Final Report Summary - PETRUS III (Implementing sustainable E&T programmes in the field of Radioactive Wastes Disposal)

Summary

Radioactive Waste management organisations (WMOs) need new type of approaches to meet their demands for human resources and to maintain the competence and availability of personnel over the life time of a repository operation. In line with the Lisbon strategy and the 2020 perspective, the “Petrus” initiative coordinates since 2005 universities, WMOs, training organisations and research institutes efforts to develop cooperative approach to education and training (E&T) in the geological disposal. The outcomes of the PETRUS III project that aims at the continuation of the European Cooperation in this area include:
Practical implementation of PETRUS training programme following ECVET principles: Starting from the outcomes of the previous PETRUS project, we have experimented the elaboration and the development of training modules defined in terms of learning outcomes in a “Competency-Based Curriculum”. The objective was to set up qualification in geological disposal that could be achieved, accredited and recognised through Professional Development (PD) training programmes. Two work-packages have been dedicated to this objective. With the help of PETRUS End-Users Council and the IGD-TP’s Competence Maintenance Education and Training Working Group (CMET), WP1 has identified the most needed job profiles and elaborated three training units based on learning outcomes for a safety Engineer. Units were detailed as best as possible to better assess the thematic content of the programmes and the corresponding qualification level. The implementation of this programme was the subject of WP2. Faced with the delay in the implementation of ECVET system across Europe, we have elaborated the framework for the effective setting up of the programme. In particular, the learning agreement model that is essential for the accreditation evaluation, the learner profiles including the criteria for accepting the students, a model for linking ECVET and ECTS systems, the description of the prototype of the planned program and the Memorandum of Understanding, the duties of competent institutions in the procedures of implementation as well as relevant information for the evaluation of the administrative efficiency and transparency as a part of the quality control have been drafted.

Elaboration of multidisciplinary training and research framework for PhD student: This topic has been developed in the frame of WP3. Multidisciplinary lectures have been elaborated for PhD students and were taught in an innovative format during the two PETRUS PhD Conferences held in Nancy in 2015 and in Delft in 2016. Around seventeen participants have attended each of these events where a set of high quality lectures on radioactive waste disposal presented by outstanding international experts was combined with oral presentation and poster exhibition of on-going research work by PhD students. Prizes have been awarded to best oral and poster presentations. WP3 has also produced framework for “Doctoral School on waste disposal innovation”. The concept is to combine existing national regulation with a common complementary Innovation and Entrepreneurship (I&E) education which include organizational and geographic mobility.

Development of strategies and frameworks for maintaining PETRUS initiative over the long-term: Two WPs have been dedicated to support the permanent improvement of the project and to develop strategy for its sustainability. In order to foster the organisation and the management of PETRUS E&T programmes Think-tank activities have been developed In WP4 with the setting up of 3 end-users meetings and 3 workshops with the IGD-TP CMET working group. During these meetings job profiles identified in WP1 have been assessed, the learning outcomes were reviewed and the appropriateness of qualification mechanism has been examined. A steering board created in the frame of this WP allowed adapting the technical programme of the project in particular regarding modification arose from the revision of the ECVET system. Strategic plan for sustainability of the PETRUS initiative has been established in the frame of WP5. Close exchanges with ENEN Association allowed the creation of framework for the integration of radioactive waste disposal E&T activities under the Association umbrella. Among 20 partners of PETRUS consortium 12 have already joined the association and 2 others will join in March 2017. ENEN dedicated a Working Group to pursue the efforts and accomplishments achieved so far within PETRUS initiative. WP5 has also established close relationship with ENETRAP III project on E&T in radiation protection and organized exchange of lectures between the two consortiums. This cooperation will continue and will be extended to other nuclear sectors within the ENEN structure.
Project Context and Objectives:
Context and objectives

The PETRUS III project is the continuation of the PETRUS initiative aiming at taking further step towards geological disposal E&T goals. The project leans on the existing state-of-the-art, takes advantage of the developments carried out in the past projects (i.e. ENEN II and PETRUS II projects) and relies on the strong partnerships created at the beginning of the PETRUS initiative and reinforced since then. The consortium will co-operate through a suitable organisational structure for co-coordinating E&T activities. In particular, the following items have been targeted:

- Practical implementation of PETRUS training programme following ECVET principles with the objective of setting up qualification in geological disposal that can be achieved, accredited and recognised both through formal and PD training programmes.
- Elaboration of multidisciplinary training and research framework for PhD student with the objectives of fast-tracking the research activities in geological disposal by proposing customised training programmes and by organizing periodic PhD workshops to putting these programmes into the practice.
- Development of strategies and frameworks for maintaining PETRUS initiative over the long-term by fostering collaboration with the IGD-TP and creating framework to integrate radioactive waste disposal E&T activities into the ENEN Association structure.

With the concrete decision for implementing the radioactive waste disposal in several European countries, it is likely that specific skills demanded in the future in this field will differ from those required in the past. Beyond meeting immediate demands, there is a necessity to change the way of thinking about skills acquisition and consider the importance of the long term needs. This means that together with traditional pathways to qualifications flexible approach to professional learning and development must be envisaged mainly through qualification targeted training programmes. The focus of PETRUS III project regarding the training activities was the effective implementation of the professional development programme targeting qualification at the academic Master’s level. This has been the topic of the two first work-packages. The broader objective of WP1 and WP2 was to define how the training provision leading to high-level qualifications might best be configured to meet the end-users demand for skills linked to associate professional occupations. For this purpose the consortium has leaned on the “European Credit system for Vocational Education and Training” (ECVET) approach as practical instrument. WP1 applied the general “philosophy” of the ECVET system to the case of radioactive waste disposal. The first task in introducing ECVET system was the establishment of the most needed job profile followed by the establishment of the Learning Outcomes that shape the content of the training programme. Learning outcomes are statements of what a learner knows, understands, and is able to do on completion of a learning process. WP1 has precisely clarified the knowledge, skills and competences a holder of a qualification must have acquired to satisfy a specific job profile in geological disposal field. This was accomplished with the help of the PETRUS End-users Council and cooperation with the IGD-TP and its Competence Maintenance, Education and Training working group in the frame of WP4.

