A holistic and Scalable Solution for research, innovation and Education in Energy Transition

D2.2 Report on RIE needs related to energy transition

Work Package	WP2 - Energy transition skills identification and societal challenges
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Executive Summary

This document reports the main findings about the activity carried out to identify the skill needs required from the labour market in the multiple areas cross-related to the transformations associated with the energy transition to a low-carbon society and to tackle skills gaps as well as skills mismatches.

This challenging objective has been pursued through the implementations of a double track approach:

1. from one side, we carried out a review of well-established national studies focused on the KSCs related to the energy transition;
2. on the other side, LS has undertaken a desk analysis with the first aim to identify the most innovative technologies correlated with the clean energy transition.

The most important findings achieved from the above activities are:

- there is a pressing need for universities to introduce a **holistic approach** in many of the courses for university students who, at the end of their curriculum of study, will likely undertake a kind of job related to the energy transition. This holistic approach shall allow the delivery of inter-disciplinary KSCs, namely embedding technical-scientific disciplines and areas as well as soft skills and abilities to cope with societal challenges;
- the outstanding importance to **establish ecosystems,** where various stakeholders from universities (professors and students from different disciplines), large and small-medium sized industrial and business companies, research institutes, public agencies (e.g. at the local level) and end-users, collaborate to develop case-based and problem-based learning modules, innovative courses and train-the-trainer strategies related to sustainable energy (EE and RES) in a real-life context.

Focusing on learning programs, modules and innovative academic courses for the Clean Energy sector, we **identified and scrutinized a number of relevant projects and databases** which offers an **extensive selection of education and training courses, topics and specialisations** providing the necessary skills for most of the energy transition needs.

In this context, we firstly have focused our attention on the three technologically most important areas of energy research and innovation in the field of sustainable energy, namely:

1. Energy Efficiency (EE)
2. Renewables Integration
3. Smart Grids and Energy Systems

For the **EE area**, we found that, at least a generic understanding of the following topics should be covered: **System Simulation/Modelling, (Renewable) Technologies/Energy Sectors - All, Energy System Control, Technology Use, Building Design**. Additionally, certain topics need to be covered in much more detail, e.g., general methodologies for energy management, economic evaluation of EE measures and risks assessment, building energy management, power plants O&M.

At doctoral level, the **interdisciplinary integration of different topics** needed to achieve systemic energy efficiency should take priority.

Focusing on **RES**, a broad range of master's, doctoral and research programs in all renewable energy technologies (e.g. solar PV, concentrated solar power, wind, geothermal, hydro, wave, biomass, etc.) have been identified. However, distributed, multi-source generation raises complex multidisciplinary questions about technical, environmental, economic and social issues. For this reason, educational and training programs on RES integration should cover, at least, the following topics: **an overview of RES,** including a comparison with non-RES; **how RES interface with the energy grid** and other energy

systems; understanding of how different forms of energy are used and their **respective value to society;** energy system interaction **to balance production with demand,** across time and geography**; the economic, social and political factors influencing energy and the role of society and citizens in the take-up of renewable energy solutions**.

The wide range of different challenges in **smart grids and energy systems** require a varied skill set, while also a few specific topics such as smart meter communication requirements and models to predict and match demand should be studied. Designing/delivering master's programs on smart grids and energy systems entails to focus on: Energy Infrastructure-Smart Grids-Distribution Networks; (Renewable)Technologies/Energy Sectors - Chemical (e.g. bio-fuels) and either combine these or explore a specific field.

Evaluating skill mismatches for the clean energy sector, e.g. as difference between demand potential of needed skills and the number of 'uncovered posts', is a very complex task, often compromised by a lack of sufficiently good statistical information. For that reason, this report includes data, from the literature review, which concern just **cross-sectoral skill shortages**.

Going back to the search of **basic skill needs**, some examples of technical skills and competencies definition cross-related to sustainable energy discipline engineering specialisation have been summarized in the last part of section 4.

Finally, even if a very deep and extensive groundwork have been already fulfilled at European level, it clearly emerges the need of a systematic work to be done.

As a way forward to achieve the fundamental goal of **identifying and updating**, along the time, **research and learning skills**, we are proposing a **methodology** which main points for action are:

1. **to foster a strong commitment from university leaders**. This should allow more student-led ideas and innovative initiatives, new models of learning, including the greater inclusion of digital technologies, a life-long commitment to the continued development of new energy-related professional skills by employers and employees;
2. **interviews to a specific focus group** including representatives selected from universities (either technical and SSH Departments), research institutes, training organizations, industrial companies, authorities, and the citizen;
3. **elaboration and delivery of an ad hoc questionnaire** addressed to a wider audience.

The combined utilization of the last two kinds of different tools should enable to mitigate the specific weakness points of each of them; additionally, activity 3 can benefit of the synergies from the Questionnaire implemented by UNINA in the framework of Task 2.1.

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List of Acronyms

Abbreviation / acronym	Description
CE	Community Energy
CAWI	Computer assisted web interviewing
EC	European Commission
ECTS	European Credit Transfer and Accumulation System
EE	Energy Efficiency
EERA	European Energy Research Alliance
ESI	Energy System Integration
ET	Energy Transition
EUA	European Universities Association
FF	Fossil Fuels
HLG	High Level Group
IEA	International Energy Agency
ICT	Information and Communication Technologies
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
ISIC	International Standard Industrial Classification
IOT	Internet of Things
LMSI	Labour market and skills intelligence
LS	Logical Soft
KETs	Key Enabling Technologies
KSC	Knowledge, Skills, Competences
PPAs	Public Power Purchase Agreements
PV	Photovoltaic
RES	Renewable Energy Sources
RIE	Research Innovation Education
SET – Plan	Strategic Energy Technology - Plan
SSH	Social Sciences and Humanities

Abbreviation / acronym	Description
STEM	Science, Technology, Engineering and Maths
TFEC	Total Final Energy Consumption

1. Introduction

1.1 Purpose & scope

The purpose of this document is to report the main findings from the activity carried out to identify the skill needs required from the labour market in the multiple areas cross-related to the transformations associated with the energy transition to a low-carbon economy and to tackle skill gaps as well as skill mismatches.

Considering the factors that shape research (Figure 1), the achievement of this challenging objective has been pursued through various steps that can be easily understood from the reading of the 'structure of the deliverable' detailed in the next page.

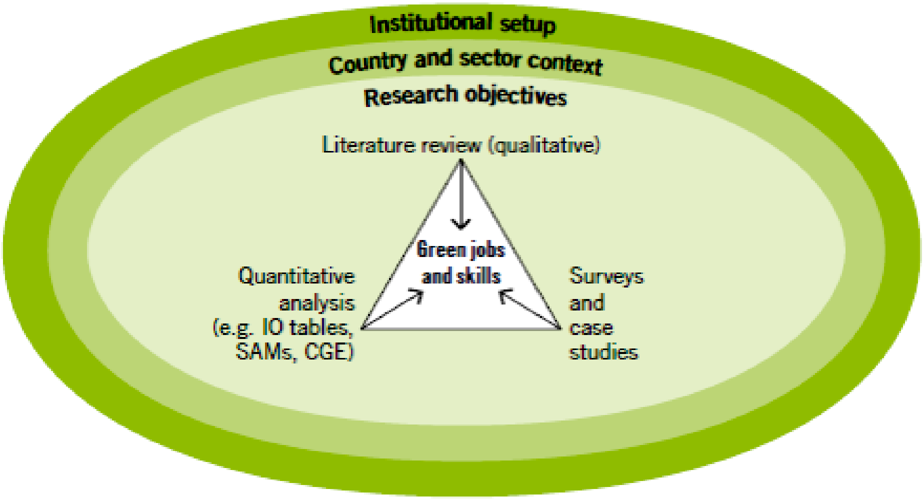

Figure 1 - Factors that shape research

1.2 Structure of the deliverable

This report (part of Work Package 2, Task 2.2 "Skill shortage, training, and educational needs") summarises the review findings and provides information on educational and vocational training needs, including key competences induced by the on-going energy transition to a low-carbon economy. Efforts have also been addressed to identify current skill shortages and to tackle future skills gaps.

More in detail, the report includes the following sections:

2. "The Drivers of change: How the energy transition is shifting KSC needs", where are recalled the main ways by which the energy transition toward a low-carbon economy will likely affect skill needs evolution;
3. "Review of well-established studies focusing on the KSCs related to the energy transition", that summarizes the results of a twofold activity, from one side a review of well-established national studies focused on the KSCs related to the energy transition (complete review presented in Annex 1), on the other side a desk analysis aimed to identify the most innovative technologies correlated/embedded with the energy transition;
4. "KSC needs and RIE gaps" which identifies the gaps between Knowledge, Skill and Competences needs and interprets them to RIE needs taking into account the available educational programs. In particular, the first part of the section refers to the skill needs linked with the three technologically most important areas of energy research and innovation in the field of

sustainable energy, namely energy efficiency, renewables (integration) and smart grids and energy systems. Then, we provide a summary of information and data about cross-sectoral skill shortages for ICT professionals, e-Leadership and Key Enabling Technologies (KETs). Some examples of basic technical skills and competencies definition cross-related to sustainable energy discipline engineering specialisations which have been identified from the existing databases are showed in the last part of the section, while a more extensive list of topics and specialisations is included in the Annex 2;

5. "A pathway to timely identify skill needs: The way forward", keeping in mind that skill needs identification is a dynamic task which evolves across the time, in parallel with several factors, such as the technological development, legal and regulatory framework, industry needs, environmental requirements, etc. clearly emerges the need of implementing a systematic work to identify and update interdisciplinary research and learning skills. To achieve this fundamental goal, we are proposing a qualitative methodology which main points for action are:
    a. interviews to a specific focus group including representatives selected from universities (either technical and SSH Departments), training organizations, industrial companies, authorities, and the citizen;
    b. elaboration and delivery of an ad hoc questionnaire addressed to a wider audience.
6. Conclusions.

1.3 Relation to other WPs and Tasks

The main goals of the task 2.2 are:

- exploit the information that will be contributed by the organisations involved in the ASSET community;
- review well-established studies relevant to the skills that are in shortage, the training needs and user requirements for both new talents and upskilling of the current workforce as well as the needs to increase social awareness.

It is expected that this deliverable will allow ASSET consortium to identify the skill shortage and evaluate training needs related to the energy transition topics. Therefore, this task is strictly connected to T2.3 (Framework for learning programme models in the energy sector) and WP3 (Energy transition programs preparation), as the outcomes of T2.2 will be the basis for designing ASSET learning graphs and defining the content of ASSET educational programs.

2. The drivers of change: How the energy transition is shifting KSC needs

Global warming and environmental degradation are threatening the sustainability of many kinds of economic activity around the globe. Even if global warming was developing gradually and thus the solutions could be gradual, best climatologists and scientists and their institutions worldwide are emphasising that the process is non-linear[1] and that it is very urgent to take actions to shift towards a low-carbon economy.

The transformation associated with the clean energy transition affects skill needs, at least, in four possible ways:

1. firstly, the green transformation shifts activities in the economy, for example from those that are less energy efficient and generate higher CO_2 emissions towards those that are more efficient and less polluting (e.g. use of renewable sources to produce electricity, instead of fossil fuels in large generating facilities);
2. secondly, new skills will be needed by workers in many existing occupations and industries in the process of greening the existing jobs. For example, within the automotive industry, workers across a range of jobs, from engineering design to the assembly line, will have to work with new fuel-efficient technologies (e.g. hybrid and electrical vehicles). In another example, farmers in many parts of the world will have to adjust to more severe drought conditions, requiring them to learn how to grow new crops or new methods for producing the same crops (e.g. through hydroponic systems);
3. thirdly, structural changes induced by the introduction of new policies and regulations (driven by the dual imperatives of limiting climate change and fostering sustainable growth);
4. fourthly, the development of new technologies and practices result in the emergence of some entirely new occupations. For example, with reference to the development of innovative technologies, it is worthy to mention the astounding trends of digital technologies (Figure 2) lead by impressive decline of collection, storage and transmission costs (over 90%, from 2008 to 2016).

[1] Due to the accumulation of carbon dioxide in the atmosphere and several additional contributors such as increasing water vapor and less light being reflected into space due to the melting ice mass.

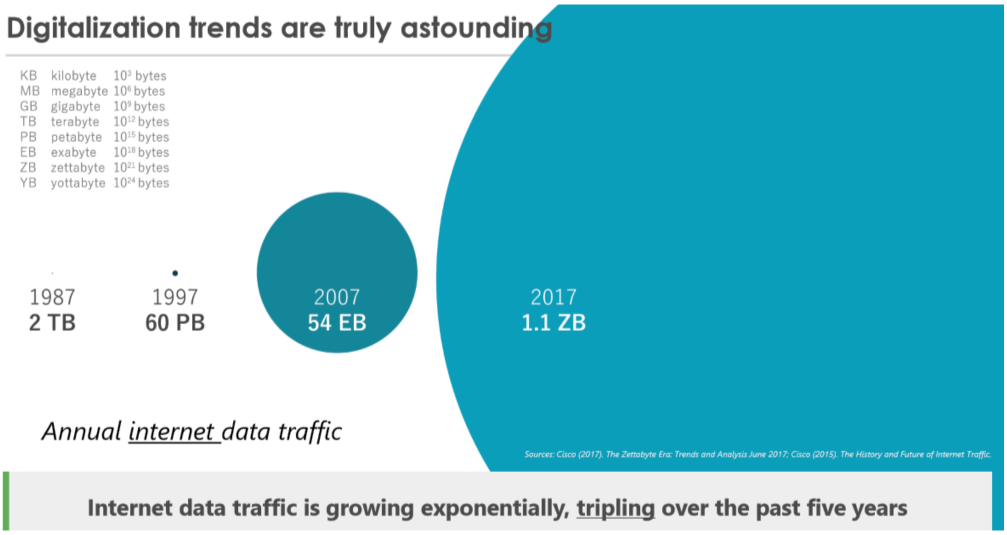

Figure 2 - Digitalization trends[2]

The four mentioned drivers of change are interrelated. All sources of change – shifts between industries, development of new occupations and changing skill profiles within occupations - alter the skill profiles of occupations and thus affect training needs and delivery.

The scale and extent of these changes depend in turn on the speed and breadth of technological and market changes in the green transformation.

[2] Source: IEA, Modernising energy efficiency through digitalisation, Brian Motherway, Head of Energy Efficiency, March 2019

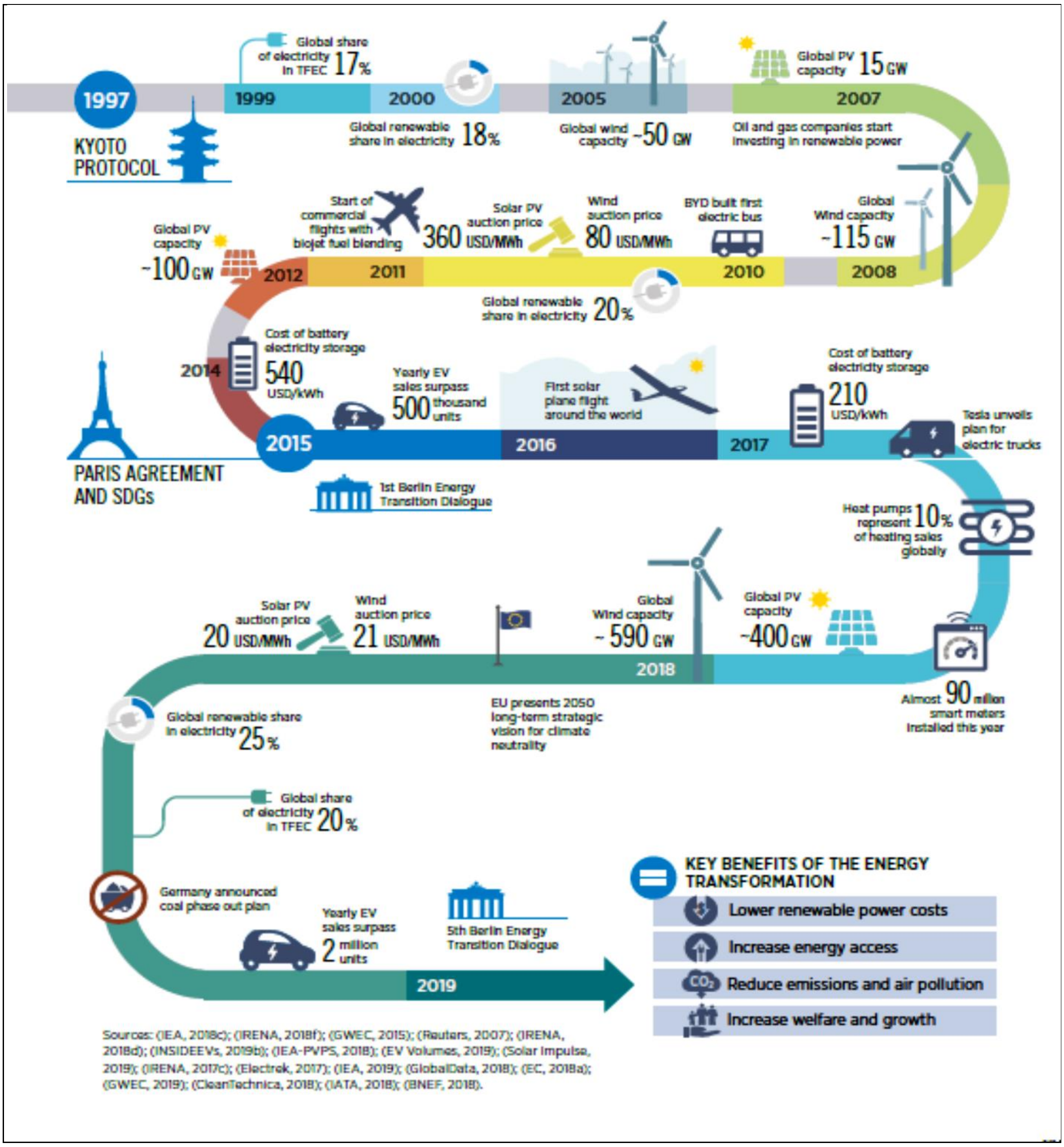

Figure 3 - Recent progress of the energy transformation - Key milestones[3]

In that regard, the EU set out very challenging climate and energy targets for 2020 and 2030. Achieving these goals will require huge technical and economical efforts necessary to decarbonise the whole economy, but, at same time, it would enable the EU to maintain the first mover advantage, notably in energy efficiency and renewable energy.

