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Strategic Energy Technology (SET) Plan Roadmap on Education and Training

Availability and mobilisation of appropriately skilled human resources

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1. Introduction

The European Union is taking decisive actions to move beyond the economic crisis by creating the conditions for a more competitive economy with higher employment. Europe 2020[1], the European Union's ten-year growth strategy, aims at delivering growth that is: smart, through more effective investments in education, research and innovation; sustainable, thanks to a decisive move towards a low-carbon economy; and inclusive, with a strong emphasis on job creation and poverty reduction.

The energy sector is one of the main areas where action is needed to meet these objectives. Developments in the energy field are key for realising the move towards a sustainable and secure low-carbon economy - meeting the climate and energy targets for 2020, and addressing the long-term vision towards reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050[2]. Delivering sustainable growth in a vast and developing sector such as energy creates also prospects for enhancing the competitiveness of European enterprises, creating new markets and job opportunities, and strengthening the European industrial base.

Implementing the EU policy objectives in this field is largely dependent on the advancement of efficient and cost-effective low carbon energy solutions. However, successful implementation of energy innovation is far from straightforward. As energy is a commodity, innovation entails competing on cost against highly optimised energy systems with well-established incumbents – the toughest kind of innovation environment.

The European Strategic Energy Technology Plan (SET Plan)[3] was launched in 2007 as the technology pillar of the EU energy and climate policy in order to address the energy innovation challenge. Since then, it has established a strategic frame for the development and advancement of low carbon energy solutions, encouraging joint actions among the Commission, EU Member States and industry/research organisations with the aim to pool resources and achieve quicker and cost-efficient implementation.

In moving forward energy technology innovation, the SET Plan has recognised that one of the key elements for successful implementation at EU level is the availability and mobilisation of appropriately skilled human resources.[4] The energy sector is an evolving field which creates new job opportunities but at the same time requires the development of new skills and competences, in line with the objectives of the Europe 2020 Flagship Initiative "An agenda for new skills and jobs". The growing education and training needs in the low carbon energy area have already been highlighted in

[1] COM(2010) 2020 final: "Europe 2020 – A strategy for smart, sustainable and inclusive growth"

[2] COM(2011) 112 final: "Roadmap for moving to a competitive low-carbon economy in 2050"; COM(2011) 885/2: "Energy Roadmap 2050"

[3] http://setis.ec.europa.eu/

[4] COM(2007) 723 final: "A European Strategic Energy Technology Plan (SET-Plan). Towards a low carbon future"; COM(2013) 253 final: "Energy Technologies and Innovation"

a number of recent Commission education and employment policy frameworks[5] such as the Communications "Rethinking Education" and "Towards a job-rich recovery".

The challenges are significant. On the one hand, a growing low carbon energy sector requires the education, training or re-skilling of a significant number of additional workforces in the coming decades. At the same time, energy innovation creates a massive need for new talents, upgrade of existing curricula and programmes, and the incorporation of training in real environment. The challenges for the education and training institutions and their legal frameworks will be to ensure a workforce flow of researchers, engineers and technicians who are able to generate new knowledge and to meet the requirements of evolving technologies and labour markets. In parallel, training for managers and decision-makers in the field is needed to design and implement appropriate frameworks for the development and deployment of new energy solutions.

The SET Plan Roadmap on Education and Training presented in this document addresses the human resource challenge for the energy research and innovation sector and constitutes an integral part of the SET Plan agenda. It puts forward recommendations for key education and training activities to advance the provision of adequate human capital and to assist the development of the necessary cooperation frameworks among academia, research institutes and business. It should be seen against the general background of the need for more graduates in the STEM field and the lack of engineers in the economy.

The Roadmap document may serve as a programmatic guide for energy education and training activities for both the European Union's and Member States' programmes. It is for the involved stakeholders to implement the recommended actions, with, where necessary, support from the European Commission and Member States' governments.

2. Roadmap Development

2.1. Concept and methodology

The SET Plan Roadmap on Education and Training addresses the human resource challenge in the low carbon energy field by proposing a comprehensive European programme on energy education and training. It builds on the research and industrial initiatives of the SET Plan, and covers all main low carbon energy solutions, addressing the whole innovation chain and work profiles at all levels – researchers, engineers, and technicians, including also the management level; trainers to provide for an adequate training force; as well as capacity building for public authorities and decision-makers.

The Roadmap is based on 13 assessment reports which were developed as a first step in order to ensure a comprehensive analysis. These assessments, published together with the Roadmap document, provide an in-depth analysis of the state of the art and challenges for education and

[5] COM(2012) 173 final "Towards a job-rich recovery" and its accompanying SWD(2012) 92 final "Exploiting the employment potential of green growth"; COM(2012) 669 final "Rethinking Education: Investing in skills for better socio-economic outcomes"; COM(2011) 567 final "Supporting growth and jobs – an agenda for the modernisation of Europe's higher education systems"; COM(2012) 392 final: "A Reinforced European Research Area Partnership for Excellence and Growth"

training in the field of low carbon energy, proposing also recommendations to address the identified needs. They cover key low-carbon energy fields: 'bioenergy', 'carbon capture and storage', 'concentrated solar power', 'electricity grids', 'energy efficient buildings, thermal energy networks and smart cities integration aspects', 'energy storage', 'fuel cells and hydrogen', 'geothermal energy', 'nuclear energy', 'photovoltaics', and 'wind and ocean energy', as well as some horizontal aspects: 'system integration' and 'coordination of education and training systems'.

The assessment has been coordinated by a core group comprising the European Commission and key organisations in the field of energy education and innovation, namely:

- the European Platform of Universities engaged in Energy research, education and training (EPUE), part of the European University Association, comprising more than 170 universities active in the energy field;
- the SET Plan European Energy Research Alliance (EERA) as a representative of the energy research community in Europe;
- KIC InnoEnergy, the European Institute of Innovation & Technology's Knowledge and Innovation Community in the energy field;
- the European Strategic Partnership for Sustainable Energy Education, Innovation and Technology (SEEIT), involving additional European university and research institutions;
- the European Sustainable Energy Innovation Alliance (eseia), enlarging further the coverage of university, research and business organisations;
- the European Strategy Forum on Research Infrastructures (ESFRI), as a representative of research infrastructures in Europe and the possibilities they offer for education and training activities.

The working groups that participated in the elaboration of the assessment reports include more than 130 experts coming from academia, research institutes and industry, including representatives of the above organisations, as well as field experts representing the SET Plan European Industrial Initiatives and other relevant European industry groupings.

Extensive consultations have been organised in the course of the Roadmap development process with the participation of a wide pool of stakeholders coming from the different SET Plan formations, energy technology platforms, industrial associations, and other related groupings, in order to ensure relevant feedback on the assessments prepared by the experts.

In developing the Education and Training Roadmap, attention has been paid to ensure added value and complementarities with the SET Plan initiatives as well as with the other EU frameworks on energy, education and employment.

2.2.Boundary conditions

The Education and Training Roadmap provides a robust agenda of the efforts needed over the next 10 to 20 years on energy education and training in the EU, based on the best available information

today, gathered in consultation with all involved stakeholders. In view of the large scope and dynamism of the field of low carbon energy and the horizontal character of the education and training field, this Education and Training Roadmap needs to be seen in conjunction with and complementary to other related activities under the SET Plan, including the development of clusters of excellence and innovation hubs. It also aims to support other related EU initiatives and policies in the field.

3. The challenge of training a growing and skilled workforce for the low carbon energy sector

3.1.A growing demand for human capital

The energy challenge

The Energy Roadmap 2050 explores the challenges posed by delivering the EU's decarbonisation objective while at the same time ensuring security of energy supply and competitiveness**.** Even though the precise technology mix is uncertain, all decarbonisation scenarios lead to a considerably higher demand for low carbon energy technology innovation and deployment compared to current levels. For example, the share of renewable energy (RES) in the EU rises substantially in all scenarios, achieving at least 55% in gross final primary energy consumption in 2050, up 45 percentage points from today's level at around 10%.

As outlined in the Energy Roadmap 2050, such an all-embracing transformation will affect employment and jobs, requiring education and training and a more vigorous social dialogue. Occupations in traditional markets will be reduced, while new jobs will be created within the low carbon sector. At the same time, industry expansion in the low carbon energy technology fields will lead to increased competition among the different sectors for qualified staff. Education and training initiatives in the right fields are crucial to assist this transition, and to boost the potential of the low carbon technology market. Missing out on this opportunity may hinder the development and deployment of energy technologies, and slow down the transformation to a sustainable energy system.

The scale of the challenge is considerable. A rough analysis within the assessment reports performed for this exercise reveals that today the low carbon energy fields covered in this Roadmap employ around 9 million people.[6] Within this figure, around 1.2 million are directly engaged within the value chains of low carbon energy supply technologies (up to 2 million if we consider also the bioenergy agriculture and forestry supply chain); around 6.2 million are engaged on the demand side, energy efficient buildings having the highest share; about 900 thousand are employed in the electricity and thermal networks value chains, including energy storage developments. Within the total number, around 5-10% are researchers, 20 to 32% are engineers and 35 to 70% technicians (variations depending on the field with some emerging fields having more than 30-50% researchers).

[6] The figures are approximate and are based on the assessment reports for the different fields.

Considering the 2050 vision, the analysis within the assessment reports shows that an additional workforce of around 5 million people will be needed by 2020. This figure shows the new positions that will be created as well as the number of replacements that will be needed. From 2020 to 2030, the estimated new positions and replacements amount to around 6.3 million additional workers. In practice, this presents a projected doubling of the workforce by 2030. In parallel, a large number of the current workforce in these and adjacent sectors should undergo re-training, making the challenge even more perceptible.

While such trends and projections may change in time, the scale of the challenge will remain. The transformation of the market will lead to new developments in the field that raise considerably the requirements towards the education and training sector, while increasing the burden for energy research organisations and businesses looking for skilled human resources.

The need for STEM[7] graduates

According to Eurostat[8], in 2011, the graduates in the STEM field comprised 22.6% of all EU-27[9] graduates (EQF 5-8)[10]. This accounts for approximately 1 088 000 STEM graduates in 2011. The number has been stable over the last five-six years.

When we look at the Human Resources in Science and Technology (HRST), the total number in 2012 was 93 885 000 (43.6% of the total active EU-27 population), of which around 71% (66 469 000) have completed education at the third level in the science and technology field of study. The HRST core (all scientists, engineers and technicians with education at the third level currently in occupation, excluding managers and other positions) accounted for 45 588 000. If we consider only scientists and engineers, the number is 15 888 000.

The current supply and demand for HRST on the market shows explicitly the need for highlighting STEM as a priority area for education in the EU in general. At the same time, increasing the understanding of career pathways followed by STEM graduates could contribute to better education provision and stronger attractiveness for the study field.

These trends have strong implications also for the development of the low carbon energy market. With a large number of diversified technology fields, energy innovation depends heavily on STEM graduates for its human capital development. Relevant information on the new opportunities that emerge in the low carbon energy sector is essential for attracting additional students to this area.

An additional measure is to encourage the re-profiling of non-STEM active workers. This necessitates the development and promotion of lifelong learning with appropriate qualification credits that enable interested persons to gain the necessary knowledge, skills and competences.

[7] STEM fields or STEM education is an acronym for the fields of study in the categories of science, technology, engineering, and mathematics.

[8] http://epp.eurostat.ec.europa.eu/portal/page/portal/education/introduction

[9] The data is drawn before Croatia became an EU Member State.

[10] EQF - European Qualification Framework

3.2. A complex and evolving energy sector

Meeting the Energy Roadmap 2050 objectives requires the development of high-performance and competitive low carbon energy solutions. At the same time, many of the low carbon technology options are not yet mature. The energy sector changes slowly, while ensuring deployment of new and efficient solutions needs to be implemented with speed if the EU is to meet its decarbonisation goals and ensure competitiveness of European research and businesses.

Human resources are one of the driving forces behind these developments. The EU needs researchers, engineers and technicians, managers and decision-makers capable of moving forward the development and uptake of new solutions. Core science and engineering knowledge remain crucial as an important base for each energy field. Such core knowledge and competences needs to be "topped off" by specialised education on the respective energy applications based on the latest research results.

With the resulting restructuring of the market, flexibility in these developments is crucial, building bridges from one field to another, and allowing the development of transferrable skills and competences. While new professionals will enter the market, the existing workforce will also have to undergo quick and effective re-training in order to be able to respond to new requirements. Building the right re-training programmes becomes an important pre-requisite for facilitating movements across fields.

In parallel, competences in management, business and entrepreneurship, economic and social sciences will be important drivers for moving technology development and uptake forward. In addition, economics and finance programmes need to include energy performance and services as a topic within their curricula.

The complexity of the system calls also for multidisciplinary and system integration education. Interdisciplinary education is often needed for paradigm shifts in new concept and technology developments. At the same time, diverse energy and other technology systems become more interconnected, requiring strategic planners and managers with a good understanding of core technology themes, but also competent in design and management of complex systems of systems. In parallel, individual specialists have to undergo training in subjects in emerging related disciplines so that they are able to develop and implement solutions that are integrated elements of a complete system.