In order to support recognition, it is important to develop mutual trust and understanding between the different actors of the training programme. A Memoranda of Understanding (MoU) has been established to bind partners involving in the implementation of the training programme. The key point of the MoU is that the learning outcomes for which credits are awarded by one or the other of the partners can be recognised irrefutably. This relies in particular on the reliability and effectiveness of the outcomes’ assessment procedures that has been developed during the past project and was improved in the present
An appropriate model for the “learning agreement” that is the key operational document has been prepared in order to address the mobility issues. The challenge in such work consists in defining what exactly will be the subject of mobility in context of identified learning outcomes and what kind of common assessment indicators can be used.

The objective of the WP2 was to embed the PETRUS training programme in a higher education system for accreditation purpose. The main goal was to implement the PETRUS training programme in at least one of the partner universities as a pathway for the obtainment of a Master degree with recognition agreements from other partners is targeted. Unfortunately, due to the postponement of the implementation of the ECVET system across Europe, it was not possible to effectively implement the programme from the administrative point of view. However, the project produced a prototype programme with an instructional plan assessed against Quality Assurance procedure and criteria. Qualification through higher Education system implies comparability between European Credit Transfer and Accumulation System (ECTS) and ECVET. Although these two systems represent different methodological approaches both aim at facilitating mobility and mutual recognition. To fully support the PETRUS qualification goals, it is crucial that these two systems become connected. WP2 has studied tools and methodologies to facilitate linkage between ECTS and ECVET.

Pursuing its efforts for improving the scientific knowledge of future experts, PETRUS III has also addressed the challenge of multidisciplinary skill for PhD students and young researchers. The work-package dedicated to this issue targeted the enhancement of the young researchers’ capability in tackling complex topics related to radioactive waste disposal that is by nature a cross-disciplinary issue. Indeed, higher education has always had the responsibility to produce individuals having high expertise in a given field of interest. However, in the field of geological disposal we are faced ever more complex problems that require systems thinking, bringing about growing importance of producing professionals who have the skills to work with people from a diverse set of disciplines. This new educational challenge has been addressed by proposing the “Doctoral School on waste disposal innovation”. The concept is to combine existing national regulation with a common complementary Innovation and Entrepreneurship (I&E) education which include organizational and geographic mobility. Leaned on inter-university collaboration, the Doctoral School the academic objectives are to inaugurate new subjects in emerging fields of study and to promote the intersection of diverse research areas. The collaborative programme will offer PhD students the opportunity to undertake part of their research activity in direct link with industrial partners. WP3 has also set-up and coordinated the provision of short training programmes allowing participants to understand the multi-faceted nature of the geological disposal problem and to obtain the necessary skills to communicate with others to produce a collaborative solution through a common scientific perspective. To disseminate this programme the project also organized 2 annual events where doctoral students presented their "work in progress", exchanged the results of recent and on-going research in different fields of development and gained valuable feedback from fellow students and from senior experts and academics.

Another important task developed is related to Making PETRUS initiative sustainable that was the main recommendations of the PETRUS end user council. The project dedicated two work-packages to achieve this goal. WP4 was devoted to create coordination links for ensuring better provision of E&T in the field of geological disposal of radioactive waste. Developing and sustaining a programme that can foster interest in education and training in radioactive waste disposal requires effective supporting structures that can make the delivery of learning solutions possible. Sustaining E&T requires interest from partners at every level within the consortium but also and above all those external to the consortium. For this purpose the
first task of WP4 was the creation of link with the IGD-TP. The IGD-TP has initiated as part of the deployment of its Strategic Research Agenda (SRA) a working group on Competence Maintenance, Education and Training (CMET). The PETRUS III project complemented the work of this CMET group from the E&T provider side. The WP4 organised periodic common workshops with CMET to: i) review professional qualifications and skills, ii) identify the supply gap, iii) improve the offering and the quality of training provided iv) examine appropriate conditions for mutual recognition of professional qualifications and v) establish Education and Training Roadmap. Unfortunately, due to the cessation of the CMET activities during the project lifetime the objectives of this WP have not completely achieved, notably concerning the establishment of single permanent coordination point responsible for developing and maintaining the PD scheme. The second task of this work-package was the establishment of a steering board for maintaining the PETRUS educational programme. The board was instrumental for overcoming some organizational obstacles including solving practical problems arisen from modifications of technical modalities of the ECVET system during the project life.

Embedding the PETRUS initiative in a broader network than one constituted by the PETRUS consortium was the topic of WP5. The process has as an objective to help the PETRUS programme to enhance its mission, strategy, infrastructure, and to better answer to long term perspective of the E&T needs in the field of radioactive waste disposal. In this frame the main task of WP5 was the integration of the PETRUS initiative into ENEN Association structure. The ENEN approach to education and training is quite similar than the one envisaged by the PETRUS initiative. Among 20 partners of PETRUS consortium 12 have already joined the association and 2 others will become member in March 2017. ENEN dedicated a Working Group to pursue the efforts and accomplishments achieved so far within PETRUS initiative. WP5 has also established close relationship with ENETRAP III project on E&T in radiation protection and organized exchange of lectures between the two consortiums. This cooperation will continue and will be extended to other nuclear sectors within the ENEN structure.

Project Results:
Main results of the PETRUSIII project

- Elaboration of the PD training programme using ECVET model

The objective of the WP1 is to use the “European Credit system for Vocational Education and Training” (ECVET) principles and to develop “competence-based” curriculum for the elaboration of the radioactive waste disposal Professional Development training programme. ECVET integrates existing instruments into a single framework in order to secure staff career pathways and to ensure that credit gained can be internationally recognised. The first task in introducing ECVET system was the establishment of the most needed job profile. This was accomplished with the help of the PETRUS End-users Council and cooperation with the IGD-TP and its Competence Maintenance, Education and Training (CMET) working group. Through a methodological approach and in connection with European Qualifications Framework (EQF) and European Quality Assurance in Vocational Education and Training (EQAVET) instruments the profile of a safety engineer specialized in assessment and safety analysis for Construction License of a Selected Site has been established and the corresponding Learning Outcomes in terms of knowledge, skills and competences have been developed. The prepared job profile is summarised below:

Role: The safety engineer specialised in integrating and analysing site specific geochemical and hydrogeological data as an input data for carrying out numerical modelling and calculations for dose estimation under various likely scenarios for the [ future] repository:
Functions: To produce scoping models and perform numerical simulations to provide phenomenological and conceptual description of the behaviour of the repository system and of each repository and geological component during the (evolution of the repository) operating and post-closure periods, in space and time (thermal, hydraulic, chemical, mechanical, gas, radiation and biological processes and the potential release and transfer of radionuclide/toxic substances into biosphere), including related uncertainty analyses.

