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ANNETTE PROJECT
Advanced Networking for Nuclear Education and Training and Transfer of Expertise

DELIVERABLE D 3.2
Report on the criteria for selecting the E&T products

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P	Prototype	
D	Demonstration	
O	Other	

Author(s) Guillem Cortes, Michèle Coeck, Tom Clarijs, Nele Kesteloot, Lisanne Van Puyvelde, Concetta Fazio, Gunnar Buckau, Emi Kassim, Dario Manara, Irmgard Niemeyer, Pascal Franco, Filip Tuomisto, Behrooz Bazargan-Sabet, Harry Eccles, Jonathan Francis and Sandeep Kadam

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RE	Restricted to a group specified by the partners of the ANNETTE project	
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	Name	Follow-up Email to Coordinator	Date
Prepared by	Guillem Cortés and WP3 partners		24/10/2019
Reviewed by Referee(s)	WP3 partners		
Quality assurance (QA leader)	Leon Cizelj		
Approved by Coordinator	Pedro Diéguez Porras		

ABSTRACT:

This report contains the description of E&T products prepared in the basis of the task 3.1 of WP3 as can be seen in deliverable D3.1. The E&T products covers the fields of geological disposal, radiation protection, nuclear fuel properties, and nuclear safeguards and security. Some of the topics are adapted to new technologies as e-learning or MOOCS, combined with conventional formats as text books or lecture slides. These products will be a start point to continue with the updating of new E&T material in the field of nuclear engineering.

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1. Objective of the work

In the framework of the ANNETTE (Advanced Networking for Nuclear Education and Training and Transfer of Expertise) project and as part of the work package on "generational transfer of expertise: promoting knowledge, skills and competencies preservation in front of personnel turnover" (WP3), UPC lead the task 3.2. This task is aimed to coordinate the preparation of education and training (E&T) material on nuclear engineering, according the criteria described in report D3.1, related with task 3.1 of this work package (WP3).

2. Description and Objectives of Task 3.2

The main objectives of WP3 are 1) to analyse mechanisms for sustainable production of educational material in nuclear areas; 2) identify those areas with less information available or need an upgrade; 3) coordinate the development of educational material for new generation of researchers and professionals in view of continuous professional development; 4) elaborate the educational material, making use of new technologies as e-learning or MOOCS, combined with conventional formats as text books or lecture slides.

In this report are described the E&T products that have been elaborated on the basis of the needs identified in the previous report, the deliverable D3.1 [1]. In this sense, the E&T material covers many topics as Nuclear Fuel Cycle, Nuclear Safeguards, Nuclear Security, Radiation Protection, and Geological Disposal. This E&T material has been elaborated by experts of the areas described before from European universities and research institutions as Joint Research Centre (JRC), Belgian nuclear research centre (SCK•CEN), Uppsala University (UU), Université de Lorraine (UL), University of Central Lancashire (UCLAN), Forschungszentrum Jülich (FZJ), Universidad Politécnica de Madrid (UPM), CEA/INSTN.

3. E&T material developed

3.1. Introduction

The section 3.2 of this chapter shows a description of the materials prepared including the format and how to obtain them.

3.2. E&T materials

The titles of the E&T materials prepared in the frame of ANNETTE are:

- 1) Back-end of the nuclear fuel cycle: an overview
- 2) Nuclear energy: Life cycle
- 3) History of nuclear safeguards
- 4) Non-destructive assay

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- 5) The nuclear fuel cycle
- 6) Introduction to nuclear safeguards
- 7) Introduction to Nuclear Security: Regulations and delivery
- 8) Uncertainty quantification in risk modelling for radioactive waste disposal
- 9) Geological disposal: Site selection
- 10) Geological disposal: Radionuclide transport in porous media

This E&T materials are described in next tables, that contain the following items: Topic, Title, Author/s, Description, Format, how to obtain this material (link...), and the WP3 partners involved in its preparation.