The transformation in the energy sector requires also the build-up of competent public authorities and an informed civil society. Decision makers engaged in energy developments at regional and national level need to be informed about new developments in the energy field as well as about their associated opportunities and impacts. An understanding of the different technology fields and the challenges they face would contribute to the development of adequate policies and support schemes. In parallel, service providers and professional end users need to undergo training when new technology options become available. Civil society and the general public should also be informed about emerging energy solutions, which would contribute to market uptake, deployment and use of new technology.

3.3.Increasing the efficiency and adequacy of the system

Today, new energy technology development, deployment and operation are largely hindered by the existing fragmentation of the education and training system in Europe. In the low carbon energy field, education and training systems differ significantly from one Member State to another, some universities being more efficient in addressing the new technology challenges in their programmes, while others are still lagging significantly behind, with no evident or effective changes in their curricula in the last decades. Vocational education and training schemes also differ widely from one country to another, while the training that is provided through them is not always recognised internationally in Europe. This fragmentation can lead to varying quality of the human capital in different states and poses recognition barriers for businesses that hire international human resources, hindering mobility of workers and slowing down the labour market transformation.

The Bologna 1999 Process[11], the EU Agenda for the modernisation of higher education institutions[12], the Copenhagen 2002 Process[13], and the creation of the European Research Area[14] show the need to organise a more coherent education and training system which helps to address education and innovation challenges that transcend national borders. In the low carbon energy field, these processes need to be supported by better coordination and structuring at EU level, pooling of resources for joint and efficient development and implementation of new programmes, enhancing knowledge exchange and the development of quality accreditation systems.

The evolving knowledge base in the low carbon energy field requires also new ways of teaching and learning, addressing both students and current professionals in the field. The education and training system needs to provide adequate core engineering knowledge on the one hand, but also to be flexible, to adapt to new requirements and provide new emerging knowledge, skills and competences, thus producing graduate students who can become the so much needed 'change agents' on the market. Furthermore, the development of management, entrepreneurial and communication skills, teamwork, critical thinking and problem-solving should be developed in line with engineering knowledge, thus encouraging a spirit of constructive risk-taking and innovation.

The restructuring of the energy sector creates also the need for updating the skills of a large number of professionals already employed in the field. Such large re-skilling needs can only be met if the necessary vocational training opportunities exist within professional training institutions, while higher education remains open to continuing professional education/quality lifelong learning.

A more responsive education system requires also improved coordination and cooperation among the academia, research and business environment. Such cooperation is fundamental for the development of relevant curricula on the one hand, but also for enhancing the mobility of students, trainers and professors, research and business staff, allowing knowledge exchange across Europe, and creating opportunities for practical experience and engagement in real research and business environment. Educational and training programmes need to be coupled to Europe's best laboratory

[11] http://www.bologna-berlin2003.de/pdf/bologna_declaration.pdf

[12] COM(2011) 567 final "Supporting growth and jobs – an agenda for the modernisation of Europe's higher education systems"

[13] http://ec.europa.eu/education/pdf/doc125_en.pdf

[14] COM(2012) 392 final: "A Reinforced European Research Area Partnership for Excellence and Growth"

facilities, including national research infrastructures, research institutes' laboratories, or industrial technology pilot and demonstration facilities. Such cooperation frameworks with research and industrial infrastructures would enhance the overall quality and agility of the system, and facilitate innovation developments.

4. SET Plan Roadmap on Education and Training

In order to respond to these challenges, the SET Plan Roadmap on Education and Training proposes a structural approach, calling for large-scale education and training actions that aim to stimulate long-lasting efforts, enhance innovation developments in the energy field and boost the competitiveness of European industry and research. The Roadmap is designed with the following three main guiding objectives:

- To address knowledge, skills and competences needs and gaps via building networks, pooling capacities and allowing quick and wide replication.
- To reinforce the education and training system's link with the business and research environment.
- To plan and enable skill development and mutual recognition, at the same time facilitating the dissemination of new knowledge, techniques and tools.

A key element of the Roadmap is to bring about a structural change in the European education and training landscape by enhancing the coordination and integration of national capacities through dedicated networks and fostering industrial involvement through targeted instruments and partnerships at EU level. A core task of these structures in the short term is to develop innovative solutions for education and training, and to propose new schemes that address the urgent needs of the field at a pilot scale. The originality of the approach is that once these innovative solutions are validated and successfully applied, they can be scaled up and further replicated to meet the full needs of the sector, taking advantage of the coordination structures and partnerships in place.

Accordingly, the SET Plan Roadmap on Education and Training is built around three interlinked headings, organised to address the above objectives. The following sections highlight the type of recommended actions proposed under each heading. Concrete activities to kick-start these actions are proposed and listed in the Roadmap annex.

Heading 1: Filling the Knowledge, Skills and Competences gap

The overall goal of the activities listed under this heading is to address Knowledge, Skills and Competences (KSC) needs and gaps via building networks, pooling capacities and allowing quick and wide replication.

In particular, two types of actions are encouraged: *Networks of Universities with links to Business and Research* and *Vocational Education and Training Networks,* supporting the development of both academic education and vocational training.

Such networks are proposed in the fields of bioenergy, carbon capture and storage, concentrated solar power, energy storage, electricity grids, fuel cells and hydrogen, geothermal energy, nuclear fission and fusion energy, photovoltaics, smart cities including energy efficient buildings, wind and ocean energy, heating and cooling, heat utilisation & thermal networks, and energy systems integration.

Networks of Universities with Links to Business and Research

The *Networks of Universities* should gather stakeholders along the technology value chains, including a core network of universities and other higher education institutions, relevant research institutes, industry/business associations, and companies in the field. They may provide academic education as well as lifelong learning programmes.

The proposed networks have the following guiding objectives:

- To establish a flexible framework for developing new and upgrade of existing curricula in the respective evolving technology field, including blue-sky research, and involving of a broad range of experts from academia, research organisations and business.
- To speed up the process of implementing such curricula within and outside the networks by helping higher education institutions to structure their studies along the developed programmes.
- To facilitate the development of joint degree programmes among different universities via the envisaged streamlining and integration of curricula, teaching materials, teaching and learning methods at EU level.
- To create links to relevant research and industrial infrastructure(s) in order to provide access for training of students and staff.
- To encourage skill-led strategies for education, providing students and professionals with the latest technology trends.
- To develop a new generation of professorships and trainers in fields where expertise is lacking.
- To create a forum for relevant stakeholders from research, higher education institutions, industry and the public sector to exchange information on educational needs and share knowledge and experience.

Vocational Education and Training Networks

Vocational Education and Training Networks should involve technical training centres, vocational institutes and technical schools, universities and continuing professional education institutes, companies from related industries, business and research organisations, as well as other relevant actors in the vocational training field such as vocational orientation/career guidance bodies, bodies

responsible for accreditation, qualification or certification. They should focus on the skills development and upgrade of staff from key stakeholders along the technology value chains such as industries, related services, research organisations, public authorities, and professional end users.

The vocation education and training networks have the following guiding objectives:

- To establish a flexible framework for developing new and upgrade of existing vocational education or training course modules, involving relevant experts from education and training bodies, research organisations and business.
- To speed up the process of implementing such modules via joint programme development and sharing of experience within the network.
- To promote the incorporation of a strong practice element within the vocational education schemes, including hands-on training in business/research settings.
- To develop a new generation of trainers in fields where expertise is lacking.
- To provide a framework to harmonise vocational education and training, strengthen the mutual recognition of qualifications, and monitor vocational education and training efforts.

Heading 2: Fostering involvement of business and research, access and uptake by the labour market

The overall goal of the actions listed under this heading is to reinforce the education and training system's link with the business and research environment.

In particular, two types of actions are encouraged: *Mobility and Cooperation Partnerships among Academia, Research Institutes and Businesses* (which include European Collaborative Education Mobility Programmes for Low Carbon Technologies; Mobility and Cooperation Programmes for Research and Technical Staff, Professors and Trainers; Industrial Doctorate Programmes) and *Infrastructure Support to Education and Vocational Training*.

Mobility and Cooperation Partnerships among Education and Training Providers, Research Institutes and Businesses

Mobility and Cooperation Partnerships are proposed for all low carbon energy technology fields, with the following guiding objectives:

- To allow students to move to business and/or research facilities within their curricula, and gain practical experience and orientation in the field.
- To facilitate mobility, practical experience and knowledge exchange for business/research and teaching staff in education and training organisations, research institutions and industry.

- To allow business and research staff to teach at higher education institutions and training institutions, transferring their know-how into knowledge for graduate students or lifelong learners.
- To improve the interaction and student/staff mobility between research institutions and higher education institutions across Europe via fostering joint research projects and programmes, including a training component.
- To facilitate high-quality fundamental and applied scientific research through mobility and cooperation frameworks.
- To stimulate lifelong learning and transnational mobility, and facilitate access to technology facilities.
- To develop and update quality curricula and teaching materials, integrating work-based learning and responding to labour market needs.

Infrastructure Support to Higher Education and Vocational Training

Infrastructure Support to Higher Education and Vocational Training actions aim to facilitate access for education and training purposes to large national research infrastructure facilities, industrial and research technology pilot and demonstration facilities, and research institutes' laboratories.

As such, they have the following guiding objectives:

- To build joint education and training programmes, projects and exchanges among research infrastructures/industrial installations and relevant education and training providers.
- To ensure quality education and training by engaging a broad range of experts from education and training bodies, research and industry.
- To provide a platform for practice oriented education on all levels (students, engineers, researchers, etc.).
- To offer career tracks for researchers in the field.
- To speed up the process of technology development, market uptake and replication via educating and training professionals about new developments in the field, and/or via the implementation of joint research and innovation projects.
- To provide the respective technology field with additional attractiveness for creative and entrepreneurial scientists, researchers, engineers, and other professionals.

Heading 3: Planning and enabling skills development, transfer and recognition

The overall goal of the actions listed under this heading is to plan and enable skill development and mutual recognition, at the same time facilitating the dissemination of new knowledge, techniques and tools.

In particular, three types of actions are encouraged: *Virtual Learning and Information Platforms; Knowledge, Skills and Competences Recognition and Transfer Programmes; and Human Resources and Skills Observatories.*

Virtual Learning and Information Platforms

The SET Plan *Virtual Learning and Information Platform(s)* proposed in this Roadmap has the following guiding objectives:

- To speed up the modernisation process for relevant curricula and in particular to increase the capacity for multidisciplinary education by providing quality controlled digital educational content to education and training institutions.
- To facilitate education and training activities in the field when key expertise is concentrated at relatively few universities or training centres, while the education and training needs are quite widespread.
- To establish virtual education and training programmes and modules as well as other open educational resources, allowing the inclusion of expert lecturers via a virtual faculty exchange.
- To provide access via distance learning tools to remote research infrastructures, test facilities, data banks, and other valuable components in education and training.
- To enable the quick implementation of programmes for continued education, including “train the trainers” programmes.
- To strengthen networking between knowledge centres.
- To offer on the public side an open portal to create awareness about energy technologies.

Knowledge, Skills and Competences Recognition and Transfer Programmes

The *Knowledge, Skills and Competences Recognition and Transfer Programmes* aim to define the learning outcomes[15] of education and training programmes for all formal occupational profiles at all relevant levels of the European Qualifications Framework (EQF). The Programmes should also aim at the application of the European credit systems (ECVET and ECTS) as well as of the European quality assurance instruments (EQAVET tool box and ENQA Guidelines), with the following objectives:

- To develop trust between education and training providers across borders through a common understanding of quality in education and training.
- To compare and possibly strengthen the mutual recognition of qualifications and to harmonise the assessment of learning outcomes.
- To facilitate workforce mobility and retention of suitably qualified and experienced personnel across the EU.
- To allow a fast and efficient knowledge, skills and competences transfer from one technology field to another.
- To provide confidence in the safe and secure development and production of energy in developing countries through the use of defined learning outcomes in their education and training programmes.

Human Resources and Skills Observatories

In order to fine-tune educational programmes for the expected dramatic increase in the need for well-educated employees and entrepreneurs in this field, understanding and qualifying the future workforce is necessary. Thus, it is proposed to establish a *Low Carbon Energy Technology Human Resources and Skills Observatory/ies* with the following guiding objectives:

- To produce and regularly update a quality-assured database on the short-, medium- and long-term needs of human resources in the different low-carbon technology fields, based on a sound methodology.
- To conduct periodical surveys of business and research organisations' skills requirements in order to help education and training institutions to adapt academic/vocational courses and programmes.
- To regularly review and assess the Roadmap's implemented education and training activities in order to monitor achievements and impact generated.

[15] Learning outcomes (or results) are what a learner knows, understands and is able to do after a course of learning, as opposed to learning inputs such as the length of a learning experience or the type of institution, etc. The EQF, a transparency instrument voluntarily applied by Member states, uses learning outcomes defined in terms of knowledge, skills and competences.

- To provide a common reference system for education and training in the field via ECTS/ECVET and related portfolios of learning outcomes, thus supporting cooperation as well as harmonisation of European approaches to strengthen the skill base of the workforce, at the same time encouraging excellence and new developments.

In the nuclear fission field, there is already such an existing structure - EHRO-N (European Human Resources Observatory for the Nuclear Energy Sector)[16], which is ensuring the governance in the field. In order to develop further EHRO-N's activities, it is proposed to establish national EHRO-N contact points in the Member States, as well as to develop a European Nuclear Sector Education and Training Council.