KNOWLEDGE (Cognitive competence)
- Understand the specific characteristics of the host rock contributing and harming the containment and the isolation of the emplaced waste form/s (understand the requirements contributing to safety and safety functions). EQF 6.
- Able to understand the impact of the processes (THMCGRB) and their coupling on the evolution of the components and the global repository. EQF 5-6
- Understand the migratory processes and potential transport paths/routes from the waste container to the biosphere. EQF 6
- Understand the basis of hydrological processes/groundwater flow, geochemistry including microbial processes and solute chemistry. EQF 5-6
- Able to carry out simple models for scoping calculations within the current repository context for flows and radionuclide transportation. EQF 6
- Able to apply the basics of reliability and risk management for a repository system (probabilistic/deterministic approach). EQF 6
- Understand the basic radiation and nuclear safety principles for containment and isolation (ALARA, SAHARA, graded approach, multi-barrier concept, ...). EQF 5
- Master the basics of radioactivity and of the nuclear fuel cycle and its safety. EQF 4
- Understand the physical and radiological characteristics of the waste form and the radionuclides from the waste forms. EQF 4

SKILLS (Technical and functional competence)
- Able to analyse and integrate basic scientific knowledge from various sources (bench- field experiments) in order to select relevant input data and models for applications. EQF 6
- Select, use and improve the appropriate simulation tools and codes for calculations (common codes: Porflow, Feflow, Aster, Comsol, Fluent, PhreeqC, PHAST). EQF 6
- Interpret the outcomes of the simulations in support of safety arguments and identify the related uncertainties in the outcomes. EQF 6
- Interpret the outcomes of the simulations in support of safety arguments and identify the related uncertainties in the outcomes. EQF 6
- Physical and numerical conceptualisation of the normal and altered scenarios. EQF 5-6
- Able to manage all kinds of uncertainties in the models, using deterministic and multi-parametric probabilistic approach. EQF 6
- Provide solutions to improve the system design and progressive management of disposal operations during the active control period of the repository. EQF 5-6
- Use complementary information (multiple arguments, performance indicators) to strengthen the outcome interpretation from the modelling. EQF 5-6.

COMPETENCE (Attitude; behavioural and personal competence)
- Able to work and coordinate interdisciplinary calculation team consisting of own staff and consultants. EQF 6
- Able to integrate interdisciplinary data and able to synthesize results. EQF 5-6
- Able to think analytical. EQF 5
- Willing to take and demonstrate accountability. EQF 5
- Able to recognise safety culture behavior. EQF 5.

Within the second task, WP1 breaks down the profile in three Units. The Units programs were detailed as best as possible in terms of training contents with the estimation of corresponding delivery time. The overall contents of these units are:

Unit 1 constitutes the basic learning outcomes for a quantitative safety assessment in particular the quantification of the migration of radionuclides. This includes the rock characteristics, water/rock interactions and underground water flow. The content of this basic unit is classically covered in master programs specialized in hydrogeology. Thus, nuclearization of professionals with hydrogeology background seems to be adequate for the designed qualification.

Unit 1: Basics – 70 hours
- Understand the host rock / site physical and chemical characteristics
- Understand water/rock interaction
- Understand the basics of hydrogeology
- Understand hydrogeological modelling

The second unit includes the fundamental learning outcomes on radioactivity, safety, waste disposal sites, the engineered barrier system (EBS) and site evolution with time. Unit 2 constitutes the core Unit for nuclearization of professionals originating from non-nuclear industrial fields.

Unit 2: Basics – 60 hours
- The phenomenon of radioactivity and fuel cycle
- Basics of risk assessment and management
- The concept of engineered barrier system (EBS)
- Safety requirements for disposal of radioactive waste, Safety assessment and safety case
- Situations description and scenarios
- Safety functions and indicators
- The THMCGRB multi processes

This third Unit is based on the learning outcomes of Unit 1 and Unit 2 including data gathering and management, mathematical and numerical modelling, uncertainties and quality management.

Unit 3: Safety and performance analysis for radioactive waste disposal – 90 hours
- Data gathering and management
- Select and use physical, mathematical and numerical models for assessment of the performance of a repository
- Uncertainties management
- Quality management strategies and procedures

The content of a Memorandum of Understanding (MoU) has been established in the frame of WP1. This is a voluntary partnership agreement where E&T mobility is concluded between competent bodies. The purpose of the MoU is to set the general framework of cooperation between training providers and agencies to provide training for qualification of learners. Also, the MoU aims to set the framework for credit transfer including training contents and Units of Learning Outcomes (ULO) as well as the mutual acceptance of the partners’ respective criteria and procedures for quality assurance, assessment, validation and recognition of Learning Outcomes (knowledge, skills and competences).

New organizations could join the MoU upon the acceptance of the founding parties.
For each mobility period a template for Learning Agreement (LA) has been established. The mobility of individual learners is through special arrangement defined between the learner, the sending organization and the host institution. The main aspects of a LA include the assignments, the related course objectives, the evaluation process and the validation and recognition mechanisms.

- Actual implementation of the PD training programme

The objective of the WP2 is to implement the PETRUS training programme as a pathway for the obtainment of a Master degree with recognition agreements from other partners. Even if in some countries qualification can be earned from a professional society, the recognition of this qualification allowing its holder to work in another member state necessitates in general a legal status. Given that almost all of the European universities have adopted the Bologna process and will also applied Copenhagen process that help the development of vocational education in higher education system, accreditation of PETRUS programme through academic institutions seems to be the best way to guarantee its recognition at European level.

The content of the programme to be implemented has been defined in WP1. WP2 produced the necessary documents for the accreditation process. However, due to the general postponement of the deployment ECVET system across Europe, it was not possible to concretise the effective implementation of the work done in WP2 within this project. Therefore the outcomes of the WP2 are mainly the study of frameworks and preparation of procedures that can be applied once the ECVET system will be effectively operational at European level. This includes accreditation procedures, model for linking ECVET and ECTS systems, prototype of PD programme and self-evaluation.