Topic	Title	Author/s
Nuclear Fuel Cycle	Back-end of the nuclear fuel cycle: an overview	Jean-Paul Glatz, Concetta Fazio
<p>Description</p> <p>The back-end of the nuclear fuel cycle concerns the handling of the spent nuclear fuel discharged from present light water reactors as well as from future advanced reactors. The objective of this lecture is to give an overview of the back-end of the nuclear fuel cycle options that are under consideration in the different world regions. The lecture is structured such as to address scientific studies and their transposition to practical implementation. Moreover, also policy and policy support actions are included.</p> <p>There are different options for the back-end of the fuel cycle that range from "once through" to advanced recycling. In the introductory part of the lecture the spent nuclear fuels composition and characteristics are summarised, since they are at the basis of the scientific and technological issues for the implementation of the back-end of the nuclear fuel cycle. Moreover, whatever option is considered to handle the spent nuclear fuel, there will be always the need of a geological repository. The scientific needs for the development of the geological repository made of different host rocks are detailed. Furthermore, the impact on the geological repository of applying reprocessing and advanced recycling processes of the spent fuel is also shown and discussed. The lecture addresses the reprocessing process as applied today on LWR spent nuclear fuels and the advanced Partitioning and Transmutation of the so-called Minor Actinides (Am, Np, Cm) to reduce the burden on a geological repository. The lecture includes the performance of reactor systems for transmutation and the requirements on the partitioning process. Moreover, the two main partitioning routes, i.e. aqueous chemistry and pyro-chemistry are introduced and details for their implementation discussed. For any option of the back-end of the nuclear fuel cycle process that will be chosen for implementation, the spent nuclear fuel will have to be stored in an intermediate storage for a given period of time. During the storage time the spent nuclear fuel will evolve in terms of microstructure due to aging and some key aspects of this evolution is also indicated in the lecture.</p>		
<p>Format</p> <p>e-learning recorded lectures</p>	<p>Link / channels to obtain the material: the lecture has been recorded and can be made available. It is expected to be able to upload it on the ANNETTE website or any other site as given per instruction by the coordinator</p>	
<p>WP3 partner/s</p> <p>Joint Research Centre (JRC)</p>		

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Topic	Title	Author/s
Nuclear Fuel Cycle	Nuclear Energy: Life cycle	Vincenzo V. Rondinella, Concetta Fazio
Description Nuclear Energy contributes with 11% to the world carbon-free electricity production through the operation of more than 450 nuclear power reactors worldwide. The nuclear energy life cycle as addressed in this lecture has its focus on both the nuclear reactors technology and the fuel needed to produce energy. The nuclear physics basics of nuclear energy production and the basic differences between reactor technologies developed worldwide. The lecture is structured such as to address scientific studies and their transposition to practical implementation. Moreover, also policy and policy support actions are included.		
Format e-learning recorded lectures	Link / channels to obtain the material: this lecture is not yet registered. The slides would be available but the recording, for technical reasons has not been done	
WP3 partner/s Joint Research Centre (JRC)		

Topic	Title	Author/s
Nuclear safeguards	History of nuclear safeguards	Sophie Grape
Description The material consists of material prepared for a lecture on the topic, as well as an exercise that was performed in smaller groups.		
Format <i>The material consists of three parts: Power point lecture material, a case study exercise and a short video (part of the so-called MOOC on safeguards) introducing the participants to the topic.</i>	Link / channels to obtain the material The material will be available on the SCK CEN homepage.	
WP3 partner/s Uppsala University (UU)		

Topic	Title	Author/s
Nuclear safeguards	Non-destructive assay	Sophie Grape
Description The material consists of material prepared for a lecture on the topic, as well as a desktop exercise.		
Format <i>The material consists of three parts: Power point lecture material, a desktop exercise on the topic and a short video (part of the so-called MOOC on safeguards) introducing the participants to the topic.</i>	Link / channels to obtain the material The material will be available on the SCK CEN homepage.	
WP3 partner/s Uppsala University (UU)		

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Topic Nuclear safeguards	Title The nuclear fuel cycle	Author/s Sophie Grape
Description The material consists of material prepared for a lecture on the topic.		
Format <i>The material consists of two parts: Power point lecture material, and a short video (part of the so-called MOOC on safeguards) introducing the participants to the topic.</i>	Link / channels to obtain the material The material will be available on the SCK CEN homepage.	
WP3 partner/s Uppsala University (UU)		