5. Synergies and complementary measures

The SET Plan Roadmap on Education and Training has a multi-sector approach, developing actions that require a restructuring of the education and training system, building networks and partnerships, and pooling resources for more effective and efficient implementation. Such a framework makes it possible to address in a coordinated manner also interdisciplinary aspects in education, which is vital for the further development of many of the low carbon technology fields. Commonalities between the structures need to be taken into consideration to allow joint implementation when different technology fields require it, building synergies and realising economies of scale. In parallel, themes such as energy efficiency, environment and sustainability should become an integral part of all energy education and training programmes. In addition, in view of the importance of system integration for the future energy system, system integration aspects should be considered in all proposed education and training actions.

Complementary measures should also be implemented to support the Roadmap activities. European public information campaigns are needed to show growth prospects and developments in the field and mobilise a workforce of young people entering the job market as well as to encourage job-seekers with other backgrounds to join the technology value chains. Such campaigns are needed also to inform the general European public about the opportunities and requirements of low carbon technologies and the utilisation of such technologies within their local context. Networks of technology and science museums such as Ecsite[17] - the European network of science centres and museums - should be encouraged to engage in the low carbon technology field, presenting energy technology exhibits in an interactive way, and organising visits by school classes in order to raise the interest of pupils and students in the field.

Such activities should be accompanied by measures to overcome gender barriers and occupational segregation, to enhance the quality of employment in the energy sector, and to support the role of social partners which facilitate the interaction between industry, trade associations and academia.

[16] http://ehron.jrc.ec.europa.eu/

[17] http://www.ecsite.eu/

6. International cooperation with countries outside the EU

Education and training and technology markets are global in nature. At the same time, education and training is crucial for effective and efficient technology development and uptake. The EU needs to seize these opportunities. Strategic alliances should be developed with quality higher education institutions globally in order to advance the development of outstanding programmes. On another level, international cooperation in the education and training field can prepare the local workforce in regions outside of Europe and speed up the deployment of energy technologies developed by European research organisations and industry. Activities may include the implementation of joint education and training programmes with academic and training institutions outside of Europe, but also mobility and cooperation partnerships for academic and research/industry staff. For example, in the field of concentrated solar power, such programmes need to be encouraged with the MENA[18] region, while in the carbon capture and storage field, cooperation is sought with countries such as China, the USA, Australia, Canada, India, and Japan. Building international alliances and partnerships can also support the EU industry to access the global energy technology markets for energy applications, strengthening the EU position in the global energy sector. In addition, if properly designed for the global market, EU-developed virtual learning material can be of significant importance for fast deployment of modern technology.

7. Implementation principles

The SET Plan Roadmap on Education and Training presented in this document is intended to contribute to and promote coherence and synergy among the education and training activities of all concerned stakeholders. It puts forward comprehensive education and training measures which are key for the development and uptake of low carbon technologies in Europe, thus contributing to the SET Plan implementation and the Energy Roadmap 2050 vision.

The Roadmap is aimed to be implemented in the context of the SET Plan. In the implementation frame, it needs to be ensured that actions are undertaken and supported at the right level, according to the general subsidiarity principles.

Actions having a strong EU added value may benefit from the opportunities offered within EU programmes such as Horizon 2020 and Erasmus+. Such actions might include networking and cooperation across borders among different European actors, bringing in economies of scale, mobility, enabling skills development and recognition at European level.

A large number of activities can be encouraged also at Member State level, according to national strategies and priorities. This can be complemented with support that may be provided by national or regional authorities under the Cohesion Policy funds within the framework of their innovation and skills strategies.

Last but not least, a strong engagement of all stakeholders - academia, the research community and industry - is pivotal for successful implementation.

[18] Middle East and North Africa – geographically contiguous region located in South-Western Asia and North Africa.

The Roadmap should link also to other European Initiatives on energy education and training to ensure a comprehensive coverage of the Roadmap proposals and effectiveness and efficiency of the implemented schemes.

For successful implementation of training and certification needs identified in the Renewable Energy Directive[19], the recast of the Energy Performance of Buildings Directive[20] and the Energy Efficiency Directive[21], the Roadmap should be implemented with the involvement, where relevant, of the public authorities in Member States responsible for the transposition of these directives.

Cooperation with international strategic partners to the EU should also be explored when mutually beneficial.

In order to monitor the development of the recommendations listed in this document, it is proposed that the SET Plan Steering Group follows up the Roadmap's implementation. The SET Plan Information System SETIS[22] will assist this process.

[19] Directive 2009/28/EC

[20] Directive 2010/31/EU; Delegated Regulation (EU) No 244/2012

[21] Directive 2012/27/EU

[22] http://setis.ec.europa.eu/

ANNEX - SET Plan Education and Training Roadmap - Recommendations for Actions

Note: The actions proposed in this Annex address activities identified as needed following the assessment and recommendations of the stakeholders involved in the making of this Roadmap[23].

1 Filling the knowledge, skills and competences gap

1.1. Networks of Universities with links to Business and Research

The overall goal of the networks of universities and other relevant higher education institutions listed in this section is to address knowledge, skills and competences needs and gaps via building networks, pooling capacities and allowing quick and wide replication. As such, they have the following **guiding objectives**:

- To establish a flexible framework for developing new and upgrade of existing curricula in the respective evolving technology field, including blue-sky research, and involving of a broad range of experts from academia, research organisations and business.
- To speed up the process of implementing such curricula within and outside the networks by helping higher education institutions to structure their studies along the developed programmes.
- To facilitate the development of joint degree programmes among different universities via the envisaged streamlining and integration of curricula, teaching materials, teaching and learning methods at EU level.
- To create links to relevant research and industrial infrastructure(s) in order to provide access for training of students and staff.
- To encourage skill-led strategies for education, providing students and professionals with the latest technology trends.
- To develop a new generation of professorships and trainers in fields where expertise is lacking.
- To create a forum for relevant stakeholders from research, higher education institutions, industry and the public sector to exchange information on educational needs and share knowledge and experience.

The networks should gather stakeholders along the technology value chains, including a core network of universities and other higher education institutions, relevant research institutes,

[23] Assessment reports are available at http://setis.ec.europa.eu

industry/business associations, and companies in the field. They should support lifelong learning and contribute to mobility across the EU. Furthermore, they should seek to have a global approach, and create links to relevant universities and quality organisations also outside the EU.

It is important to note that the proposed networks can be implemented separately, jointly and/or in coordination with each other. All developed programmes should list the defined learning outcomes (according to ECTS and ECVET[24] principles), outlining also possible synergies among different energy fields.

When interdisciplinary subjects are addressed, the networks should seek to involve all relevant school departments for a joint development and implementation of the programmes' curricula.

The proposed master and PhD programmes may be implemented as separate programmes, or as a specialisation within an established discipline.

The programmes should follow innovative teaching approaches, including the development of entrepreneurial and management skills when relevant.

Actions that address second and third cycle of higher education (i.e. master and doctoral programmes) can be implemented also as education and training programmes within the vocational training networks under Action 1.2.

Action 1.1.1 Advanced Network(s) for Bioenergy Education and Training

The Advanced Network(s) for Bioenergy Education and Training should involve higher education institutions and research centres with expertise and/or facilities in one or more of the bioenergy-related disciplines – mechanical, chemical, biochemical and electrical engineering, biology disciplines, safety and accident prevention, as well as energy management, agriculture and forestry, and bio-resource logistics.

The network(s) needs furthermore to create links among the universities/research organisations involved and related industrial players such as the European Technology Platform for Sustainable Chemistry, the European Biofuels Technology Platform, different chemical and biofuels industries, electricity grid operators and other relevant actors.

Two pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: European Master and Doctoral Curriculum "Biorefinery Engineer"

The goal of this master curriculum and subsequent doctoral curriculum is to enable alumni to develop and engineer advanced biorefinery systems within the framework of the bioeconomy and the objectives of the SET Plan. It should be developed by an interdisciplinary team of educators with

[24] Following the latest developments of the EU's Bologna 1999 and Copenhagen 2002 processes.

backgrounds in mechanical, chemical, biochemical and electrical engineering, biology disciplines, safety and accident prevention, environment and sustainability, and other related studies in cooperation with the European Technology Platform for Sustainable Chemistry, the European Biofuels Technology Platform, chemical and biofuels industries, smart grids' developers and operators, and other relevant actors.

- EQF Level: 7-8
- Timeframe for implementation: Year 0+2

Activity 2: Prototype Master and Doctoral Curriculum "Bio-resource Value Chain Manager", Introduction of Elective Courses in the Field at Advanced Bachelor Level

The goal of this prototype bachelor courses and subsequent master and doctoral curriculum is to enable alumni to manage the supply chain of bioenergy technologies in particular regional contexts and optimise resource utilisation within the framework of the bioeconomy and the SET Plan objectives. It should be developed by an interdisciplinary team of educators with backgrounds in agriculture, economics and technology, and practitioners from across the bioenergy value chain. Close connections to research and industry is required.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+2

Action 1.1.2 Advanced Network(s) for Carbon Capture, Utilisation and Storage (CCUS) Education and Training

The *CCUS Advanced Network(s) for Education and Training* should involve higher education institutions, research institutes, laboratories and industrial installations federated along the CCUS value chain. The network needs to include also relevant business and law schools due to the importance of legal and communication studies for the CCUS field.

The network(s) should provide courses at bachelor and subsequent master level covering the CCUS value chain as well as post-graduate complementary master programmes in CCUS, leading to a specialised CCUS engineering degree.

One pilot activity is proposed to kick-start the operation of this advanced network(s):

Activity 1: A Multi-disciplinary Master Programme on CCUS, Introduction of Elective Courses in the Field at Advanced Bachelor Level

The multi-disciplinary CCUS Master programme may be organised as a 2-year joint-degree programme. The first 6 months of the first year can be devoted to common courses on basic concepts in CCUS. Afterwards, the students may opt for a specialisation between capture, utilisation and storage fields and choose elective advanced courses during the last 6 months. The 2nd year may

be devoted to internship, integrated projects and master thesis in collaboration with laboratories and industry.

An extensive part of the CCUS programme can be based on existing courses today. Courses on capture and transport can easily be adapted and improved from existing ones. Regarding the courses on storage, a gap is identified on risk assessment and management of geological carbon storage – such curricula needs to be developed within the programme.

In addition, courses on legal issues, economics and communication skills should be adapted from existing ones in other areas (such as nuclear energy) or created within the CCUS education network(s).

- EQF Level: 6-7
- Timeframe for implementation: Year 0+2

Action 1.1.3 Advanced Network(s) for Concentrated Solar Power (CSP) Education and Training

The *Advanced Network(s) for CSP Education and Training* should involve higher education institutions competent in the CSP field, and build strong links to related research organisations and businesses.

In order to serve better the needs of EU research and businesses in the field, the curricula to be developed under the network(s) should be open as much as possible to neighbouring countries from the southern Mediterranean through joint degrees. This is especially important since the largest market for CSP will be in the MENA[25] region and well educated and trained local personnel is required for proper building and operation of the solar plants.

One pilot activity is proposed to kick-start the operation of this advanced network(s):

Activity 1: European Master and Doctoral Curriculum "Concentrating Solar Power", Introduction of Elective Courses in the Field at Advanced Bachelor Level

The focus of this activity is the development of a programme for the implementation of new bachelor, master, and doctoral curricula in the CSP field. The realisation of double or joint degrees should be done not only at the European, but also at the EU-MENA level. Such curriculum needs to be open to lifelong learning as well as e-learning.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+4

[25] Middle East and North Africa

Action 1.1.4 Advanced Network(s) for Electricity Grids Education and Training

The *Advanced Network(s) for Electricity Grids Education and Training* should involve higher education institutions in the electricity grids field, and build strong links to related research organisations and businesses.

The programmes should be developed in cooperation with the European Technology Platform for the Electricity Networks of the Future[26], the electrical energy equipment manufacturing industry and other relevant stakeholders.

In order to serve better the needs of EU research and businesses in the field, the curricula to be developed under the network(s) should be open as much as possible to neighbouring countries from the southern Mediterranean through joint degrees. This is especially important also due to the expansion of transmission networks and connection of individual countries.

Three pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: European Master and Doctoral Curriculum "Smart Electricity Grids Engineer"

The goal of this master curriculum and subsequent doctoral curriculum is to enable alumni to develop and engineer advanced electricity grids economy systems within the framework of the electricity grids economy and the objectives of the SET Plan.

It should be developed by an interdisciplinary team of educators with backgrounds in physics, chemical and electrical engineering, control engineering, information and communications engineering, game theory and mechanism design, techno-economic and social studies such as institutional economics (tariff structures), and other related fields.

- EQF Level: 7-8
- Timeframe for implementation: Year 0+2

Activity 2: Development of Modern Modular Curricula and Joint Teaching Projects for Photovoltaics Integration into Electricity Grids

The curricula should address essential core elements from the value chain, creating links between traditional disciplines and smart electricity grids, thus providing bridges between existing courses and skills needed to develop, manufacture, install and maintain the systems for integration of photovoltaics into electricity grids. In addition, teaching modules should be created which will aid the integration of smart grids in the environment. Although eventually growing into many full scale bachelor and master programmes in connection with smart grids, this scheme should also be used to develop professional courses in academia for staff in the field who need (re-)training for specific parts of the value chain.