Accreditation of an educational program is an example of a continuous quality assurance process where operations and services carried out by educational institutes will be frequently evaluated by an external body or agency to determine if applicable standards are met. The PETRUS PD programme aims to apply ECVET-principles as instruments for mutual recognition and enables integration of existing academic training to this process. Comparisons of European standards for higher education institutes committed to the Bologna-process and principles and standards of ECVET programs have been done indicating that they share similar key principles. Furthermore, due to the similar requirements for the implementation of vocational and academic training programs, the accreditation procedures and standards set for higher educational institutes can be apparently utilized in the Petrus PD program.

Comparison of guideline documents for ECVET-programs and quality assurance guidelines for internal and external evaluation of educational programs in Finland and in France also indicate that the program developed in WP 1 will comprise the key inputs to the accreditation documents. The learning agreement model is essential for the accreditation evaluation as well as the role of different end-users in the planning of the contents of the program and selection thematic areas and the learner profiles including the criteria for accepting the students.

European institutes of higher education committed to the Bologna-process are already expected to implement QA/QC-procedures that involve frequent examination and internal evaluation of resources, processes, outputs, and outcomes and apply external accreditation of their educational programs. The Self-evaluation report prepared as the deliverable of WP2 has been prepared by modifying the self-evaluation guideline document applied in Aalto University as a part of the self-assessment and accreditation (external auditing) of its Bachelor’s programs. Assumption was made that the development of and maintenance of resource-demanding and overlapping QA/QC-procedures specific for an ECVET-program will not be necessary in partner universities. Instead, the educational institutes should commit themselves in the MOU to the implementation of QA/QC as required from the institutes of higher education.
in Europe and frequent reporting of the outcomes internal and external evaluation to the management group of the PD-program and partner universities using the guideline document.

The principles of an ECVET include the documentation of the qualification system that is considered to provide the knowledge, skill and competency (KSC) base for the entry route to professional practice. The KSCs needed for qualification must be linked with expected learning outcomes defined as statements of what a learner is expected to know, understand and/or be able to do at the end of a period of learning. The qualification is described in terms of “units” of learning outcomes. Units can be associated with a certain number of “credit points” in order to provide an illustration of the relative weight of the unit and associated learning outcomes in the over-all qualification.

As a standard European students are expected to earn 30 ECTS credits per semester and 60 ECTS credits per academic year. Studies of one academic year is equivalent to 60 credits (ECTS) involve about 1600 hours of full-time work. Therefore, one ECTS-credit corresponds to approximately 27 h of studies (including both contact teaching and individual and independent self-studies). According to BETWIN-approach project, the total number of ECVET points should be first allocated to a qualification as a whole and subsequently subdivided and allocated to each unit according to its relative importance within the qualification. In PETRUS project the different units were associated the estimates of “typical teaching hours in university MSc-programs” totaling 225 hours. Using these hours as a measure of the relative weights of the three PETRUS ECVET units can be estimated to be correspondingly 33, 27 and 40 % of the total qualification.

In order to be in line with the ECTS system, 60 credits should be allocated to the learning outcomes expected to be achieved in a year of formal full time vocational education and training. The units would therefore correspond to 40, 32 and 48 ECTS credits. However, the strict adherence to linking procedures similar to those proposed in BETWIN-project would apparently require substantial harmonization of the terminology and possibly endless comparison of past and present course descriptions in different partner universities before the course outcomes could be clearly linked to the distinguished learning outcomes providing the foreseen qualification. Such harmonization would be beyond the objectives of the Petrus III-project or would not directly serve the objectives of EURATOM (van Goethem, 2012) considering essentially ECVET-programs as instruments of mobility and life-long learning. Furthermore, the BETWIN approach does not work very well when students with variable educational background are going to be nuclearized. The work load required from the student can be different and calls for flexibility in the credit allocation and consideration of the previous learning achievements. Therefore, a more flexible approach is proposed where the responsibility of the applicant to provide all relevant documents and certifications in a form of a portfolio that:

- Can be used to verify that the described training can be linked to the delineated learning outcomes and KSCs and that the foreseen learning outcomes have been achieved.
- Can be used to assess the workload and EQL-level can be estimated, and particularly credited in terms of ECTS-system so that the integration of the ECVET-based education can be done at the academic institute providing the MSc-degree
- The studies and learning achievements are in line with the delineated competence based curriculum and the requirements of Master’s degree in terms of ECTS-program (including e.g. a thesis).

• Addressing the challenge of multidisciplinary skills at PhD level

The objective is to assemble a multi-disciplinary training programme to support career skills development
of future young researcher. Indeed, most complex topics in radioactive waste disposal are cross-disciplinary. To enter in this field the students must develop transferable and generic skills and competencies exceeding the specific topic of the PhD. For this purpose, PETRUS III proposes training courses around subjects that either can be tackled from different disciplines point of view or understanding of them necessitates combination of different types of skills.

WP3 has set-up and coordinated the provision of training programmes allowing participants to understand the multi-faceted nature of the geological disposal problem and to obtain the necessary skills to communicate with others to produce a collaborative solution through a common scientific perspective. To disseminate this programme multidisciplinary lectures have been elaborated for PhD students and were taught in an innovative format during the two PETRUS PhD Conferences held in Nancy in 2015 and in Delft in 2016. Around seventeen participants have attended each of these events where a set of high quality lectures on radioactive waste disposal presented by outstanding international experts was combined with oral presentation and poster exhibition of on-going research work by PhD students. Prizes have been awarded to best oral and poster presentations.

During the period June 22-26, 2015, Université de Lorraine hosted the First PETRUS PhD Conference in Nancy, France. The objective of the conference was to bring PhD students involved in research on different fields of radioactive waste management and disposal together with academics and professionals. The event was also a forum for knowledge exchange and collaboration among professionals and PhD students. It enabled PhD students to meet with their peers and to take contact with senior academics and researchers with similar interests, as well as to act as an informal job market whereby students demonstrate their abilities and attract attention to their prospects.

The duration of the conference has been fixed to a full week. Each day was split into morning and afternoon sessions. During the morning sessions selected PhD Students gave an overview of their works through short oral presentation followed by discussion and exchange of ideas with the audience and with a jury composed of 4 senior academics with extensive experience in supervision. The afternoon sessions were dedicated to high quality lectures in various fields of studies on radioactive waste disposal emphasizing the multi-disciplinarily aspect of the topics.

