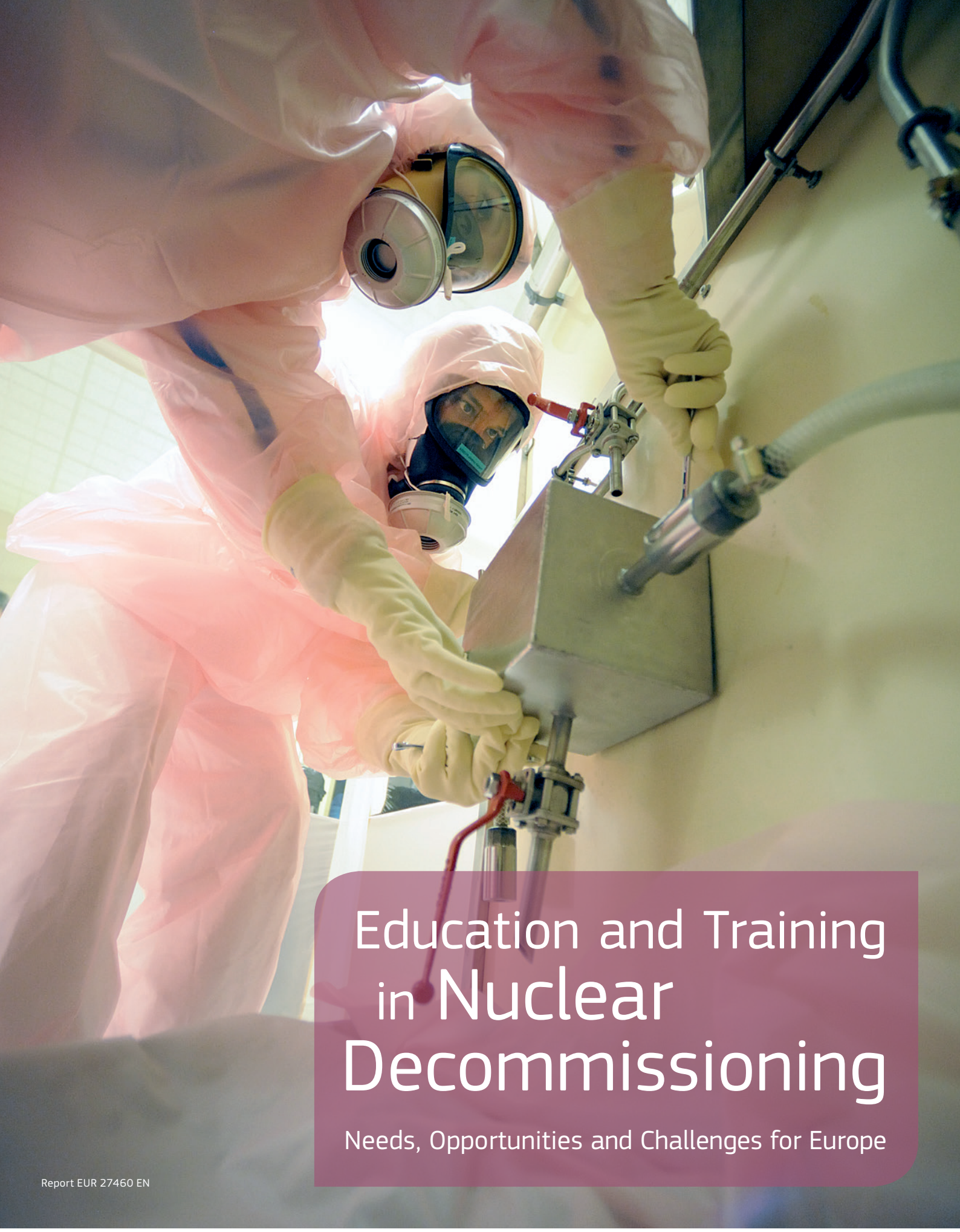

Education and Training in Nuclear Decommissioning

Needs, Opportunities and Challenges for Europe

Report EUR 27460 EN

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Foreword

The decommissioning of nuclear facilities is an industrial activity that is growing worldwide, creating job opportunities at all educational levels.

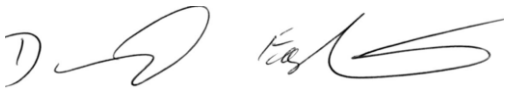
Over the last decades, European companies have been involved in decommissioning projects that are targeted at delivering an environmentally friendly end-product such as a fully restored green field site that can be released from regulatory control, in line with the 'circular economy', as promoted by EU and national policies.

European industry has acquired know-how and today Europe can position itself at the top level in the world decommissioning market. However, in view of the expected expansion of the activities, efforts are necessary to maintain this leading position and, in particular, to ensure and share the underpinning knowledge, skills and competences.

In this perspective, the University of Birmingham in association with the European Commission's Joint Research Centre have organised a joint seminar[1] to address the following questions in relation to education and training in nuclear decommissioning:

- What are the competence needs for the future?
- What are the education and training opportunities?
- How can we stimulate interest and future talent?

In answering these questions the present report gives suggestions for helping the development, coordination and promotion of adequate education and training programmes at EU level in nuclear decommissioning. It highlights, in particular, the necessity to improve the long term planning of the resources and competences, addressing the specifics of decommissioning activities, to give more visibility to the career possibilities in the sector, and to enhance the cooperation between the existing education and training programmes, providing also more clarity in the learning outcomes.



Vladimir Šucha

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[1] "Education and Training in Nuclear Decommissioning", 16th - 17th April 2015, Birmingham, UK
http://www.birmingham.ac.uk/research/activity/energy/events/education-training-nuclear-decommissioning.aspx

Content

1 Introduction

Nuclear decommissioning encompasses all technical and management actions associated with ceasing operation of a nuclear installation and its subsequent dismantling to remove it from regulatory control, including the site remediation.