[26] http://www.smartgrids.eu/

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Activity 3: Development of Modern Modular Curricula and Joint Teaching Projects for Transnational Bulk Carrier Grids

Planning and operations of European transmission networks and markets is crucial to ensure appropriate cross-border coordination and support European standardisation and interoperability, enabling access to any type of grid users.

The curricula should address the development of joint processes optimising the transmission grid infrastructure in local, regional or European context, for example design, development and operation of pan-European electricity markets by load-flow control to alleviate loop-flows and increased interconnection capacities.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Action 1.1.5 Energy Storage Education and Training Network(s)

The *Energy Storage Education and Training Network(s)* should involve higher education institutions and research centres with competences and/or facilities in one or more of the energy storage related technologies: electrochemical, chemical, thermal, mechanical, and/or superconducting magnetic energy storage.

The network should build links to appropriate research laboratories for education and training purposes, facilitating at the same time exchange of researchers among academia and research facilities.

The main focus areas addressed within the network(s) include:

- Education and training on the different storage technology options
- Profiling and engineering of complete systems
- Developing economic models for energy storage systems
- Research training at the forefront of established and emerging energy storage technologies

Three pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: Development of Energy Storage Learning Modules for Integration in Higher Education Traditional Programmes

The learning modules should be designed to be incorporated into European master and doctorate programmes. They should cover the different energy storage technology options with a particular emphasis on 'electrochemical energy conversion and storage', 'high and low temperature thermal energy storage', energy storage modelling and storage integration in the energy system. This should be done in collaboration among scientists, university faculty and industry, which are members of or are associated to the *Energy Storage Education and Training Network*. The materials need to facilitate e-learning and the rapid advancement of knowledge in the field.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+2

Activity 2: Master of Science Curriculum on Advanced Materials in Energy Storage

The Master of Science Programme on Advanced Materials in Energy Storage should be open to Bachelor of Science engineers from chemical, physics, and materials engineering.

It should combine engineering sciences (transport phenomena, engineering thermodynamics, energy materials science, and e.g. renewable energy and sustainable energy utilization) and materials science (physical chemistry, electrochemistry, chemical and physical measurement techniques, advanced atomistic or molecular modelling).

The curriculum should also include theories of energy storage technologies and their place in a sustainable energy system.

The MSc Action should be developed as a "joint Master of Science" (double or joint degrees) and contain training on research infrastructures through close links to research institutes.

- EQF Level: 7
- Timeframe for implementation: Year 0+2

Activity 3: PhD Programme on Innovation Pathways for Energy Storage 2020

The programme should cover a variety of storage technologies, with PhD topics organised into work packages such as:

- battery technology;
- high temperature thermal energy storage (HTES);
- short term storage technologies for load management (which could be thermal energy storage as well as what is commonly referred to as "electrical storage" technologies) and
- seasonal storage technologies and materials.

The PhD programme should be organised as a joint programme including universities with excellent R&D in the area, industries for co-funding and industrial placement, sharing of infrastructure capacities, and mobility of students (joint or double degree).

It should contain a common course package (order of 20 ECTS) on system integration, innovation, intellectual property, "idea to product", etc.

- EQF Level: 8
- Timeframe for implementation: Year 0+2

Action 1.1.6 Education and Training Network(s) in the Fuel Cells and Hydrogen Field with Links to Industry

The *Education and Training Network(s) in the Fuel Cells and Hydrogen Field* should involve higher education institutions, research and businesses along the fuel cells and hydrogen value chain, covering the different fuel cells, materials and systems, and hydrogen application areas:

- Renewable hydrogen production (special focus on electrolysis) and storage;
- Low temperature fuel cells (for instance for applications in transport, for portable devices, etc.);
- High temperature fuel cells (for instance for applications in power generation, transport, etc.)

One pilot activity is proposed to kick-start the operation of this advanced network(s):

Activity 1: Development and Implementation of Relevant Curricula at University Level

The focus of this activity is to develop courses on fuel cell and hydrogen for engineers (mechanical, chemical, electrical, etc.) and scientists (physics, chemistry, etc.). It should provide also multi-purpose teaching materials (including simple demonstration equipment) at a range of levels, which can be incorporated in local programmes to support local training and education in the area of fuel cells and hydrogen.

The results of the FCH JU project TrainHy-Prof (Building Training Programmes for Young Professionals in the Hydrogen and Fuel Cell Field) can be used as a starting point.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+2

Action 1.1.7 Network(s) for Geothermal Energy Education and Training

The Network(s) for Geothermal Energy Education and Training should involve industrial platforms, higher education institutions and research centres with expertise and/or facilities in one or more of the geothermal energy-related disciplines – geosciences, material sciences, mechanical engineering, computational sciences, safety and accident prevention, economic and legal sciences.

The network(s) should address heat supply, electricity and co-generation. It needs to involve competent actors such as the EERA Joint Programme on Geothermal Energy and other relevant academic and industry organisations.

Three pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: Integration of Block Courses in Existing Programmes with a Focus on the Combination of Geoscience and Mechanical Engineering

The goal of this activity is to satisfy in a first step the urgent needs of the geothermal industry. The courses should be developed by an interdisciplinary team of educators with backgrounds in the disciplines described above. Education in the classroom should be completed by practical training at field test sites.

The courses could be used also for continuing professional education programmes.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Activity 2: Master Programme in Geoenergy (with Specialisation in Geothermal Energy)

The goal of this master programme is to prepare highly qualified professionals for the future market in geothermal energy. It should be developed by an interdisciplinary team of educators with backgrounds in the disciplines described above. It needs to further foster synergies with other disciplines within geo- and renewable energy. Close connections to research and industry is required.

- EQF Level: 7
- Timeframe for implementation: Year 0+2

Activity 3: Train the Trainer Programme

The goal of this activity is to address the growing need for qualified professors and other educators and trainers in the geothermal energy field. The programme should be developed by an interdisciplinary team of educators with backgrounds in the disciplines described above. Close connections to research and industry is required.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+2

Action 1.1.8 Advanced Network(s) for Nuclear Fission Education and Training

The *Advanced Network(s) for Nuclear Fission Education and Training* builds on or develops further the European Nuclear Education Network (ENEN)[27], the European Network for Education and Training in Radiation Protection (ENETRAP)[28] or other relevant networks.

The target public of this EU-wide action consists primarily of research and industry workers at the higher education level, i.e. levels 6 to 8 of the EQF.

Within this network(s), new profiles linking the nuclear sector (including all applications of ionising radiations) to the other energy sectors and society should be developed. Proposals at the level of MSc and/or PhD networks should be based on Private-Public Partnerships and could be taken up e.g. by a group of universities having both nuclear and social sciences in their programmes in association with private stakeholders of the nuclear value chain.

Support for lifelong learning and borderless mobility should be encouraged, in particular, to ensure multilateral exchanges and a close link with the existing research infrastructures, including large facilities. Obstacles preventing the mobility of qualified nuclear experts should be removed (e.g. national regulations regarding specific nuclear job qualifications, cultural or linguistic barriers, or different technological cultures).

The strategy and end user needs should be discussed with the *European Human Resources Observatory - Nuclear Energy* (EHRO-N)[16].

One pilot activity is proposed to kick-start the operation of this advanced network(s):

Activity 1: Development of Professional Master Courses in Nuclear Technologies at the Frontier of Knowledge

Within this activity, professional master courses should be developed for (young) researchers and engineers working in, among others, industry, consultancy companies or regulatory bodies, to enhance their Knowledge, Skills and Competences (KSC) in nuclear technologies, with emphasis on issues agreed upon with the main stakeholders. This means in particular, for nuclear fission, that the content of the courses is in alignment with the vision of the various European Forums and Technology Platforms (e.g. SNE-TP, IGD-TP and ENEF) and with the strategic objectives of other authoritative groups, associations and forums concerned (e.g. MELODI, ENSREG, HERCA). They should include learning content related to scientific-technological as well as socio-economic issues, such as: advanced safety systems; technological improvements in components and structures; radiation protection; waste management; decommissioning and dismantling; nuclear system engineering; global analyses of the energy market; market entrepreneurship; participation of industry in public engagement processes (aiming among others at developing Corporate Social, Environmental and Financial Responsibility).

[27] http://www.enen-assoc.org/
[28] http://enetrap2.sckcen.be/

The master courses should be composed of modules: one year of Master Degree yields typically a total of 60 ECTS (i.e.: four classroom modules and two practical modules). Apprentice schemes, internships, hands-on training and all types of innovative approaches to learning should be promoted. This type of programme needs strong interactions between universities and industry and should be conducted also together with research organisations and public regulatory bodies. The courses should involve "trainers" from academic institutions and industry as well as mixed "executive committees" to set up and pilot the programme. The proposed master courses should be open to continuing professional development (CPD) programmes, taking advantage of and into account the relevant EU policy approach ("Copenhagen Declaration on enhanced European cooperation in vocational education and training", 2002). Following this, the evaluation of the students' outcomes should refer to quality assessment of learning outcomes, bridging ECTS (*European Credit Transfer and accumulation System*) and ECVET (*European Credit system for Vocational Education and Training*)[29].

- EQF Level: 6-7
- Timeframe for implementation: Year 0+2

Action 1.1.9 Further Development of FuseNet

The objective of this action is to enhance and develop further the European Fusion Education Network (FuseNet)[30].

FUSENET should further stimulate, support and coordinate fusion education in Europe, aiming to attract students to fusion and to provide them with quality education in the field. The network should continue to implement high-quality PhD programmes. In addition, FUSENET needs to develop and share educational tools, stimulate student mobility and act as matchmaker between industry and research laboratories/academia for student internships and vacancies.

- EQF Level: 6-8
- Timeframe for implementation: ongoing

Action 1.1.10 Advanced Network(s) for Photovoltaics Education and Training

The Advanced Network for Photovoltaics Education and Training should involve higher education institutions and research centres with competences and/or facilities in photovoltaics and one or more related disciplines such as metallurgy, chemical and power engineering, systems engineering, material science, process engineers, physics and chemistry, optics, power electronics and energy economics alongside business, administration and management.

[29] All activities should follow the Euratom Basic Safety Standards.

[30] http://www.fusenet.eu/

There is a need to build research partners and capacities, and to incentivise the use of the latest research results in photovoltaics academic and professional training programmes in order to enhance developments in a field that is very dynamic and research-intensive.

One pilot activity is proposed to kick-start the operation of this advanced network(s):

Activity 1: Development of Modern Modular Curricula and Joint Teaching Projects in Photovoltaics

The curricula should address essential core elements from the value chain, creating links between traditional disciplines and photovoltaics, thus providing bridges between existing courses and skills needed to develop, manufacture, install, maintain, and dismantle photovoltaic generators – for example, solar cell processing for chemists; optical processes in photovoltaics for electronic engineers, etc. In addition, teaching modules should be created which will aid the integration of photovoltaics in the built environment. Although eventually growing into many full scale bachelor and master programmes in photovoltaics, this scheme should also be used to develop professional courses in academia for staff in the field who need (re-)training for specific parts of the value chain.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Action 1.1.11 European Smart Cities Education and Competence Network(s)

The *European Smart Cities Education and Competence Network(s*) should involve providers of education and training, proficient research groups, industry and public authorities, addressing in a coordinated manner topics such as integrated urban energy planning, urban energy networks, energy efficient buildings, and urban energy supply.

Close links should be ensured with activities under Actions 1.1.4 and 1.1.13.

Three pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: A European Joint-degree Master Programme in the Field of Integrated Urban Energy Planning

The master programme should focus on urban energy planning at the management level including quality control. Targeted professionals are urban energy strategy developers, urban energy coordinators, urban energy policy experts, and urban energy advisors.

The curriculum should be developed by an interdisciplinary team of educators and professionals in the field, with backgrounds in mechanical engineering, electrical engineering, architecture, urban planning, system integration, business planning and management, economics, environmental engineering and other related disciplines.

- EQF Level: 4-7

- Timeframe for implementation: Year 0+2

Activity 2: Master Programme in the Field of Planning District Heating and Cooling (DHC) Systems with Renewable Energy Sources (RES) Integration

The objective of this master curriculum is to enable alumni to plan the efficient integration of RES (e.g. heat pumps, solar heat and biomass) to DHC networks. The programme should cover the planning of new systems, but also the integration of RES into existing DHC systems.

The curriculum should be developed by an interdisciplinary team of educators and professionals in the field, with backgrounds in mechanical engineering, thermodynamics, system integration, environmental engineering, urban planning, business planning and management, economics, and other related disciplines.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Activity 3: Train the Trainer Programme

The *Train the Trainer Programme* within the Smart Cities Education and Competence Network(s) provides education and training for a new generation of academics specialised on the interfaces between the different energy topics and urban infrastructure layers (building-to-grid, multi-source energy networks, buildings as storage, large-scale RES integration in urban environments, etc.).