It is mainly for that reason that the Energy Union strategy has set out the objective to create an environment that allows investors and businesses to fully seize new opportunities, and consequently be able to generate new jobs and growth.

Indeed, a transition towards a low carbon economy driven by innovation offers opportunities for growth and jobs as new businesses and job profiles will emerge. In particular, growth sectors such as renewable energy or energy efficient products and services provide opportunities for European technological leadership.

[3] Source: IRENA (2019), Global energy transformation: A roadmap to 2050 (2019 edition), International Renewable Energy Agency, Abu Dhabi.

This transformation also requires restructuring between sectors, with for instance expected negative impacts on traditional fossil fuel extraction industries.

However, to enable this economic transformation, the **workforce across a wide range of sectors** would need to adapt to new business models and methods and **meet the demand for new green skills**.

3. Review of well-established studies focusing on the KSCs related to the energy transition

To identify KSC needs linked with the clean energy transition, we followed a double track approach:

1. from one side, we carried out a review of well-established national studies focused on the KSCs related to the energy transition.
2. on the other side, LS has undertaken a desk analysis with the first aim to identify the most innovative technologies correlated/embedded with the energy transition. In this case, the review has been implemented through a top–down approach, hanged on the investigation about reports and papers issued by the main energy R&TD networks and international organisations, such as EERA, IEA, EC services, IRENA, EUA, etc. Starting from the outcomes of that literature review, we implemented a further activity that enabled us to identity a set of skill needs cross-related to the identified innovative technologies and of cross-sectoral skill shortages. The identified skill needs, which are showed section 4, represent information that interested universities might evaluate and/or consider for introduction among their learning courses.

3.1 National context

The activity carried out with reference to the first item has been **implemented with strong involvement support and contributions from various project partners**, namely ECOPOWER (from The Netherlands), OTEA & UWA (for Greece), UNINA (for Italy), UPV (for Spain), EASE (for Belgium) and RWTH (for Germany).

The main outcomes concern the identification of several national and international studies and reports implemented by various qualified authors to individuate KSC needs necessary to ensure a balance between education and vocational training and the labour market of the energy sector, in the next future.

Despite the national situation can vary among different countries in terms of transformation objectives, socio-economic dynamics, structure of energy production and energy consumption, value systems and the maturity of civil society, most of those studies include information and data having a few common characteristics that can be used to find out the needs for knowledge, skills, and competencies relevant to energy transition, in a number of member states.

While an extensive annotated list of those studies, achieved by collecting and putting together information provided by ASSET project partners, as well as from the specific investigation done by LS, is included in Appendix 1, hereinafter we recall a summary of the main findings from the literature review on skills and competences for the energy transition carried out at a national level.

3.1.1 Papers in French

The reviewed literature places emphasis on the need for novel regulatory frameworks and innovative governance as well as for raising awareness of the public audience. With respect to the jobs and employees' profiles, the building sector is expected to represent 43% of the jobs in the energy transition, while coordination skills having multi-disciplinary backgrounds is also highly needed. The documents reveal the need for energy transition and digital transition to converge and additionally the need to deeper involvement of women in the sector.

3.1.2 Papers in Dutch

While SER (Social and Economic Council of the Netherlands) advices for appropriate labour and education training of employees by social partners and the government in order to strengthen the support in Dutch society for the energy transition, the development of employment in energy-related sectors may face complications in adapting current standards as converging themes describe the patterns of complex dependencies in the energy system, rather than leading to precise predictions. For that reason, technological advances in fields such as urban energy progressively involve the participation of specialists from multiple scientific backgrounds. Crucial also is that we explore choices in the transition between supply and demand to soften the bottleneck caused to the labour market.

3.1.3 Papers in Spanish

The categorisation of the transition's required properties, as a dynamic transformation process, can be defined and summarised in three main groups. These are Sustainable Mobility, Consumer sectors and efficiency and future scenarios, along with their subcategories and prerequisites. But for this transformation to be fruitful, discussions about the approach of the transition between employers, unions and governments should be accomplished. That is because, it is important to create and provide with activities which will boost employment, presenting certain job titles. Specifically, the Spanish national training system proposes skills development and presents employment opportunities on: a) Sustainable mobility b) Building rehabilitation, and c) Energy generation.

3.1.4 Papers in Italian

Even though there are high hopes and opportunities for the changing scene of Italy's renewable energy industry, tensions are present with implications focused on the institutional, relational, and territorial dimensions to unfold how energy innovations occur within territorial contexts.

The main sector-bound scenarios are outlined regarding the reduction of energy impacts, the priority analysis sectors and work processes, with the aim of identifying and analytically describing professional roles, either innovative or re-qualified and their verification through the analysis of both expressed and potential professional and educational requirements. In this respect, we are witnessing the socio-economic impact of development policies on Italy's energy efficiency in terms of job and professional relapse resulting in benefiting the workers while also attracting new ones. In order to provide individuals with sustainable choices, it is significant not only to enhance the employees' education profile by establishing projects such as 'The Crux' to prepare future applicants, but also awaken their ethical point of view to ensure the security, health and well-being of the public is of primary importance and to meet society's need for sustainable development.

On the other hand, environmental innovations may have a negative effect on employment as knowledge diffusion process through intra-industry externalities assumes a crucial role in the employment effects of innovation. To battle this, clear and strong economic strategies and actions to favour job creation relative to environmental activities are needed for a full sustainable achievement of firms.

3.1.5 Papers in Greek

There is a strong need to train energy experts and environmentally sound fresh technologies and building methods as well technologies, as structures have a strong impact on energy consumption and on the types of materials that can be used to power any building. Soft skills are clearly required in all kinds of employment, not just in the energy industry; in all sectors of the Greek economy, individuals with elevated concentrations of soft skills are extremely required. There is a definite need for Greek people to be informed and encouraged by greener behaviour.

A program for the training of unemployed persons in certified Vocational Training Centres with compulsory employment in green professions was announced. The energy setting in Greece is accomplished through the creation of the required legislative and legal system. It involves the development, adoption and tracking of the execution and assessment of energy policies capable of generating a structure for the evolution of the energy generation combination. The energy industry may be a prerequisite for economic growth. Another significant driver of this industry is the reality that renewable sources are immediately related to the green economy and development in Greece, even though RES is faced with many hindrances.

3.1.6 Papers in German

In Germany, there is a big gap between the demand and offers in the area of digitalization, data science, IT-security, and information and communication technology as well as a high demand for programs on storage technologies, load management, control engineering as well as modelling and simulation. A wide range of training courses is already available for the common types of production from wind, sun and biomass, even if a need to develop programs that investigate sector coupling/ interactions is still present. It emerged also a clear lack of modular and part-time continuing training courses.

There is a need to provide training to people who wish to work in the energy sector but are coming from another field of expertise (lateral entry) along with vocational training. A shortage in skilled workers is expected for SHK (i.e. building sanitation, heating, and air conditioning). Even without a full "Energiewende", programs have to be in place to enable the inclusion of women, older people, people with an immigrant background, young people without vocational qualifications, and people with disabilities in the workplace.

Open platforms and workshops are necessary for open discussions to increase public communication with stakeholders and experts. To enlarge the acceptance and inclusion of different societal sectors, workshops to raise awareness on a responsible research and innovation process should include different stakeholders such as members of the research community, industrial companies, educators, citizens, etc. More learning spaces, where civil society organisations, scientists, and policymakers learn to deliberate directly, openly, and reflexively on preferences and choices are necessary.

3.2 Summary from the reviewed literature

The evolving scene of the world's energy industry has started to increasingly evolve and hold strong hopes and possibilities towards a greener future. For this to happen, the most common and significant variant presented for the energy transition to occur is education and training.

In their content, the reviewed documents underline the adversities which green technologies and practises will have to face and address for the purpose of gradually becoming even more accepted and exploited. In addition, for the green transformation to bring positive outcomes, discussions about the approach of the transition between employers, unions and governments should be accomplished. That is because, it is important to create and provide a framework which will boost employment.

Another significant driver for growth is the reality that renewable sources are immediately related to the green economy, and development. Thus, the energy industry may be a prerequisite for economic development, even though RES are faced with many hindrances. It is also wise to say, we are witnessing the socio-economic impact of development policies on energy efficiency in terms of job and professional relapse resulting in benefiting the workers while also attracting new ones.

A further discussed issue is the fact that knowledge diffusion process through intra-industry externalities assumes a crucial role on the employment effects of innovation. To adequately face the associated potential risks, it is necessary to realise a clear and stable regulatory and legal framework which favours job creation for environmentally friendly products manufacturing and, thus, a sustainable development of firms.

After analysing the national literature, it becomes clear that:

- the **implementation of the energy transition vision requires people** (all citizens, employers, employees and policy makers) **to change their attitudes**, recognise sustainability as a major issue and realise the need to multi-disciplinary understanding;
- the intensity of the **needs for different skills and/or multidisciplinary backgrounds is different among EU countries**; for example, in Italy socio-territorial issues are more prominent, while in Spain three more narrow sectors (sustainable mobility, building rehabilitation, energy generation) are in great need of green professionals;

- **as evolving fields, energy, transport and manufacturing require continuous updating of the knowledge base**. Many of the low carbon technology options are not yet mature. Hence, there is a **need to systematically update research, education and training programs** at all levels with new research-based and industrial knowledge and to **provide adequate interdisciplinary integration of knowledge** from relevant fields. This should go in parallel with encouraging and supporting new knowledge creation and basic research developments in universities, including joining efforts along common objectives, as well as developing adequate professional training schemes to provide for shifts in the existing workforce;
- evidence from a number of countries shows that **skill shortages have already occurred** in a number of "green" sectors and occupations. Such shortages affect, particularly, SMEs, which are often relatively unaware of the technological and operational adaptations required by the low-carbon developments;
- In the manufacturing sector, the **shift to greener technologies** has **generated** a significant **need for specific** engineering **skills** (e.g. electric engineering for hybrid cars, manipulation of light materials, product design) or for specific occupations (e.g. energy auditors, photovoltaic installers, insulation workers, environmental engineers);
- **systems of skills formation that foster labour mobility and transfer of existing skills** to different sectors, locations and workplaces (e.g. lateral entry) are needed. A large number of the current workforce in these and adjacent sectors should undergo re-training;
- new programs have to be implemented to enable the inclusion of women, older people, people with an immigrant background, young people without vocational qualifications, and people with disabilities in the workplace, making the challenge even more perceptible;
- to enlarge the acceptance and inclusion of different societal sectors, **workshops to raise awareness on a responsible research and innovation process** should involve several different stakeholders;
- **more learning 'spaces'**, where civil society organisations, scientists, and policymakers learn to deliberate directly, openly, and reflexively on preferences and choices **are necessary**.

3.3 Main findings from the desk analysis about innovative technologies

Developments in the fields of energy, transport, manufacturing, agriculture and also in land use are key for realising the move towards a sustainable and secure low-carbon economy - meeting the EU climate and energy targets for 2020 and 2030 and addressing the long-term vision towards reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050[4].

In reality, implementing the EU policy objectives in this field is largely dependent on the development and advancement of efficient and cost-effective low carbon energy solutions, a key objective of the EU's Strategic Energy Technology (SET) Plan.

An analysis performed for the SET Plan Education and Training Roadmap shows that in 2012 the main low-carbon energy fields employed around 9 million people. Realising the 2050 vision, the performed analysis reveals a projected doubling of the workforce by 2030.

The above considerations explain the usefulness of the b. activity that we carried out in order to identify skill needs linked with innovative technologies and to find out the likely expected impact of the ET on stakeholders.

This work involved an attentive analysis of reports and papers issued by some of the most qualified national and international organisations which work to foster reliable, affordable and clean energy,

[4] With the international COP21 Paris Agreement governments agreed to limit global temperature rise to "well below 2°C" and make efforts to limit the rise to 1.5°C.

such as International Energy Agency (IEA), International Renewable Energy Agency (IRENA), the EC services (e.g. Strategic Energy Technology Information System), the European University Association (EUA), or other bodies operating in the field of vocational education and training, such as Cedefop, International Labour Office (ILO).

While an indication of **skill needs linked with the innovative technologies** is **provided** in the next **section 4**, hereinafter we summarize the **most important findings** about the **expected impact** of the energy transition on **stakeholders**; these findings, in our opinion, represent a real added value with respect to the predominant current vision.

University needs

- there is a pressing need for universities to introduce a holistic approach in many of the courses for university students who, at the end of their curriculum of study, will likely undertake a kind of job related to the energy transition. This **holistic approach**, pursued, for instance, by bringing groups of students with different backgrounds together to understand the various angles from which a specific discipline looks at such challenges, shall allow the delivery of inter-disciplinary KSCs, namely embedding technical-scientific disciplines and areas as well as soft skills and abilities to cope with societal challenges. They also help develop interdisciplinary communication skills.

  The above-mentioned need comes from the consideration that one of the big energy transition challenges is social, requiring us to overcome political, economic, behavioural, cultural and territorial barriers. **Social sciences and humanities** are therefore as important as engineering and natural sciences, contributing theoretical and conceptual frameworks, methodologies.

  Indeed, we should be aware that any energy transition roadmap will interact with the evolution of the socio-economic system upon which it is deployed, producing a series of outcomes that can be understood as the **socio-economic footprint**[5].

The degree to which this footprint includes benefits or less favourable outcomes depends on the synergies between the energy transformation and the evolution of the socio-economic system. The balance between benefits and less favourable outcomes varies by region due to their diverging transformation ambition and different socio-economic dynamics.

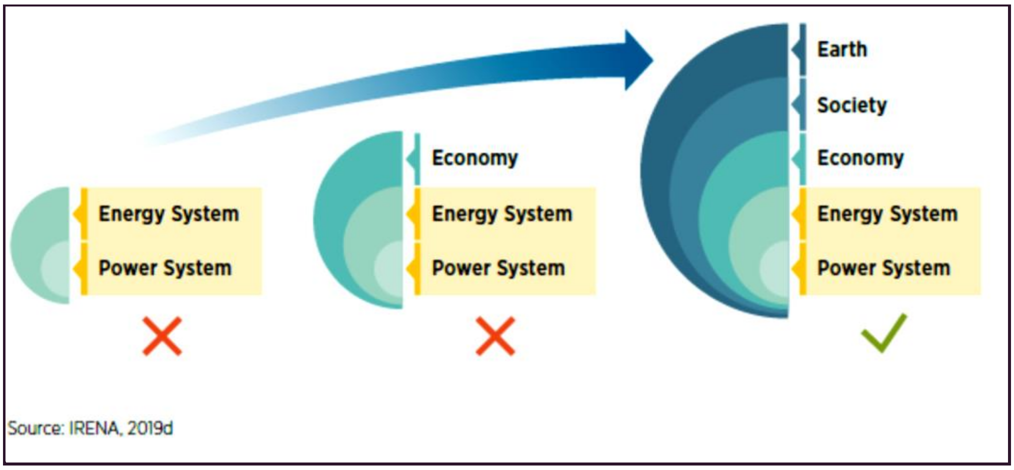

Figure 4 - The embedded nature of the energy system

The power and energy systems are embedded into the wider socioeconomic system, which in turn is embedded into the earth and its climate. In order to avoid dysfunctional outcomes, a holistic policy framework is needed to frame and support the transition (Figure 4).

[5] The socio-economic footprint of the energy transformation measures the net result of the multiple interactions between the energy transformation and the socio-economic system

Furthermore, most energy researchers and specialists agree on the concept that a meaningful clean **energy transition cannot occur** without a **strong involvement** of the **citizen** whose role should evolve, moving from the current position of simple end-user or passive consumer to the one of a very active players of tomorrow' energy system (Figure 5).

Figure 5 - Empower energy consumers

Finally, the creation of **Communities Energy (CEs)** that can be seen as the societal response to the Great Recession that began in 2008 and lasted most of the subsequent decade. In fact, they appear as a viable option to guarantee the best operation of a large number of small renewable plants.

CE initiatives today are more diverse than at any time previously and are likely to continue to act as incubators for pioneering initiatives addressing virtually all aspects of energy. However, despite the growth of CEs, we ought to be aware that large multinational energy firms remain the dominant vehicle for the delivery of the energy transition, while a good operation of CEs will require a strong involvement of SSH skills to help address the many open societal issues arising from the global change.

The key need for energy specialisation enhanced by a broader perspective can be illustrated by the recent integration of T-shaped skills into programmes at several universities. The vertical bar of the T represents the depth of skills and expertise related to a specific field, while the horizontal bar represents a more general understanding of other disciplines, creating an ability to work with experts in other areas and apply knowledge in other areas of expertise.

For future energy specialists, the horizontal T bar should include opportunities to learn about other technical areas as well as a range of social, economic, regulatory, human and political topics, to provide an understanding of whether and how different technical approaches will be adopted. Social science and humanities specialists (e.g. Market Economists, Lawyers, Political Scientists, Urban Planners) will need to know about a range of technical topics as part of their horizontal T bar. They will also need to learn about views across the social sciences

Stakeholders' involvement

- the outstanding importance to **establish ecosystems** where various **stakeholders** from universities (professors and students from different disciplines), large and small-medium sized industrial and business companies, research institutes, public agencies (e.g. at the local level) and end-users of the technology, **collaborate** to develop case-based modules and problem-based learning, innovative courses and train-the-trainer strategies related to sustainable energy (EE and RES) in a real-life context.

  The implementation of such an approach will have a double positive impact:

  - to upgrade the competence profiles of researchers and engineers for the energy transition;
  - to enhance the capacities of European universities.

4. KSC needs and RIE gaps

The aim of this chapter is to identify the gaps between Knowledge, Skill and Competences needs and the available educational programs. Towards this aim, we first present the knowledge, skills and competencies needed with emphasis to those that are in shortage and we interpret them in RIE needs, taking also into account currently available educational programmes. Our final goal is to confirm that ASSET programmes fill in current gaps and also identify additional gaps to be filled outside ASSET. Another important goal is to ensure that not only technical but also cross-disciplinary and societal aspects are taken into account.