Interest in this first conference was most encouraging with 73 participants from all around Europe. There were a number of extremely interesting papers. In total 15 research works have been selected for oral presentations on the basis of extended abstracts. The quality of discussions with the audience was very high and sometimes very enthusiastic. The jury selected the two best presentations for special prizes awarded in a ceremony organized during the social event.

7 lectures of 1:30 length have been taught during this event. Professor Karsten Pedersen from Chalmers University and Microbial Analytics AB, Sweden talked on microbiology in nuclear waste disposal met with strong success. Radiation Protection and the impact of the new EU BSS on Waste Management was the subject of Dr. Danyl Pérez Sánchez (CIEMAT, Spain) presentation. Dr. Snehasis Tripathy from Cardiff University, UK presented an interesting lecture on modelling the coupled physical and chemical processes in engineered barrier systems in relation to safety analysis/assessment. Professor Jean-Marc Montel from Université de Lorraine, France talked about Natural analogue studies in the geological disposal of radioactive wastes. radioactive waste forms in the context of geological disposal was the subject of Professor Abdesselam Abdelouas from Ecole des Mines de Nantes, France. Radioactive waste management and social issues presented by Ms. Jenny Rees, Head of Public Relations and Added Values in SKB, Sweden was among the highlights of the lecture session. Finally, Professor FCO Javier Elorza from Mining School of Madrid, Spain presented a high level lecture on Hydro-mechanical and
transport processes in radioactive waste disposal.
All of those presentations can be downloaded from the official website of the event at: www.petrus2015.eu
The PETRUS-OPERA PhD Conference was the second annual event organised within the PETRUS III project. The location of this event was the Delft University of Technology (TU Delft) and was held in conjunction with the completion of the national research programme in geological disposal OPERA (http://www.covra.nl/disposal/opera-disposal) on 27th June-1st July. The conference was organised by TU Delft, with support from the Université de Lorraine.
The conference had three main components: (i) a school – where expert lectures were given; (ii) a conference – where the participants could present their work and get feedback; (iii) field trips – where context for the work presented could be gained. 70 participants followed this event.
17 lectures of 45 min each have been taught by:
- Denis Bykov (TU Delft) on Origin of radioactive waste, classification, solutions
- Monika Skrzeczkowska (IAEA) on Principles of radioactive waste disposal
- Ewoud Verhoef (COVRA) Waste management, storage and disposal programme
- Erika Neeft (COVRA) on How to develop a source term for disposal of waste (waste families, inventory)
- Philip Vardon (TU Delft) on Underground disposal: design, construction and mechanical behavior
- Rob Wiegers (IBR) on Cementitious materials for repositories
- Karsten Pedersen (Micans) on Microbes, barrier functions and nuclear safety cases
- Alex Bond (Quintessa Ltd) on Why does heat matter in radioactive waste disposal?
- Johan H. ten Veen (TNO) on The hydro-geological setting – present state and predictions of the future
- Guido Deissmann (Jülich) on Waste packaging and degradation
- Tobias Reich (University Mainz) on Speciation of actinides during migration in argillaceous rocks
- Hans Meeussen (NRG) on Radionuclide transport and retardation
- Ulrich Noseck (GRS) on Natural Analogues
- Anne Bergmans (University of Antwerp) on Radioactive Waste Management and Geological Disposal: a long term socio-technical challenge
- Lucy Bailey (OECD-NEA) on Role and purpose of the Safety Case
- Sarah Watson (Quintessa) on Modelling to underpin the Safety Case
- Klaus-Jürgen Röhlig (Clausthal University of Technology) on Confidence building in the presence of uncertainties
Site visits have been organized at Delft Research Reactor, COVRA Radioactive waste storage facility and SCK•CEN Underground research laboratory (HADES)
WP3 has also established the proposal for the organization of “Petrus Doctoral School on Geological Disposal Innovation”, to be implemented in collaboration with ENEN Association in order to produce doctors with an innovative and entrepreneurial (I&E) mind-set. The concept is built on the existing nationally regulated doctoral degrees awarded by the participating HEI according to their respective local regulations and a common complementary Innovation and Entrepreneurship (I&E) education in conjunction with industrial partners. The Doctoral School includes three unique elements in addition to the regular doctoral work:
- The Doctoral School provides a mandatory standardized I&E education in addition to the existing nationally regulated doctoral degrees. This I&E education would consist of two phases: a Business Competence phase followed by a hands-on Business Development Experience.
- The Doctoral School stipulates a minimum amount of organizational and geographic mobility between partners of different character.
- The Doctoral School encourages doctoral candidates’ thesis topics to be aligned with the ENEN Strategic Innovation Agenda (SIA) as implemented in the specific Action Lines of ENEN.

- **Think-Tank activities and link with the IGD-TP**

  The works done in WP4 had as an objective to be more responsive to the needs of waste management organizations and stakeholders in large, to bring inputs and to get support from the platform, and to ensure more efficient and permanent coordination of the PETRUS initiative in order to facilitate its sustainability. The WP4 activities were organised through PETRUS III steering board, PETRUS III End-users Council and as collaboration with IGD-TP’s CMET WG. Links between the PETRUS III project and IGD-TP’s CMET WG was established to continue the E&T initiatives and their deployment relying on the support of the radioactive waste community. This involves setting-up of a strategic policy to match E&T supply with demand and to find a continuing framework for the Professional Development scheme and its coordination. Steering board work was coordination between WP1, WP2 and WP3 to use the “European Credit system for Vocational Education and Training” (ECVET) principles and to develop “competence-based” curriculum for the elaboration of the radioactive waste disposal Professional Development training program that will be accredited for qualification at academic Master’s level, to implement the PETRUS training programme at least in one of the partner universities and to extend this cross-board collaboration to the creation of training programmes and multidisciplinary research tasks for PhD students. The work of the Steering Board was focused on issues related to the PETRUS E&T programmes’ governance as:
  - Follow the quality and programmes’ progress especially between WP1, WP2 and WP3 activities and propose adjustments and improvement as necessary.
  - Supervise the provision of end-users council and the IGD-TP CMET working group to evaluate, develop, market and pilot the PETRUS education and training programmes. Good example is the job profile “Safety Engineer – Assessment and Performance Analysis for construction license of a selected site” developed using ECVET principles (WP1). The profile has been reviewed and improved by the PETRUS III end-users Council with IGD-TP CMET WG and ANDRA collaboration.
  - Organising two Extended End Users Council meeting with different stakeholders of EFTS to get additional inputs for PETRUS E&T program
  - Realisation of policy for including new recourses, opportunities and partnerships to the existing programmes. Link between PETRUS III project and ENETRAP III project has been established through the preparation of a specific radiation protection course relative to waste disposal case that will be taught in the frame of PETRUS training programme.
  - Help to manage the practical organisation of the training programmes and shape the long term development in conjunction with WP5.