Nuclear decommissioning is an industrial reality and significant growth can still be expected. Out of more than 200 nuclear power reactors that have been built in Europe, one third are currently permanently shut down. Various types of nuclear fuel cycle facilities and research infrastructure have also become obsolete and stopped operation. Moreover, after the Fukushima accident in 2011, some countries decided on, or envisage accelerating the closure of their oldest reactors. But today only few of the reactors that have been shut down have been fully decommissioned, the rest being either in a standstill status of 'safe conservation', in a transition phase (including the decommissioning licencing) or at different stages of decontamination and dismantling.

These growing expectations of the decommissioning market create the potential for new activities over the coming decades and a clear global positioning of the European Union will be an asset. It will stimulate the export of services and equipment, especially to countries having a large nuclear programme, whilst disseminating the highest levels of safety and environmental care.

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The availability of qualified and experienced personnel will be essential to support the EU nuclear decommissioning, and will be probably one of the most critical issues to address. For many years, the European nuclear sector has faced an increasing difficulty in recruiting and maintaining staff with the required expertise. It can be expected that the decommissioning industry will face a similar or even more significant shortage of competent personnel.

Over the last decades several EU countries have seen new initiatives emerging to address the issue, going from short professional induction training programmes to extensive academic graduate and postgraduate courses. Pathways should be explored as to how these initiatives can be supported, eventually coordinated and promoted.

Objectives of this policy support document

This document explains the context in which nuclear decommissioning is progressing in the European Union and provides suggestions on the way forward to support education and training.

First, it aims to identify from industrial players and organisations the views on the actual needs for the development of knowledge, skills and competences in nuclear decommissioning.

Second, the document addresses the existing education and training opportunities in nuclear decommissioning and indicates how they could be further stimulated.

Finally, the document reflects on how studies and jobs in nuclear decommissioning could be positively perceived and how careers in this area can be particularly attractive, supported by adequate education and training programmes meeting the needs of industry.

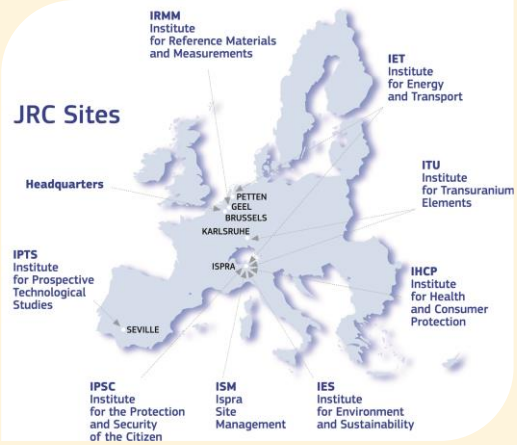
The approach followed

The document is drafted as a synthesis of presentations and discussions following a two day seminar organised in 2015 jointly by the University of Birmingham and the European Commission's Joint Research Centre. The seminar was attended by a number of representatives of European universities, industry, research institutes and support associations involved in education, training and in human resources management, all linked to decommissioning activities (see list in annex). Young professionals were also invited to share their views.

The document, once drafted, was submitted for review to all participants in the seminar as well as to other interested experts. The present version is the outcome of this process.

Role of the European Commission, Joint Research Centre (JRC)

As the Commission's in-house science service, the JRC's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle. Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners. The JRC research activities are spread over seven institutes (located in Belgium, Germany, Italy, the Netherlands and Spain) and employ about 3000 staff members from all EU member states.



For over two decades the JRC has been involved in the decommissioning of its own old and shutdown nuclear installations which were originally built following the signature of the Euratom Treaty in 1957. In this sense, the JRC has acquired a large and practical experience in decommissioning as well as in the management of radioactive waste.

In view of the growing EU decommissioning market and associated challenges, the European Parliament, during its debates on the future Euratom research programme, requested that JRC builds upon its experience and further reinforces its support for safe decommissioning in Europe. Improving knowledge management and promotion of education and training in decommissioning are some of the areas in which the JRC will contribute.

Role of the University of Birmingham

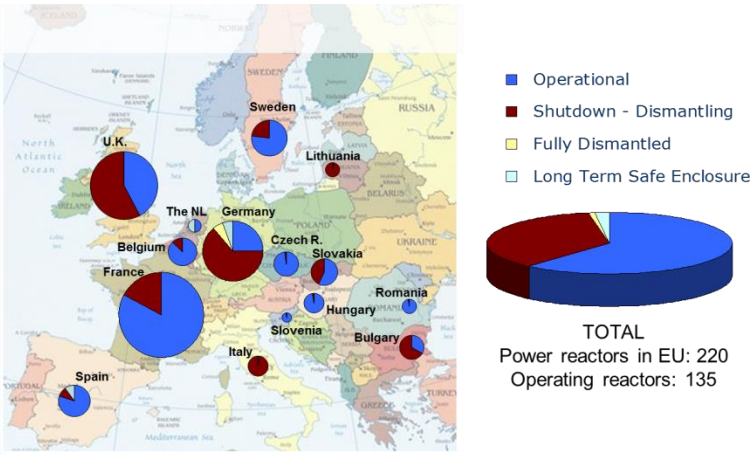
The University of Birmingham was established by Queen Victoria by Royal Charter in 1900 and was the UK's first civic or 'redbrick' university. The first phase of building work on the campus was completed in 1909 under the auspices of the esteemed architect Sir Aston Webb.

The University has close to 30,000 students drawn from 150 countries. Birmingham is one of the UK's major participants in the Erasmus programme, which encourages student exchanges between leading European institutions.