Our study is based on literature review with **Error! Reference source not found.** being the main s ource that provides an overall view of the sector as well as internal consortium discussions. The analysis of the outcomes from relevant projects and of information from existing databases gives the chance to get an overall picture of KSC needs and the available learning programs, modules and innovative academic courses which enable students to acquire/internalise the skills that are needed by the labour market across the energy transition to a low-carbon economy. Obviously, skill needs will heavily depend on the profile of the 'Energy Professional'. Here, we are making reference to the definition from the UNI-SET Project[6], stating that is as someone with "the set of knowledge, skills and attitudes required to provide the required quantity and quality of energy to every end-user at the lowest price, based on the consumption of minimal raw materials with minimum environmental impact, using a rational lifecycle covering all phases from production to end-use". This definition also indicates that **the need for cross/multi-disciplinary study** is only a starting point that will need to evolve to a truly interdisciplinary education, in which subjects are analysed, synthesised and harmonised into a coordinated and coherent whole. Students and researchers that graduate with these new profiles will include: **Energy System Scientists/ Engineers, Energy Economists and Energy Policy Makers**.

In the first part of this chapter, we address our attention on **the three technologically most important** areas of energy research and innovation in the field of sustainable energy, namely:

- Energy Efficiency
- Renewables Integration
- Smart Grids and Energy Systems

while afterward we will present information and data **about cross-sectoral skill shortages** with focus on ICT professionals and key enabling technologies (KETs). It is worth stressing that ***even in the three technological areas,*** **the KSC mentioned** are not only technical **but address legal, ethical, economic and societal aspects.**

In each of the areas addressed we include tables with the Knowledge, Competences and Skills needed. In **each table**, we also indicate:

a) the EQF level currently considered appropriate for tackling the relevant KSCs;
b) The type of need, i.e. whether it is technical/economic/legal/societal or other;
c) The stakeholder group mostly interested and affected by the availability of the relevant KSC. This last information is important for the Universities and training actors so as to design educational/training programs that better match the requirements of the targeted groups.

The stakeholder groups are divided into the following categories:

- Stakeholder group 1: Universities, research centres, training actors;
- Stakeholder group 2: Companies from the energy sector;
- Stakeholder group 3: Policy makers, authorities, public administrations, market regulators

[6] Project Report "Energy Transition and the Future of Energy Research, Innovation and Education: An Action Agenda for European Universities" - December 2017

- Stakeholder group 4: Societal actors (NGOs, consumers' associations, professional associations, trade unions, industrial associations, chambers of commerce);
- Stakeholder group 5: Energy citizens (individuals as potential energy citizens, prosumers (producer & consumer), Renewable Energy Communities - RECs, Renewable Energy Sources Cooperatives – Rescoops - and Rescoops federationss;
- Stakeholder group 6: Students (university) and new employees

It should also be highlighted that there is a debate around the definition of "Competence" as compared with "skills". As such, their definition in the following tables reports mainly "how" much competent a person would be with respect to a certain skill.

Lastly, in the ending part of this section, we will highlight some examples of technical skills and competencies definition cross-related to sustainable energy discipline engineering specialisation which have been identified from the spotted databases (a more extensive, even if nor definitive neither exhaustive, list of disciplines and specialisations is included in the Annex 2).

4.1 Energy Efficiency Strand

The correct adoption and utilization of best available efficient technologies is crucial to achieve global and local energy efficiency targets. The needs detected in this sector as captured in **Error! Reference source not found.** are presented in the following table where we have also mentioned the target group and we provide more elaborate skill definition compared to the literature.

Table 1 - Topics for educational courses in relation with energy efficiency

Energy Efficiency				
Knowledge	**Competence**	**Skills**	**EQF**	**Type**
The factors that influence systemic energy efficiency, incl. integrating energy along life cycles and within the spatial/ geographic context (stakeholder group: 1,2,5,6) sector: all	The relationship between energy efficiency and life cycle (stakeholder group: 1-6) sector: all	Propose energy efficiency measures at process level, possibly underpinned by data gathering (stakeholder group: 1,2,6) sector: industry	Master	**Technical**
	EE technologies and planning methods in industry and buildings (stakeholder group: 1,2,6) sector: industry, building	Multi-physics modelling and simulation (stakeholder group: 1,2,6) sector: industry, building	PhD	**Technical**
	EE planning method (stakeholder group: 1,2,6) sector: industry	Energy efficiency assessment and evaluation Design and implementation of energy efficiency equipment and strategies	PhD	**Technical**
Instrumentation for energy measurement Measurement of energy consumption and losses Interpretation of energy	Energy saving data Metering and Verification. Simulation results and data gathered from measured consumption to improve energy efficiency (stakeholder group: 1-6) sector: all	Propose energy efficiency measures and efficiency improvements in a life cycles perspective (stakeholder group: 1-6) sector: all	Master	**Technical**

Energy Efficiency				
Knowledge	**Competence**	**Skills**	**EQF**	**Type**
data Design of new instruments and services for energy efficiency Non-intrusive load monitoring (stakeholder group: 1,2,6) sector: energy industry				
Energy management (stakeholder group: 1,2,6) sector: all	Technology use (stakeholder group: 1,2,6) sector: all	System Simulation/ Modelling (stakeholder group: 1,2,6) sector: industry, building	Master	**Technical**
Thermodynamics Building Design (in terms of energy efficiency)	Building Design (in terms of energy efficiency) (stakeholder group: 1,2,6) sector: building	Energy System Control (stakeholder group: 1,2,6) sector: all	Master	**Technical**
Specific energy efficient technologies for residential, tertiary and industrial sectors Power plants O&M. Modules related to single efficient technology for the Tertiary, Residential and Industry sectors (e.g. CHP, LED, Building insulation, Heat Pumps, etc.) Integration of energy resources at building level Standards of the thermal and electrical energy system (stakeholder group: 1,2,6) sector: industry, building	Power plants O&M. Modules related to single efficient technology for the Tertiary, Residential and Industry sectors (e.g. CHP, LED, Building insulation, Heat Pumps, etc.) (stakeholder group: 1,2,6) sector: industry, building	Design of energy management systems for commercial buildings Efficient energy management systems for data centres (stakeholder group: 1,2,6) sector: building	Master	**Technical**
	Rebound effect. Understand through behaviour analysis: – how EE improvements relate to improvements in quality of life, and – how to incentivise a utility to foster the lowest possible level of end-user consumption (stakeholder group: 1-6) sector: all		PhD	**Technical**
Life cycle costs analysis of energy use with regards to generation efficiency (stakeholder group: 1,2,6) sector: all	Calculate economic indicators (i.e. NPV, IRR, PBT) to evaluate cost-effectiveness of new installations/ interventions (stakeholder group: 1,2,6) sector: all	Propose profitable and sustainable (costing) Energy Efficiency Improvement Measures (EEIMs) (stakeholder group: 1,2,6) sector: all	Master	**Economical**

Energy Efficiency				
Knowledge	**Competence**	**Skills**	**EQF**	**Type**
The impact of pricing scheme (e.g. cost-reflective tariff vs progressive tariff of kWh) on management and new installations (stakeholder group: 1,2,3,6) sector: energy industry	Evaluate the impact of the tariff structure on the exploitation of innovative efficient technologies (e.g. heat pumps, Evs, etc.) (stakeholder group: 1,2,3,6) sector: energy industry	Propose innovative business models for increased energy efficiency (uptake) (stakeholder group: 1,2,6) sector: all	Master	**Economical**
The deployment barriers for efficiency improvements (stakeholder group: 1-6) sector: all	Social barriers as part of a holistic analysis to improve energy efficiency (stakeholder group: 1-6) sector: all	Propose and apply new models for fostering behavioural change by end-user (stakeholder group: 1,5,6) sector: all	Master	**Social**
	Social barriers as part of a holistic analysis to improve implementation/integration (stakeholder group: 1-6) sector: all	Consider social barriers (stakeholder group: 1-6) sector: all	Master	**Social**
The roles of actors in and impact on efficiency improvements (stakeholder group: 1-6) sector: all	The impact of (new) technical processes in their spatial and social context. Social and behavioural aspects of energy efficiency (stakeholder group: 1-6) sector: all	Interaction among different actors along the value chain/in the spatial context to improve systemic EE (stakeholder group: 1-6) sector: all	PhD	**Social**
Stakeholder interaction (consumers, prosumers, investors, etc.) for systemic energy efficiency (stakeholder group: 1,4,6) sector: all	Socio-technical issues: – how the various sectors use energy and interact within and with each other how RE technologies then penetrate the larger socio-technical status quo and transform the energy system (stakeholder group: 1-6) sector: all	Deep analysis on how innovation can create technological niches for energy efficiency (stakeholder group: 1,2,6) sector: industry, building	PhD	**Social**
Environmental regulations on efficiency and requirements (stakeholder group: 1-6) sector: all	Adequate incentives for citizens and companies to move towards better energy efficiency (stakeholder group: 1,3,4,6) sector: all	Foster the adoption of Minimum Environmental Criteria within Procurement processes in the Public sector. (stakeholder group: 1,4,6) sector: all	Master	**Legal, Regulatory**
Potential impact of economic incentives for energy (stakeholder group: 1-6) sector: all			Master	**Legal, Regulatory**

Energy efficiency issues must form an integral part of any master's programme for students wishing to plan and operate industrial sites and/or residential and commercial buildings. In addition to the general energy-related components, a fraction of the methodologies and technologies curriculum should be dedicated to ***energy efficiency*** modules.

At least, a generic understanding of the following topics should be covered: System Simulation/ Modelling, (Renewable) Technologies /Energy Sectors – All, Energy System Control, Technology Use, and Building Design.

Additionally, a number of specialised topics need to be covered in much more detail, for example, widespread methodologies for energy management (e.g. implementation of energy diagnosis, energy management systems complying with ISO 50001, methods and protocols for metering and verification of energy savings,..), economic evaluation of EE measures and risks assessment, building energy management, power plants O&M, along with modules related to single efficient technology for the Residential, Tertiary and Industry sector (e.g. Building insulation, CHP, LED, Heat Pumps, Electric Motors and Drives, HVAC, Hybrid and EVs, , Fuel Cell, Energy Storage, etc.).

These generic elements do not need to be provided as stand-alone courses – they could be integrated in other parts of the curriculum dealing with related issues.

At doctoral level, the interdisciplinary and transdisciplinary integration of different players needed to achieve systemic energy efficiency should have priority. Course elements must complement knowledge acquired at master's level, to ensure that all doctoral candidates in energy-relevant disciplines have a **fundamental understanding** of:

- Energy efficiency technologies and planning methods in industry and buildings.
- Stakeholder interaction (consumers, prosumers, investors, etc.) for systemic energy efficiency.
- Social and behavioural aspects of energy efficiency. This point is highly important, given that to fully realise the potential energy saving it is not sufficient to exploit the most efficient technologies, but it is also required to use them in the better possible way[7].

Overall, the following are considered important **research subjects**:

- Energy efficiency planning method – Many different planning methods are used in different disciplines and at different levels. The potential benefits of combining planning methods need more thorough research.
- Total energy requirements – European industry is a major energy consumer. Increasing the energy efficiency of industrial systems and outside factory gates (e.g. local and regional energy systems) is a major field of research for better energy efficiency. Transport is also a major energy consumer and while the efficiency of a particular mode of transport (land, air, water) is often examined, little work considers the optimal combination of these different modes.
- Model collaboration - Many scientists acknowledge that the best model classes should be combined for a new and more integrated approach to modelling. Models do not need to be larger and/or more complex. By using model collaboration, different approaches and tools can be combined.
- Socio-technical transitions - Meeting EU energy efficiency goals will require the transformation of our entire energy system from how energy is produced, distributed, and consumed to how the various sectors use energy and interact within and with each other. Accomplishing this requires an understanding of how such transitions occur, the identity of the players and how they are connected in the larger value chain (e.g. property owners

[7] Qualified studies give an estimation of the energy savings associated with behavioural change ranging from 5 to 30 %, depending on the sector involved.

versus residents). It also requires research into how innovation can create technological niches for energy efficiency, and how these then penetrate the larger socio-technical status quo and transform the energy system.

- 'Rebound' effect - Any energy efficiency initiative must also include mechanisms and strategies to understand and counteract the so-called 'rebound' effect. Behaviour analysis and incentive structures need to be identified to give a better understanding of how efficiency improvements relate to improvements in quality of life and of how to incentivise a utility to foster the lowest possible level of end-user consumption.
- (electrical, heat, etc.) and then calculating conversion efficiency.

A distinction may be opportune for PhD programs that differ from other academic programs as they involve original research in a specific area to generate *new knowledge and insights*. They consequently tend to be narrow and focussed. However, doctoral programs in the field of energy should equip successful students with an additional, broader understanding of how their research can be applied, as this is highly beneficial for careers at universities, in the ***energy industry and related business and public bodies, including regulatory agencies, NGOs***, etc.

4.2 Renewables Integration Strand

Policy support and technology cost reductions are leading to rapid growth in variable renewable sources of generation, putting the power sector at the forefront of emissions reduction efforts but requiring the entire system to operate differently in order to ensure reliable supply.

The transition to a low-carbon society is largely dependent on the successful integration of energy from low-carbon, renewable sources. Significant progress is required to meet 2020 and 2030 EU Energy Strategy targets. As for energy efficiency, also in this case, a wider utilisation of renewable energy sources is a necessary condition to achieve global and local sustainable energy targets.

However, to achieve the Integrated SET Plan ambition for an Energy Union that's number 1 in energy efficiency and renewables, it will not be sufficient to only have highly efficient low-cost technologies: renewable technologies must also be successfully integrated into the EU's energy system. Here, with 'Renewables integration' we intend fully and effectively integrating RE technologies in a way that maximises their contribution to meeting our energy needs. The developing concept of Energy System Integration[8] is obviously an important aspect for integrating renewables.

It is internationally regarded as a key emerging approach in energy research and industry, as demonstrated by: (I) the creation of the US industry and iiESI National Labs, and (ii) the new European Energy Research Alliance Joint Programme in ESI.

Energy system integration, needed as long-term solution to meet energy demand, requires a holistic approach effectively integrating a range of different energy technologies. One major challenge, here, is the need to get **efficient interconnection between established, mature technologies and new, renewable technologies** to achieve an efficient overall energy system from production to user. The challenge for micro-grids or emerging energy communities is to integrate several new technologies.

A **critical issue** involved in the greater use of **renewables** is that they are **intermittent and random available** – so greater emphasis needs to be placed on appropriate **energy storage systems, renewable sources integration across time and geography and availability of excess generation capacity** (redundancy) with respect to the needs; excess capacity can then be used to produce hydrogen from water electrolysis.

Renewables offer an opportunity to embed distributed sources into existing energy infrastructure, which is increasingly seen as a more flexible alternative to large centralised electricity generating

[8] ESI is defined as: "the process of coordinating the operation and planning of energy systems across multiple pathways and physical scales in order to deliver reliable, cost effective energy services with less impact on the environment"

facilities. Distributed, multi-source generation raises complex multidisciplinary questions about technical, environmental, economic and social issues.

With reference to involved **companies**, they will soon **have to face** with **another layer of complexity** as they take on responsibility for system integration and must meet new requirements, such as up and down flexible generation and adding storage to their sites. They will also be exposed to major commercial risk as the share of guaranteed revenues from feed-in tariffs and public power-purchase agreements (PPAs) declines and commercial terms become more stringent.

To cope with these challenges, companies will need:

- to optimize activities across the entire value chain, from engineering to commercial capabilities (in engineering, for instance, operators will need to optimize plant design to maximize yield and minimize costs).
- to capture both sets of economies, whether globally (for technological economies of scale in areas such as procurement, for instance) or locally (for market understanding and analysis).

Companies will also need **strong capabilities in hybrid technologies and storage** to counteract intermittency and meet future regulatory demands.

The needs detected are included in the following table.

Table 2 - Topics for educational courses in relation with renewables and their integration in smart energy systems

Renewables Integration				
Knowledge	**Competencies**	**Employment Skills (Master level)**	**EQF level**	**Topics**
Basic knowledge of how energy systems influence energy flow (stakeholder group: 1,2,5,6) sector: all	Characteristics of energy vectors, including capacities, efficiencies, the importance of the rate of charge/ discharge and network location (stakeholder group: 1,2,6) sector: all	Approaches that maximise the contribution of renewable technologies including - Control and monitoring of systems with variable RES generation - Control and monitoring of DC systems - Control and monitoring of hybrid systems (stakeholder group: 1,2,5,6) sector: energy industry	6-8	**Technical**
Successful integration of renewable sources in different sectors (stakeholder group: 1-6) sector: all	The interconnection between established, mature technologies and new, renewable technologies Integration technologies based of HVDC Integration technologies based on AC-DC hybrid systems (stakeholder group: 1,2,6) sector: all	Modelling and integration of RES system with the existing energy system Integration technologies based of HVDC Integration technologies based on AC-DC hybrid systems (stakeholder group: 1,6) sector: energy industry	6-8	**Technical**
How to achieve an efficient overall energy system from production to end-user Optimization of renewable	The comparison with non-RES energy sources and vectors. (stakeholder group: 1-6) sector: all	Different energy storage and buffering options for different energy vectors. Optimization of renewable energy usage	6-7	**Technical**

Renewables Integration				
Knowledge	**Competencies**	**Employment Skills (Master level)**	**EQF level**	**Topics**
energy usage (stakeholder group: 1-6) sector: all		(stakeholder group: 1,2,6) sector: energy industry		
The current status and future potential of many RES and how each of them can be developed and brought together as a holistic system (stakeholder group: 1-6) sector: all	Overview of the technology (including working principles), markets, barriers and techno-economic performance (stakeholder group: 1-6) sector: all	Develop techno-economic data projections for the modelling community and policy makers (stakeholder group: 1,3,6) sector: all	6-8	**Technical**
The usability and management of different energy vectors, such as electricity, fuels, heat and hydrogen (stakeholder group: 1,2,5,6) sector: all	Energy system interaction to balance production with demand, across time and geography (stakeholder group: 1,2,5,6) sector: all	Approaches to controlling energy flows Control of power flow in local energy systems Integration of local energy systems and DSO (stakeholder group: 1,2,6) sector: energy industry	7-8	**Technical**
The costs related to RES exploitation and operation (stakeholder group: 1,2,3,4,6) sector: energy industry	Determine: capital and operating costs; thermal efficiencies and technical lifetimes; GHG gas emissions, water consumptions (stakeholder group: 1,2,6) sector: all	Propose solutions consistent with the local energy market and required future shifts (stakeholder group: 1-6) sector: all	6-7	**Economical**
Energy market functioning (stakeholder group: 1-6) sector: energy industry	How energy market participation might affect control (stakeholder group: 1-6) sector: energy industry	Analyse energy markets, energy poverty, ownerships, system service and regulatory costs (stakeholder group: 1,2,3,4,6) sector: all	7-8	**Economical**
kW vs kWh tariffs, capacity/ consumption prices of smart meters (stakeholder group: 1,2,3,4,6) sector: energy industry	Business cases from a consumer, utility and/or aggregator point of view (stakeholder group: 1,2,5,6) sector: energy industry	Propose business models for complex energy systems (stakeholder group: 1,2,5,6) sector: all	7-8	**Economical**
The role of society and citizens in the take-up of renewable energy solutions, e.g. public perceptions of energy (stakeholder group: 1-6) sector: all	The value attributed from the society to energy-service (stakeholder group: 1,3,4,6) sector: energy industry	Create/propose new types of tariff which reflect the social value of RES (e.g. internalize the external costs associated to FF utilization) (stakeholder group: 1,3,4,6) sector: energy industry	6-7	**Social**
The social impact of using renewable energy to minimise environmental impact (stakeholder group: 1-6) sector: all	Shift approach from energy demand to energy services supply (stakeholder group: 1,2,5,6) sector: energy industry		6-7	**Social**