During the PETRUS II project the End-user Council (EUC) has been created and its membership has been extended outside of the PETRUS consortium. This Council has played an important role in the success of the past project and was instrumental in helping on the coordination of the project. Therefore, it was agreed to maintain also in PETRUS III the End-user Council as a strategic structure with the aim to provide the E&T providers in the PETRUS III project advice on real end-user needs and to promote the development of E&T resources for the personnel in geological disposal.

The objectives of the End-user Council were to provide advice, insight, input and vision for the strategic development of the project and to comment and review the project’s products/outputs from the end-user perspective and with this help with coordination. This includes providing information on the needs and views of stakeholders, providing feedback and advice on programmes and curriculum, communicating...
and advocating the PETRUS programme interests to external constituencies, assisting the project as potential employers, mentors, and resources for internships contacts and finally providing fresh perspective on project sustainability issues.

According to the Description of Work (DOW) of PETRUS III project the EUC held three meetings in connection to the regular project meetings. First meeting was in Kalmar, Sweden with the establishment of membership of EUC and agreement on the Terms of References. At this meeting also the plan was developed for the support of project deliverables in line with the project timetable. It was agreed to focus on WP 1 with producing of template for learning agreement, record system for acquired credits and professionals, and development of two trainee profiles related to performance and safety assessment engineer profile. Attention was given also on WP2 activities with accreditation procedure, linking ECVET with ECTS and prototype of PD programme and on WP 3 deliverables dealing with development of Ph.D. training courses, an annual Ph.D event and with inter-university collaboration where also EUC reflection is expected. Other two WPs (4 and 5) are more cross-cutting and will not require the separate contribution on the work, but advice and suggestion from EUC. At the first EUC meeting also an overview of status and demands for E&T activities at the waste management organisations (WMO) was exchanged. It was recognised by all participants of EUC that harmonised and well developed skills, competences and knowledge for different positions in the radioactive waste and spent fuel management are most important and needed. The availability of harmonised university programs for different levels of education are most desired. Although some problems with new employments possibilities at the WMO were recognised due to the current economic crises in Europe and consequent employment frees, however in near future (perhaps in five years’ time), there will be a definite need for recruitment, but it is impossible to say how many engineers and when. It was also stressed that the education and training is needed also for other institutions, not just waste management organisation, like regulatory bodies, technical support organisation and others, therefore the number of interested will be larger than expressed by PETRUS participants and guests.

The second meeting took place in Lisbon, Portugal and was organised as an extended meeting also with project partners and invited participants’ presence. The meeting included several presentations on management system for RWM, leadership and safety culture in RWM, how to facilitate access to expertise and to maintain competences in geological disposal, presentation of IAEA learning programmes and views related to education on RWM form faculties and WMO. It was pointed by all presenters that there are available systems for education and training which address the needs on WMO, but there is a problem with new employments, with interest within students to devote to nuclear technology and RWM which is also supported by public perception about nuclear which is in majority negative. Some challenges at the WMO have been recognised, like adoption of systemisation of positions which are subject of approval at different levels and could take several years to be approved, need for longer view (across several decades) based on the developed plans or programs to be implemented in the country – in this respect also EURATOM Waste Directive 2011/70 can be helpful requiring adoption of National Program on RWM (including research and development section). It was also pointed out the problem with attracting people. There is no career development, no financial motivation. In Europe, it seems there are different reasons why people are not attracted. Therefore, the strategies would need to be developed on public awareness and long term carrier possibilities for RWM which would be supported by education and training.

The third meeting of the End-user Council was organised in Ljubljana, Slovenia and also included broader participation from all project participants and some guests. The meeting was focused on the connection with other EU initiatives which are under development like JOPRAD and SITEX II projects and are related
also to training and education in the RWM. Both are developing the Strategic Research Agenda (SRA) on EU level from implementer and regulatory point of view. The SRAs will form the basis for developing a kind of European Joint Programming, giving the topics and priorities for EU level investigations and research in RWM. Also the E&T will be included in this new EU level frame. The presentation on the communication of knowledge again raised the importance of having more clear strategy on the communication of knowledge for E&T, which would also include the necessity of the independence of research institutions and universities from industry to assure credibility in the public. The French model on the cooperation between the universities, research institutes and industry was presented and it was agreed that such approach could be a good basis for future. Also the dissemination challenges in the new Information and Communication technologies were mentioned. It is clear that the old approach with books and scientific papers is not functioning well anymore. Therefor the focus of communication strategy would need to be the media which are used by younger generation like videos, social media and similar. The products should be developed to be used in internet and could be easily distributed. The student should be also trained in communication aspect of their work.

Sustainability, external collaborations and link with ENEN

WP5 addresses sustainability and continuation of the PETRUS initiative from structural and organisational point of view and cooperation outside of the EU. Link with the ENEN Association will be set up in order to develop a long-term vision and to create a coherent and dynamic strategy for achieving the integration of the education and training on radioactive waste disposal in this Association. The objective was to integrate the PETRUS consortium into the ENEN’s structure in order to ensure the permanent structural management, wider its overall means and place the E&T on radioactive waste disposal in a good basis for interaction with other sectors of nuclear E&T managed by the ENEN. This includes in particular the adaptation of the “European Master of Science in Nuclear Disciplines” label developed by the Association for it use in the frame of radioactive waste disposal and a roadmap for integration including the description of different steps in achieving the objective such as programme’s policy and visibility, infrastructure, stakeholders’ involvement, base for program funding and support, evaluation of spill over effects etc.