Within the programme, adequate courses, seminars and materials for trainers at all education (EQF) levels (apprentices, students, professionals, etc.) should be developed. The curricula needs to cover all thematic areas related to smart cities: integrated urban energy planning, urban energy networks, energy efficient buildings, and urban energy supply.

Representative offices at national level may be established to facilitate the programme development and implementation.

- EQF Level: 3-8
- Timeframe for implementation: Year 0+2

Action 1.1.12 Wind and Ocean Energy Education and Training Network(s)

The *Wind and Ocean Energy Education and Training Network(s)* should include higher education institutions, research institutes, laboratories and industrial installations federated along the wind and ocean energy value chain, industrial associations and platforms such as EWEA[31], TPWind[32] and the European Ocean Energy Association[33].

The network(s) may build on, link to and/or help to develop further the European Academy of Wind Energy[34]. Furthermore, the network(s) should take into account the recommendations of European Wind Energy Technology Platform's latest training report[35].

Three pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: Flexible Master Programmes in the Wind Energy Field with Modular Building Blocks

The objective is to develop and implement advanced courses on bachelor level, joint-degree programmes on master and doctoral level as well as part-time programmes on advanced academic level issuing a university certificate to be used as building blocks in lifelong learning modular education. Thus, the programmes should be open to students as well as professionals in the field. Topics to be addressed include wind and siting, testing and measuring, boundary layer meteorology, atmospheric fluid dynamics, wind energy systems, offshore construction, operations and maintenance, environmental impact and regulations, and others.

Such specialised programmes can be based on e-learning supplemented by occasional presence on campus or be developed as traditional campus education. E-learning modules will allow access to infrastructures for remote laboratory exercises.

The programmes should build on the experience gained in on-going joint wind energy master programmes, and should have a global reach from the outset.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Activity 2: Flexible Master Programmes in the Ocean Energy Field with Modular Building Blocks

The objective is to develop and implement advanced courses on bachelor level, joint-degree programmes on master and doctoral level as well as part-time programmes on advanced academic level issuing a university certificate to be used as building blocks in lifelong learning modular education. Thus, the programmes should be open to students as well as professionals in the field.

[31] http://www.ewea.org/
[32] http://www.windplatform.eu/
[33] http://www.eu-oea.com/
[34] http://www.eawe.eu/
[35] European Wind Energy Technology Platform, (2013). *Workers wanted: The EU wind energy sector skills gap*. [report]

Topics to be addressed include wave and tidal energy technology engineering and management, fluid dynamics, wave and wind energy floating platforms, ocean energy systems, offshore operations and maintenance, environmental impact and regulations, and others.

The joint programmes should seek to ensure access to existing prototypes for education and training purposes.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Activity 3: Train the Trainers Programmes

Within this activity, special short- to medium-term courses should be developed and implemented for teachers and trainers in the field. The aim is to rapidly increase the number of qualified teachers and the effort should be closely linked to the development of the local teaching curricula in the regions with emerging markets. The focus of the programmes is on the interdisciplinary level of advanced courses, which bring wind and ocean energy education to the next level of integrated master and PhD programmes.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Action 1.1.13 Advanced Network(s) for Education and Training on Heating and Cooling, Heat Utilisation and Thermal Networks

The *Advanced Network(s) for Education and Training on Heating and Cooling, Heat Utilisation and Thermal Networks* should involve higher education institutions in the heating and cooling and thermal energy field, and build strong links to related research organisations and businesses.

The programmes should be developed in cooperation with the Renewable Heating and Cooling European Technology Platform[36] and the DHC+ Technology Platform[37], the thermal energy equipment manufacturing industry and other relevant stakeholders.

In order to serve better the needs of EU research and businesses in the field, the curricula to be developed under the network(s) should be open as much as possible to neighbouring countries from the European Neighbourhood Policy.

Close links should be ensured with activities under Action 1.1.11.

Two pilot activities are proposed to kick-start the operation of this advanced network(s):

[36] http://www.rhc-platform.org/

[37] http://www.dhcplus.eu/

Activity 1: European Master and Doctoral Curriculum "Smart Thermal Grids Engineer"

The objective is to develop European master and doctoral courses for engineers with two or more years of working experience. Based on the developed curricula, several modules should be adapted for continuing education courses (each one or two days) without a degree.

E-learning should be an integral part of the curricula to allow students and professionals from all over Europe to join the courses. Apprentice schemes, internships, hands-on training and all types of innovative approaches to learning should be promoted.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+3

Activity 2: Master Programme in the Field of Sustainable Heating and Cooling Technologies

The objective of this master programme is to prepare highly qualified professionals to fulfil the needs of the future European heating and cooling market. It should be developed by an interdisciplinary team of universities, research institutes and business. A close link between research and industry is required. The programme should cover the specific basic sciences (thermodynamics, mechanics, chemistry, electrical engineering) but also simulation/modelling sciences, economic aspects, life cycle, scope of application.

The curriculum should also include integration with other fields such as combination of heat pumps with photovoltaics, integration of heating and cooling equipment in district thermal energy networks, and integration with electricity grids.

Education in the classroom should be complemented by practical training at field test sites.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Action 1.1.14 Advanced Energy Systems Integration Education Network(s)

The *Advanced Energy Systems Integration Education Network(s)* should link to and build on the relevant technology education networks and programmes listed above in order to address system integration aspects.

One pilot activity is proposed to kick-start the operation of this advanced network(s):

Activity 1: Master and Doctoral Curriculum "System Integration Management", Introduction of Elective Courses in the Field at Advanced Bachelor Level

A bachelor and subsequent master and doctoral curriculum for systems integration should include interdisciplinary curricula in mathematics, economics, and energy technology. It should engage

practitioners across different systems such as smart electricity and thermal grids, energy storage, bioenergy and other relevant energy solutions, process integration, smart cities, regional management and government advice. The curricula should enable alumni to manage complex systems including integration of different energy and related technologies.

Subjects to be addressed include: complex data management and analysis; optimisation of processes resulting from the connection of different subsystems; dealing with uncertainty (scenarios, statistics, fuzzy analysis); multi-objective, multi-criteria tools; establishing/managing multidisciplinary teams to solve complex problems.

Social sciences curricula should be included as complementary to natural sciences.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+2

1.2 Vocational Education and Training Networks

The overall goal of the vocational education and training networks listed in this section is to provide vocational education and training in domains with potential shortages/domains needing new or upgrade of existing competences. As such, they have the following **guiding objectives**:

- To establish a flexible framework for developing new and upgrade of existing vocational education or training course modules, involving relevant experts from education and training bodies, research organisations and business.
- To speed up the process of implementing such modules via joint programme development and sharing of experience within the network.
- To promote the incorporation of a strong practice element within the vocational education schemes, including hands-on training in business/research settings.
- To develop a new generation of trainers in fields where expertise is lacking.
- To provide a framework to harmonise vocational education and training, strengthen the mutual recognition of qualifications, and monitor vocational education and training efforts.

The *Vocational Education and Training Networks* should involve technical training centres, vocational institutes and technical schools, universities and continuing professional education institutes, companies from related industries, business and research organisations, as well as other relevant actors such as vocational orientation/career guidance bodies, bodies responsible for accreditation, qualification or certification. The course modules should be developed in cooperation between the sectorial industrial associations and relevant academia/innovation partnerships.

The networks should focus on the skills development and upgrade of staff from key stakeholders

along the technology value chains such as industries, related services, research organisations, public authorities, and professional end users while supporting lifelong learning and facilitating mobility across the EU.

It is important to note that the proposed networks can be implemented separately, jointly and/or in coordination with each other.

All developed programmes should list the defined learning outcomes (according to ECVET38 principles), outlining also possible synergies among different fields, as well as relation to existing second and third cycle education (i.e. master and PhD programmes).

The programmes should follow innovative teaching approaches, incl. the development of entrepreneurial and management skills when relevant.

Action 1.2.1 Vocational Education and Training Network(s) in the Field of Bioenergy

The *Vocational Education and Training Network(s) in the Field of Bioenergy* should integrate competences in all or some of the following disciplines: agricultural biomass production, forestry biomass production, systems and basic technology engineering, safety and accident prevention, environment and sustainability, business administration and marketing.

Four pilot activities are proposed to kick-start the operation of this network(s):

Activity 1: Vocational Training for Skilled Biomass Management and Bioenergy Personnel

The objective of this activity is to develop dual, cooperative vocational training (with 3 years duration) as well as a re-training for personnel with an agricultural and/or forestry background. The activity should build on experience in Member States, while pursuing an EU-wide curriculum, strengthening the mutual recognition of qualifications and harmonising the assessment of learning outcomes. The curricula should take into consideration country specific situations in terms of legislation, feedstocks, farm and industry structure, etc.

The training should address:

- young people who aspire to a vocational qualification in biomass and bioenergy;
- farmers and foresters;
- workers from agriculture and forestry;
- all persons interested in biomass and bioenergy.

[38] Following the EU's Copenhagen 2002 Process.

The curriculum should involve the following areas: basics of the energy industry, forestry and agricultural biomass production, systems engineering, environment and sustainability, occupational safety, business administration.

- EQF Level: 1-6
- Timeframe for implementation: Year 0+2

Activity 2: Skills Upgrade for Conventional Bio-based Industries

The activity aims to address conventional bio-based industries such as sugar, pulp & paper and food industry.

Within this activity, tailor-made training modules should be developed targeted at mid- to high-level management, engineering staff, procurement and marketing personnel in order to improve their awareness of opportunities posed by bioenergy utilisation as well as to provide them with the necessary skills to implement bioenergy technologies within their industries. The courses should be addressed to each sector individually and provide a full programme for skills-upgrade for all involved employees and management.

- EQF Level: 4-6
- Timeframe for implementation: Year 0+3

Activity 3: Skills Upgrade for Advanced Bio-based Industries

The activity aims to address advanced biorefineries' supply chains (agricultural residues and dedicated biomass not in competition with food and feed) linked to innovative technologies.

Within this activity, tailor-made training modules should be developed targeted at engineering staff, management, procurement and marketing personnel in order to provide them with the necessary skills to develop, manufacture, implement, operate and maintain advanced bioenergy technologies within their industries. The courses should be addressed to each sector individually and provide a full programme for skills-upgrade for all involved employees and management.

- EQF Level: 4-6
- Timeframe for implementation: Year 0+3

Activity 4: Skills Upgrade for Energy Consultants in the Bioenergy Field

The proposed activity aims to provide training modules targeted towards different groups of energy consultants (consultants to individuals, business and industry, communities/regions, etc.) and upgrades their know-how concerning bioenergy solutions within their sphere of activity. Modules have to be developed for distance learning (using the European bioenergy virtual learning platform as a dissemination channel). National bioenergy associations (under the coordination of the European Bioenergy Association) may be involved in organising courses in their national context.

- EQF Level: 3-8
- Timeframe for implementation: Year 0+3

Action 1.2.2 Vocational Education and Training Network(s) in the Field of Carbon Capture, Utilisation and Storage (CCUS)

The *Vocational Education and Training CCUS Network(s)* should integrate competences in all or some of the following disciplines: carbon capture (power generation, petro-chemistry), transport of fluids, CO_2 utilisation, and storage (e.g. experience from oil and gas industries).

Two pilot activities are proposed to kick-start the operation of the network(s):

Activity 1: Skills Upgrade for Conventional Industries Involved in CO2 Capture (power generation, industrial sectors such as petro-chemistry, chemicals manufacture, iron & steel and cement industry), Transport of Fluids, Utilisation and Storage (e.g. oil & gas industries)

Conventional existing industries should play a key role in implementing CCUS according to the SET Plan goals. These industries have already excellent access to human resources whose expertise can be matched to the CCUS value chain. Electro-mechanical and chemical engineers have a sound education for the operation and maintenance of capture units, fluid–mechanical engineers for the transport and geoscientists for the storage.

Within this action, tailor-made training modules should be developed within the CCUS Vocational Education and Training Network(s), targeted at mid- to high-level technicians and engineers with the objective to upgrade their competences according to the CCUS needs. The courses should address each sector individually, i.e. CO_2 capture, transport, utilisation and storage technologies.

- EQF Level: 4-6
- Timeframe for implementation: Year 0+2

Activity 2: Skills Upgrade for Energy Consultants in the CCUS Field

The proposed activity aims to provide training modules targeted towards different groups of energy consultants (consultants to individuals, business and industry, etc.) and to upgrade their know-how concerning CCUS solutions within their sphere of activity.

The training modules should be developed within the CCUS Vocational Education and Training Network(s) for on-site or distance learning, and may use different European platforms, such as the ZEP (Zero Emission Platform), EUA/EPUE, KIC-InnoEnergy, IEA GHG R&D Programme among others as dissemination channels. Courses can also be organised in collaboration with relevant international institutions.

National associations, research institutes, engineering consultancies, universities and technical high schools, which may be current members or later associated to the Vocational Education and Training

Network(s), can then be invited to organise courses in their national context, depending on the needs within each country.

- EQF Level: 3-8
- Timeframe for implementation: Year 0+3

Action 1.2.3 Vocational Education and Training Network(s) in the Field of Concentrated Solar Power (CSP)

The *Vocational Education and Training Network(s) in the Field of Concentrated Solar Power* should involve vocational training institutions, research institutes, installations and facilities competent in the field.

