Industry:** Training courses, Job opportunities, Seminars, Conferences

**Instruments and Funding**
Events, Conferences, Courses, Coordination Projects
Membership fees, EU FP and EACEA Support
Purpose and Objectives of the ENEN Collaboration

Objective

Preservation and Development of Expertise in the Nuclear Field by Higher Education and Training

This objective should be realized through cooperation between universities, research organizations, regulatory bodies, the industry and any other organizations involved in the application of nuclear science and ionizing radiation.
### Financing Mechanism

**Receipts**

<table>
<thead>
<tr>
<th>Membership contributions</th>
<th>30 %</th>
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<tbody>
<tr>
<td>Universities</td>
<td>10 %</td>
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<tr>
<td>Research Centres</td>
<td>10 %</td>
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<td>Industry</td>
<td>5 %</td>
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<tr>
<td>MoU Members</td>
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<td>Projects</td>
<td>70 %</td>
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**Expenses**

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<th>Secretariat Staff</th>
<th>12 %</th>
<th>(Management)</th>
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<tbody>
<tr>
<td>Meetings, accounting</td>
<td>4 %</td>
<td>(Management)</td>
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<tr>
<td>EMSNE, PhD, Events</td>
<td>10 %</td>
<td>(Activities)</td>
</tr>
<tr>
<td>Projects Staff</td>
<td>74 %</td>
<td>(Activities)</td>
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</table>
Particular Subjects of Collaborative Work
European Master of Science in Nuclear Engineering

Implementation since 2005
2005  3 laureates, F, Ro
2006  7 laureates, B, F, Ro, E
2007  11 laureates, B, F, I, E, UK
2008  12 laureates, B, F, I, E, UK
2009  13 laureates, F, I, E, UK
2010  22 laureates, B, F, I, E
2011  24 laureates, B, F, I, Ro, Sk, E
2012  17 laureates, F, I, E
2013  16 laureates, I, E, Se

including 6 students exchanged with Japan (EUJEP project)
Totals B 8, F 21, I 36, Ro 5, Sk 1, Se 1, E 50, UK 3
Total 125 Alumni
CONSORTIUM
Consortium Agreement (Short Term)
Project ENEN III Fission Training Schemes

1. Definitions
2. Purpose
3. Entry into Force, Duration, Termination
4. Responsibilities of Parties
5. Liability towards Each Other
6. Governance Structure, Coordinator, Committees
8. Foreground and Background
9. Access Rights
10. Non-disclosure of Information
11. Miscellaneous
12. Signatures
COLLABORATION CONSORTIA

Particular Subjects of Collaborative Work

European Framework Programme 7 projects
Funded by the European Commission

- ENEN-III - European Fission Training Schemes
  Engineering 4 target groups – 6 job profiles
  19 Partners in 11 countries

- NUSHARE – Safety Culture – 3 Target Groups
  7 Partners – 3 countries

- PETRUS III Waste Management and Disposal
  17 Partners in 10 countries

- TRASNUSAIFE Safety Culture – 2 Target Groups
  19 Partners – 9 countries
ENEN – III Fission Training Schemes

Objective

To establish a Training Scheme which covers its
Structuring
Organization
Coordination
Implementation

In cooperation with training organisations
Local
National
International

To provide training courses & sessions at the required level to professionals in
Nuclear organizations
Contractors
Subcontractors

To establish a common certificate for professionals at European level
ENEN – III Fission Training Schemes

Partners
19 Partners in 11 countries

Coordinator
ENEN Association (F)

Research and technical support centers
SCKCEN (B), JSI (SI), ISAR (D)

Universities
UCL (B), AALTO (FI), LUT (FI), INSTN (F), BME (H), CIRFEN (I), DUT (NL)
UPB (RO), UL (SI), UNED (E), UPM (E), UPC (E), UCLAN (UK)

Training Organisation
TECNATOM (E)

Industry training center
AREVA (F,D)
ENEN – III Fission Training Schemes

Four training schemes

A) Basic Nuclear Topics for Non-Nuclear Engineers
   At nuclear facilities, contractors, subcontractors