Renewables Integration				
Knowledge	**Competencies**	**Employment Skills (Master level)**	**EQF level**	**Topics**
User engagement with their energy consumption (stakeholder group: 1-6) sector: all	Determine the limits and constraints of any technological solution and its integration (stakeholder group: 1,2,6) sector: energy industry	Analyse public perceptions of energy, energy practices, energy choices, prosumers, energy dialogues and the differing ways in which energy affects different clients (stakeholder group: 1,4,5,6) sector: energy industry	6-7	**Social**
How user involvement affects the energy system (stakeholder group: 1-6) sector: all	Country differences in regulatory environments - identify/propose future improvements (stakeholder group: 1,3,4,6) sector: all	Develop useful tool for policymakers for helping to identify future priorities for research, development and demonstration (RD&D) (stakeholder group: 1,3,4,6) sector: all	6-7	**Legal, Regulatory**
Legal and Regulatory framework (stakeholder group: 1,3,4,6) sector: all	Potential legislation barriers for RES adoption and how to overcome them (stakeholder group: 1,3,4,6) sector: all	Act to ensure a level playing field for all competing energy sources (stakeholder group: 1,3,4,6) sector: all	6-7	**Legal, Regulatory**
		Develop effective economic and policy frameworks that engage and incentivise companies to adopt new renewable technologies. (stakeholder group: 1,3,4,6) sector: energy industry	6-7	**Legal, Regulatory**

Digital tools and skills will be key to competitiveness along the asset life cycle, from site identification to project EPC, predictive maintenance, and revenue analytics. There are also interesting challenges for local generation and use versus energy 'sharing' across local and national boundaries. The roadmap from existing energy generation and technologies network to this new world will be complex, partly due to the different and evolving levels of contribution from current technologies and more sustainable and renewable approaches. A broad range of technological improvements will be required through the implementation period.

Successful integration of renewable sources will also partly depend on our ability to continue to improve the efficiency of all current and future technologies in the energy chain (in other words, **renewables sources** and **energy efficiency** cannot be treated as independent systems but **have to be always jointly analysed**).

Due to the complexity of each of these problems, energy system professionals will need a broad **understanding** of many renewable technologies, their **current and future potential** and a sense of how each can be developed and brought together as a holistic system.

In this context, it is important to be aware that economic and energy policy frameworks also exert a considerable influence on the impact of energy technologies. In the past, this was often overlooked, but a review of the deployment of, for example, solar PV/thermal in Europe confirms that actual integration was driven more by economic and policy frameworks than by technology improvements.

The scale of the challenge for the 2020 and 2030 horizons confirm that technological improvements will have to be accompanied by effective economic and policy frameworks that engage and incentivise companies to adopt new renewable technologies (e.g. guaranteeing a level playing field).

Before dealing with learning programs for Renewables Integration, we underline that a broad range of master's, doctoral and research programmes in all renewable energy technologies (e.g. Solar PV, wind, geothermal, hydro, wave, biomass etc) has been identified by highly qualified sources (e.g. UNI-SET University Survey and Atlas). However, to achieve the Integrated SET Plan ambition for an Energy Union that's number 1 in renewables, it is not sufficient to only have highly efficient low-cost technologies. Renewable technologies must also be successfully integrated into the EU's energy system. So, this is the area where the on-going rapid developments are requiring new skills to face the emerging issues arising from the interaction between renewable sources and the existing energy system.

Master's programmes

Master's programmes in Renewables Integration can be grouped into four general categories:

a. Those that focus on a specific renewable technology, e.g. wind energy, PV, biomass, etc.
b. Those that focus on the grid, where renewable sources are an interesting and significant contributor.
c. Those that focus on application in a specific sector, so on actual integration in practice, e.g. buildings with integrated PV.
d. Those providing a wider overview of a technology, e.g. thermo-technical conversion

System and integration aspects are currently **often missing** from these four different master's programme types, although they need to be included.

The basis of a master's curriculum in renewable energy integration should allow every student to know how different renewable sources interact with the energy system, with society and the wider environment, and where their specific focus fits in the energy system from both a technical and social perspective.

The main components of a master's curriculum on integrating renewable energy sources should cover the following generic elements:

1) An overview of renewable energy sources including a comparison with non-renewable energy sources. The **basic working principles** of these technologies, **their intermittent and site-specific characteristics**, potential contribution, respective **efficiencies and future potential**.

2) **How renewable energy sources interface with the energy grid** and other energy systems, considering the factors that affect their efficiency. Approaches that maximise the contribution of renewable technologies, minimise associated carbon emissions and **optimise life cycle considerations**.

3) **Recognition** that **society tends to consider energy services as more desirable than energy itself** - the social value of what energy can achieve is higher than its intrinsic value. This energy-service approach generalises energy as a demand that needs to be met using renewable energy to minimise environmental impact. Indeed, **what people actually need is not energy but energy services** and this requires an understanding of how different forms of energy are used and their respective value to society.

4) **Knowledge of the different energy networks and vectors** to which these renewable energy sources are being connected. This should include an understanding of the usability and management of different energy vectors, such as electricity, fuels, heat and hydrogen.

5) **Energy system interaction to balance production with demand**, across time and geography. Students should also appreciate the importance of new, reflexive and autonomous approaches to controlling energy flows. Micro-grids offer a viable alternative in certain circumstances and these contexts should be understood. Different energy storage and buffering options for different energy vectors. The characteristics of these energy vectors, including capacities, efficiencies, the importance of the rate of charge/discharge and network location to make students aware of their potential and the numerous challenges of including them in the energy network.

6) Any energy related master's programme must also **consider the economic, social and political factors influencing energy**. It is therefore important to consider the role of society and citizens in the take-up of renewable energy solutions. The appreciation of these perspectives helps develop a better understanding of the limits and constraints of any technological solution and its integration. This includes public perceptions of energy, energy practices, energy choices, prosumers, energy dialogues, and the differing ways in which energy affects different clients. An overview of energy economics, including energy markets, energy poverty, ownerships, system service and regulatory costs should also be covered.

Giving graduates a holistic perspective will ensure that they can make a broader contribution to society.

<u>Doctoral studies</u>

Existing programs mainly focus on developing new technology, (e.g. a new type of more efficient and sustainable thin-film solar cells), while very **few programs include system-oriented activities**. This **condition should be overcome** by including minimum system-level knowledge as part of the PhD curriculum. Consequently, the framework combining specific and generic knowledge also applies. This framework adds value to doctoral research studies, as it gives students greater awareness of how individual research projects contribute to the energy system. Modelling and expanding on these new integration strategies and their implications for future renewable energy technologies should be also useful.

The **multi-/inter-disciplinary approach also provides significant opportunities** for **new cooperation** at many levels, including within an institution, connecting scientific, engineering and social science researchers and networking doctoral candidates. The possibility to study Business Intelligences as well as Strategic Thinking and Analysis of Scenarios in order to equip students with the ability of design and anticipate future challenges and trends could be also considered at a doctoral level but probably also at the master's degree level.

There are many **opportunities for cooperation within university groups and between universities and industry**. All this help ensure that the future workforce embraces the more multi-disciplinary, holistic approach essential to achieving the successful integration of renewable technologies.

4.3 Smart Grids and Energy Systems Strand

Information Communication Technology (ICT), Internet of Things (IoT) and Artificial Intelligence (AI) have been the driving force behind smart technologies and are therefore also key to further developments in these and related fields. In the energy sector, the initial drive towards a Smart Grid came from the growth in small, distributed energy generation combined with an interest in achieving high levels of self-consumption or local consumption of that energy. This meant that the grid moved away from its previous hierarchical structure.

Additionally, an interest in shifting energy consumption in the periods when low-carbon energy is plentiful and/or exploiting the flexibility of some consumption to provide services to the grid as a whole, speeded up the development of smart grid. Consequently, the **current smart grid context involves finding the means to identify and use new flexibilities in generation, consumption, storage** or network assets to manage the electricity grid, while recognising that the traditional flexibility of fossil-fuelled, central generation is not any more available as in the past.

However, the concept of smart grid development can also include the move towards smart metering and the reduction of unnecessary AC/DC conversions and of transmission and distribution losses by introducing decentralised distribution networks.

There is an increasing trend towards a network of different networks and even different energy types (electrical, heat) that need to be interconnected and need to communicate with each other to deliver an optimised solution, to ensure resilience.

All these changes aim to find better ways **to match generation with consumption**, especially as renewable based generation is available intermittently, random and therefore unable to track demand. Thus, **capacity building to predict renewable output is particularly important** for demand planning.

The needs detected are included in the following table.

Table 3 - Topics for educational courses in relation with smart grids and energy systems

Smart Gris and Energy Systems				
Knowledge	**Competencies**	**Skills**	**EQF level**	**Type**
The functionality of grid components and distribution of grid dynamics such as grid dynamic behaviour in power electronics power systems (stakeholder group: 1,2,6) sector: energy industry	The interplay of distributed generation/local use/network operation constraints to ensure grid stability and energy efficiency dynamic of systems of systems (stakeholder group: 1,2,6) sector: energy industry	Propose solutions to update network operation to emerging constraints, with the ability to work across borders between different systems (stakeholder group: 1,2,6) sector: energy industry	6-8	**Technical**
Individual/multi energy grid components and (multi-energy) system theories/interactions (stakeholder group: 1,2,6) sector: energy industry	Holistic system analysis and modelling of electrical grids, thermal and gas distribution systems as multi source/carrier systems (stakeholder group: 1,2,6) sector: energy industry	Overall energy system analyses and implementations to improve energy flexibility by playing on the different energy vectors Design of control and monitoring for multi-energy systems (stakeholder group: 1,2,6) sector: all	6-8	**Technical**
Energy Infrastructure-Smart Grids-Distribution Networks (stakeholder group: 1,2,6) sector: energy industry	Control and communication structures for smart grid systems, including big data elements Digital automation of distribution systems Big data Artificial Intelligence techniques for energy Cloud services for energy New communication technologies (e.g. LTE) for automation and energy management	Integrate correlated information and synchronized measurements Digitalization of automation in distribution Integration of energy and smart city services Programming and data management (for start-ups in energy services) (stakeholder group: 1,2) sector: all	6-7	**Technical**

Smart Gris and Energy Systems				
Knowledge	**Competencies**	**Skills**	**EQF level**	**Type**
	Platforms for energy and the smart city Microgrids (stakeholder group: 1,2) sector: all			
The costs related to grid operation (stakeholder group: 1,6) sector: energy industry	Design and propose innovative tariff schemes to positively influence the energy market in certain directions (stakeholder group: 1,6) sector: energy industry	Propose solutions compatible with the local energy market and required future shifts (stakeholder group: 1,3,6) sector: energy industry	6-8	**Economical**
Energy markets (stakeholder group: 1,3,5,6) sector: energy industry	How energy market participation might affect control (stakeholder group: 1,3,5,6) sector: energy industry	Optimise market participation for different actors (stakeholder group: 1,2,3,6) sector: energy industry	7-8	**Economical**
kW vs kWh tariffs, capacity/ consumption prices of smart meters (stakeholder group: 1,3,6) sector: energy industry	Business models for technologies serving different grids (stakeholder group: 1,3,6) sector: energy industry		6-7	**Economical**
The role of society and citizens in the take-up of renewable energy solutions, e.g. public perceptions of energy (stakeholder group: 1,5,6) sector: energy industry	The value of critical energy infrastructure for different consumer types (stakeholder group: 1,5,6) sector: all	Create/propose new types of utility/ prosumer contracts and interaction with existing regulatory environments (stakeholder group: 1,3,5,6) sector: all	6-7	**Social**
The social impact of the various energy markets (stakeholder group: 1,2,5,6) sector: all	Solutions for overcoming potential barriers (stakeholder group: 1,2,5,6) sector: all	Problem-solving from the start to the end of a project (stakeholder group: 1,2,5,6) sector: all	6-8	**Social**
User engagement with their energy consumption (stakeholder group: 1,5,6) sector: all	How user involvement affects the energy system (stakeholder group:1,5,6) sector: all	Professional, social/environmental contextual awareness (stakeholder group: 1-6) sector: all	6-8	**Social**
The role of regulators and grid codes (stakeholder group: 1,2,3,6) sector: energy industry	Country differences in regulatory environments - identify/propose future improvements Influence factors in policy making Pre-standardization activities: testing, use case definition, technical argumentation (stakeholder group: 1,2,3,6) sector: energy industry	Apply grid codes Design to meet regulatory mandates Design for flexibility for expected regulatory changes Ability to propose and support changes to standards and regulation (stakeholder group: 1,2,3,6) sector: energy industry	7-8	**Legal, Regulatory**

Smart Gris and Energy Systems				
Knowledge	**Competencies**	**Skills**	**EQF level**	**Type**
Legislation issues and potential multi-scale governance of energy systems (stakeholder group: 1-6) sector: all	Potential legislation barriers for multi-energy systems and how to overcome them (stakeholder group: 1-6) sector: all	Appreciate the importance of legislation and standardization (stakeholder group: 1,3,6) sector: all	7	**Legal, Regulatory**
The political agendas of actors along the energy value chain (stakeholder group: 1-6) sector: all		Interact with different actors along the energy value chains (stakeholder group: 1-6) sector: all	6-8	**Legal, Regulatory**

The wide range of different challenges in smart grids and energy systems require a varied skill set. Individuals must possess a broad general knowledge to, e.g. appreciate impact and context, while also being able to focus on the details of a very specific topic such as smart meter communication requirements and allowing the smart grid to predict and match demand.

Designing/delivering master's programmes on smart grids and energy systems entails to focus on the following topics**: Energy Infrastructure - Smart Grids - Distribution Networks; (Renewable) Technologies / Energy Sectors - Chemical (e.g. bio-fuels)** and either combine these, or explore a specific field, such as solar, or wind in more detail to focus on a specific type of system. The main objective should be to ensure that part of a PhD study leads the candidate to adopt an all-round approach that appreciates the social, economic, political, environmental, aspects of his work. There are many **key research topics** that need investigation: **decentralised locations, energy storage, the creation of autonomous system-of-systems, long-term reliability and security**, to name a few. It is also necessary to examine how systems will be integrated with other systems, **analyse their life cycle and the materials used to construct them**, the challenges for interactions between new and existing systems as well as their individual and overall sustainability.

4.4 Cross-sectoral skills shortages

Often a lack of skills can be evident in knowledge-intensive sectors. This is the case of several sectors and professions involved in the energy transition, where **evaluating skills shortages**, e.g. as a difference between demand potential of needed skills and the number of 'uncovered posts', is a **very complex task**, often compromised by a lack of sufficiently good statistical information.

For that reason, while a methodology for identifying and updating, across the time, research and learning skill needs is included in the next Section 5, hereinafter we will **show data**, from the literature review, which concern just **cross-sectoral skill shortages**[9]**.**

Cross Sectoral KSC				
Knowledge	**Competencies**	**Skills**	**Level**	**Type**
Digital innovation and transformation (stakeholder group: 1-6) sector: all	Implications for practitioner and e-leadership skills in SMEs and start-ups (stakeholder group: 1,6) sector: all		Master	**Technical**

9 Source: COMMISSION STAFF WORKING DOCUMENT Analytical underpinning for a New Skills Agenda for Europe

Cross Sectoral KSC				
Knowledge	**Competencies**	**Skills**	**Level**	**Type**
DIGITAL MEDIA SPECIALIST ROLE (stakeholder group: 1-6) sector: all	Designs and maintains the holistic architecture of business processes and information systems (stakeholder group: 1,2,6) sector: all	Lead inter-disciplinary staff, and influence stakeholders across boundaries (functional, geographic) (stakeholder group: 1,6) sector: all	Master	
INFORMATION SECURITY MANAGER ROLE (stakeholder group: 1,6) sector: all	Business Savvy skill: Innovate business and operating models, delivering value to organisations (stakeholder group: 1,6) sector: all	- Forecasting needs for information - Understanding customer needs - Solution orientation - Communication (stakeholder group: 1,6) sector: all	Master	
DIGITAL EDUCATOR ROLE (education in the context of business incubator and accelerator schemes) (stakeholder group: 1,6) sector: all	Digital Savvy skill: Envision and drive change for business performance, exploiting digital technology trends as innovation opportunities (stakeholder group: 1,6) sector: all	• Big data analytics & tools • Cloud computing & virtualization (stakeholder group: 1,6) sector: all	Master	
Basic Knowledge on digital Entrepreneurship (stakeholder group: 1,2,4,5,6) sector: all	A partnership approach (stakeholder group: 1,6) sector: all		MOOC	

4.4.1 Focus on ICT professionals

Rapid uptake of new digital technologies, driven by developments in such areas as big data, Internet of Things, cloud computing, Business intelligence, machine learning, Artificial Intelligence, robotics and mobile and wearable technologies, has led to rapidly rising demand for ICT professionals in all sectors of the economy including energy. Thus, bottlenecks are particularly large for ICT professionals.

Employment of ICT professionals has grown by 2 million over the last decade, with more than half of the new jobs being created in the last three years. A significant amount of the demand remains unfilled and it is **forecast that the demand-supply gap will nearly double** from 365,000 in 2015 to almost 800,000 **by 2020**. The largest gaps are expected for the UK, Germany, Italy, France, the Netherlands and Sweden.

A major impediment to filling these new jobs is **the lack of new computing graduates**. Despite strong demand and above average wages, not enough young people, particularly women, are choosing to study and ultimately graduate in ICT; with graduate numbers even having fallen substantially compared to a decade ago.