The University of Birmingham Physics and Technology of Nuclear Reactors Master course has been running since 1956 and a post-graduate programme in Radioactive Waste Management and Decommissioning is well established to cater for the growing demand in this sector. The University has the largest UK set of nuclear training programmes, delivering close to 100 graduates into the UK nuclear sector per year. The University published the conclusions of a policy commission in 2012 on "The Future of Nuclear Energy in the UK", which included highlighting skills and training gaps in the nuclear sector.

2 Progressing with nuclear decommissioning in the European Union

Although experiences with the decommissioning of disused installations date from the earliest stages of the history of the nuclear industry, the practice has clearly gained in importance over the last decades. Several EU countries have decided to undertake the decommissioning of their oldest shutdown reactors and facilities. Some first pilot projects were managed under R&D programmes (e.g. the BR3 reactor in Mol, Belgium)[2], but today the activity has grown and reached an industrial scale.



Situation nuclear power reactors in the EU

However, a complete decommissioning, starting from the end of operation of a reactor until its final release from regulatory control, is a long term process, which can exceed easily ten to twenty years for large installations. After the first stages comprising the evacuation of the residual nuclear fuel and the decontamination or removal of the most radioactive components, the intrinsic radiological safety risks in the reactor are decreased by several orders of magnitude. But still, the further in depth decontamination, the gradual dismantling of the equipment and the buildings, the segregation of the various types of waste and the final monitoring require a lot of planning, organisation and work (see related scheme on next page). This long term process explains why today, in Europe, despite a growing know-how, only few major nuclear installations have been fully decommissioned.

In view of the financing of such decommissioning projects, EU countries are obliged to ensure financial reserves to cover the expected liabilities.[3] In some countries those liabilities are budgeted by the respective utilities, in others they are accounted by a dedicated national organisation. By way of example, decommissioning cost estimates for a nuclear power reactor range from 0.5 to 2 billion euro. Expected costs can be for some specific installations much higher, e.g. an estimated 100 billion UK pounds for the decommissioning of the whole Sellafield site in the UK. Only a fraction of this budget is aimed to cover the effective decontamination and dismantling works, a significant part of the budget will be allocated to ensure waste treatment and disposal and to the safe conservation operational costs until the decommissioning is concluded.

Actually, the economic benefit of decommissioning could be questionable: decommissioning will not allow utilities to earn money but will only consume the allocated decommissioning financial reserves. However, there are on the contrary some important economic drivers in *not* postponing the activities: commencing early will limit the reactor safe conservation costs, will limit risks for degradation

[2] The European research programme in decommissioning started under the 4th Research Framework Programme in the mid-1990's. Four pilot decommissionning projects were chosen to compare the differences in the approach: a fuel processing plant (AT1 in La Hague); a gas-cooled reactor (WAGR in Windscale); a boiling water reactor (KRB-A Gundremmingen in Germany) and a pressurised water reactor (BR-3 in Belgium). Later on, a VVER type reactor (Greifswald in Germany) has been added to this list of pilot decommissioning sites.

[3] Council Directive 2011/70/Euratom of 19 July 2011 on the management of spent fuel and radioactive waste - (L 199/48 Official Journal of the European Union 2.8.2011) http://ec.europa.eu/energy/nuclear/waste_management/waste_management_en.htm

with time and will ensure the availability of an operational workforce retaining memory of the installation.

On top of economic considerations, there are also more fundamental drivers for the progression of decommissioning, particularly the ethical and social obligations to remediate to the historical liabilities and not to create cost and burden for later generations. This principle is in most countries translated in national policies and legislation, but is also directly linked to the credibility of the nuclear energy industry: the commitment to demonstrate that decommissioning is indeed a feasible final step of the nuclear life-cycle (or 'moving towards a circular economy'[4]).

"Demonstration of decommissioning at an industrial scale, as a 'last but feasible step' of the nuclear life-cycle, is essential for the credibility of the nuclear energy option."







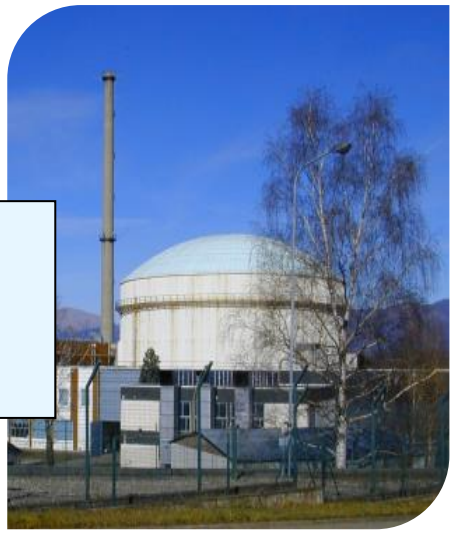





[4] 'Moving towards a circular economy': The European Commission is aiming to present a circular economy strategy to transform Europe into a more competitive resource-efficient economy, addressing a range of economic sectors, including waste. http://ec.europa.eu/environment/circular-economy/index_en.htm

Nuclear Decommissioning – main steps

Nuclear decommissioning encompasses several steps which are in principle sequential but which can in some circumstances overlap :



Preparatory Phase

- ❑ Characterisation: inventory of the radioactivity present in the installation
- ❑ Lifecycle planning of decommissioning work
- ❑ Planning of staff and financial resources
- ❑ Safety assessment and Environmental impact assessment
- ❑ Authorisation process

Evacuation of residual spent nuclear fuel

- ❑ Evacuation of spent nuclear fuel to interim storage facility in view of deep geological disposal or reprocessing (recycling)

Decontamination

- ❑ Chemical or mechanical removal of radioactivity levels from the highest contaminated components

Dismantling equipment and infrastucture

- ❑ Removal of large metallic components and evacuation for cutting or off-site melting
- ❑ Removal of disused equipment and infrastructure (ducts, trays, pipes, cables, ..); substitution if necessary by small mobile units
- ❑ Segregation of waste, decontamination, cutting and packing

Release of the buildings

- ❑ Measurement of the residual building components (walls, floors, ceilings, ..)
- ❑ Decontamination where needed

Demolishment buildings (if not re-used)

- ❑ Demolishment of the building structures

Final release of the site

- ❑ Monitoring absence of contamination of the soil
- ❑ Decontamination if needed
- ❑ Release from regulatory control

Waste & Material Management

Most nuclear decommissioning steps generate waste and reusable materials; they are characterised and segregated in different categories, in view of their further treatment, packing and evacuation for recycling or disposal.