B) Design Challenges for Generation III NPP
   2 professional profiles:
   - Systems and Components Engineer
   - Safety Engineer

C) Construction Challenges for Generation III NPP
   2 professional profiles
   - Heating, Ventilation, Air Conditioning Engineer
   - Instrumentation Engineer

D) Conceptual Design Challenges for Generation IV Reactors
   Engineers, Scientists, Researchers
ENEN – III Fission Training Schemes

Conceptual Design Challenges for Generation IV Reactors

STEP 1
Definition of training scheme learning outcomes and modules

STEP 2
Student prerequisite assessment and student selection

STEP 3
Student interview for development of the individual training plan

STEP 4
Start of the training activities according to the training scheme
ENEN – III Fission Training Schemes

Conceptual Design Challenges for Generation IV Reactors

Learning to KNOW
A. Training Methods
1. Classroom Training
2. E-Learning
3. Case studies
4. Know How transfer during on the job training

B. Evaluation Method
1. Written examination
2. Oral presentation of a chosen subject

Learning to DO
A. Training Methods
1. Analytical calculation during workshops
2. Practical training on mock-ups
3. Experiments at small scale facilities
4. On the job training

B. Evaluation Method
Practical examination oral or in writing

Learning to BE
A. Training Method
1. Visit nuclear facilities
2. Sensibilisation workshops
3. On the job training

B. Evaluation Method
1. Feedback of the mentor

STEP 5  Training Certificate with EU wide recognition by Europass
In the ENEN – III project the Bloom taxonomy has been used to generate learning outcomes in the cognitive (knowledge), psychomotor (skills) and affective (attitudes) domain.

**STEP 1**

Definition of the areas of interest in the field of

- **Knowledge**
  
  *What should the GEN IV engineer know?*

- **Skills**
  
  *What should the GEN IV engineer be able to do?*

- **Attitudes**
  
  *How should the GEN IV engineer behave/react?*
COMPETENCE ANALYSIS FOR A GEN IV ENGINEER

Cognitive domain: Knowledge

Areas of interest independent of the specific GEN IV design under study

Introduction to GEN IV systems and technology 9 LOs
Introduction to Lead Cooled Fast Reactor 6 LOs
Introduction to Sodium Cooled Fast Reactor 6 LOs
Introduction to Gas Cooled Fast Reactor 1 LO
Introduction to the Very High Temperature Reactor 2 LOs
Introduction to the Supercritical Water Reactor 5 LOs
Introduction to the Molten Salt Reactor 4 LOs

General Safety Features of GEN IV Systems 3 LOs
Structural Materials for GEN IV Reactors 9 LOs
Fuels for GEN IV Reactors 11 LOs
GEN IV and the Closed Fuel Cycle 9 LOs
**COMPETENCE ANALYSIS FOR A GEN IV ENGINEER**

**Cognitive domain : Knowledge**

Areas of interest for each of the specific GEN IV designs under study

Design specific knowledge for the Reactor Concept

<table>
<thead>
<tr>
<th>LOs Developed</th>
<th>SFR</th>
<th>LFR</th>
<th>SCWR</th>
<th>MSR</th>
<th>GC</th>
<th>VHTR</th>
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<tr>
<td>Core design</td>
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<td>5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<tr>
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<td>14</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Primary Circuit Design</td>
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<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Instrumentation Techniques</td>
<td>1</td>
<td>14</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Safety Issues related to the Coolant</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>
Psychomotor domain: Skills

Areas of interest independent of the specific GEN IV design under study

Developing engineering tools necessary for the analysis of the design
8 LOs

Working with Self-developed Engineering Tools or Off-the-Shelf Tools
3 LOs

Working with nuclear design codes
2 LOs

Cost Estimates (costs, time) for the Engineering Work
1 LO

Order Processing, Project Management and Communication
19 LOs
COMPETENCE ANALYSIS FOR A GEN IV ENGINEER