The demand for ICT professionals is more than supply. **The shortage** (calculated as the number of open posts) is estimated to reach 756,000 in 2020. This figure can be described as 'demand potential' for ICT jobs. Of these 756,000 there are 530,000 potential additional jobs in ICT practitioner occupations and around 226,000 at ICT management level.

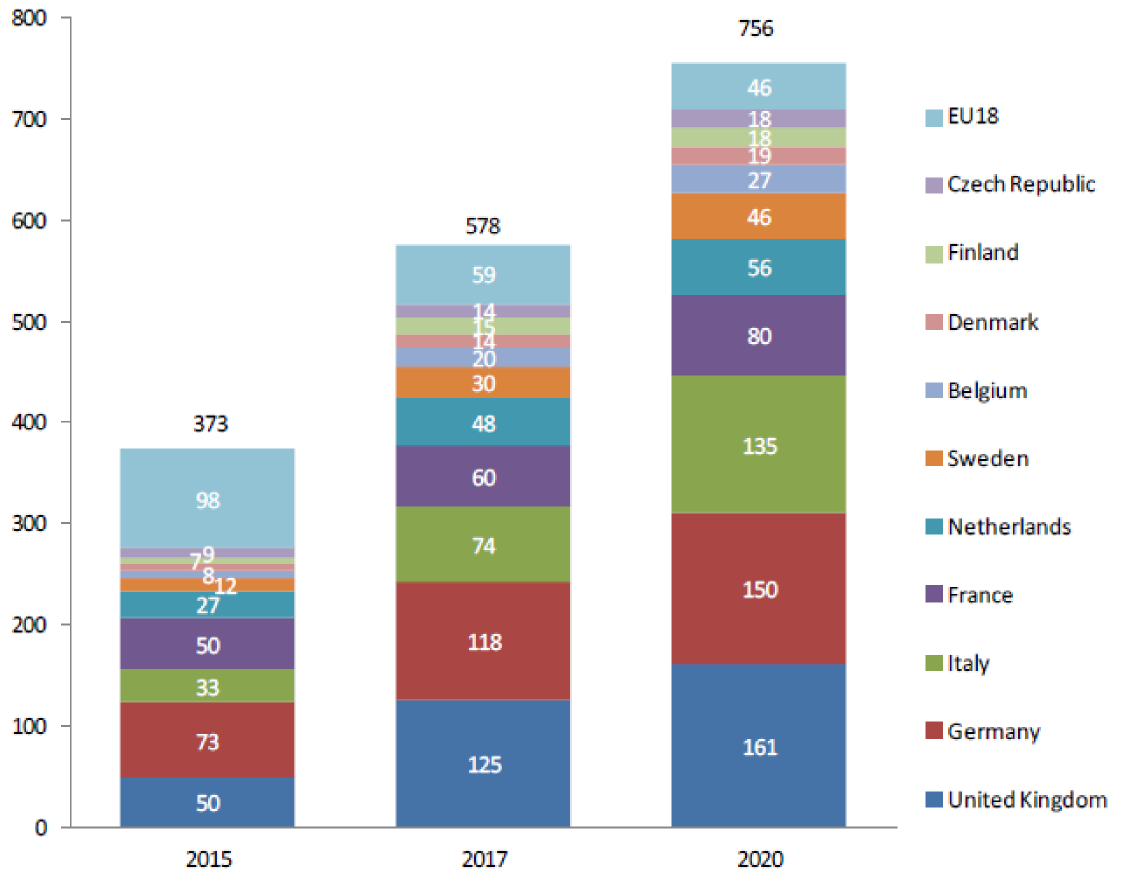

Figure 6 - e-Skills Vacancies Estimate - 'Main forecast scenario': Distribution of vacancies per country ('000s)[10]

4.4.1.1 Outlook for ICT professionals

Demand for ICT skills keeps growing at an enormous pace. The trend in core IT jobs has been up to 4% growth p.a., the growth in management jobs up to 8% growth p.a. However, demand for medium level skilled associate and technician jobs is declining. In total, despite the crisis, new jobs have been created in Europe continuously. Thus, there is a **need to continuously increase the quality and the relevance of e-skills**. At the same time, although graduate figures seem to stabilise, supply from universities does not seem to keep pace.

Job growth is largest in highly skilled jobs such as management, architecture and analytics positions, and this reinforces the need for more and better e-Leadership skills. Usually, these positions are recruited from the group of experienced professionals and other (non-ICT) managers; this fact, together with a presumed lack of entry level jobs at medium level skills may evolve into recruitment bottlenecks in the longer term. However, at the same time the pace of change seems to be still increasing in **ICT jobs, and new job profiles** appear which naturally cannot yet be fully covered in statistical classification, such as **Big Data and Cloud computing specialists**. Many of these jobs are not genuinely ICT jobs but will be at a professional level, for instance in finance, marketing, or consulting – helping new business processes be defined and implemented.

This is a huge opportunity for creation of new jobs generated in all industry sectors, beyond the traditional pathway of ICT studies, but with a strong imperative for ICT to permeate other and new educational trajectories. ICT has been traditionally a field in which outsiders – in terms of formal education or career trajectory – play a crucial role. However, recently increased efforts are made to

[10] Source: Commission Staff Working Document Analytical underpinning for a New Skills Agenda for Europe

reach a higher level of professionalisation of the profession, which increasingly includes formal education requirements. These are not necessarily to be sought in a traditional university or vocational education, but may still be acquired later in the career, a temporary solution that the ICT profession has maintained like perhaps no other profession for decades. Nevertheless**, increasing requirements of formal education make continuous professional education, lifelong learning and executive education even more important**.

4.4.2 e- Leadership skills shortages

Ensuring ICT-based innovation opportunities are identified, grasped and guided to fruition requires e-leadership at the different stages in the innovation life cycle. It is seen as particularly critical not only to be able to envision an innovation, and to assess its likely success in the organisation, but also to communicate this vision to executive colleagues controlling the resources impacted by the proposed organisational change. This was implemented as the provision of two key e-leadership component roles.

The first is the role of proposing an innovation project. The success of a proposal was conceptualised as an innovation project resulting from the proposal. Making proposals not leading to a project can be taken as an indicator of failure in e-leadership, having arisen either from inability to assess business outcome appropriately or inability to persuade business colleagues of the probability and value of the business outcome.

A second key component of an e-leadership role is seen as that of guiding an innovation project to success. This is not implementation of an IT solution, nor even managing its implementation, but acting as the client for the innovation project - assessing proposals, monitoring conformance to requirements, accepting results etc., including acting as client for delivery of solutions from outside organisations. Both these e-leadership component roles are required ensure that innovative IT applications and services are identified and successfully deployed to improve performance and competitiveness.

4.4.2.1 Outlook for e-Leaders

Recent research demonstrates that there is a significant demand of e-leaders in Europe. First attempts to quantify the existing e-leadership workforce based on company's involvement in ICT based innovation activities result in some 620,000 e-leaders in European enterprises. Around 70% of e-leaders are found in SMEs and interestingly enough, we see 59% of e-leaders outside the IT department, coming from lines of business, and 41% being IT department employees.

Closing this skills gap requires an ecosystem perspective, connecting the demand and supply side stakeholders of e-leadership skills. Responding to the inadequacies in the skills market flagged by stakeholders across the EU, the European Commission has launched the EU e-skills strategy and the "Grand Coalition for Digital Jobs". After responding to requirements for increased professionalism among ICT practitioners and developing strategies and instruments to bridge the gap between e-skills demand and supply at that level, the new focus is on the skills gap in the e-leadership domain. The first pan-European initiative on e-leadership was launched in 2013 (www.eskills-guide.eu).

A key practical instrument in communicating skills requirements are the new e-leadership curriculum profiles, which specify core skills, learning outcomes, understanding and competences required by e-leaders today, whether they lead innovation teams bringing specialist understanding of topics such as enterprise architecture or take full responsibility for enterprise innovation at company level.

A key element of these curriculum profiles and the guidelines is the requirement for mapping existing programmes onto the skills and competences of the European e-Competence Framework (www.ecompetences.eu). The e-leadership curriculum profiles and guidelines use and applicability has been demonstrated by the universities and business schools directly participating in this initiative in several European countries. Response by the education community is picking up with already more than 20 universities and business schools having evaluated their programmes against the new e-leadership profiles. Further dissemination and substantial stakeholder engagement were achieved through 10 regional cluster events throughout Europe reaching out to more than 1,200 stakeholders and experts. The initiative continues to be open to education institutions, industry and associations understanding e-leadership skill requirements in the workplace.

The European Commission launched the complementary e-Leadership Skills for Small and Medium sized Enterprises action in January 2014. This Commission initiative is complementary to the above one on 'New Curricula for e-Leadership' and focusing on entrepreneurs, managers and advanced ICT users in SMEs, start-ups and gazelles (www.eskills-lead.eu). This initiative has developed guidelines for designing e-leadership training and education for SMEs and start-up companies. It has shown the divers pathways to e-leadership for SMEs and demonstrated how five pioneering European universities and business schools have addressed the lack of appropriate e-leadership education through developing and teaching innovative short and longer-term e-leadership courses for this target group.

4.4.3 Focus on Key enabling technologies (KETs)

KETs are a group of six technologies: micro and nano-electronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies. They have applications in multiple industries and help tackle societal challenges. Countries and regions that fully exploit KETs will be at the forefront of creating advanced and sustainable economies. The **growth potential of KETs heavily relies on both the quality of skills possessed by the current and future employees**, as well as the number of people qualified, available and willing to work in KETs. Therefore, skills imbalances in KETs are likely to significantly diminish KETs growth potential and employment effects.

In its report of June 2011, the first HLG recommended that KETs skills should be promoted within the framework of the regional policy through the European Social Fund. In its status Implementation Report, the second HLG invited to put in place a European-wide education and training plan for KETs. The HLG also highlighted the need to ensure a pool of skilled multi-KETs technologists through the Future and Emerging Technologies (FET) Programme. The HLG emphasised the need for the EC, Member States and regions to address the current KETs-related skills imbalances in a comprehensive and integrated manner across all technical levels in various KETs domains.

To this end in January 2014, the Commission launched an initiative aiming to address the skill requirements for KETs. The report for the "Vision and Sectoral Pilot on Skills for Key Enabling Technologies" was prepared by Price Waterhouse Cooper (PwC). PwC analysis suggest that the key challenges leading to a mismatch in KETs skills in Europe include:

(I) a need for a regular (re-) training of current employees;

(II) **educational programmes being not fully aligned with industry needs**;

(III) high replacement needs of employers, or needs to attract new people to replace the outgoing workforce, i.e. both retiring employees and people going to other sectors;

(IV) low awareness of KETs when students make critical choices;

(V) relatively unattractive image of KETs as a field to work in;

(VI) limited opportunities to study KETs;

(VII) 'brain drain' of highly qualified people to other countries.

4.4.3.1 Demand and supply analysis of KETs skills

Due to an absence of comprehensive and harmonised employment data for KETs, the data presented below should be considered as approximate estimates.

- Demand for KETs skills in 2013 equalled an estimated total of 2,234,000 technical KETs professionals and associates. Highly-skilled KETs employment accounts for 55% of total employment, 37% medium-skilled employment and 8% low-skilled employment.

- Between 2013 and 2025 an additional 953,000 KETs professionals and associates will be needed to satisfy demand. On average, between 2013 and 2025, there will be an additional demand of 79,000 KETs workers per year (between 2013 and 2025, an increase in demand for KETs skills of 43% is expected).
- A key share of the extra demand is made up by replacement demand (e.g. due to retirement or moving to other sectors) with a total of 772,000 KETs professionals and associates. Expansion demand (i.e. new jobs) is estimated to be a relatively small share of total additional demand for KETs skills till 2025, with a total of 181,000 KETs jobs.
- **Most of jobs** related to additional demand (62%) will **require highly skilled people**, though there is also a relatively strong increase in demand expected for medium skilled people in KETs (30% of additional demand).
- The **data show potential for a skills gap**, both for high and medium skills: a possible gap in the range of approximately 21,000 to 83,000 highly-skilled KETs employees per year and 10,000 to 44,000 medium-skilled KETs workers per year, depending on how the field develops. Trend analysis shows that medium-level KETs skills potentially face both an increase in demand and a decrease in the number of graduates, which could further aggravate the current situation. Companies facing difficulties in attracting medium-level KETs skills right now are likely to find it increasingly more difficult to attract qualified professionals with these skills in the future.

PwC estimations show that ample supply of STEM graduates is anticipated in the future to satisfy the demand for KETs skills. However, currently, most of these graduates do not flow to KETs, which can partially be explained by a relatively unattractive image of KETs as a field to work in.

In order to reduce the discrepancies between education and industry needs, a European project NanoEIS (“Nanotechnology Education for Industry and Society”) **has produced model curricula for bachelor, master and doctoral studies** that can be used to check contents of existing study offers and to help structure new ones.

These model curricula combine the hard-core subjects needed in this area with other skills that are in demand by industrial and non-industrial employers. With industry and students both arguing for a stronger consideration of more general topics like health, safety, regulation and environment, it is up to university teachers and administrators to adapt to the needs of industry.

4.5 Additional evidence on KSC needs

The findings presented in the previous sections are clearly confirmed by different organisations across EU [11] and in national studies as already shown in chapter 3. Employers give particular importance to master’s programs that highlight problem or challenge-based learning, particularly when the content addresses real issues in a company’s economic and/or business environment, and also **programs that include social/human contexts** such as ethics and user interactions.

In any case, the **holistic perspective of the energy system** refers to and operates between established disciplinary specialisations including: Mechanical Engineers, Electrical Engineers, ITC Specialists, Management Sciences, Social Sciences, Economics, Policy Makers, and Experts in Inter-disciplinary Dialogue.

For that reason, hereinafter some examples of **technical skills and competencies (TSC)** definition cross-related to sustainable energy discipline engineering specialisation are summarized, while a more extensive, even if nor definitive neither exhaustive, list of topics and specialisations extracted by the above-mentioned databases is included in the Annex 2.

- Electrical Engineering Management

[11] https://www.skillsfuture.sg/skills-framework/energyandchemicals

TSC Description	Manage the design, technical specification, selection, modification and troubleshooting of electrical engineering equipment and systems in process plants		
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**
	Interpret designs, technical specifications, modification designs, constructability methods, maintenance procedures and asset integrity to provide electrical engineering discipline support to production, maintenance and project teams	Develop designs, technical specifications, modification designs, constructability methods, maintenance procedures and asset integrity to manage electrical engineering discipline support to production, maintenance and project teams	Evaluate designs, technical specifications, modification designs, constructability methods, maintenance procedures and asset integrity to drive high standards of electrical engineering discipline support to production, maintenance and project teams

- Electrical Field Maintenance Management

TSC Description	Interpret and apply routine and non-routine electrical field maintenance and inspection work instructions and regimes to ensure optimal availability and reliability of electrical equipment and control systems in process plants			
TSC Proficiency Description	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Recall fundamentals of electrical principles and electrical equipment to assist in electrical maintenance tasks, at field, in a safe and reliable manner	Identify and apply electrical maintenance and inspection procedures and work instructions to perform electrical maintenance tasks, at field, in a safe and reliable manner	Interpret electrical maintenance and inspection regimes, work instructions and procedures to coordinate electrical maintenance tasks at field	Develop electrical field maintenance and inspection regimes, workflows and procedures to reduce likelihood of failure and ensure maintenance tasks are performed correctly and consistently

- Inspection Engineering Management

TSC Proficiency Description	Manage fixed equipment and piping inspection schemes, materials selection, construction, corrosion control, condition and fitness-for-service through on-stream, risk-based monitoring programmes and downtime inspections to provide inspection engineering technical support to maintenance, engineering design and project teams				
	Level 2	**Level 3**	**Level 4**	**Level 5**	**Level 6**

	Identify and apply inspection engineering techniques, methods, standards, data analysis, life-cycle principles and equipment risk-based monitoring techniques to support inspection on fixed equipment	Interpret inspection engineering techniques, methods, standards, data analyses, life-cycle principles and equipment risk-based monitoring techniques to conduct inspection engineering on fixed equipment	Analyse inspection engineering techniques, methods, standards, data, life-cycle principles and equipment risk-based monitoring results to conduct inspection engineering on fixed equipment	Review inspection engineering techniques, methods, standards, data analyses, life-cycle principles and equipment risk-based monitoring techniques to manage inspection engineering on fixed equipment and piping	Drive direction and strategies in inspection engineering on fixed equipment and piping to advocate on-stream risk-based monitoring programmes and downtime inspection

- Instrumentation and Control Design Engineering Management

TSC Description	Manage the technical design, selection, specification, modification and troubleshooting of instrumentation and control systems in process plants to provide instrumentation and control engineering design and support to production, maintenance and project teams		
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**
	Interpret designs, technical specifications, modification designs, constructability methods, maintenance procedures, and asset integrity techniques to provide instrumentation and control systems engineering design and support to production, maintenance	Develop designs, technical specifications, modification designs, constructability methods, maintenance procedures, and asset integrity techniques to manage instrumentation and control engineering design and support to production, maintenance	Evaluate designs, technical specifications, modification designs, constructability methods, maintenance procedures, and asset integrity techniques to drive high standards of instrumentation and control engineering design and support to production, maintenance

- Instrumentation and Control Field Maintenance Management

TSC Description	Perform routine and non-routine instrumentation field maintenance and inspection work to ensure optimal availability and reliability of instrumentation in process plants			
TSC Proficiency Description	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Recall fundamentals of instrumentation and control principles and instrumentation and control devices to assist in instrumentation maintenance tasks in a safe and reliable manner	Identify and apply instrumentation maintenance and inspection procedures and work instructions to perform instrumentation maintenance tasks at field in a safe and reliable manner	Interpret instrumentation maintenance and inspection regimes, work instructions and procedures to coordinate instrumentation maintenance tasks at field	Recall fundamentals of instrumentation and control principles and instrumentation and control devices to assist in instrumentation maintenance tasks in a safe and reliable manner

- Instrumentation and Control System Maintenance Management

TSC Description	Interpret and implement maintenance regimes, processes and procedures for programming, configuration and maintenance of control systems to ensure optimal availability and reliability of process plant and equipment			
TSC Proficiency Description	Level 1	Level 2	Level 3	Level 4
		Interpret maintenance regimes, processes and procedures for the programming, configuration and maintenance of control systems to maintain control systems in a safe and reliable manner	Facilitate the implementation of maintenance regimes, processes and procedures for the programming, configuration and maintenance of control systems to manage control system maintenance tasks in a safe and reliable manner	

- Mechanical Field Maintenance Management

TSC Description	Perform routine and non-routine mechanical field maintenance work to ensure optimal availability and reliability of mechanical rotating and static equipment in process plants			
TSC Proficiency Description	Level 1	Level 2	Level 3	Level 4
	Recall fundamentals of mechanical rotating and static equipment and systems to assist in mechanical maintenance tasks in a safe and reliable manner	Identify and apply mechanical maintenance procedures and work instructions to perform mechanical maintenance tasks at field in a safe and reliable manner	Interpret mechanical maintenance and inspection regimes, work instructions and procedures to coordinate mechanical maintenance tasks at field	Develop mechanical field maintenance and inspection, procedures to reduce likelihood of failure and to ensure maintenance tasks are performed correctly

- Reliability Engineering Management

TSC Description	Manage life cycle costing, root cause failure analyses, reliability modelling and assessments, fit-for-purpose analyses and failure patterns of plant and equipment to provide reliability engineering technical support to production, maintenance and project teams			
TSC Proficiency Description	Level 3	Level 4	Level 5	Level 6
		Interpret reliability engineering techniques, methods and standards, life-cycle analyses and equipment risk analyses to provide reliability engineering support to production, maintenance and project teams	Investigate reliability engineering techniques, methods and standards, life-cycle analyses and equipment risk analyses and reliability modelling techniques to manage reliability engineering support to production, maintenance and project teams	Set direction for reliability engineering strategies to drive high availability, integrity and reliability of plant equipment and systems

4.6 Summary of currently available educational and vocational programmes

Within the EU, degree and postgraduate programs in sustainable energy can vary in terms of duration, content, curriculum, level of detail, degree, etc. However, there are some common features that can be used to classify the available programs. The main classification criteria include topic/sector, duration, assigned credits, type of degree and delivery method. Most programs are full-time studies with a duration from 12 to 24 months to complete and end with a thesis or equivalent research project. Courses are generally offered in the traditional face-to-face modality.