Usual management approaches are :

High & Intermediate Level waste
(less than 1% of total volume)

- ❑ Packing in specific hermetic/shielded containers
- ❑ Interim storage in view of later deep geological disposal

Low Level Waste
(approximately 10% of total volume)

- ❑ Off- or on-site conditioning (incineration, supercompaction, melting)
- ❑ Immobilisation in containers or drums (grouting or other)
- ❑ Interim storage/evacuation for final disposal

Very Low Level Waste and Clearable Material and Waste
(approximately 90% of total volume)

- ❑ If applicable: measurement for release of the material from radiological control (i.e. 'clearance')
- ❑ If not clearable: treatment, packing and evacuation for final disposal

3 Competence development in nuclear decommissioning: what are the needs?

Progressing with nuclear decommissioning will be driven by policies, legislation and economic considerations but crucially will depend on the availability of competent human and infrastructure resources. Relying on efficient and motivated personnel is a key success factor.

Most decommissioning programmes are implemented over several years via a sequence of projects and activities of different nature. This explains, at least in part, the variety of the skills required. Those range from senior site managers and programme managers to project managers, engineers (electromechanical, chemistry, construction, geology, ..), operational managers, safety managers (safety case and licensing), operational and technical staff (decontamination, dismantling, waste characterisation, treatment and transport, maintenance) and surveillance staff (radiological protection, safety and security).

Complementary to operational staff, the usual important number of diverse contracts and their complexity will also require relying on competent financial and legal support. And the specialised nature of the activities will also require attracting, developing and maintaining the competences, and thus the implementation of an appropriate human resource management.

In the transition phase from the closure of an installation to its decommissioning, part of the competences can be acquired by professional conversion of part of facility operating staff. But experience shows that some activities require recruitment or outsourcing. Several disciplines are involved and a series of pinch point areas exist, i.e. disciplines for which shortages have been identified or are expected.

Ensuring also a continuity of scientific competences linked to decommissioning should not be forgotten. Although many of the techniques have reached maturity after they were tested and applied on the first sites, there are still areas requiring R&D[5]. Particular attention is needed for the further *development* of existing techniques, to make them more efficient (less time-consuming, less waste producing) and safer (less radiation exposure risks, less occupational hazards, more ergonomically sound).

"Decommissioning is not an exact science: it is a continuous and challenging search for innovative solutions"

Main identified 'Pinch Point' areas for nuclear decommissioning

- *Programme and Project Managers*
- *Engineers specialised in Decontamination & Dismantling Techniques and in Waste Management*
- *Safety Case/ Licensing Specialists*
- *Radiological Protection Advisors*
- *Radiation Metrologists and Radiochemists*
- *Skilled technicians and operators for dedicated equipment.*

From the discussions that focussed on acquiring and maintaining the needed competences, the following issues appear essential to be taken into consideration:

- the adequate management of the cultural change, which is created by the transition from operation to decommissioning;
- the long term planning of the essential competences;
- the retaining of knowledge, independently of the possible turn-over of staff;
- the importance of collaboration between the players involved;
- the need to facilitate mobility (both cross-border and cross-sector).

A better understanding of the prospects of the decommissioning market over the coming decades will also help future planning of human resources.

[5] See for example: "R&D and Innovation Needs for Decommissioning Nuclear Facilities", Radioactive Waste Management (OECD/NEA 2014) - https://www.oecd-nea.org/rwm/pubs/2014/7191-rd-innovation-needs.pdf

From operation to decommissioning: dealing with a cultural change

When the decommissioning programme follows directly from the shutdown of a facility there are obvious reasons to maintain the operational staff employed, to the extent that it is achievable; the remaining staff are familiarised with the installations and do not need to be relocated to other sites or re-employed in other utilities or eventually made redundant.

However, experience has shown that companies embarking from operation to decommissioning face an important cultural change. Targets are changing from operating and maintaining a facility using known technologies, to the dismantling and final demolishment of the installations. When moving to decommissioning, the nature of the work changes significantly and will require more flexibility. Activities become mainly project, cross discipline based, necessitating a broader knowledge, especially of new technologies. The available competences do not neatly map from operations to decommissioning.

The organisation will have to adapt to the needs. It will be important to ensure an efficient programme management to support the changes. Investment in training will have to be planned to adapt and strengthen the competences or skills. Several new competences will have to be also attracted from external organisations.

Management will have a key role in maintaining people's spirit and commitment towards an end goal which is very different to those of an operational facility.

Long term planning of the essential competences

The usual significant time scales of decommissioning processes require that specific attention goes into the long-term strategic planning of recruitment and training needs with an appropriate profile in terms of both time and scale.

Obviously this approach is essential for the key disciplines for which currently a shortage is already experienced or is forecasted.

It can be worthwhile to define customized extensive training programmes to fill this gap. Examples of those are discussed in a next section of this document.

A clear vision should exist on possibilities for personal career development, which can be facilitated by the various job opportunities that decommissioning activities can offer.