Today education and especially training in CSP involves mostly large installations and facilities. These are mainly available at research institutes and should continue to be taken into consideration for training purposes. However, such large-scale facilities are normally available only in the southern European countries. For vocational training, it would be advisable to set up laboratory scale training facilities distributed over Europe in order to enhance knowledge and research development in the field.

Two pilot activities are proposed to kick-start the operation of this network(s):

Activity 1: Vocational Training Programme in Plant Maintenance

The focus of this programme is on providing technical and economic background knowledge for the maintenance of CSP plants and to provide training of the personnel in efficient, careful and cost effective maintenance. The target audience is workers in the field of plant maintenance.

The training scope should be on laboratory scale with some additional and optional components, ensuring also access to large-scale facilities for training purposes. Sun simulator technology should be considered to support the institutions in order to provide reliable and flexible training capacities.

This activity should include also the elaboration of training materials.

- EQF Level: 1-5
- Timeframe for implementation: Year 0+4

Activity 2: Simulator for Operational Personnel

CSP plant operation is a complex matter and much information needs to be accessible to operators in order to avoid reducing the performance of the plant or endangering the safety of personnel or equipment. Today, operators are trained mainly by more experienced personnel of the operation companies. If new concepts or schemes are implemented, operation errors may occur due to lack of

experience. It is important to structure the teaching and training of operation personnel accordingly to prepare such personnel for all problems that may occur.

This activity provides training in simulators which would acquaint the operation personnel with all steps and potential failures in the operation process. Such training can be useful also for experienced personnel to frequently refresh their knowledge as well as to place operators in situations that simulate possible operation problems.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+4

Action 1.2.4 Vocational Education and Training Network(s) in the Field of Electricity Grids

The *Vocational Education and Training Network(s) in the Field of Electricity Grids* should integrate competences in all or some of the following disciplines: electrical and mechanical engineering, systems engineering, control engineering, information and communications engineering, renewable energy and conventional generation (flexible load), institutional economics (tariff structures), business administration, occupational safety, and other related fields.

Activity 1: Vocational Training in the Field of Advanced Electricity Grids

The objective of this activity is to develop dual, cooperative vocational training (with 3 years duration) as well as re-training for personnel with an electricians' background.

The training should address:

- young people who aspire to a vocational qualification in international transmission and local distribution electricity grids (especially smart grids);
- workers from conventional electricity grid activities;
- all persons interested in international transmission and local distribution electricity grids (especially smart grids).

The curriculum should cover different areas related to smart grids as outlined above.

- EQF Level: all
- Timeframe for implementation: Year 0+2

Action 1.2.5 Energy Storage "Academy" for Vocational Education and Training with Links to Industry

The *Energy Storage Academy for Vocational Education and Training* should involve relevant academia and industrial actors, creating a professional training network in Europe. It should integrate competences in all or some of the following disciplines related to energy storage: systems and basic technology engineering, system optimisation modelling, drilling and installation, operation and maintenance, safety and accident prevention, sales engineering (incl. HVAC[39]), business administration and marketing.

Vocational training in this field should address the whole workforce value chain, from design, manufacturing and construction, to operation and maintenance.

One pilot activity is proposed to kick-start the operation of the Academy:

Activity 1: Energy Storage Fundamentals for Professionals

Conventional existing industries will play a key role in energy storage development, installation and operation. These industries have already excellent access to human resources associated with their expertise, e.g. electro-mechanical or chemical engineers, electricians or HVAC[40] technicians among others.

Within this activity, tailor-made training modules should be developed and implemented, targeted at mid- to high-level technicians and engineers, with the objective to upgrade their competences in relation to different energy storage options. The course modules should address each energy storage option individually.

- EQF Level: 3-6
- Timeframe for implementation: Year 0+2

Action 1.2.6 Vocational Education and Training Network(s) in the Field of Fuel Cells and Hydrogen

The *Vocational Education and Training Network(s) in the field of Fuel Cells and Hydrogen* should integrate competences in all or some of the following disciplines: systems and individual technology engineering, safety and accident prevention, business administration and marketing. The network(s) should address different fuel cells, materials and systems, and hydrogen application areas:

- Renewable hydrogen production (special focus on electrolysis) and storage;
- Low temperature fuel cells (for instance for applications in transport, for portable devices, etc.)
- High temperature fuel cells (for instance for applications in power generation, transport, etc.)

[39] Heating, Ventilation and Air Conditioning

[40] Heating, Ventilation and Air Conditioning

Modules should be developed for the different stages of the value chain - industrial innovation, design and engineering, manufacturing, installation, operation and maintenance (incl. performance assessment), commercialisation.

One pilot activity is proposed to kick-start the operation of this network(s):

Activity 1: Skills Upgrade for Professionals in Industry

This activity aims to address the development and implementation of tailor-made training modules targeted at low, mid and high-level technicians and engineers of the fuel cells and hydrogen industry, from major companies to SMEs[41] and start-ups. The courses should provide a full programme for skills upgrade for the different levels of professionals, and should address each application area individually.

Both core and generic skills and competences should be addressed, in particular core skills such as electrochemistry, process engineering, power electronics, architecture of electric systems – energy management systems, risk management and hydrogen safety, advanced materials and new synthetic techniques for hydrogen storage and fuel cell components, nanomaterials and nanotechnologies, characterization methods including 3-D and in-situ techniques; as well as generic competences, for example chemistry adapted to energy including hydrogen and fuel cells, electrical engineering, heat and mass transport, electronics and control, mechanical engineering, testing protocols, standardisation, methodologies of quality control, energy management, energy economy.

- EQF Level: 4-6
- Timeframe for implementation: Year 0+2

This activity should build also on the experience developed within HyProfessionals, a project supported under the FCH JU.

Action 1.2.7 Vocational Education and Training Network(s) in the field Geothermal Energy

The *Vocational Education and Training Network(s) in the Field of Geothermal Energy* should integrate competences in all or some of the following disciplines: geosciences, material sciences, mechanical engineering, computational sciences, safety and accident prevention, economic and legal sciences.

The network(s) should address heat supply, electricity and co-generation. In the field of heat supply from shallow geothermal, activities should build on the experience developed within the Geotrainet initiative[42].

One pilot activity is proposed to kick-start the operation of this network(s):

[41] Small and Medium-Sized Enterprises

[42] www.geotrainet.eu

Activity 1: Courses Combining Geoscience and Mechanical Engineering

The goal of this activity is to address interdisciplinary competences needed within the geothermal industry. The courses should be developed by an interdisciplinary team of educators with backgrounds in the disciplines described above, in cooperation with the Network of Universities under Action 1.1.7. Education in the classroom should be complemented by practical training at field test sites.

- EQF Level: 3-8
- Timeframe for implementation: Year 0+2

Action 1.2.8 Vocational Education and Training Network(s) for Nuclear Fission

The objective of this action is to support vocational education and training network(s) including both independent institutions and industry-driven centres in order to ensure high-quality and up-to-date continuing professional development (CPD) programmes for the nuclear sector (including medical applications of ionising radiations). The network(s) should address the knowledge, skills and competences continuously needed in the nuclear sector for a large number of personnel but also training needs related to the competences at risk. This action should be seen as being complementary to the Advanced Network(s) listed under 1.1.8. The strategy and end user needs should also be discussed with the EHRO-N[43] and with the ENEN[44], as well as with other relevant networks such as EUTERP (European Training and Education in Radiation Protection Foundation)[45].

A key task for this network(s) is to further develop and operate European Fission Training Schemes (EFTS) in strategic domains such as safety, radiation protection and waste management in line with the European Qualification Framework (EQF) and the ECVET principles.[46] These EFTS should consist of a variety of learning paths adapted to a variety of profiles in all nuclear sectors with the aim to bridge university knowledge with skills and competences needed in industry and other organisations concerned.

- EQF Level: 5-8
- Timeframe for implementation: Year 0+2

Action 1.2.9 Oriented Training Programme in Fusion

The objective of this action is to enhance the Goal Oriented Training programme (GOT) run under EFDA to target the gaps in the competence profiles of the workforce. In-company and/or part-time

[43] http://ehron.jrc.ec.europa.eu/
[44] http:/www.enen-assoc.org/
[45] http://www.euterp.eu/
[46] All activities should follow the Euratom Basic Safety Standards.

training schemes and courses should be developed to teach fusion-specific technology to engineers and technicians who work in industry.

- EQF Level: 6-8
- Timeframe for implementation: ongoing

Action 1.2.10 Vocational Education and Training Network(s) in the Photovoltaics Field

The objective of this action to create centres that link industrial and educational institutions where students and staff can master specific skills required in industry. In order to generate new insights and ideas, *the Vocational Training Network(s) in the Photovoltaics Field* should address basic knowledge, skills and competences continuously needed in the photovoltaics sector. These centres should be operating on a commercial basis, and be interdisciplinary to cover the entire photovoltaics energy sector.

The training centres should address also utility topics. The integration of a high proportion of photovoltaics in public networks requires a close cooperation between academia and the utility sector. Such 'utility training centres' will help the academia to understand the needs of network operators and prepare teachers and students for the new developments which are expected in the energy markets as a results of the high penetration of photovoltaics in energy supply networks (energy-pricing, network tariffs, etc.).

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 1.2.11 Vocational Education and Training Network(s) in the Field of Smart Cities

The *Vocational Training Network(s) in the Field of Smart Cities* should integrate competences in all or some of the following disciplines: integrated urban energy planning, energy network planning and development, urban energy supply, energy-efficient buildings and energy performance standards, integration of RES in buildings, and other related disciplines.

Current state-of-the-art skills should be updated for all levels of education (management, engineering and technician levels) according to latest technology and innovation trends in order to unlock the full potential of people already on the job market.

Three pilot activities are proposed to kick-start the operation of this network(s):

Activity 1: Skills Upgrade for Urban Planners, Architects and Engineers in the Smart Cities Field

This activity should develop tailor-made training modules targeted at technicians, engineering staff, or architects to improve their awareness of new developments and provide training on required interdisciplinary and system integration topics. The courses should address each sector individually and provide a full programme for skills upgrade for all involved.

The skill upgrade modules should aim to create innovative and independent experts, with critical distance and reflection of the new theories and solutions that increasingly arise in the context of smart cities. Creative design and planning methods need to be combined with innovative technologies to provide high-quality, energy-efficient, resilient urban areas.

Competences to be developed include:

- Coordination and networking between urban planning and energy planning, on the technical but also economic and regulatory level;
- Renewable energy sources and/or district heating and cooling/combined heat and power in urban renovation/regeneration programmes as well as in new developments;
- Finance competences for the development of economical and financially sustainable projects;
- New tools and instruments supporting urban transitions and innovative smart cities functionalities.
  - EQF Level: 5-8
  - Timeframe for implementation: Year 0+2

Activity 2: Skills Upgrade for Technicians in the Field Energy-efficient Buildings

This activity aims to develop tailor-made training modules targeted at technicians (construction workers, HVAC[47] technicians, plumbers, electricians, etc.) to improve their knowledge about green building technologies through their life-cycle (installation, maintenance, removal, disposal, recycling). Such modules should cover topics such as solar thermal and other RES installation, sustainable construction materials use, refurbishment of buildings with the use of new materials and systems, energy performance monitoring and assessment, energy certification and other related subjects. At the same time, modules for senior workers should include knowledge of newly adopted energy performance standards, leadership in green building retrofit projects and advising on energy efficiency.

- EQF Level: 3-5
- Timeframe for implementation: Year 0+2

This activity should be implemented in coordination with the Build-Up Skills Initiative.[48]

[47] Heating, Ventilation and Air Conditioning

[48] http://www.buildupskills.eu/

Activity 3: Training on Energy Management for Decision-Makers, Energy Managers and Professionals in Municipalities and in Business/Industry

This activity is targeted at decision-makers, energy managers and professionals in municipalities, regional authorities and in business/industry, and offers education and training programmes on overall energy management and possible solutions such as energy efficiency service contracts including energy performance contracting and their financing.

Education and skills upgrade in the field of overall energy management services to end-users (industries, tertiary, collective buildings, public premises, district heating and cooling networks, etc.) should be adapted with a view to optimise their energy consumption and CO_2 emissions, and to develop renewable energy solutions.

- EQF Level: 3-7
- Timeframe for implementation: Year 0+2

Action 1.2.12 Wind and Ocean Energy Vocational Education and Training Network(s)

The *Wind and Ocean Energy Vocational Education and Training Network(s)* should involve vocational training institutes as well as other leading knowledge institutions in the field. It should aim to connect regions with expertise in wind and ocean energy with regions of emerging markets where expertise is lacking. It should also seek to include new markets in neighbouring to the EU regions in the east and south, where there is a potential for European industry. The network(s) should take into account the recommendations of European Wind Energy Technology Platform's training report[49]. The experience of existing networks such as the Atlantic Power Cluster[50] in the field of marine renewable energy should also be considered.

Two pilot activities are proposed to kick-start the operation of this network(s):

Activity 1: Vocational Education and Training in the Wind and/or Ocean Energy Field

The aim of this programme is to provide education and training in the field to emerging markets where expertise is lacking. In addition to the vocational module courses offered, the programme should include also guest teacher secondment, supply and exchange of teaching materials, and visiting programmes for students and professionals at leading teaching and training facilities. The courses should cover the entire technology value chains.