The main modules of the program consist of lectures and seminars based on credit and which finish with written exams at the end of each semester. Some programs are offered as part-time options with distance learning and online resources for self-learning. For distance learning programs, short seminars or exams are often required on campus. The complete online programs are designed for part-time study and have a typical duration of 2-3 years.

Nearly all programs are offered based on a common credit system (ECTS) that is approved by the majority of European universities. Several courses offer other degrees, e.g. Diploma or Certificate that correspond to a lower number of credits and provide an alternative to a full Master program. English is the prevailing language with some programs available in multiple languages.

In terms of contents, some programs have a more general curriculum, for example, renewable energy in general, others are more narrowly focused on a single technology such as wind, solar, biofuels, etc.

A distinction among types of programs may also be achieved dividing the ones that equip new entrants with skills and knowledge for specific occupations in the sector at their respective entry levels and programs for experienced employees or individuals to broaden or deepen specific skills and knowledge for various occupations in the sector.

While an atlas of programmes delivered by Universities exists in https://energy.eua.eu/energy-education.html, this is far from a full list of available programmes and need to be extended to cover additional programmes and criteria like vocational programmes and MOOC or blended styles of learning.

4.7 Conclusions

In this chapter, we have surveyed the literature to capture the Knowledge, Skills and Competences needs for the energy transition to be accelerated. These needs have been organised in four domains: three technical energy systems related domain and one cross-sectoral addressing “horizontal” KSCs. A first mapping of the needs to target groups and EQF level has been pursued. This can fuel the design of new programmes in a way that matches the detected needs. Another need detected is the need for including problem-based learning modules while MOOC and remote learning potential has not been fully exploited.

Additionally, ASSET consortium considers that the highlighted KSC needs should be complemented with an articulated information system/ toolbox addressed to help:

a. understand the career pathways and the attributes needed to take on a particular occupation in the sector;

b. understand the skills and competencies required for the job role and identify relevant training programmes to help you become qualified personnel;

c. plan for vertical career progression within the track that you are currently in, or for lateral career moves across the tracks;

d. identify skills gaps that you are lacking in your current or next job role.

At the end of this section, as a general conclusion, we can state that in Europe a group of sound databases and relevant projects do exist which provide indications about best practices and innovative approaches for the delivery of energy-related programmes across all disciplines as well as a wide selection of education and training courses and topics and specializations to deliver the necessary skills for facing the "grand societal challenges" of energy transition and climate change.

While the above statement reflects the **very deep and extensive groundwork already done**, it is important to keep in mind that **skill needs identification is a dynamic task which evolves across time**, in parallel with many factors, such as the technological development, legal and regulatory framework, industry needs, environmental requirements, etc.

Among significant **work still pending**, a high priority is related to the pressing need to define contents and modalities for delivering programs and courses enabling:

- an **adequate holistic approach**, that is how SSH skills will be also provided to students and professionals, in addition to the scientific-technological disciplines;
- **new knowledge creation** and basic research developments in universities, including joining efforts along common objectives, as well as developing adequate professional training schemes **to meet expectations** arising from **industrial companies** and the **society**.

Even if much about these two issues has been referred in the previous sections, in the next section 5 we will present a proposal of a methodology that might be utilised to update the skill needs, in line with the evolving framework conditions over the time.

5. A pathway to timely identify skill needs: 'The way forward'

5.1 Challenges related to skill needs' identification

The detailed design of research into skills for the transition to the low-carbon economy is no doubt complex. There are specific challenges to be considered, namely;

- Boundaries of sectors relevant for transition mostly do not match standard sectoral definitions (Figure 7 Wind energy sector example).

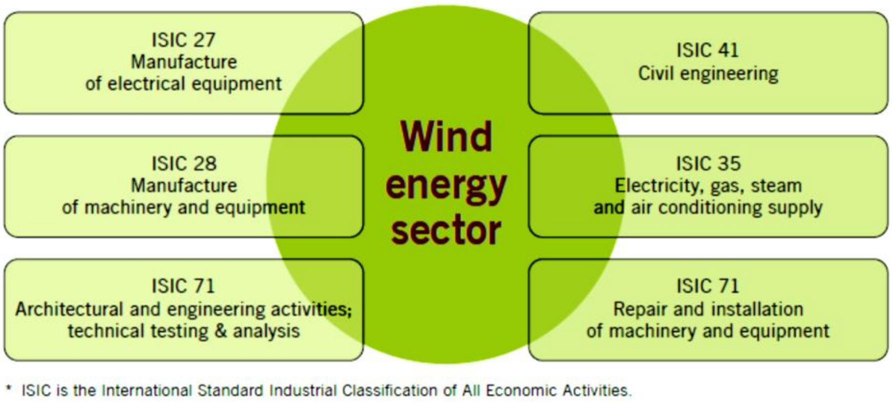

Figure 7 - Schematic overview: Wind energy sector composed of synthetic sectors based on standard ISIC sector classifications

Special arrangements are required to use statistical information available and create new "synthetic" sectors for quantitative analysis that are usually segments of sectors as defined in standard sector classification.

- Occupations relevant to green sectors are a moving target. In a context of rapidly changing technologies, the skills content of occupations changes. These occupational changes are generally not reflected in national classifications of occupations and consequently, do not figure in statistical systems.

- Research on skill needs for the low-carbon economy is often compromised by a lack of sufficiently good statistical information. Labour force surveys or employers' surveys are key sources of statistical information for skills research. Yet they often do not allow for a clear attribution of companies or occupations to specific green sectors, for the reasons pointed out above.

- It is difficult to define green jobs in a way that is satisfactory for all purposes. While there are many competing definitions, most practical skills research questions are sufficiently specific so that research can proceed without any requirement for a universally agreed green jobs definition.

Consequently, a widespread methodological approach is not feasible. In general, it is useful to refer to the following four distinct levels of competence analysis: macroeconomic; sectoral; occupations and skills; education and training.

5.2 Skill needs' identification: a proposed methodology for the ASSET project

Our skills research project focuses on education and training for the transition to the low-carbon economy. Also, in that case, some minor issues, which impede an easy identification of skill needs, persist such as:

- a scarcity of data on the classification and incidence of green jobs;
- a need for more standardized approaches for the preparation of taxonomies of green jobs and related occupations and for quantitative methods of analysis.

Anyhow, as mentioned at the end of the previous section, we should be aware that skill needs assessment is a dynamic task which evolves over time, in parallel with several factors, such as the technological development, the legal and regulatory framework, industry needs, environmental requirements, etc.

Therefore, there is a **need of systematic work to be done** in order to define contents and modalities of programs and courses enabling:

- the **provision of interdisciplinary/multidisciplinary skills** integrating the technological topics with SSH competences. New cross-disciplinary approaches are required to allow that different energy technologies, systems, economies and markets, new regulatory frameworks, consumer behaviour insights, and other social and cultural aspects are all combined to holistically solve the existing challenges;
- **new knowledge creation** and basic research developments in universities, **including joining efforts with industry along common objectives**, as well as developing adequate professional training schemes to meet expectations arising from industrial companies and the society in the field of digital/smart technologies;
- **a strong commitment ensured from university leaders**. This should allow more student-led ideas and innovative initiatives, **new models of learning**, including the greater inclusion of digital technologies, **a life-long commitment** to the continued development of **new energy-related professional skills** by employers and employees and, last but not least, improved communication and sharing of resources and expertise, resulting in less duplication of work, creating more time to focus on developing new cooperation and the necessary interdisciplinary research and teaching skills.

5.2.1 A methodology for skill needs' identification

As a way forward to achieve the fundamental goal of **identifying and updating**, across the time, **research and learning skills**, we are proposing a **qualitative methodology** whose main points for action are as follows:

a. **interviews to a specific focus group** including representatives selected from universities (both technical and SSH Departments), research institutes, training organizations, industrial companies, authorities, and the citizen;

b. **elaboration and delivery of an ad-hoc questionnaire** addressed to a wider audience.

The combined utilization of these two kinds of different tools should enable to mitigate the specific weakness points of each of them, that is to say, the insufficiency of getting a representative sample for the a. case along with the risk to collect information and data from a less informed/qualified group of people in the b. case.

Additionally, the above-mentioned activity **b. can benefit by the synergies** from the **Questionnaire implemented by UNINA** in the framework of Task 2.1.

Skills research questions and appropriate types of methodology suitable to implement a search for skills needs for the benefit of training and education systems are schematized in Table 4.

Table 4 - Skills research questions and appropriate types of methodology

Level of Question	Type of Question	Some Key Headline Questions	Type of Methodology
Training and education	Qualitative	What sources of skills are available? What types of training and education are needed? How can they be provided?	Qualitative
	Quantitative	What is the existing stock of people with the right skills and training available to be recruited? What is the current flow of newly trained people available to be recruited? What flow will be needed in the future?	Qualitative, Quantitative

As examples of questions to be answered to understand how skill requirements are changing and are expected to change in the future, and to examine how well national training systems are anticipating and responding to these new needs, we propose the following:

- Where do new recruits to meet a skill need (such as wall insulation installer) actually come from? Is there a better way to train them?
- What should be changed in a course to prepare trainees and students to meet new skills requirements associated with the transition to the low carbon economy? For example, how should technician and engineer level courses in electrical engineering be changed to better meet the skills needs of renewable energy sectors? Rather than adapting existing courses, is there a need for new specialised courses in, for example, re-engineering (innovating) Energy Services.

In conclusion, we can state that anticipating skill needs for the low carbon economy is complex and poses significant challenges. Minor difficulties are linked with definitions of occupations and sectors, shortcomings in statistics, problems with defining a green job, and differences in the dynamics of employment in different types of green activity.

The current most significative challenges, related to the implementation of new interdisciplinary approaches as well as to the creation of new knowledge, particularly in the field of digital/smart technologies, could be effectively faced through the implementation of the proposed methodology.

6. Conclusion

The dual imperatives of limiting climate change and fostering sustainable growth are currently appearing to be reasonable grounds for an energy transition to a low-carbon economy. Anyhow, in this regard, we must be aware that the transition to clean energy imply a lot of very complex transformation processes, with enormous impacts and risks for investors, customers, and the climate.

One crucial factor needed to mitigate those risks and help that this transition will take place with the more potential benefits and the less unfavourable outcomes for the involved stakeholders and the society at large, is represented, understandably, by the availability of a wide range of interdisciplinary skills needed to address the many technical, economic and social challenges.

We should remember that skills are not a poor servant of the economy, expected merely to react and adjust to any change. The availability of a suitably trained workforce capable of further learning inspires confidence that in turn encourages investment, technical innovation, economic diversification and job creation as well as support the industry to capture the opportunity at hand and to mitigate the risks.

With the aim to anticipate future skills required from the labour market in the multiple areas cross-related to the transformations associated with the energy transition to a low-carbon society, we carried out a set of activities which main outcomes have been:

1. a pressing need for universities to introduce a **holistic approach** in many of the courses for university students who, at the end of their curriculum of study, will likely undertake a kind of job related to the energy transition. The SSH have widely ranging views and perspectives on energy and conceptualise energy issues in fundamentally different ways to those often found in technical/scientific contexts. An awareness of these different views is essential. Equally, social science programmes in the fields of energy, climate and the environment need to engage with the basic disciplines of science, engineering and technology;
2. the outstanding importance to **establish ecosystems** where stakeholders from universities (professors and students from different disciplines), large and small-medium sized industrial and business companies, research institutes, public agencies (e.g. at the local level) and end-users of the technology, collaborate to develop case-based modules (problem-based learning and more), innovative courses and train-the-trainer strategies related to sustainable energy (EE and RES), in a real-life context;
3. the establishment of systems of skills formation **enabling labour mobility and transfer of existing skills** to different sectors, locations and workplaces. A large number of the current workforce in fossil fuels and adjacent sectors should undergo re-training;
4. **skill shortages** have **already emerged** in certain "green" sectors and occupations, from a number of countries. Such shortages affect, **in particular, SMEs**, which are often relatively unaware of the technological and operational adaptations required by the low-carbon transformation. **Closing this skills gap requires an ecosystem perspective**, connecting the demand and supply side;
5. **more learning 'spaces'**, where civil society organizations, scientists, and policymakers learn to deliberate directly, openly, and reflexively on preferences and choices **are necessary**;
6. **lifelong learning** is a fundamental component for employees to keep up-to-date with the latest research and technological developments of their sector;
7. to take account of different **local energy needs** and conditions when designing new programme needs (we have to look at what local markets can provide).

8. the identification of a **number of learning programs** to deliver skills that are needed by the labour market across the energy transition to a low-carbon economy;
9. the indication of data and information about **cross-sectoral skill shortages** for ICT and KETs;
10. an **overview** of **technical skills and competencies definition** cross-related to sustainable energy **discipline engineering specialisation**;
11. a **proposal of a methodology for identifying and updating**, over the time, research and interdisciplinary/multidisciplinary teaching **skills,** in the field of sustainable energy.

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[11]2011c. Comparative analysis of methods of identification of skill needs on the labour market in transition to the low carbon economy (ILO, Geneva).

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[23]SHAPE ENERGY the European platform for energy-related social sciences and humanities (energy-SSH). This innovative Platform bring together those who 'demand' energy research – including businesses, policymakers, and NGOs, who can use it to develop practical initiatives – with those who 'supply' that research. https://shapeenergy.eu/

8. Annex 1: Literature Review - Skills and Competences for the Energy Transition. Collection of national data input

8.1 Papers in Dutch

Energy transition and employment - Opportunities for a sustainable future (2018), presented to the Minister for Social Affairs and Employment and to the Minister for Economic Affairs and Climate

https://www.ser.nl/-/media/ser/downloads/adviezen/2018/energietransitiewerkgelegenheid.pdf

The SER (Social and Economic Council) has issued a piece of advice on measures to be taken in the labour market and in the education field in relation to the international agreements in the Paris agreements. Cashing in on the opportunities of the energy transition, while ensuring that those opportunities are there for everyone. Employment in sustainable energy activities will continue to grow in the coming years, as a result of the major investments in new technologies that are already being and will be done. This will not work without the people who are going to work in the new energy sectors. Because the new jobs often do not fit seamlessly with the work that people do today, and that may disappear. The SER sees it as an explicit task for social partners and the government together to make that appropriate. This will also be necessary to strengthen support in Dutch society for the energy transition.

Technopolis (group) (2016), Final report Qualitative impact of the Energy Agreement on employment

https://www.topsectorenergie.nl/sites/default/files/uploads/Algemeen/Eindrapport_Kwalitatieve_impact_Energieakkoord_op_werkgelegenheid%5B1%5D.pdf

It is to be expected that future employment in energy-related sectors will not be of the exact same nature as current work in energy. This research has identified potential developments in the nature of employment and bottlenecks that prevent the adaptation of current competencies and profiles. A number of cross-cutting themes have been identified on the basis of document analysis and discussions with experts: factory building, system integration, energy coaching, ICT, and lifelong learning. These intersecting themes do not lead to precise predictions but provide a description of patterns that emerge from the complex set of dependencies and interactions in the energy system.

Ir. Erik Knol (Qeam) (2016), Exploratory exploration Human Capital with regard to Urban Energy; Exploration at the request of the Top Sector Energy and TKI Urban Energy and commissioned by the Rijksdienst voor Ondernemend Nederland (RVO)

https://www.topsectorenergie.nl/sites/default/files/uploads/HCA/Orienterende%20verkenning%20Human%20Capital%20voor%20Urban%20Energy.pdf

This document is the result of a brief exploratory exploration focused on the domain of urban energy. The aim of the document is to emphasize a number of perspectives to provide the necessary inspiration for discussions and initiatives that concern the training of technical (hbo) professionals for the energy transition (of tomorrow). Technological developments within the urban energy domain increasingly require the involvement of specialist professionals, while there is also an increasing need to connect expertise from a variety of disciplines. In this document a framework is introduced to give the necessary guidance in terms of competences / skills of the (future) T-shaped engineers. The framework provides competency suggestions for 1) perception and understanding, 2) designing and acting, and 3) communicating, participating and collaborating.