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The retention of knowledge

Independently of the long term planning of recruitment, training and professional development, a management system must be put in place to guarantee the preservation of the knowledge of the facility and its historical records and to ensure the knowledge transfer to future workforces. This issue can be especially challenging in cases of a deferred dismantling strategy, whereby active decommissioning only starts after a lengthy period of safe enclosure of the reactor.

Support can be provided by entities specialised in decommissioning and assisting the operators in the development and implementation of knowledge management programmes for the plant and contractor personnel involved in various phases of decommissioning activities. International organisations including the International Atomic Energy Agency (IAEA) are currently providing expertise in this area.

Collaboration between organisations

With the growing number of facilities reaching or approaching the decommissioning phase, it is necessary to share lessons learned and

good practices in decommissioning, waste management and site remediation. Although the decommissioning market is already very competitive, advantage can be taken from collaborations between the organisations to enable the development of the right competences. Decommissioning sites require a close interaction between operators, consulting and engineering companies, industrial service providers, waste agencies, etc. as well as the independent regulatory bodies. All stakeholders have an interest that the key skills are both developed and matched to demand – scale and time. It is clear that no single organisation can achieve all decommissioning goals.

"Bridging across EU providers will help drive up standards"

There is a clear need to share best practice across the European Union to ensure that the organisational costs linked to the knowledge, skill and competence development associated with decommissioning are optimised. Several examples exist at national level. Organisations in the UK, Germany and France are merging efforts for integrated training programmes. 'Competence clusters' have been created to merge knowledge and experience. Innovative systems have also been developed and put in place to enable the assessment, recording and demonstration of workforce competence, showing workers have the right skills, knowledge and attributes for the task required[6].

International organisations such as the IAEA, the OECD Nuclear Energy Agency (NEA) and the European Commission also play a role in the sharing of information on decommissioning practices.

Facilitating mobility

Mobility of decommissioning experts is also an important factor to consider. Decommissioning activities are implemented sequentially. For some steps specific competences are required for a well-defined period, limited in time (which can extend to a few years). There exist opportunities for teams of decommissioning experts to move from project to project thus maximising the cost benefit return to companies that develop the skills-base.

In a European context, mobility faces language and cultural barriers, but the differences of safety and environmental regulations and of on-site requirements appear to be an even more important constraint. There is still work to be done in moving towards a harmonisation of European safety practices on the decommissioning sites.

Clearly, the nuclear decommissioning business is still in an early stage of development. Given the number of facilities that have been shut-down and facilities that are anticipated to be closed in the near future, the market for decommissioning is expected to grow and will last at least for many decades.

However, presently it is not clear how fast these market expectations will be realised. Some contradictory figures exist. The European decommissioning industry and organisations would benefit if a sound assessment is made of the prospects of the market (including human resources needs) over the coming years, based on the nuclear policies and forecasts in the EU member states. Such an in-depth exercise would help organisations to plan over a longer term.

[6] Example is the 'capability model' developed by the employer led and funded 'National Skills Academy for Nuclear' (NSAN) Board in the UK https://www.nsan.co.uk/products-services/capability-model

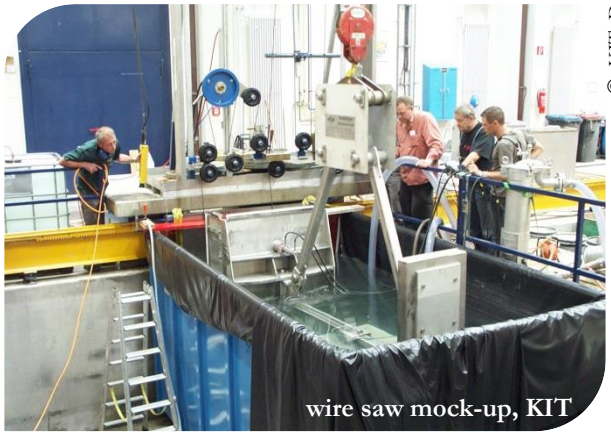
4 What are the education and training opportunities?

A survey of the education and training opportunities in Europe shows that the evolution of nuclear decommissioning activities over the last decades has triggered the development of several programmes, particularly in the three main 'nuclear' EU countries: France, Germany and the UK.

Education in decommissioning and waste management is currently provided as follows:

- PhD programmes and dedicated Professorships in decommissioning linked to engineering (an example is in Germany the 'Professorship on Decommissioning of Conventional and Nuclear Facilities' at the Karlsruhe Institute of Technology (KIT));
- two to three year or postgraduate taught Masters courses focussed on decommissioning knowledge (examples are in the UK the one year 'MSc in nuclear decommissioning and waste management' at the University of Birmingham or in France the 'ITDD Master – ingénierie, traçabilité et développement durable' at the Université J. Fourier in Grenoble);
- dedicated modules in decommissioning integrated in a more general Master course in nuclear science or nuclear engineering (example are in Belgium the 'Belgian Nuclear higher Education Network or BNEN', in the UK the 'Nuclear Technology Education Consortium or NTEC' modules at various Universities or in France the 'Nuclear Sciences and Technologies engineering' degree sharing courses at CNAM/INSTN (50%) and apprenticeship in industry (50%));
- Bachelor degree with specialisation (about one year) in decommissioning (examples are in France the courses on decommissioning and waste management at the University of Caen and the University of Nîmes).

Some programmes allow students the flexibility to develop managerial skills aimed at running decommissioning projects. It is essential to develop non-technical skills required such as commercial awareness, project organisation, communication, team leadership, example being the 'UK Certificate of Nuclear Professionalism'.


wire saw mock-up, KIT

Most of these programmes have been established following the explicit request of industry, while teaching staff are for a large part professionals and those seeking employment in the sector. The programmes also typically include knowledge transfer on specific projects or equipment: indeed it appears that nuclear decommissioning is a privileged area for practical, problem-based in-field learning. Dismantling techniques not only involve the development of the theory but need a close interaction with industry for their practical understanding.