During the development of the PETRUS-III Project each one of the above mentioned objectives has been addressed in steps. In particular, in Deliverable D5.51 the structure of the ENEN Association was described in the benefit of the (possibly very few) representatives of the PETRUS-III Consortium members who were not fully aware of the history and of the actions of the Association. In the first chapters of this deliverable, the main milestones and results achieved by ENEN were summarised, including the actions made in the frame of the ENEN-II project, which represented a first successful attempt of joining the activities of the radiation protection and the geological disposal and waste management communities into the frame of an Association that was born from the project “European Nuclear Engineering Network”, though it immediately evolved towards a broader spectrum of actions by selecting the name of the founded Association as “European Nuclear Education Network”. This choice, as noted in D5.51 prepared since the very beginning ENEN to host and/or support the Education and Training actions going on in Europe in all the nuclear fields. At the time of writing D5.51 this led to affirm that “in principle, the step for coordinating the activities of the PETRUS Consortium within ENEN is already in place”. The D5.51 report included also a section entitled “Future Strategies and the PETRUS Consortium” which sketched the strategies of the Association for future work, also in relation to the integration into it of the PETRUS Consortium. In particular, the following items were considered:

- the need to better promote the EMSNE quality label: the remarks on this aspect stemmed from an
internal reflection especially on the geographical distribution of the EMSNE Alumni and on other issues making difficult the cross-border mobility of the European students; however, the issue was discussed also to propose that “efforts developed in the past and planned for the future by the PETRUS consortium for establishing certifications in the field of geological disposal will find a natural background to be further developed within ENEN”;

- better exploiting the large potential of the Association, in terms of further involvement of its members: though also this reflection was the result of an analysis of the internal ENEN dynamics, it was recognised that “The inclusion of the PETRUS Consortium within ENEN, as the objective of the Task 5.1 will provide additional potential to the Association, while an appropriate form of management of the PETRUS Consortium within ENEN will be the operation of a dedicated Working Group.”
- further planning of information actions, knowledge management, better use of existing resources for student and teacher mobility, further involvement of stakeholders within ENEN, and the need to revive the activity of the working groups within the Association were other items of the proposed reflection, aimed at presenting a comprehensive picture of the life of the Association; in this regard, the involvement of the PETRUS consortium was identified as very important, e.g. in promoting the positive movement based on the idea of “coordination” of E&T actions in the nuclear fields, which resulted in setting up the ANNETTE proposal, now financed as a EU Project; it is indeed necessary to recognise that, together with embryonal reflections developed in the frame of the MELODI platform, the presence of Task 5.1 in PETRUS project was one of the occurrences that contributed to realise that times were ripe enough for launching the global action of coordination named ANNETTE, as meaningful acronym for Advanced Networking for Nuclear Education and Training and Transfer of Expertise.

The deliverables D5.52 and D5.53 then addressed the issues of the integration of PETRUS curricula into the European Master Label and the suggestion for a protocol for course and student exchanges.
Two different proposals for the Master Label were envisaged by ENEN for the internal discussion within the PETRUS Consortium:
- a European certification for continuous professional development: this proposal was considered as a “stand-alone” option to be achieved at some adequate level of education and to be certified in an appropriate “passport” basing on the learning outcomes and the EQF levels identified in previous reports;
- a European certification in the frame of a MSc: in addition to the previous proposal, the possibility to release the certification in the frame of a MSc title was considered.

These proposals were based on prior work performed in the frame of the PETRUS-III project. In particular, in the report D1.13 the profile of a safety engineer in the field of geological disposal of radioactive waste was considered, defining its job requirements at the level of Knowledge, Skills and Competencies, thus involving different EQF levels for each mentioned requirement. Then, the report merging the two deliverables D1.4 “Learning outcomes” and D.1.5 “Programme units and associated credits” sketched in greater details three course units, involving 75 teaching hours of “Basics” (Unit 1), 60 hours of “Foundation for Radioactive Waste Disposal” (Unit 2) and 90 hours of “Safety and performance analysis for radioactive waste disposal” (Unit 3).

In the report D5.53 an example of Learner Exchange Agreement was proposed, to be used for the student mobility in the frame of the PETRUS Consortium in order to provide a formal basis for allowing exchanges as proposed in the study programme. The example, adapted from a really applicable protocol for inter-university exchanges, has been reformulated to be applicable also between non-academic course providers.
In summary, all the requested issues were properly addressed in order to facilitate the integration of the
PETRUS Consortium within the Association. The benefits that the PETRUS Consortium is receiving by the present process of integration within the ENEN Association, the following can be mentioned:
- the involvement in the new roles of the Association in favour of Education and Training within Europe;
- the involvement in the actions of ENEN beyond Europe, pursued through projects aimed at opening windows of cooperation with specific areas of the world in which nuclear education is developed;
- the involvement in the relations with IAEA and the regional networks which have been developed under its aegis.

In change, the ingress of the PETRUS Consortium is bringing to the ENEN Association its valuable contribution in terms of long lasting experience in the development of E&T actions and of the existing network of international contacts already established in its frame.

Among 20 partners of PETRUS consortium 12 have already joined the association and 2 others will become member in March 2017.

• Project Management

The objective of the WP6 is to manage the PETRUS III project so as it achieve all of the goals described in DoW in conformity with the expected quality. WP6 was also in charge of knowledge management activities, communication and dissemination of the outcomes of the project.

Work Package 6 supports the Project by managing “information technology” tools and works on several components of the information system to support the targets of the project. The establishment, maintenance and further development of such components have been split between two of the participating organisations - ENEN association and the Czech Technical University in Prague (CTU). The tools involved in internal communication during the project are handled by the CTU whilst communications outside the project are operated by ENEN.

ENEN’s responsibility for the establishment of the public project webpage guarantees the seamless implementation into the existing structure of the ENEN association website, ENEN webpages also contain interface to Database - the well-established tool for providing the up-to-date information on education and training in the nuclear field over the European Union countries and beyond it.

The CTU provided the “temporary” service required for project communication (common e-mail address/ list and working data storage with restricted access) and hosted the “homepage” domain: www.petrus3.eu. The PETRUS III public main page may also be reached via a direct link from the ENEN main page (www.enen-assoc.org/).