Weterings, A. et al. (2019), Friction on the labour market due to the energy transition: a model survey, Den Haag: PBL/Maastricht: ROA

https://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2019-frictie-op-de-arbeidsmarktdoor-de-energietransitie-3438.pdf

This report lays the foundation for a model that can be used to identify the sectors, professions and training that can lead to bottlenecks in the labor market as a result of the energy transition that is being pursued in the Climate Agreement. The model is intended to explore the short and medium-term effects of choices in the energy transition policy (such as what type of investments are stimulated, timing of those investments and with which policy instruments) on the connection between supply and demand on the labour market.

8.2 Papers in Spanish

Los empleos de la transición energética. Retrieved from:

https://www.empleaverde.es/recursos/publicaciones/europeas/los-empleos-de-la-transicion-energetica

The document is focused on the new jobs related to the energy transition.

The activities that will boost the new jobs are:

– Energy rehabilitation strategies integrated into spatial planning (self-consumption, shared self-consumption -microgrids-, efficient heating and cooling urban systems, net balance smart meters with interaction with the user, energy consumption monitoring and automation -TICs-, building integrated electric vehicle charge infrastructures, integrated energy efficiency projects.
– Closed distribution grid for industrial, agricultural or commercial zones, with shared services.
– New building and housing rehabilitation (renewable integration)

These activities will lead to new jobs:

– Specialists in self-consumption with energy storage and microgrids in buildings, SMEs and agricultural holdings.
– Specialists in energy rehabilitation and near-zero energy consumption buildings, with renewable integration and smart devices.
– Specialists in efficient heating and cooling urban grids using renewables (biomass or geothermal energy).
– Energy manager specializing in audits, energy certification of buildings and evaluation of energy efficiency projects.
– Electric vehicle and charge infrastructure manager in buildings and parkings. - Heating and cooling biomass installations technician.
– Demand response, energy services and smart devices technician.
– Specialist in carbon footprint and circular economy.

This work is based on the following reports and documents:

“Perspectivas sociales y el empleo en el mundo 2018”, International Labour Organization ILO 2030 Energy and climate objectives resolution, 5th of february 2014, European Parliament “Plan de Energías Renovables 2011-2020”, Spanish Government.

“Plan de acción Nacional de Eficiencia Energética en España 2011-2020” Spanish Government.

“Comisión de Expertos de Transición Energética. Análisis y propuestas para la descarbonización” Spanish Energy Ministry.

http://www6.mityc.es/aplicaciones/transicionenergetica/informe_cexpertos_20180402_veditado.pdf

This document is a deep analysis of the energy sector in Spain related to the energy transition. There is not any mention to new working competences, but it serves as a basis to support all the statements that appear in the previous document.

The Energy Transition is a dynamic transformation with the following characteristics:

- We do not know exactly which technologies will lead the change to a new decarbonized energy supply.
- There are many actors involved: production companies, consumers, regulatory organisms, autonomic al local public administrations, territories, social interlocutors, vulnerable collectives,…
- There are new theoretical and practical knowledge to be acquired.
- Any current intervention could carry irreversible changes in the future, so it must to take decisions respecting the intergenerational interests.

Sustainable Mobility

European Commission adopted a strategy to accelerate the transition in road transport:

- Optimization of the transport system improving its efficiency. This includes mobility digital systems solutions, fixation of fair prices (road pricing based on actual kilometres travelled) or multimodal promotion.
- Increasing the low emissions renewable energy used in the transport system. Incorporation of advanced and synthetic biofuels. Developing of the refuelling infrastructure. Normalization of electric mobility.
- Different measures to promote emission zero vehicles, with a specific strategy for trucks and buses.

Consumer sectors and efficiency

One of the main actions in terms of energy efficiency in Spain is the approval of a system of energy-saving obligations by means the “Fondo Nacional de Eficiencia Energética” from the Ministerio de Energía, Turismo y Agenda Digital (MINETAD).

By means, this system the required parties (gas and electricity companies and petrol products operators) are obliged to make a financial contribution National Fund of Energy Efficiency.

This Fund is conducted to:

- Aid to the manufacturing sector for the developing of energy saving and efficiency projects.
- Local supporting programs for public lighting renewal.
- Mobility aid (i.e. transport sector companies).
- Improving the desalination plants energy efficiency.

- Enhancement of energy efficiency in the railway sector.
- Energy renovation of catering establishments, commercial sector and manufacturing sector.
- Buildings energy rehabilitation.
- Communication campaigns.

The grid in the future scenario

In the scenarios till 2030, specifically electrical scenarios it is considered an increasing of the interconnection capacity with France, from a current 5,000 MW till a capacity of 8,000 MW.

The grid must satisfy three basic principles:

- Security: the ability to satisfy the consumer energy demand by all the time.
- Competitiveness: the costs must be reasonable.
- Sustainability: the capacity to attend the long-term demand without non-acceptable impacts on the environment or the system financial equilibrium.

These three basic principles will be applied even with an increase in renewable production plants, allowing the connection and evacuation of produced energy there where it is produced. Wind and solar energy are decoupled from the consumption profile. They require a grid able to transport and distribute the local surpluses to other deficit areas. The electrical grid must allow accessing the renewable resource even considering the development of storage technologies. The combination of transport grids and storage require a technical and economic analysis in the context of high renewable penetration.

The transition strategy towards a decarbonized economy finds the uncertainty associated with the evolution of certain technologies with high impact. These technologies could be the nonhydraulic electrical storage, CO2 capture, hydrogen economy, centralized and distributed generation and interconnection developing uncertainties that could affect the supply security.

The grids must provide flexibility considering centralized or distributed generation, centralized or distributed storage, and self-consumption.

Future grids are more intelligent, with big data volumes in order to take and management decisions (technical and economical).

Just energy transition

There are some sectors that will not adapt to the energy transition. For these sectors is mandatory to establish some strategy plans in order to minimize the effects in the workplace.

The measures should include:

- Manufacturing policies support, territorial or sectorial.
- The reactivation of affected zones, with private and public investments.
- Adequacy of training of labour groups aimed to new sectors.
- Social protection.

“La aplicación de las directrices de la OIT sobre la transición justa en el contexto de la transición energética española” Fundación CONAMA. Noviembre 2018.

http://www.conama2018.org/download/bancorecursos/C2018/Informe%252520final%252520OIT_V2.pdf

The document is a study to offer a guiding policy framework in the processes of ecological conversion and energy transition, responding, from the perspective of social dialogue between employers, unions, and governments around the world, to the just transition approach.

Considering the Spanish national training system, some considerations can be made:

- The capacity of the national training and qualification system to answer to the new professional competencies associated with the energy transition is the biggest challenge.
- The previous experience with the digital transition will be useful to select the planning tools and coordination between actors, at the sector level and even in the company level (prospecting instruments, sectorial commissions, specific plans development, etc.). There is a common characteristic to both transitions: it is transversal to sectors and to the size of the companies.
- system related to the time required to implement the new technology programs. In order to accelerate the re-qualification of the experienced workers, it would be possible to implement a skill accreditation system instead of a qualification accreditation system.
- In the transport electrification sector it is possible to attend the professional's demand with the current programs, but deeply increasing their digital skills.
- The strong growth of demand for self-consumption and distributed energy would require a specific plan. Coordination between training centres and professional associations is proposed in order to train the human resources of the new companies or companies that develop similar activities.
- A point of concern is the lack of human resources in STEM (Science, Technology, Engineering, and Mathematics) titles. Now, there are vacancies in the industry in this kind of jobs. It can be a significant brake on the transition.

Skills developing proposal

The social interlocutor and the government must develop the skills and capacities needed to facilitate the energy transition. The proposals focus on four axes:

- Measures to give a stable regulatory and cooperation framework for the development of the necessary actions and the involvement of the whole of actors with competences in this field.
- Improve the fit between the professional competencies demanded by the sustainable companies and those that the workers contribute. Prospecting tools are proposed and, above all, greater cooperation between training centres (universities or training professional) and companies. This adjustment between demanded competencies and offers are contemplated both in the field of the energy transition as in the digitization, given the dependence that the first go to have of the latter.
- Favour the requalification and professional reorientation of workers affected by the restructuring processes. The performances more pointed out in this point are the elaboration of a specific plan; the change of focus towards accreditation of competences, which allow valuing professional experience; and make possible combinations between training systems to facilitate training multiple itineraries.
- Guarantee effective equality in access for women, vulnerable groups and the rural population to training. It requires to ensure access to information and flexible and adapted training formats.

Employment opportunities

Sustainable mobility

- Greater manufacturer of electric vehicles in Spain. Re-qualification of the sector workers.
- Development and progress in technologies related to the electrification of transport.
- Creation and development of electric recharge infrastructures.

- Renewal of the Spanish mobile fleet with special emphasis on older diesel vehicles.
- Increase and improvement of public transport.
- Connection by public transport and improvement of mobility in rural areas.
- Improvement of mobility in large cities.
- Creation and improvement of railway infrastructures.

Building rehabilitation

- Increase in energy savings and efficiency.
- Generation of economic activity without the need to build new houses.
- Creation of employment due to a large number of buildings to be rehabilitated and the historical importance of the construction sector in Spain.
- Promoting self-consumption and distributed energy.
- Generation of new business opportunities based on eco-sustainable construction.
- Amortization of the initial investment for energy savings.
- Increase in innovation in materials and processes and incorporation of intelligence and technology.

Energy generation

- Spain has geographical and climatic conditions for development and renewable energy generation.
- Creation of employment in the installation of solar panels, administrative management, and maintenance of the facilities.
- Development and creation of opportunities in territories and rural areas through biomass and self-consumption.
- Greater control of spending, energy savings and empowerment of consumers through self-consumption.
- Better access and management of energy.

8.3 Papers in Italian

1) Carrosio, Giovanni; Scotti, Ivano (2018). "Istituzioni e politiche per la transizione energetica fra locale e globale", in: Giorgio Osti, Luigi Pellizzoni (Eds), Energia e innovazione tra flussi globali e circuiti locali, EUT Edizioni Università di Trieste, pp. 257-273.

PDF version:

https://www.openstarts.units.it/bitstream/10077/22321/1/13_BSA5Energia_innovazione.pdf

In the energy transition process, district heating networks and wind farms play a key role. The technicians believe that the complementarity between these two methods of producing electrical and thermal energy can be a response to the problems of balancing the network during the transition phase. From the social point of view, these two technologies could contribute to establishing models of co-provision involving new social actors in the energy field.

Despite that, their real socio-organizational change appears contradictory. In Italy, these options are dominated by large utilities and there are no cases of circularity between wind power and district heating. Furthermore, an Italian model of transition does not emerge, but many regional models, which give a non-univocal shape to the transition on a national scale.

The influence of socio-territorial features on the energy transition seem relevant. For this reason, the chapter focuses on the institutional, relational and territorial dimensions to unfold how energy innovations take place within territorial contexts. In this respect, the energy transition is investigated considering both the district heating and the wind power in Italy.

2) Magnani, Natalia; Patrucco, Daniela (2018). "Le cooperative energetiche rinnovabili in Italia: tensioni e opportunità in un contesto in trasformazione", in: Giorgio Osti, Luigi Pellizzoni (Eds.), Energia e innovazione tra flussi globali e circuiti locali, EUT Edizioni

Università di Trieste,pp. 187-207.

This chapter analyzes the emergence in Italy since the 2000s of a new strand of renewable energy cooperatives, different from historical ones. First of all, different existing typologies of renewable energy cooperatives are identified, taking into account two analytical dimensions: the distinction between mutual benefit and public benefit, on the one hand; and the tension between relational forms focused on the community of place versus a community of interests, on the other. Furthermore, through a research-action methodology, the focus shifts on a case study of an energy cooperative, Retenergie, which is particularly interesting in the Italian panorama, both due to the significant number of citizens-consumers involved and for its recent attempt to expand from the energy production segment to the distribution segment.

3) Rugiero, Serena (2012). L'efficienza energetica in Italia: competenze e figure professionali emergenti per la green economy, in "ARGOMENTI" 35/2012, pp. 53-75.

DOI:10.3280/ARG2012-035003

The aim of this paper is to evaluate the socio-economical impacts of the development policies regarding energetic efficiency in Italy, in terms of relapse on occupation and professionality.

By taking into account the policy goals for energy efficiency contained in the European treaties and the national normative, the sectors which are regarded by these policies are identified, as well as the transformation and new demand of skills and professional roles in these sectors as « new emerging green profiles ». The analysis shows that the transformation of professions induced by the energy efficiency policies has a strongly transversal character : by activating a demand of new professionality and skills in different branches, the processes of technological and productive innovation tied to energy efficiency can also interest a wast array of workers also outside the « traditionally » green sectors. These workers would benefit from reconversion processes to the « new green profiles » guided by specific educational programs.

4) Cappellaro, Francesca (2015) Engineering in Transition. Approaches, strategies, and technologies for implementing system innovation towards sustainability, [Dissertation th sis], Alma Mater Studiorum Università di Bologna. Dottorato di ricerca in Ingegneria ci ile, ambientale e dei materiali, 27 Ciclo. DOI 10.6092/unibo/amsdottorato/6885.

Pdf version: http://amsdottorato.unibo.it/6885/

With the aim to provide people with sustainable options, engineers are ethically required to hold the safety, health, and welfare of the public paramount and to satisfy society's need for sustainable development. The global crisis and related sustainability challenges are calling for a fundamental change in culture, structures, and practices. Sustainability Transitions (ST) have been recognized as promising frameworks for radical system innovation towards sustainability.

In order to enhance the effectiveness of transformative processes, both the adoption of a transdisciplinary approach and the experimentation of practices are crucial. The evolution of approaches towards ST provides a series of inspiring cases which allow identifying advances in making sustainability transitions happen. In this framework, the thesis has emphasized the role of Transition Engineering (TE). TE adopts a transdisciplinary approach for engineering to face the sustainability challenges and address the risks of un-sustainability. With this purpose, a definition of Transition Technologies is provided as a valid instrument to contribute to ST.

In the empirical section, several transition initiatives have been analyzed especially at the urban level. As a consequence, the model of living-lab of sustainability has crucially emerged.

Living-labs are environments in which innovative technologies and services are co-created with users active participation. In this framework, the university can play a key role as a learning organization. The core of the thesis has concerned the experimental application of transition approach within the School of Engineering and Architecture of the University of Bologna at Terracini Campus. The final vision is to realize a living-lab of sustainability. Particularly, a Transition Team has been established and several transition experiments have been conducted. The final result is not only the improvement of sustainability and resilience of the Terracini Campus but the demonstration that the university can generate solutions and strategies that tackle the complex, dynamic factors fuelling the global crisis.

5) Isfol, Mencarelli E. (a cura di), La formazione per la sostenibilità energetica: permanenza nel lavoro e nuova occupazione, Roma, Isfol, 2014.

Pdf version: http://isfoloa.isfol.it/xmlui/handle/123456789/1383

The challenge to which educational systems will have to face in the immediate future is to make all work sustainably from an energetic point of view, not only the ones tied to eco-innovation.

The research uses the relationship between education on energetic issues and employment, offering evaluation items on its efficacy in connection to employment inclusion and to other opportunities of professional growth. The results presented in this volume highlight the high employment potential connected with a transition to sustainable energy foremost regarding the inclusive possibilities which open in this vast sector for young persons, women and workforce exiting branches which are in crisis. At the same time, the strengthening and the innovation of educational processes confirm to be central for the realization of the new energetic model and for the enhancement of its employment possibilities.

6) Ammassari, Rita; Palleschi, Maria Teresa (Eds.) (2012) Energie rinnovabili ed efficienza energetica : settori strategici per lo sviluppo sostenibile: implicazioni occupazionali eformative, Roma , ISFOL.

Pdf version: http://bw5.cineca.it/bw5ne2/opac.aspx?WEB=INAP&IDS=18209

The research presented in this volume identifies and describes innovative professional roles of strategic relevance for sustainable development able to enact European guidelines regarding the reduction of energetic impacts. The focus is set on the sectors: “Eco-sustainable energetic systems”, “Low environmental impact architecture”, described in terms of energetic efficiency and resource reduction, “Agri-food and short supply chain”. In the first part of the research the main sector-bound scenarios, the priority analysis sectors and work processes are outlined, with the aim to identify and analytically describe professional roles: either innovative or which need to be requalified; in the second part these roles have been verified through the analysis of professional and educational requirements, both expressed and potential.

7) Aldieri, L.; Vinci, C.P. (2018). Green Economy and Sustainable Development: The Economic Impact of Innovation on Employment, Sustainability, 10(10), 3541. https://doi.org/10.3390/su10103541

The paper has investigated two important questions. On one hand, the analysis has enriched the empirical evidence concerning the impact of green economy investments on firm-level jobs. On another hand, the knowledge diffusion process in the environmental contexts has been further explored by analyzing the impact of Marshallian externalities.

Indeed, we can observe many studies investigating the link between innovation for increasing firm-level output or productivity and job-creation effects, but they often ignore the indirect effects of own investments on other firms' employment. This paper tries to fill this gap in the previous literature by assuming a relevant role of knowledge process for the green economy activity.

The complex combination of job displacement and compensation forces of innovation seems to be affected by knowledge spillovers. Indeed, from the empirical results, we can observe that Marshallian spillovers in the green economy have a negative impact, by confirming the prevalence of the displacement effect. This finding is extremely important for policy implications. Indeed, not only economic incentives to allow the transition to cleaner technologies are required but also stronger actions to favor job creation relative to environmental activities are needed for full sustainable achievement of firms.

8) Comodi, G. et al. (2019). "Analysis of labour market needs for engineers with enhanced knowledge in renewable energy in some European and Latin-American Countries", in Yan, J; Yang, HX; Li, H; Chen, X (Eds.) Innovative Solutions for Energy Transition, Energy Procedia (Vol. 158), 1135-1140. DOI: 10.1016/j.egypro.2019.01.279

One of the main challenges related to the renewable energy labour market is that of human capital and as a consequence, the educational profile of future employees is of paramount importance. Unfortunately, the skill level gained at University does not always fit with the practical needs of the industry thus reducing the benefit-cost ratio of new employees and slowing down the transition to a green economy. Within this context, 'The Crux' project co-funded by EU under the framework of the Erasmus + program aims at improving the renewable energy engineering curriculum at different university levels in several Universities of Latin America and Europe. In order to better appreciate the potential impact of the project, a survey on the labour market need for specialists with enhanced knowledge and skills in renewable and sustainable energy technologies has been conducted in the related EU and Latin America countries. More precisely, 60 organizations have been interviewed and almost 70% of them are interested in employing engineers with enhanced knowledge on renewable energy in the next three years. The analysis has shown significant discrepancies between EU and Latin American organizations. In fact, while future employees in EU countries will be mainly related to solar energy and management, the former together with wind and biomass will represent the main renewable energy working sector in Latin American countries. Moreover, MSc level will be the most demanded in EU while bachelor education seems to satisfy the future industry requirements in Latin America. Despite each country having its own needs, the research carried out under this EU project confirms the potential of renewable energy education on the global labour market in the near future.