> ***"Education and Training play a key role in shaping the future culture of decommissioning"***

Complementary to those education programmes, which are mainly addressed to students or young professionals at the start of their career, several shorter vocational *training* programmes exist focussing on professionals having already work experience in the nuclear field but whose job evolution requires new competences linked to decommissioning activities. A few such examples are:

- The JRC ' Summer School on Nuclear Decommissioning and Waste Management' (one week, on the JRC-Ispra site, Italy);
- the 'Technology and Management of the Decommissioning of Nuclear Facilities' course at the AREVA Nuclear Professional School (one week by the Karlsruhe Institute of Technology (KIT), Germany);

- the Belgian Nuclear Research Centre SCK•CEN courses on 'Decommissioning of Nuclear Installations' (one week open courses and customized courses at the SCK•CEN site, Mol, Belgium);

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- the 'European Decommissioning Academy' organised by the Slovak University of Technology (three weeks of courses, on-site training at the Slovak decommissioning sites and technical tours in Austria, Switzerland and Italy);
- the CEA/INSTN international course on 'Dismantling Experience of Nuclear Facilities' (one week, including a tour of dismantling sites);
- the IAEA ad hoc training programmes and possibilities for e-learning.

Decommissioning activities also require specific workers' technical and administrative skills related to decontamination (specific processes), dismantling (operating specific equipment), waste treatment, waste measurement (waste characterisation devices), radiological checks and surveillance, transport, accountancy, etc... All these skills require ad hoc training which are, in general, organised by the industrial organisations or nuclear research and training laboratories.

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A survey of the current provision shows that various education and training programmes exist; they will probably need to grow to meet a future increased demand. This evolution highlights the need for harmonisation of the outcomes, for cooperation between universities and institutes and for further enhancing the collaboration with all participants involved in decommissioning (industry, safety authorities and associated technical support organisations, waste management and decommissioning agencies, research centres).

Harmonisation of the education and training outcomes

Although education and training programmes can differ in their focus, harmonisation of the outcomes would provide more clarity and be beneficial for both students and trainees not to mention companies that rely on such highly skilled staff. Further standardisation would stimulate mobility and the possibility for universities and institutes to attract students from abroad, particularly from smaller countries for which the development of a rather specific education programme in decommissioning is not viable.

Standardisation can be applied at all levels and should be in line with the effective knowledge and skills needs, as identified in the previous section.

For academic education programmes a series of modules exist, spread over one to three years. These academic modules are weighted according to the 'ECTS' credits[7] which importantly creates a high degree of transparency across the EU.

For vocational training programmes (aiming e.g. at specific job qualifications), the system 'ECVET' has been introduced for the identification and mutual recognition of the requested learning outcomes[8]. Where applicable, ECVET points are awarded to learning packages; some of them are developed for the nuclear domain. A harmonised definition of the necessary profiles needed in decommissioning combined

[7] ECTS or 'European Credit Transfer and accumulation System' is a credit system designed to make it easier for students to move between different countries. It is a central tool in the Bologna Process, which aims to make national systems more compatible.
http://ec.europa.eu/education/ects/ects_en.htm

[8] ECVET means 'European Credit System for Vocational Education and Training' and follows the 2002 Copenhagen process.
http://ec.europa.eu/education/policy/vocational-policy/ecvet_en.htm

with mutual recognition schemes across the EU could support the development of the adequate training modules and clarify the learning outcomes.

Cooperation for shared education and training programmes

Where a certain degree of uniformity of the outcomes is recognised, a more intensive EU-wide cooperation could be pursued. Given the scale of university programmes in decommissioning will remain relatively modest, synergies could be created by sharing the best courses or e.g. by sharing the possibilities for on-the-job learning in industry.

For vocational training, it appears that the 'summer school' concept of training over one to three weeks offers an attractive opportunity for employers who want to enhance the professionalism of their staff in decommissioning with a focus on practical experience. In order to share resources, a European 'pool of learning initiatives' could be supported offering at different locations a series of courses, visits and practical studies. An EU 'quality label' or 'endorsement' could be issued to those initiatives contributing to qualitative competence building in decommissioning.

Collaboration with the nuclear industrial organisations

"We need to work in partnership and we need to own external training"

The education and training programmes should closely interact with industry in order to respond to the projected demand. As mentioned above, an example is given in the UK by the 'National Skills Academy for Nuclear', established as a strategic body that represents the industry to stimulate, coordinate and enable excellence in skills to support the nuclear programme. In a similar way the 'EMEIN'[9] initiative in France is an open forum for companies and academic institutions to discuss and identify industrial needs in matters of education and training in the field of maintenance, dismantling, decommissioning and waste management in nuclear facilities. These needs are set out in a core 'Competency Reference Guide' in order to develop new education and training programmes.

The concept of partnerships with a variety of industrial organisations could be further developed in order to align the learning outcomes to the real needs. Partnerships could be embedded in joint EU education and training programmes grouping universities, schools and directly interested industrial actors in nuclear decommissioning, including stages to allow students and trainees to be confronted with the reality on-the-field in nuclear installation.

Collaboration could be also established by setting up joint EU programmes dedicated to some key decommissioning profiles, an example being taken from what is already achieved for other specific competences needed in the nuclear sector (e.g. the Euratom PETRUS III project focusses on the qualification of safety engineers for geological disposal [10]).