- EQF Level: 4-6
- Timeframe for implementation: Year 0+2

[49] European Wind Energy Technology Platform, (2013). *Workers wanted: The EU wind energy sector skills gap*. [report]
[50] http://atlantic-power-cluster.eu/

Activity 2: Train the Trainers Programmes with Focus on New Markets and Vocational Training

This activity is closely linked to the Train the Trainers Programmes under Action 1.1.12.

The objective is to create a sufficient numbers of qualified "trainers" for vocational training in the regions with emerging markets. Special short- to medium-term courses should be developed and implemented to address these needs.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 1.2.13 Heating and Cooling, Heat Utilisation and Thermal Networks Academy

The Heating and Cooling, Heat Utilisation and Thermal Networks Academy should involve relevant academia and industrial actors, creating a professional education and training network in Europe. It should integrate expertise in systems and basic technology engineering, system optimisation modelling, installation, operation and maintenance, safety and accident prevention, sales engineering (incl. HVAC[51]), business administration and marketing, as well as in heating applications, cooling applications, heat and cold storage, thermal demand, smart thermal grid management (multi sources and multi users), renewable energies, smart cities and smart grids, urban planning, system integration, ICT solutions, and others.

Vocational training in this field should address the whole workforce value chain, from planning, design, manufacturing and construction, to operation and maintenance, and dismantling.

One pilot activity is proposed to kick-start the operation of the Academy:

Activity 1: District Heating and Cooling and the Smart City – Smart District Heating and Cooling Solutions for Professionals and Researchers

Conventional existing industries will play a key role in development, installation and operation of district heating and cooling solutions.

Within this activity, tailor-made training modules should be developed and implemented, targeted at young technicians, engineers and urban planners, but also professionals in the areas of law, political science, business and others, with the objective to upgrade their competences in relation to smart district heating and cooling solutions. The modules should address each part of the value chain separately, while ensuring necessary linkages.

- EQF Level: 6-8
- Timeframe for implementation: Year 0+2

[51] Heating, Ventilation and Air Conditioning

Action 1.2.14 Energy Systems Integration Vocational Education and Training Network(s)

The *Energy Systems Integration Vocational Training Network(s)* should link to and build on the relevant technology education and training networks and programmes listed above in order to address system integration aspects.

Three pilot activities are proposed to kick-start the operation of this advanced network(s):

Activity 1: Skills Upgrade Programmes for Professionals in the Field

This activity should develop tailor-made training modules targeted at mid- to high-level management, engineering staff, and procurement and marketing personnel in order to improve their awareness of the systems complexity and the need to address sustainability aspects.

The courses should be developed by relevant industrial associations, professional associations (engineering/architecture/economists associations), universities and innovation networks. They should combine theoretical foundations of systems engineering and architecture with practical exercises to instil solid understanding of systems architecture and design principles.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Activity 2: Skills Upgrade for Systems Integration Consultants using a Credit Obligatory System

The main objective of the skills upgrade for energy consultants programme is to improve the qualification of consultancies' staff in the system integration field.

The proposed activity should provide training modules targeted towards different groups of energy consultants (consultants to individuals, business and industry, communities/regions, etc.) and upgrade their know-how concerning integration of solutions in a framework of evaluation of impacts by monitoring and measuring.

This training should be subject by certification from a European issuing body.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Activity 3: Introduction to Energy Storage Devices and Systems for Professionals

The course targets professionals in the field such as system and electrical engineers, mechanical design engineers, project engineers and programme managers, supervisors and technical managers, and system integrators.

The course modules should focus on identifying and selecting the types of energy storage devices, their chemistries, properties, as well as understanding energy storage construction, system application, and system integration.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

2 Fostering involvement of business and research, access and uptake by the labour market

2.1 Mobility and Cooperation Partnerships among Education and Training Providers, Research Institutes and Businesses

Mobility and cooperation partnerships listed in this section have the following **guiding objectives**:

- To allow students to move to business and/or research facilities within their curricula, and gain practical experience and orientation in the field.
- To facilitate mobility, practical experience and knowledge exchange for business/research and teaching staff in education and training organisations, research institutions and industry.
- To allow business and research staff to teach at higher education institutions and training institutions, transferring their know-how into knowledge for graduate students or lifelong learners.
- To improve the interaction and student/staff mobility between research institutions and higher education institutions across Europe via fostering joint research projects and programmes, including a training component.
- To facilitate high-quality fundamental and applied scientific research through mobility and cooperation frameworks.
- To stimulate lifelong learning and transnational mobility, and facilitate access to technology facilities.
- To develop and update quality curricula and teaching materials, integrating work-based learning and responding to labour market needs.

The mobility and cooperation partnerships should gather stakeholders along the technology value chains, including academia, professional training institutes, research organisations, companies in the field, and relevant research infrastructure facilities.

Partnerships may address one or more technology fields. The actions listed below can be implemented separately or in different combinations with each other.

Action 2.1.1 European Collaborative Education Mobility Programmes for Low Carbon Technologies

The *European Collaborative Education Mobility Programmes for Low Carbon Technologies* are aimed at students at university level as well as at participants in different vocational training schemes. They are different from current student mobility programmes as they require more flexibility regarding the duration of the stays as well as strict coordination between the universities and business/research facilities receiving students. Different programmes for cooperation range from compact pilot plant exercises with durations of 2-4 weeks to team projects of 1-3 months to individual research projects with 6 months to 3 years duration. Innovative schemes such as collaborative learning journeys through different academia, research and business organisations should also be encouraged. The mobility plans have to include the definition of measurable objectives as well as a detailed schedule and procedures for grading student achievements. A quality control should be applied to guarantee certain performance and integrity criteria.

While some of the programmes could be elaborated as integrated part of educational programmes, others could be developed as independent from university programmes and offered to interested students as an additional framework where they could gain further technology competences in the field.

The mobility programmes may be implemented in close collaboration with the Networks of Universities (Actions under 1.1), the Vocational Training Networks (Actions under 1.2), and the Infrastructure Programmes (Actions under 2.4).

- EQF Level: all
- Timeframe for implementation: Year 0+1

Action 2.1.2 Mobility and Cooperation Programmes for Research and Technical Staff, Professors and Trainers for Low Carbon Technologies

The *Mobility and Cooperation Programmes for Research and Technical Staff, Professors and Trainers* seek to provide access to facilities such as laboratories at universities, large-scale facilities at research institutes, industrial pilot or demonstration plants. They aim to facilitate participation of research and teaching staff in industry activities, while industrial/research staff will be invited to give lecturers to students and professionals in the field at higher education institutions and vocational institutes. Such collaboration frameworks support knowledge exchange and scientific cooperation for the advancement of knowledge and developments in the field.

This measure should facilitate also the update and development of teaching materials.

Mobility and cooperation programmes should be implemented within Europe but also in collaboration with countries and regions outside of the EU where European research and industrial actors have an interest for collaboration.

- EQF Level: all

- Timeframe for implementation: Year 0+1

Action 2.1.3 Industrial Doctorate Programmes in the Different Low Carbon Technology Fields

Objective:

- To educate researchers at a PhD level with knowledge about industrially focused research and innovation.
- To promote cooperation on research and innovation between universities and businesses.
- To facilitate knowledge transfer and networking between companies and researchers at universities across Europe.

European Industrial Doctorate Programme(s) are encouraged for all low carbon technology fields. They need to involve relevant academia, research and industrial partners, based on identified research topic objectives, encouraging cooperation across countries.

Within such programmes, PhD students or research fellows divide their time between the academic/research and the industrial setting, working on a company project.

Such programmes enable industry to localise skilled partners from universities and research institutions, at the same time providing academic support to the doctoral career of candidates working in industry. A data or information base is required to ease the contact and find efficiently relevant partners. A quality control should be applied to guarantee a high degree of success. Standards for IP relevant aspects should be implemented.

- EQF Level: 8
- Timeframe for implementation: Year 0+1

2.2 Infrastructure Support to Higher Education and Vocational Training

Research infrastructures and industrial installations in the low carbon technology fields represent unique tools at the frontier of knowledge and field expertise. The overall goal of the actions listed under this section is to facilitate access for education and training purposes to:

- Large national research infrastructure facilities;
- Industrial and research technology pilot and demonstration facilities;
- Research institutes' laboratories.

As such, the actions listed within this section have the following **guiding objectives**:

- To build joint education and training programmes, projects and exchanges among research infrastructures/industrial installations and relevant education and training providers.
- To ensure quality education and training by engaging a broad range of experts from education and training bodies, research and industry.
- To provide a platform for practice oriented education on all levels (students, engineers, researchers, etc.).
- To offer career tracks for researchers in the field.
- To speed up the process of technology development, market uptake and replication via educating and training professionals about new developments in the field, and/or via the implementation of joint research and innovation projects.
- To provide the respective technology field with additional attractiveness for creative and entrepreneurial scientists, researchers, engineers, and other professionals.

Action 2.2.1 European Network of Bioenergy Research Pilot Plant Facilities

The European Network of Bioenergy Research Pilot Plant Facilities should comprise installations from business, research institutes (e.g. EERA) and academia that feature research pilot plants for bioenergy technologies as well as key technologies along the bioenergy value chain (e.g. pelletising, raw material conditioning, conversion processes, grid integration such as biogas cleaning, etc.). It should build on the existing BRISK[52] network and enlarge it in both size and scope.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

[52] http://www.briskeu.com

Action 2.2.2 A Framework for Open Access to Carbon Capture and Storage (CCS) Laboratory Infrastructure

The ECCSEL initiative (European Carbon dioxide Capture and Storage Laboratory Infrastructure), listed within the ESFRI roadmap, is developing an open-access CCS laboratory infrastructure that could be integrated into various education and training programmes. Thus, the ECCSEL initiative is an appropriate frame that could be linked to the proposed CCUS Education Network under Action 1.1.2) and extended with the development of new educational programmes.

Within this action, specific agreements should be established within ECCSEL, including binding agreements for partner commitments pertaining to laboratory facilities, human and financial resources, and consented rules for access to the laboratory facilities.

Access to industrial pilot and demonstration facilities for education and training purposes should also be encouraged.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 2.2.3 A Programme for Access to Research Infrastructure for Education and Training Purposes in Concentrated Solar Power (CSP)

This Action aims to establish the necessary agreements to provide access to both students and external staff to research infrastructures in the CSP field such as EU-SOLARIS - the European Solar Research Infrastructure for Concentrated Solar Power.

Research and test platforms combined with training centres in the CSP field are planned or already under construction in several countries – such centres provide excellent conditions and possibilities for access to pilot or demonstration scale plants for education and training purposes.

Specific measures should be defined for the integration of infrastructures outside the EU into this programme, namely from the MENA region.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+4

Action 2.2.4 A Programme for Access to Research Infrastructure for Education and Training Purposes in Smart Electricity Networks

This Action aims to establish the necessary agreements to provide access to both students and external staff to research infrastructures, pilot and demonstration plants in the smart electricity networks field, including European infrastructure networks such as DERRI (Distributed Energy Resources Research Infrastructure).

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 2.2.5 Energy Storage Collaborative R&D Infrastructure

Energy storage research infrastructure is listed within the ESFRI[53] 2010 roadmap as a missing/emerging field that needs to be addressed.

The goal of this action is to form a network of Energy Storage research infrastructures contributing to lifelong learning and EU capacity building, in close collaboration with the activities under ESFRI.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 2.2.6 A Programme for Access to Fuel Cells and Hydrogen Research Infrastructure for Education and Training Purposes

This Action aims to establish the necessary agreements to provide access to both students and external staff to research infrastructures, pilot and demonstration plants in the fuel cells and hydrogen field, including European virtual and physical infrastructure networks such as H2FC[54] European Research Infrastructure.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 2.2.7 Network of Specialised Enhanced Geothermal Systems (EGS) Training Centre(s)

The *Specialised Enhanced Geothermal Systems (EGS) Training Centre(s)* should be developed as centres of excellence and allow the education and training of young researchers, students and current employees in the field.

At the moment only 5 EGS prototypes exist worldwide, all based in Europe. The specialised EGS training centres should originate from these or other emerging industrial geothermal project operators. Each participating industrial site should be the nucleus of a training centre. An international university cluster should be established in the vicinity of the operating site in order to guarantee optimal access for the students. For specific competences, further universities may be associated.