Affective domain: Attitudes

Areas of interest independent of the specific GEN IV designs under study
Self-reliant in gathering knowledge
Ability to transpose experience and knowledge from one specific technology to another technology
Formal Quality Control of input received and reported results
Individual, critical examination and evaluation of the tasks
Fluent in the presentation and documentation of work results
Teamwork oriented and supportive
Practising and fostering communication

Covered by 13 ‘Human Performance’ LOs and 9 ‘Behaviour’ LOs
COMPETENCE ANALYSIS FOR A GEN IV ENGINEER

Cognitive domain: Knowledge

Introduction to GEN IV systems and technology 9 LOs

1. Describe the different generations of nuclear reactors.
2. Explain the need for GEN IV reactors.
3. List the main issues assigned to GEN IV reactors.
4. Describe the 6 main concepts selected by the GIF. In particular, for each of them, indicate neutron spectrum and the nature of primary coolant.
   Comparison of the advantages and disadvantages of the different systems.
   Open issues in the development of the different technologies.
5. Compare GEN IV with GEN II and GEN III reactors.
6. Compare the potential of the 6 Gen IV systems in terms of economics, safety, sustainability and proliferation resistance.
7. Assess the economic aspects of GEN IV systems.
8. Give an overview of international networks and research infrastructures for GEN IV systems.
9. Discuss the different construction codes that can be used to design these systems with their advantages, disadvantages and shortcomings.
MATCHING COURSES TO THE REQUIRED LOs

Cognitive domain: Knowledge

Compiling and selecting courses, training sessions and training events for acquiring the qualification for GEN IV Engineer/Researcher

Courses proposed by ENEN-III Participants for the target group of GEN IV
14 courses by JSI, CEA-INSTN, UNED

Courses of GEN III (non-nuclear) supplementing GEN IV Curriculum
31 courses by JSI, SCK-CEN, CEA-INSTN, CIRTEN, TUD, UPM, BME, UCLAN

Courses of GEN III (design engineers) supplementing GEN IV Curriculum
29 courses by CIRTEN, CEA-INSTN, SCK-CEN, AREVA

Courses of GEN III (construction engineers) supplementing GEN IV Curriculum
28 courses by CIRTEN, CEA-INSTN, SCK-CEN, AREVA, UCLAN

Supplementary educational material for GEN IV topics
8 courses by AALTO, FJOH Summer School, IAEA, MATGEN-IV, EUROTRANS, ACTINET-I3, F BRIDGE School, a.o.
MATCHING COURSES TO THE REQUIRED LOs

Psychomotor and Affective domains: Skills and Attitudes

Skills and Attitudes are acquired in a variety of ways

Practical Training in dedicated sessions
- Research reactor experiments
- Radiation measurements
- Test loops and pilot scale experiments

Case studies
Virtual Reality Environments
Site visits, briefings, debriefings, discussions
Interactive and simulator sessions
On-the Job Training

Human Performance Fundamentals
Safety Culture
Radiological Protection
IMPLEMENTATION OF THE TRAINING SCHEME

Remark
The Full Implementation is beyond the project Time Schedule
The Partial Implementation has been done on a Pilot Basis

STEP 2
Trainee prerequisites assessment and trainee selection
14 Trainees have been selected from the project partners
   PhD students, postdocs, employed scientists, researchers

STEP 3
Trainee interview for the development of the individual training plan
Preparation of the supporting documents:
   - the EUROPASS Curriculum Vitae
   - My Learning Outcomes
     a comprehensive list of the learning outcomes ‘achieved’ according to the curriculum vitae and ‘to be achieved’ according to the training scheme for the specific job description

STEP 4
Mentor and trainee agree on the document ‘My Action Plan’ and a selection of appropriate courses and training sessions is planned.
IMPLEMENTATION OF THE TRAINING SCHEME