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[9] EMEIN or 'Enseignement national des Métiers d'Exploitation des Installations Nucléaires'

[10] PETRUS III ('Program for Education, Training and Research on Underground Storage') is a project granted by European Commission within the Euratom Framework Program whose objective is to promote Education and Training in geological disposal of radioactive waste. http://www.enen-assoc.org/en/training/petrus-consortium/petrus-iii.html

5 How can we stimulate interest and future talent?

Public opinion on nuclear energy is a complex and controversial issue. Views remain so polarized and they differ so much from one Member State to another that it is impossible to identify an "average EU view". But the public perception has obviously an impact on career choices.

Trends in the evolution of the nuclear workforce in Europe have been analysed by the 'European Human Resources Observatory in Nuclear' (EHRO-N)[11]. Related reports are published periodically. EHRO-N statistics show that the number of students graduating in nuclear related disciplines has slightly increased over the last five years. Despite this small positive trend, over many years a shortage of nuclear experts is expected and the situation is generally deteriorating, partially linked to the growing retirements.

The workforce of nuclear educated staff involved in decommissioning and waste management activities represents today only a fraction (< 20%) of the total nuclear employment. Most of the human resources are dedicated to the operation of nuclear facilities, to R&D and to design purposes; decommissioning is still a 'niche' activity in the entire nuclear business.

At a first glance, undertaking a career in decommissioning seems not particularly exciting; at face value it involves mainly clearing, cleaning and demolishing of reactors and facilities. This is often seen as less attractive than constructing something new – a negative rather than positive contribution. However, the finality of decommissioning is material recycling and environmental plus economic valuation, once a site is cleaned and can be released from regulatory control and reused for other purposes. Decommissioning can be challenge/problem led, due to the variety of issues to be resolved, requiring the mastery of a diverse set of knowledge and skills, with the development of a bespoke set of solutions.

"Decommissioning can be considered to be a 'noble cause', which appeals to the idealism of the young".

The experience shared by young professionals working in decommissioning showed that the job offers many advantages that make it particularly attractive:

- Decommissioning is in reality much more than clearing, cleaning and demolishing; decommissioning projects are usually complex and present an appealing technological challenge. They require creative solutions in innovative and diverse fields (e.g. in automation, robotics, measurement techniques, ...). Many new processes need to be developed to make the work more efficient. As such there is a significant element of creativity and ingenuity linked to the decommissioning activity.
- Decommissioning offers also tremendous opportunities for people who have developed expertise in reliable technologies or experience in managing projects and who are interested in mobility.
- A job in decommissioning is secure; young engineers and scientists graduating after studies dedicated to decommissioning are almost certain to find a job.
- Decommissioning is an emerging activity involving on the average young people; related jobs offer many possibilities for career development; 'horizontal' evolution by enlarging the experience over diverse decommissioning projects and 'vertical' development by increasing the managerial responsibilities.

[11] 'EHRO-N' or the 'European Human Resources Observatory in Nuclear' is operated by the European Commission Joint Research Centre and focus on the setting up and maintenance of a database and the carrying out of regular analyses, reviews, compilations and specifications related to human resources in the nuclear field. http://ehron.jrc.ec.europa.eu/

- The ethical and societal factors driving the need to progress on decommissioning contribute to the commitment for the job. Actually, decommissioning provides a service to society and can be considered as a 'noble cause': decommissioning is aiming to restore a safe environment and demonstrates that closing the nuclear energy cycle is feasible.

However, the many possibilities offered to study and to start a career in nuclear decommissioning presently appear to be rather 'hidden'. In addition, the on-going decommissioning programmes and the difficulties they face are in general presented too negatively, instead of highlighting the achievements made so far. A way of promoting decommissioning among the young generation should be pursued, starting at secondary school level, through to the universities.

Promotion could start by clarifying the existing education, training and career opportunities in Europe. Advertising the challenge and excitement linked to decommissioning could be stimulated and integrated within existing campaigns for the promotion of education and training. And more generally, promotion of decommissioning could be helped by improving the public understanding on its finality and as such presenting the activity in a more objective way.

Clarifying the existing education, training and career opportunities

The earlier section of this document has shown that in some countries there is already a wide spectrum of education and training programmes. A compilation of all possibilities and a clarification of the outcomes and of the later career opportunities could support focussed promotion campaigns.

The suggested harmonisation of the training outcomes will obviously also help to clarify the existing opportunities.

Promoting education and training in decommissioning

Several programmes are in place in Europe for stimulating education and training (best known are the Erasmus+ programme, see next page, and Marie Curie actions). Those programmes attract young students and could be a way for introducing proposals that would advertise the possibilities offered by studies linked to careers in nuclear decommissioning and stimulate interest of young students.

Material explaining the decommissioning challenges could also be presented at universities or even delivered at school level and thus stimulate interest of teachers and students at a very early stage.

In the same way focussed advertising on decommissioning could be introduced at career days and as such better highlight in a positive way the career opportunities.

Improving the public understanding of decommissioning endeavours

"Nuclear is a collective responsibility"

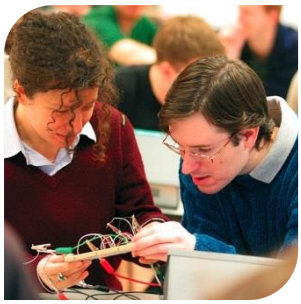
'A resilient Energy Union with forward-looking climate change policy' is one of the ten key priorities of the new European Commission. It emphasises the need for ensuring a sustainable, competitive and secure energy market in Europe. Nuclear energy presently produces nearly 30% of the EU's electricity and is 'part of the picture' in 14 out of 28 Member States.

Attempts are currently made at various levels to redefine the debate on energy and include social and societal issues, giving people a clear perspective on what is required and on what is obtained. The more the public understands, the more the trade-offs become acceptable. In this context, the place of decommissioning as the last step of the nuclear life-cycle could be highlighted.

"In the end the industry needs not just technical & organisational skills but people who can also communicate"

On a local scale, attention should be paid to the environment in which decommissioning activities are conducted. Involvement of stakeholders, informing residents in the vicinity of decommissioning sites will stimulate interest and offer local business and employment opportunities.