[53] European Strategy Forum on Research Infrastructures

[54] http://www.h2fc.eu/

The university cluster should cover the entire range of geothermal energy fields, and develop joint master and PhD programmes in "Geothermal energy", as well as individual courses. Each plant operator should have a team that will take over part of the education programme.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+3

Action 2.2.8 Access for Education and Training Purposes to Research Infrastructures and Pilot/Demonstration Facilities in the Nuclear Field

This Action aims to establish the necessary agreements to provide access to both students and external staff to research infrastructures, pilot and demonstration plants, and large nuclear facilities in the nuclear fission and fusion energy field, including European/international projects and infrastructure networks such as Generation IV experimental reactors and demonstrators for nuclear fission, e.g. MYRRHA (Multipurpose hYbrid Research Reactor for High-technology Applications), JHR (Jules Horowitz Reactor Infrastructure); JET (Joint European Torus) and ITER (International Thermonuclear Experimental Reactor) in the field of nuclear fusion, HiPER (European High Power laser Energy Research facility), IFMIF[55] (International Fusion Materials Irradiation Facility) and others.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 2.2.9 European Network of Smart Cities Research and Training Infrastructure

An extension of already existing infrastructure at EU-level should be envisaged (ESFRI) focusing in particular on the highly interdisciplinary nature of Smart Cities. It is highlighted that new laboratories (both hardware + software environments for simulation/modelling activities) etc. have to go beyond the classical use for single-technology applications with a much broader range of facilities for system analysis. Such research infrastructure should then be combined with training programmes for engineers and technicians in order to directly transfer innovation and newly gained knowledge to the education and industrial sector.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

[55] http://www.ifmif.org/

Action 2.2.10 A Programme for Access to Research Infrastructure for Education and Training Purposes in Photovoltaics

This Action aims to establish the necessary agreements to provide access to both students and external staff to research infrastructures, pilot and demonstration plants in the photovoltaics energy field, including European infrastructure networks such as SOPHIA[56] (Solar Photovoltaics European Research Infrastructure).

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

Action 2.2.11 European Programme for Access to Research and Pilot Facilities for Higher Level Education and Training in Wind and Ocean Energy

The goal of this Action is to allow access for students and trainees to research infrastructures for wind or ocean energy, pilot plants and demonstration offshore farms, through (1) access to real data (related to their performance, environmental impacts, and operation & maintenance), (2) physical access to the sites with visits and if possible (3) involvement in deployment and operation & maintenance activities, so that the trainees experience the size and complexity of the logistics involved in these operations and the difficulty and risks in accessing the equipment.

The proposed Action could be coupled to the SET Plan Wind Energy Technology Roadmap: under the action "New Turbines and Components" the SET Plan proposes a "network of 5 – 10 European testing facilities to test and assess efficiency and reliability of wind turbine systems". These testing facilities are an ideal field also for education and training activities.

Activities should also build on and expand further education and training activities at other relevant research infrastructures such as WindScanner[57] and MARINET[58].

- EQF Level: 4-8
- Timeframe for implementation: Year 0+2

[56] http://www.sophia-ri.eu/
[57] http://www.WindScanner.eu/
[58] http://www.fp7-marinet.eu/

3 Planning and Enabling Skills Development, Transfer and Recognition

3.1 Virtual Learning and Information Platforms

Action 3.1.1 SET Plan Virtual Learning and Information Platform(s)

The *SET Plan Virtual Learning and Information Platform(s)* should cover all low carbon technology fields, with the following objectives:

- To speed up the modernisation process for relevant curricula and in particular to increase the capacity for multidisciplinary education by providing quality controlled digital educational content to education and training institutions.
- To facilitate education and training activities in the field when key expertise is concentrated at relatively few universities or training centres, while the education and training needs are quite widespread.
- To establish virtual education and training programmes and modules as well as other open educational resources, allowing the inclusion of expert lecturers via a virtual faculty exchange.
- To provide access via distance learning tools to remote research infrastructures, test facilities, data banks, and other valuable components in education and training.
- To enable the quick implementation of programmes for continued education, including "train the trainers" programmes.
- To strengthen networking between knowledge centres.
- To offer on the public side an open portal to create awareness about energy technologies.

The programmes should be developed within the education and training networks listed under *Actions 1.1 and 1.2,* as well as via other relevant frameworks. This should also include the development of a fully online open source master programme in sustainable energy with engineering, financial, social, entrepreneurial and humanitarian content, including a process for introduction of latest relevant research results from all the partner institutions into the programme.

In addition, the Platform(s) should integrate a number of databases, for example:

- A database for open access e-learning material. The objective is to make learning materials readily available, facilitating up-take at institutions new to the advanced fields of energy technologies.
- An inventory of relevant European-level infrastructure facilities, which are open for education and training purposes, as well as for research and development activities.

- A database on scholarships and a job portal with a possible link to Euraxess[59].

Specific procedures for contribution, quality assurance and use of the databases will be elaborated as part of this action.

- EQF Level: all
- Timeframe for implementation: Year 0+3

3.2 Knowledge, Skills and Competences (KSC) Recognition and Transfer Programmes

The *Knowledge, Skills and Competences Recognition and Transfer Programmes* aim to define the learning outcomes[60] of education and training programmes for all formal occupational profiles at all relevant levels of the European Qualifications Framework (EQF). The Programmes will also aim at the application of the European credit systems (ECVET and ECTS) as well as of the European quality assurance instruments (EQAVET tool box and ENQA Guidelines), with the following objectives:

- To develop trust between education and training providers across borders through a common understanding of quality in education and training.
- To compare and possibly strengthen the mutual recognition of qualifications and to harmonise the assessment of learning outcomes.
- To facilitate workforce mobility and retention of suitably qualified and experienced personnel across the EU.
- To allow a fast and efficient knowledge, skills and competences transfer from one technology field to another.
- To provide confidence in the safe and secure development and production of energy in developing countries through the use of defined learning outcomes in their education and training programmes.

[59] http://ec.europa.eu/euraxess/

[60] Learning outcomes (or results) are what a learner knows, understands and is able to do after a course of learning, as opposed to learning inputs such as the length of a learning experience or the type of institution, etc. The EQF, a transparency instrument voluntarily applied by Member states, uses learning outcomes defined in terms of knowledge, skills and competences.

Action 3.2.1 Knowledge, Skills and Competences (KSC) Recognition Framework in the Nuclear Field

The Knowledge, Skills and Competences Recognition Framework in the Nuclear Field should be seen as being complementary to the above Actions 1.1.8, 1.2.8 and activities under 2.1. The strategy and end user needs should also be discussed with the EHRO-N and with the ENEN.

Two pilot activities are proposed to kick-start the operation of this framework:

Activity 1: Network of National Certification Bodies

This activity aims at establishing a Network of National Certification Bodies in charge of discussing a possible mutual recognition system for portfolios of learning outcomes using the ECVET tools (e.g. "ECVET partnerships", "Personal Transcript of Record"[61], etc). For job qualifications or functions requiring the approval of nuclear safety authorities, reference should be made to European authoritative regulatory expert bodies such as ENSREG and HERCA to discuss possible commonalities. This task should build on an initial analysis of the nuclear ECVET implementation system to be carried out by the EC DG JRC/IET (Petten, the Netherlands). The work should benefit from existing structures that are coordinated nationally in cooperation with CEDEFOP[62].

- EQF Level: all
- Timeframe for implementation: Year 0+2

Activity 2: Nuclear ECVET Implementation Pilot Project

The objective of this activity is to set up a pilot project regarding the implementation of the ECVET principles, building on the experience gained in the past and current "*Euratom Fission Training Schemes*" (EFTS).

This activity should focus on an assessment of the learning outcomes of training packages related to Design, Operation and Decommissioning. It should build on the current activities run by the JRC/IET (Petten) related to the development of a commonly recognised job taxonomy. Such pilot project should act as a role model for further ECVET implementation projects in other nuclear fields. Complementary actions conducted at OECD/NEA and IAEA should also be taken into account.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+3

[61] The mentioned "Transcript" does not constitute a license or an official authorisation (in the legal national regulatory sense).

[62] EU agency Cedefop located in Thessaloniki, Greece (depending upon the EC DG EAC / Education and Culture). The Cedefop is the "Centre européen pour le développement de la formation professionnelle" or "European Centre for the Development of Vocational Training"- http://www.cedefop.europa.eu/EN/

Action 3.2.2 Knowledge, Skills and Competences (KSC) Recognition Framework in the Low Carbon Technology Fields

The *Knowledge, Skills and Competences Recognition Framework in the Low Carbon Technology Fields* should be developed in close collaboration with the Low Carbon Technology Human Resources and Skills Observatory listed under Action 3.3.1. The nuclear field's experience with ECVET tools is useful in this respect, and should be taken into consideration.

One pilot activity is proposed to kick-start the operation of this framework. If successful, it will be applied to other energy technology fields as appropriate.

Activity 1: Wind Energy ECVET Implementation Pilot Project

The objective of this activity is to set up a pilot project regarding the implementation of the ECVET principles, building on the experience in the nuclear field.

This activity should focus on an assessment of the learning outcomes of training packages such as wind physics, rotor design, electric power systems and offshore engineering.

The schemes should seek to facilitate the transfer of higher-level knowledge and technology between disciplines, sectors and countries. The ultimate goal is to develop a European passport for Continuous Professional Development, which relies on the principles of common qualification criteria, a common mutual recognition system, and the facilitation of teacher, student and worker mobility across the EU.

- EQF Level: 4-8
- Timeframe for implementation: Year 0+3

3.3 Human Resources and Skills Observatories

Action 3.3.1 Low Carbon Energy Technology Human Resources and Skills Observatory/ies

In order to fine-tune educational programmes for the expected dramatic increase in the need for well-educated employees and entrepreneurs in this field, understanding and qualifying the future workforce is necessary. In this context, the *Low Carbon Energy Technology Human Resources and Skills Observatory/ies* should address the following guiding objectives:

- To produce and regularly update a quality-assured database on the short-, medium- and long-term needs of human resources in the different low-carbon technology fields, based on a sound methodology.
- To conduct periodical surveys of business and research organisations' skills requirements in order to help education and training institutions to adapt academic/vocational courses and programmes.

- To regularly review and assess the Roadmap's implemented education and training activities in order to monitor achievements and impact generated.

- To provide a common reference system for education and training in the field via ECTS/ECVET and related portfolios of learning outcomes, thus supporting cooperation as well as harmonisation of European approaches to strengthen the skill base of the workforce, at the same time encouraging excellence and new developments.

The Observatory/ies should be established in the context of the SET Plan Information System (SETIS)[63] and should be based on the clustering of existing innovation networks in Europe. It should be oriented along the technology supply chains and their actors in a comprehensive way. It should also take regional differences in the skill profile of different actors into account. In addition, the Observatory has to involve a large panel of stakeholders that need this information for decision making.

The Observatory/ies has to cover all levels of education, in particular academic education and vocational training.

- EQF Level: all
- Timeframe for implementation: Year 0+3

Action 3.3.2 European Nuclear Sector Education & Training Council

The Nuclear Sector Education & Training Council aims to carry out strategic analyses of gaps and shortages on a continuous basis, to provide innovative paths to improve flexibility of the sector workforces and improve learning outcomes and training supply.

In synergy with EHRO-N, it should facilitate services related to job qualifications that are based on portfolios of learning outcomes (knowledge, skills and competences) in view of their recognition across the EU; carry out detailed gap analysis in nuclear energy at all stages of the nuclear fuel cycle, including future needs of educators and trainers. This Council should work closely with national and international education and training institutions concerned with assessment, quality assurance, validation, certification and recognition of the proposed portfolios following, in particular, the ECVET guidelines. It should create synergies with relevant sector skill alliances or other industry-academia partnerships at EU level. Coordination with other energy sectors should also be developed.

- EQF Level: all
- Timeframe for implementation: Year 0+2

[63] http://setis.ec.europa.eu/

Action 3.3.3 Establishment of National EHRO-N Contact Points in the Member States (incl. a chapter for Fusion)

EHRO-N's operation should be actively supported by the EU Council and Parliament, national governments, nuclear safety authorities, nuclear industry and the education and training organisations within the EU-28. As a result, an authoritative and comprehensive network will be set up for strong interaction between nuclear energy stakeholders in the EU-28 as far as questions of nuclear human resource monitoring are concerned. To do so it is proposed to set up a Network of National Contact Points with active counterparts from the Member States, in order to strengthen the qualitative outcome of EHRO-N data, analysis and recommendations. Such a Network should be in charge of developing and devising a commonly agreed methodology and database on the demand/supply situation of nuclear human resources. This network should comprise an active communication strategy to EU and Member States' governmental, higher education, and private organisations involved in the nuclear education and training field. This network should work closely with the existing Euratom *National Contact Points*[64]: the NCPs are instrumental to raise information awareness about Euratom driven research and training actions.

The national contact points should serve also as contact points for the Nuclear Sector Education & Training Council under Action 3.3.2.

- EQF Level: all
- Timeframe for implementation: Year 0+3

[64] Euratom *National Contact Points* - http://cordis.europa.eu/fp7/ncp_en.html

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Abstract

In moving forward energy technology innovation, the SET Plan has recognised that one of the key elements for successful implementation at EU level is the availability and mobilisation of appropriately skilled human resources. The energy sector is an evolving field which creates new job opportunities but at the same time requires the development of new skills and competences. The challenges for the education and training institutions and their legal frameworks will be to ensure a workforce flow of researchers, engineers and technicians who are able to generate new knowledge and to meet the requirements of evolving technologies and labour markets. In parallel, training for managers and decision-makers in the field is needed to design and implement appropriate frameworks for the development and deployment of new energy solutions.

The SET Plan Roadmap on Education and Training addresses the human resource challenge for the energy research and innovation sector and constitutes an integral part of the SET Plan agenda. It puts forward recommendations for key education and training activities to advance the provision of adequate human capital and to assist the development of the necessary cooperation frameworks among academia, research institutes and business. The document may serve as a programmatic guide for energy education and training activities for both the European Union's and Member States' programmes.

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