Courses organized and Trainee participation in the time frame of the Project

International Seminar on Generation IV Nuclear Reactors, INSTN 2010, attended by V.R. (LUT), O-P.K. (LUT),
International School in Nuclear Engineering : Materials for Nuclear Reactor Fuels and Structures, INSTN 2011 attended by M.A. (POLIMI), and INSTN 2012, attended by C.M. (CEA)
International School in Nuclear Engineering : Nuclear Waste Management and Dismantling, INSTN 2011, attended by M.G. (POLIMI)
Réacteurs à Neutrons Rapides refroidis au Sodium, INSTN 2012, attended by P.A. (CEA)
Reliability & Safety, SCK-CEN 2012, attended by P.B. (UPM)
IMPLEMENTATION OF THE TRAINING SCHEME

Distance Learning Course organized by UNED
EVALUATION OF THE TRAINING SCHEME (example)

Qualitative Mastering of the LOs before and after selected Training Courses according to interviews with the Trainees – Training Scheme D

1. Explain the main material challenges for...
2. Identify the main classes of structural...
3. Describe the main characteristics of the...
4. Identify the main criteria to select suitable structural...
5. Develop an experimental & multi-scale...
6. Acknowledge the role of material scientists which limit...
7. List the existing programmes addressing...
8. Describe the main components of the fuel cycles...
9. Give examples of the main constraints put on the...
10. Give examples of the main constraints put on the...
11. List the major fuel options for Gen IV...

Cognitive domain: Areas of interest: Structural Materials (1-9) and Fuels (1-11)
EVALUATION OF THE TRAINING SCHEME (example)

Qualitative Mastering of the LOs before and after selected Training Courses according to interviews with the Trainees – Training Scheme B and D

Psychomotor and Affective domains:
Areas of interest: Communication (1-9) and Organization (1-13)
The ENEN-III project

- Provided a confrontation of the training schemes to the introduction of the ECVET concepts, with the need to define learning outcomes for the job profiles addressed by the project.

- Produced lists of the learning outcomes in the areas of knowledge, skills and attitudes for particular jobs and the associated courses to acquire them.

- Provided the opportunity to 36 trainees to participate to the training schemes and to acquire part or all of the learning outcomes to qualify for a particular job.

- Developed a methodology for training scheme design, development, implementation and certification.

- Facilitated and enhanced exchanges, cooperation and consensus between academia, research institutes, training organizations and industry, resulting in
  - a better understanding of the industry needs
  - the adjustment of university curricula to R&D and industry needs
  - broader personal networking for future cooperation
RECOMMENDATIONS

General recommendations

Learning outcomes have been defined in detail for the areas of interest. A large number of learning outcomes are common to all training schemes. Courses and training sessions should be evaluated from the same perspective. Gaps should be identified and covered by adapting courses or developing dedicated courses.

The analysis of the fulfillment of the prerequisite conditions can be replaced by a detailed review of the acquired learning outcomes, thereby optimizing the trainee action plan and the use of resources for achieving well-defined targets.

Learning outcomes in the areas of skills and attitudes might be combined with the areas of knowledge and covered by a single course. Typically, theoretical knowledge and implementation practice in nuclear safety courses should include a strong attitude component.

Training schemes should be conceived in a modular format for maximum flexibility and optimization of resources and time spent by the trainee.
Recommendations for Training Scheme D: GEN IV design engineer/scientist

Only a small number of courses and training sessions are dedicated to GEN IV and they are organized on irregular and ad hoc schedules. Enhanced cooperation and coordination among the stakeholders in the field is strongly recommended to cover a broad area in GEN IV related competences in a concerted and optimized way.

GEN IV development is still very much research oriented and relevant competences are scattered over a small number of research institutions and universities. The trainees are PhDs, post-docs, researchers, acquiring a large part of their skills and attitudes through on-the-job training. Their access to the physical mock-up tools and demonstration facilities deserves particular attention and support.

On-the-Job training should involve the mentor, the line-management, and the Human Resources department. It should be based on a structured plan and time schedule, it should be monitored, and be in-line with the company practices, operations, policy and culture.
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THANK YOU FOR YOUR ATTENTION