Erasmus







Life is Good

European support to joint initiatives stimulating Education and Training in dedicated areas

The *Erasmus+* programme launched by the European Commission in 2014 offers a large variety of cooperation activities open to academic institutions, research centres and other stakeholders organisations interested in developing and implementing joint initiatives in different academic and/or professional fields. The programme is structured in three "Key Actions" reflecting the level of intervention, i.e. the individual level with "Key Action 1: learning mobility of individuals", the institutional level with "Key Action 2: cooperation for innovation and exchange of good practices" and finally the political and systemic level with "Key Action 3: opportunities to support policy reform".

The list below presents some concrete examples of the type of activities that could be supported by the Erasmus+ programme in the area of nuclear decommissioning. A detailed description of the programme content and implementation modalities can be found under the following links: http://ec.europa.eu/programmes/erasmus-plus/index_en.htm https://eacea.ec.europa.eu/erasmus-plus/actions_en

- *Key Action 1 "Learning Mobility of Individuals"* offers learning, teaching and training mobility scholarships for students, trainees and staff from higher education or vocational training institutions in order to spend a teaching, learning or training period in another country. The mobility scholarships can concern short-term teaching/training assignments, as well as learning periods recognised as a part of the home degree or leading to the award of a full (joint or double) degree;

- *Key Action 1 "Erasmus Mundus Joint Master Degrees"* offers support to the creation and implementation of international master degrees organised and delivered by a consortium of higher education institutions and, if relevant, other types of organisations (such as research centres or public/private enterprises). The study/training programme must last between 1 and 2 years, includes a mandatory mobility in two different European countries and leads to the award of a double, multiple or joint degree ;

- *Key Action 2 "Strategic Partnerships"* supports *inter alia* the development of curriculum (/course modules), the organisation of international seminars or the organisation of joint staff training events between higher education institutions and, where relevant, other types of organisations (such as research centres or public/private enterprises);

- *Key Action 2 "Knowledge Alliances" and "Sector Skills Alliances"* supports activities aiming at strengthening the links and closing the gaps between the professional (/employment) sectors and the education (for the "Knowledge Alliances") or vocational training (for the "Sector Skills Alliances) sectors. Supported activities can concern *inter alia* the design, development and delivery of new learning/teaching approaches or content; the design of continuing education programmes with and within organisations; the development of joint innovative solutions for challenging issues; the definition of skills and training needs in specific economic sectors;

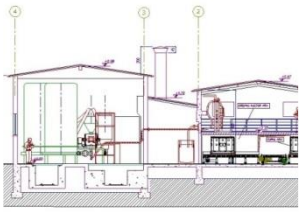
- *Key Action 3 "Prospective initiatives"* supports the development of new policies in the fields of education, training or youth, as well as joint cooperation and mutual learning activities between stakeholders having impact on European policy making.

6 Conclusions on a way forward

The necessity to progress with the decommissioning of obsolete installations and the perspective of a growing market, particularly in Europe, should be interpreted as positive driver as it creates new industrial opportunities. However, progress will only be guaranteed if the right knowledge, skills and competences can be created as required for undertaking this endeavour.

The present document has been formed by harvesting the vision of several key organisations, during a joint seminar, and tries to explain the related challenges, giving various suggestions as to a way forward. Of particular importance is the universal need for collaboration at all levels. Similarly, the reasons to look towards decommissioning with a positive mind-set received strong support.

The possible directions proposed in the present document (summarized on next page as key considerations on a way forward) will feed the nuclear decommissioning support programme of the Joint Research Centre, in line with the existing policies of the European Commission. In a larger context, this work will also support universities, institutions and employers interested in enhancing their capabilities in nuclear decommissioning.



Education and Training in Nuclear Decommissioning
Key considerations on a way forward

- *Currently, decommissioning represents an important industrial activity in some European countries and a growth of the market can be expected, which will exist over a long timeframe. To support this activity, specific knowledge, skills and competences are needed, in various disciplines. Attention should be paid to:*
  - *ensure an efficient management of the cultural change when starting decommissioning*
  - *plan of the required skills/competences over a long term*
  - *collaborate between the stakeholder organisations*
  - *facilitate mobility of a competent decommissioning workforce in Europe*
  - *enable the share of best practices and lessons learned.*

  The EU industry and organizations would be also helped by a more in-depth assessment of the future of the nuclear decommissioning activities and of their impact on the job market.

- *A wide spectrum of education and training programmes in decommissioning exists, particularly in the three main nuclear EU countries (UK, France and Germany).*
  There would be a benefit from:
  - *a harmonisation of the learning outcomes referring to the necessary curricula*
  - *cooperating for shared education and training programmes*
  - *further stimulating the collaboration with the industry.*

  More particularly, a significant step would be the combined efforts of universities and institutes to create a joint modular training programme (summer school) in decommissioning that could be practiced at different places in Europe, with well-defined training outcomes.

- *For the young generation a career in nuclear decommissioning presents many positive aspects:*
  - *a reliable work environment, and almost certain assurance of finding a job after having followed dedicated studies in decommissioning;*
  - *offering perspectives of career development, being it horizontally (variety of projects) or vertically (possibility for growing in responsibilities)*
  - *facing many interesting and always changing technological challenges, mixing competences in various disciplines*
  - *offering possibilities for mobility,*
  - *with finality a 'noble cause', as it aims at restoring a safe environment.*

  However, these activities and possibilities of careers in nuclear decommissioning are probably currently often 'hidden' or are considered too negatively. Different ways of promotion of decommissioning among the younger generation should be pursued, starting at secondary school level through to the universities.

Annex – list of participants and experts consulted

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