The PETRUS III web page contains the sections necessary to keep the public informed (project objectives, overall information, ongoing events, deliverables...). The emphasis is put on actual messages thus such information is prioritized on the webpage. The links of the Petrus Newsletters were inserted to the ENEN - Petrus III public section. Final versions of deliverables can be found on public subpage “Petrus III Deliverables”.

Modern communication channels are addressed by ENEN Google+, Facebook, Twitter and YouTube pages. These channels advertise various ENEN events, including Petrus III activities (PhD workshops). In order to support the “face-to face remote teaching” methodology developed by the PETRUS group WP6 continues to survey videoconferencing tools, their availability within the project consortium and experience with it.

Furthermore, in order to maintain external communication, every six months the project edited a Newsletter that was posted to a large audience reporting on the project development and last results and publicizing the forthcoming events. The objective was arousing the interest of institutions (like universities,
end-users, research organisations.) outside of the PETRUS consortium to join and collaborate with the project. 5 issues have been elaborated during the project life and largely distributed notably through IGD-TP and ENEN websites.

Potential Impact:
Impact and exploitation of results

The overall goal of the PETRUS III project is improving the quality and effectiveness of education and training for maintaining high level of expertise and human resources in the field of radioactive waste disposal. To provide a comprehensive response to this challenge PETRUS III bring together a consortium of universities, research centres and radioactive waste management agencies that have an excellent track record of engaging in knowledge development and therefore ideally placed to collectively assess present and future needs and contribute to the delivery of skills and expertise in this field. The project is focused on training processes related to both formal and non-formal education. It sets themselves ambitious goals to achieve highest quality results so that holders of qualifications, knowledge and skills acquired through PETRUS programmes will be able to get them effectively validated throughout the EU for the purpose of career and/or further learning.

The last 30 years have seen continuous and rather rapid scientific and technological progress in radioactive waste disposal generating training needs for people working in this field to consistently update their knowledge and skills. Furthermore, the multidimensional aspect of this area usually demands far more than individual specialization. With the concrete decision for implementing the radioactive waste disposal in several European countries, it is likely that specific skills demanded in the future in this field will differ from those required in the past. Beyond meeting immediate demands, there is a necessity to change the way of thinking about skills acquisition and consider the importance of the long term needs. This means that together with traditional pathways to qualifications, flexible approach to professional learning and development must be envisaged. Current and prospective job market development bring also about mutually recognised qualifications at EU level that become increasingly important in opening new opportunities for the mobility of professionals and their career progression. Therefore, programmes in geological disposal must be both qualification and competence-oriented and notably have to seek European recognition. At the same time, they should be flexible enough to fulfil the particular demands for specific skills. One way to achieve this is the concept of a modular, units-based, curriculum. To define how the training provision might best be configured to meet the end-users demand, the PETRUS consortium has studied the use of the “European Credit system for Vocational Education and Training” (ECVET) as practical instrument. By analogy with the European Credit Transfer and Accumulation System (ECTS) in higher education, ECVET targets the harmonisation of the European qualification systems. Qualification is described in terms of “units” of learning outcomes. Learners can accumulate required units for a given qualification programme over time, in different countries, and in different learning situations (e.g. modular courses, practical training).

Adopting the ECVET system for the mutual recognition of qualification in geological disposal would be very effective however several difficulties exist in its practical application, one of them is related to the construction of the programmes. This concerns the content of the training programmes and curricula construction that must be comparable in different institutions. Indeed, a “Competency-Based Curriculum” is needed for PD training programme while “competency standards” do not exist at the European level as far as Geological Disposal is concerned. Other problems are linked with the lack of commonly agreed
procedures and methodologies for evaluation and comparability of competences. Furthermore, as the ECVET system is not yet implemented in any EU countries, there is no reliable model to follow at this stage of development. Regarding the PETRUS training programme the solution adopted is the utilization of those national systems that are close to the general “philosophy” of the ECVET system. In this way the adaptation of the process will be facilitated when the ECVET system will officially come to the fore. PETRUS III project is the result of the strategic character of training applied to the field of radioactive waste disposal. Within this context, the project can be understood as a space for improvement of competencies through coordinated approach to qualification mechanism for Professional Development. Indeed finding rational solutions for assuring the continuation and renewal of professionals’ skills and competencies is a matter of prime importance in this area. By using competence-based approach and ECVET based model the project helps to secure the global provision, enhances transparency and facilitates professionals’ mobility across Europe. Furthermore, implementing the programme in the frame of academic system will favour unified European approach to education and training in radioactive waste disposal increasing the recognition of acquired learning outcomes when moving from vocational learning to higher education context.

The training of high-quality PhD students and early career researchers is another critical matter to radioactive waste disposal’s short-term and long-term needs. Through interaction across the disciplines the resulting knowledge can be made greater than the sum of its parts. Indeed, it is through multidisciplinary interaction that solutions for some global scientific issues related to geological disposal can be effectively found. Therefore PETRUS III tries to increase and strengthen cross-disciplinary research by providing thematic contexts for interaction and by proposing adequate training programmes through inter-university cooperative approach.

With the future in mind, the sustainability of PETRUS initiative is felt as a must, since sharing common stable framework would not only better secure the overall provision of knowledge and skills but also reduce the risk of training fragmentation. To consolidate the quality of actions already undertaken, to strengthen current development proposed in the PETRUS III project and to extend and develop further new perspectives in the field of radioactive waste disposal education and training long-term coordination and management are desirable. To achieve this goal PETRUS III developed cooperation with the ENEN for finding suitable organizational structure with ultimate goal of embedding the PETRUS initiative management under the umbrella of this association.

The maximum objective of the PETRUS III project is to place at the reach of radioactive waste disposal community improved quality education and training provision and to foster the development of research. The efforts to coordinate actions and capacities in the frame of the present project PETRUS III include also the establishment of an efficient communication channel between the Consortium and the Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP). This link allowed combining top-down and bottom-up approaches towards the identification of E&T priorities in particular as far as Professional Development training programme is concerned. Enlarging the circle and creating new partnerships were achieved through collaboration with the platform but also by strengthening link with other nuclear communities in particular with ENETRAP group that pursues similar objectives in the field of radiation protection.

List of Websites:
www.petrus3.eu
repository of PETRUS PhD lectures taught during 2015 PhD event

include pdfs of the 2016 lectures

The recorded lectures publicly available

The proceedings can be download

Related documents

final1-petrusiii-attachment.pdf

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