Topic Nuclear safeguards	Title Introduction to nuclear safeguards	Author/s Ricardo Rossa, Claudio Bergonzi, Sophie Grape, Rozle Jakopic, Thomas Krieger, Irmgard Niemeyer, Filippo Sevini, Klaas van der Meer
Description A Massive Open On-line Course (MOOC) as introduction to nuclear safeguards. The MOOC is based on the units of the ANNETTE training course on nuclear safeguards. A total of 14 videos are being collected and will be available soon online on a dedicated channel.		
Format MOOC/ video series	Link / channels to obtain the material Not yet online	
WP3 partner/s Belgian nuclear research centre (SCK•CEN), Forschungszentrum Jülich (FZJ), Joint Research Centre (JRC), Uppsala University (UU)		

Topic	Title	Author/s
Radiation protection	Developing tools in the framework of radiation protection	Alain Pin
<p>Description</p> <p>The material consists in a description/manual of OSIRIS V2 (French acronym for Tool for Simulation of work under ionizing radiation), a tool built on a virtual 3D environment in which users operate in a totally free way in the first-person.</p> <p>Through the use of this serious game, trainees have to:</p> <ul style="list-style-type: none"> - establish a predictive dose evaluation and perform several dosimetric maps depending on the configuration of circuit and equipment, i.e. dose rate measures, radioactive contamination control,... - perform the operating radioactive zoning (signs of radiological risks required at the workstation i.e. warning signs, barriers, dose rate information panels...), - define the necessary collective or portable control instruments (atmospheric contamination monitor, gamma dose rate area monitor, ...), - implement the principles of radiation protection (justification, optimisation and limitation). <p>OSIRIS V2 has to purpose to improve the functionalities (wider playground area, creation of a teaching interface to set the nature of radiation term sources: radionuclides, activity ...) and integration of a participant competence assessment tool (end of mission report printing).</p>		
Format		Link / channels to obtain the material
Text book		The file will be available on the ANNETTE homepage
WP3 partner/s		
CEA/INSTN		

Topic	Title	Author/s
nuclear engineering : reactor operation	e-learning course “basic operation of nuclear reactors (PWRs)”	Hubert Grard
<p>Description</p> <p>Reactor operation requires multiple knowledge and skills. The core of the course is built around the analysis of transients calculations performed with EasyPWR, a software developed by INSTN. Physical phenomena and the functioning of the global system is described and analysed qualitatively and quantitatively. Numerical applications are provided in such a way the trainees gain a firm grasp of the physical phenomena and major technical issues.</p> <p>The scope includes :</p> <ul style="list-style-type: none"> - Reactivity effects. Xe and Sm poisoning. - Reactor kinetics. Approach to criticality, critical state. Reactivity measurement methods (dynamic rod weight measurement, rod drop). Start of nuclear heating, Fuel and moderator temperature feedback effects and reactor operating mode. - Dynamic interactions between: electrical power, exchanged power in the SG, thermal power. Core control. Axial xenon oscillations: triggering and control. - Operating performances of PWRs and their limitations - PWRs and grid frequency control : primary/secondary/tertiary - The conventional island <p>The course is based on videos supported/associated with texts and notes.</p>		
Format		Link / channels to obtain the material
Videos and texts		LMS platform (yet to be specified)
WP3 partner/s		
CEA/INSTN		

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Topic Nuclear Security	Title Introduction to Nuclear Security: Regulations and delivery	Author/s Harry Eccles, Jonathan Francis and Sandeep Kadam
Description <p>The security of nuclear facilities and sites are of paramount importance and one consideration that will help to sustain the future of the nuclear industry. The advent of the digital age has brought many improvements for controlling commercial operations and systems, but also an equal number of challenges. The nuclear industry has for many years, operated well-proven systems for the security clearance of personnel and for the protection of information, plant and equipment; now the digital age brings new challenges for the industry. Education is an activity that shares information but effective security relies on the need to know principle. Physical security, transport details, management arrangements are examples of site-specific information that should not be communicated via education. This can result in restrictions on normal educational procedures, hence require, additional teaching techniques. UCLan is organising a four day ANNETTE workshop “Protecting the Nuclear Industry” from 21-24 October 2019 at UCLan Preston campus. This workshop, delivered by nuclear experts employed in the business and academia, will appeal to a broad section of personnel, largely, but NOT exclusively employed in the nuclear industry, contractors or postgraduate students undertaking MSc nuclear studies. E&T material on nuclear security will be developed from the workshop sessions, based on existing material that is largely in the public domain. With security per se being a sensitive topic it will be a collation of this information which is largely presented as guide lines as each Member State may interpret and apply these guidelines, differently, appropriate to their industry. E&T material will concentrate on addressing international and national nuclear security, but with emphasis on the UK position. The development of a comprehensive nuclear security culture to prevent, detect, delay and respond to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving radioactive materials will be explored.</p>		
Format Lecture slides and accompanying notes	Link / channels to obtain the material The updated E&T material on nuclear security will be available after (~4 weeks) ANNETTE workshop “Protecting the Nuclear Industry”	
WP3 partner/s University of Central Lancashire (UCLAN)		

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Topic Geological Disposal	Title Uncertainty quantification in risk modelling for radioactive waste disposal	Author/s Jérémy Rohmer
Description The text addresses the problem of uncertainty quantification for radioactive waste disposal. It focus on the problem of quantifiable and quantification of uncertainty for any models (whatever their type, analytical, expert-based, numerical) supporting the risk analysis in the field of radioactive waste disposal.		
Format Text book	Link / channels to obtain the material On Request send to Prof. Behrooz BAZARGAN SABET b.bazargan-sabet@brgm.fr	
WP3 partner/s Université de Lorraine (UL)		

Topic Geological Disposal	Title Site Selection	Author/s Behrooz BAZARGAN SABET
Description The selection of suitable sites for underground disposal of radioactive waste is the first priority as the safety and security of the facility must be guaranteed for a million years. Apart from the question of which geological layer is best suited to storage, various requirements and criteria must be satisfied in the process of the selection of candidate sites for the siting of the facility. The International Atomic Energy Agency (IAEA) and national regulators have set recommendations in the process of developing a deep geological repository. The textbook describes the requirements, suitability indicators and criteria relating to the feasibility of repository construction, long-term and operational safety and environmental impacts. It helps identifying criteria, which correspond to all the site characteristics that could be significant for the safe operation of the nuclear installation. The selection is based on description and characteristics demonstrating long-term safety and environmental suitability. It mainly relies on investigations, data acquisition and monitoring of candidate sites from topographical, geological, geophysical, geotechnical, seismological, hydrogeological and hydrological view point.		
Format Text book	Link / channels to obtain the material On Request send to Prof. Behrooz BAZARGAN SABET b.bazargan-sabet@brgm.fr	
WP3 partner/s Université de Lorraine (UL)		

Topic Geological Disposal	Title Radionuclide transport in porous media	Author/s Arturo Hidalgo, Fco Javier Elorza, Behrooz BAZARGAN SABET
Description In this chapter, based on the physical basis of the processes of groundwater flow and transport of radioactive solutes through it, the mathematical formulation of these processes, both in its isolated and coupled form, is presented in a deductive way, reasoning at the same time the hypotheses adopted at each step of their deduction and the associated limitations. In addition, the physical chemical properties involved in the fundamental laws of hydrogeology are described, discussing their range of validity and the typical values for the different types of rocks or soils that make up the geosphere. Subsequently, after the presentation of the initial and boundary conditions that occur in various real cases, the different numerical methods of solving the mathematical problems described are introduced, comparing them. Finally, several of the main international exercises for comparing, verifying and “validating” simulation codes that have been carried out so far are described and analyzed.		
Format Text book	Link / channels to obtain the material On Request send to Prof. Behrooz BAZARGAN SABET b.bazargan-sabet@brgm.fr	
WP3 partner/s Universidad Politécnica de Madrid (UPM), Université de Lorraine (UL)		

4. Conclusions

This report describes the new E&T material about nuclear engineering that has been prepared for the new generation of researchers and professionals in view of continuous professional development. The material consists on e-learning lectures, MOOCs, text books and lecture slides. The areas covered are: Nuclear Safeguards; Nuclear Fuel Cycle, recorded e-learnig lectures about "Back-end of the nuclear fuel cycle: an overview" and "Nuclear Energy: Life cycle"; Nuclear Security; Geological Disposal. Next steps related with the continuity of this task will be the implication of experts to improve the materials prepared, and review and adapt all of the materials to the new technologies.

5. References

- [1] Report on the criteria for selecting the E&T products, Deliverable D3.1. ANNETTE Project
- [2] Technical Annex – Coordination and Support Actions – ANNETTE Project
- [3] Council Directive 2013/59/EURATOM of 5th December 2013