Conclusions: Knowledge of present employees on renewable energy:

- solar energy: 44,7%
- wind energy: 14,1%
- Biomass: 15,3%
- Biofuels: 9,4%
- Management: 8,2%
- Planning: 8,2%

Knowledge of future employees on renewable energy

	Latin America	**Europe**
solar energy	32%	28,6%
wind energy	20%	0% (?)
Biomass	20%	21,4%
Biofuels	11%	7,1%
Management Strategies	13%	35,7%
other	4%	7,1%

Range of qualification of future employees on renewable energy

	Latin America	**Europe**
PhD	20,5%	25%
Master	41%	62,5%
Bachelor	38,5%	12,5%
other	4%	7,1%

8.4 Papers in Greek

1. The energy-relevant KSC needs in the Greek energy sector and society

1.1. Introduction

In this chapter, we survey the literature in Greek that tackles the needs for knowledge skills and competencies relevant to energy in Greece. From our survey in Greek literature, as supported in the next sections, three important issues have been pointed out:

a) There is a clear need for training professionals on new technologies relevant to the energy and the environment and on construction techniques and technologies as buildings strongly affect the consumption of energy and the types of resources that can be used to power up any building.

b) There is a clear need for soft skills in all types of jobs, not only on the energy sector; people possessing high levels of soft skills are highly needed in all sectors of the Greek economy

c) There is a clear need to inform and promote greener behaviour to Greek people.

1.2. Training needs reported last 6 years

According to the survey reported[12], already from 2013, the need for appropriately educated/trained people in the construction and energy sector had been realized and addressed. In Greece, buildings account for 33% of CO2 emissions and 36% of total energy consumption. This report stated that in order to meet the National 2020 targets, the construction industry needs a significant number of skilled and suitably trained workers, craftsmen and installers of energy systems capable of delivering high energy efficiency renovations and new "virtually zero energy" buildings.

[12] http://www.buildup.eu/sites/default/files/bus_projects/build_up_skills-greece_status_quo_el_0_0.pdf

The CRES, in collaboration with the National Technical University of Athens, the Technical University of Crete, the GSEVEE Small Business Institute, the GSEE Institute of Labour, the National Organization for the Certification of Qualifications and Vocational Guidance and the Technical Chamber of Greece, launched in Greece the BUILD UP Skills UPSWING. This action is being implemented in the framework of the European Commission's Strategic Initiative BUILD UP Skills to upgrade the professional qualifications and skills of the workers and technicians of the construction industry.

Required Skills

All professionals in the construction industry should be trained in view of the required qualifications for RES and / or EA applications. In relation to the priority to be given, based on the responses given by the relevant bodies through the relevant questionnaires distributed to them, the professions that appear to be / are considered to be of immediate priority in terms of the need for training are the electricians, the plumbers (who are also installers of RES systems), window glazing and / or alumina, plasterers and - obviously - builders. This amounts to a total of 700 to 1100 training courses to be implemented over a period of 7 years between 2013 and 2020.

In Greece, there is a great need to train its labor force in the construction sector, i.e. to build energy-independent buildings and to upgrade existing ones. Specifically:

- Construction and renovation of foundations, the masonry of buildings
- Specialization in high-quality insulation of masonry, floors, roofing
- Specialization in the installation of PV systems
- Installation of efficient lighting systems
- Energy surveillance systems for buildings
- Efficient replacement of heating, air conditioning systems
- Specialization in ventilation systems
- Specialization in heat pumps / geothermal
- Specialization in high-insulating glasses
- Specialization in sun-blinds
- Installation of solar thermal systems
- Specialization on green ceilings
- Installation of shutters
- Renovation of wooden floors, roofs
- Installation of wooden windows
- Construction and installation of high insulating fittings

Finally, it is worth mentioning that a program for the training of unemployed persons in certified Vocational Training Centres with compulsory employment in green professions was announced. It includes 293 Continuing Vocational Training programs to be implemented across Greece and 7,500 unemployed people are expected to benefit from them. These are "green economy" training programs relating to the production of products or the provision of environment friendly services. Training will be linked to trainees' green development practice in partner enterprises and includes 30% of the trainees who are trained for jobs.

The green training programs are considered to be the following:

- Workers involved in the construction of environmentally friendly projects

- Eco-builders
- Ecological-environmentally friendly management and operation of technical works, buildings and other activities
- Techniques for restoration and maintenance of "injured" building
- Gas engine technicians

1.3. The evolution of training needs

Although time has passed, the continuously evolving green targets push the needs for upskilling and new knowledge acquaintance by Greek engineers. According to a recent (2018) study[13] , the jobs in the energy sector in Greece have doubled between 6 2011 and 2017.

According to the reported research work[14], among the seven measures which are necessary for the achievement of national energy targets for both 2020 and longer-term, such as 2050, the following two (which are totally relevant to ASSET) are included:

a) education and training professional and / or social groups and
b) information and promotion actions to change consumer behavior. In more detail, this report addresses the contribution of European instruments for the achievements of EU energy policy in Greece.

This research work presents the Greek energy policy and, in particular, the evolution of its institutional framework, its implementation bodies, the structural policies in the Greek energy sector since the country's accession to the EU to date, and an evaluation of their results.

The strategy to meet energy needs and to solve the energy issue in Greece is achieved by creating the necessary regulatory and legal regime, which now focuses on the following general directions:

1) Environmental protection and reduction of emissions of gaseous pollutants -carbon emissions by 2050 compared to 2005 emissions.
2) Protecting the competitiveness of Greek industry and the sustainable growth of the Greek economy.
3) Reduce dependence on imported energy and oil, mainly by maximizing RES penetration and optimizing the use of domestic energy resources.
4) Security of energy supply and diversification of the energy mix through the optimal utilization of the domestic potential, especially for the development of RES technologies.
5) Strengthening of electricity networks through both cross-border interconnections and within the country, as well as the development of smart grids and grids, focusing on the development and expansion of electricity storage systems (e.g., large pumping hydroelectric power stations).
6) Reliable, affordable and adequate supply of energy and energy services to every consumer and business.
7) Increase the participation of SMEs in the transport of passenger and freight transport, modernization of infrastructure and vehicles.
8) Exploiting the proliferation of new technologies in the fields of energy demand and supply to boost domestic entrepreneurship and employment

[13] https://lmds.eiead.gr/wp-content/uploads/%CE%95%CE%A4%CE%97%CE%A3%CE%99%CE%91-%CE%95%CE%9A%CE%98%CE%95%CE%A3%CE%97-2018.pdf

[14] https://dspace.lib.uom.gr/bitstream/2159/23096/4/PapamanoliMariaMsc2018.pdf

The achievement of national energy targets for both 2020 and longer term, such as 2050, requires the design, adoption and monitoring of the implementation and evaluation of energy policy measures, which are capable of creating a framework for the evolution of the mix of energy electricity generation and trends in final energy consumption, according to the national energy planning axes. These measures are as follows:

1) interventions / changes mainly to the legislative and regulatory framework
2) infrastructure works
3) development of market mechanisms and financial instruments and / or incentives
4) adoption and promotion of new energy technologies with added value
5) education and training professional and / or social groups
6) information and promotion actions to change consumer behaviour
7) developing a mechanism for monitoring and evaluating the effects of these energy policy measures

1.4. The drivers of the training needs in Greece

An important study by the Academy of Athens on Greece's energy prospects in 2050 highlights[15] that the energy sector may be a prerequisite for economic growth. Analytically, 8 the study refers to the transformation that takes place in the global energy model and the triple challenge for the whole world and Greece, which is "de-carbonisation, digitalisation and decentralisation", i.e. strong penetration of renewable energy sources in competitive terms, digitalisation of electrical system and active participation in the decentralised energy market.

In particular, decentralised production, storage, and electricity-consumers constitute the upcoming model of the electrical system transformed from a system of concentrated generation of large quantities of greenhouse gases into a low emission, decentralised, intelligent and flexible system.

The role of consumers in Europe and around the world is becoming more and more active.

Digitalisation and modern telecommunications ensure that consumers have access to transparent and objective information. A one-way relationship is replaced by a two-way relationship between an intelligent electrical system and an active consumer.

The electricity and gas markets will be affected in the coming decades by the many challenges that the transport sector will face. In-service electrification and vehicle reengineering to minimize CO2 emissions, the development of alternative fuels such as biofuels or hydrogen, new mobility through automated transport, network and traffic management, and intelligent transport and mobility services will affect the country's energy data.

Natural gas, the so-called "bridge" linking the current fossil-fuel-fuelled power system, with the future of RES, offers to cover the system's credibility to an increasing extent. Liquefied gas transport will be the subject of an increasingly globalised and competitive market.

The above transformation will require large amounts of investment funds, interconnection networks, smart meters, vehicle storage and charging systems, other security and control systems and the required telecom and IT infrastructure and will create jobs at the same time.

Regarding the Greek energy landscape, it will adapt within the framework of European Union policy, technological developments and local specificities. Some important factors in the Greek energy landscape will be:

[15] https://www.energia.gr/article/122069/meleth-ths--akadhmias-athhnon-energeiakes-prooptikes-thselladas-me-orizonta-to-2050

- Lignite has a comparative cost advantage and has supported the growth of the Greek economy. In the future, the electricity mix will be set in a way that balances the three energy policy objectives: security of supply, economy, and environmental protection.
- The European Union's baseline scenario for renewable energy sources provides for a significant share of RES by 65% in the Greek electricity mix in 2050, with participation in the market without guaranteed prices from 2025 onwards. Thus, RES is emerging as the future dominant energy resource of Greece. However, given that the support of RES installed up to now has a cost of electricity generation in Greece of 1.3 billion Euros per year for many years, the specialisation and the timing of the RES penetration policies is a crucial factor in establishing a comparative cost advantage and minimise the extra burden. Photovoltaic on the roofs of buildings that provide the ability to manage demand to the consumer must acquire a significant share of total RES production.
- For natural gas are foreseen, transition and flexibility roles with about 20% participation in the electricity mix and expansion of its distribution networks across Greece. An important factor is the various planned or under construction pipelines which will increase security of supply, contribute to the strengthening of the regional market and generally contribute to growth and competitiveness.
- An element of radical transformation of the Greek energy landscape with great economic benefits will be the discovery and exploitation of important oil or gas deposits in the Greek Territory.

Another important driver of this sector is the fact that renewable sources are directly linked to green economy and growth in Greece. The research work reported[16] was to investigate the Renewable Energy Sector and its contribution to the green economy. For this reason, the work describes how the energy started and how the energy has developed so far and what forms it has. It examines the international energy environment and the energy sector in Greece and sets out the regulatory and regulatory framework that governs it. It also defines what renewable energy sources are and analyses in detail the types of renewable energy sources. Then, it defines what a green economy is, studies the characteristics and principles for achieving it and investigates the challenges it poses. Finally, it gives the estimations for the green economy and analyses the difference between the green economy and green growth.

Although there are no fully integrated estimations of the green economy in the European region, the following conclusions can be drawn from the key thematic evaluations:

1) There is no framework for promoting a green economy. At present, assessments are largely based on a bottom-up basis and are generally not part of a clear top-down framework.
2) The green economy is not defined clearly and consistently. It is still a new idea and refers to a mixture of existing and emerging areas, themes, principles and concepts. Most evaluations focus on one or more of these issues, but very few adopt a more integrated approach, which includes a number of concepts or the whole of the framework.
3) There is often no clear link between evaluation and the decision-making process, and many assessments do not formulate objectives or key questions that need to be addressed, rather than being informed about policymaking.
4) Institutional arrangements are vague, with a wide range of organisations and ministries involved but with limited coordination between regions and countries or between them or between the public and private sectors. This leads to some overlapping of estimates and reduces effectiveness in policymaking.

[16] http://apothetirio.teiep.gr/xmlui/bitstream/handle/123456789/9148/Kamzelis%2C%20I.%20%26Katsikas%2CG._FIN_2018..pdf?sequence=1

5) The objectives of the evaluations are not always clearly defined. This contributes to the lack of focus on many evaluations. There are also relatively few ex-post evaluations that evaluate the policy or consider how estimates have led to policymaking.
6) Evaluations are numerous but often large and indifferent, creating a mosaic of fragmented, overlapping and different assessments. In addition, the world of evaluation is constantly expanding, but today there is a lack of consistency and comparability of the basis, form and frequency of data collection and use.
7) There are clear regional differences in estimates with some issues, such as sustainable consumption and production, innovation, concentrated in the EEA countries and others in Eastern Europe, the Caucasus and Central Asia and the Russian Federation.

Many evaluations have also highlighted concerns and emerging needs, such as:

1) Countries and organisations tend to be selective on the issues under consideration. This flexibility can "weaken" the concept of the green economy to the point where it becomes almost pointless.
2) Institutional complexity linked to the development of evaluations leads to poor coordination, overlapping skills and lack of effective change.
3) Progress towards a green economy is hampered by inadequate funding, limited use of economic instruments or political emphasis on other issues.
4) There are information gaps at both spatial and time levels, partially due to the lack of monitoring systems, inconsistent data and inadequate data flow mechanisms.

1.5. Conclusion

All these mandates the need for training and education exactly on aspect and not only technologies of the energy smart grid that will enable the implementation of the energy transition.

8.5 Papers in German

Summary of findings for Germany so far:

- There is a big gap between the demand and offers in the area of digitization, data science, IT-security, and information and communication technology. [Source 1]
- There is a high demand for programs on storage technologies, load management, control engineering as well as modelling and simulation. [Source 1]
- There is already a wide range of training courses available for the common types of production from wind, sun and biomass. However, there is still a need to develop programs that investigate sector coupling/interactions. (Source 1)
- There was also a clear lack of modular and part-time continuing training courses. [Source 1]
- There is a need to provide training to people who wish to work in the energy sector but are coming from another field of expertise (lateral entry) [Source 1]
- There are websites for finding different programs in renewable energy [Source 2 and 3]
- Continuous vocational training should be provided. [Source 1, 4, 5, 6]
- Germany's vocational training program will be vital to the success of the "Energiewende" program [Source 4, 5]

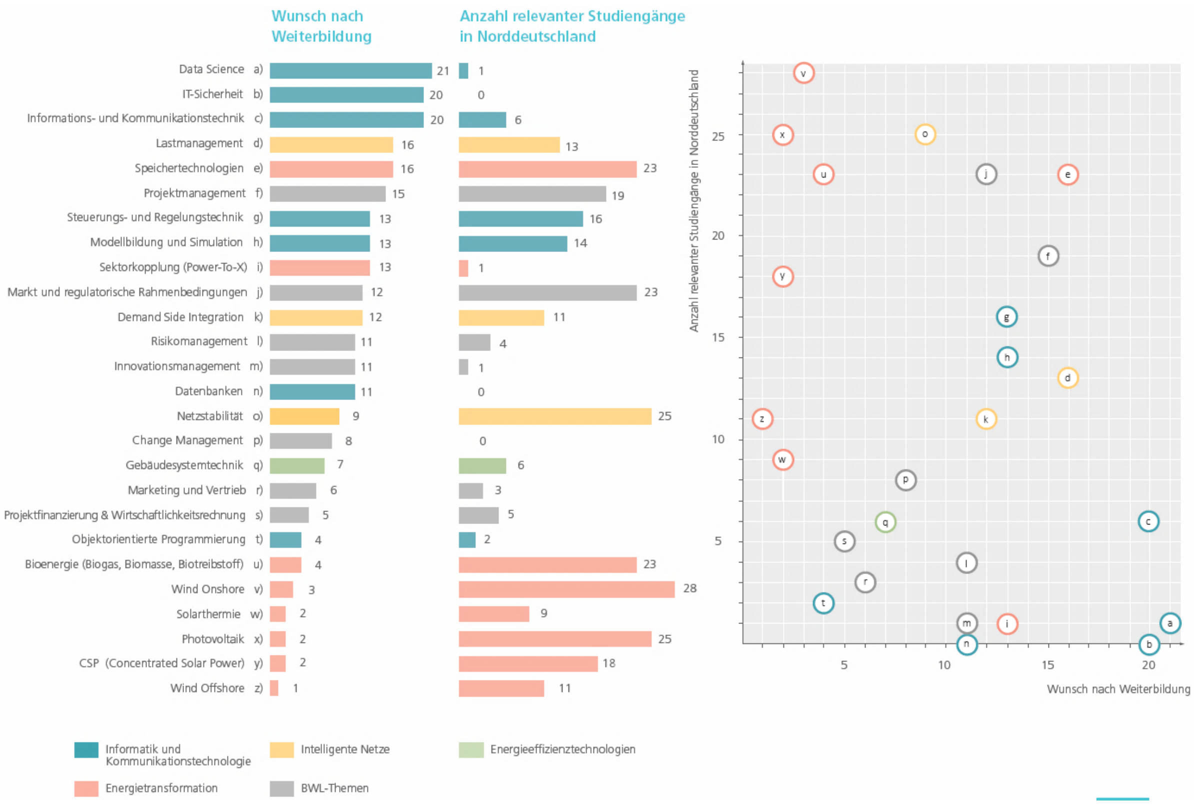
- Even without "Energiewende" there will be a shortage in skilled workers for SHK, i.e. building sanitation, heating, and air conditioning. If Energiewende will be followed, then a larger shortage is expected. [Source 5]
- To meet the need for skilled workers, programs need to be in place to enable the inclusion of women, older people, people with an immigrant background, young people without vocational qualifications, and people with disabilities in the workplace. [Source 6]
- In order to increase public communication with stakeholders and experts, open platforms and workshops are necessary to enable open discussions.
- In order to increase the acceptance and inclusion of different societal sectors, workshops to raise awareness on a responsible research and innovation process should include different stakeholders: members of the research community, industrial companies, educators, citizens, etc. [Source 8]
- There is a need for more learning spaces where civil society organizations, scientists, and policymakers learn to deliberate directly, openly, and reflexively on preferences and choices. [Source 8,9]
- Scattered examples of good practice can be found but coordinated resources would be a valuable asset

Source 1: Outputs of the project NEW 4.0 (Norddeutsche EnergieWende 4.0)

http://www.new4-0.de/downloads/

A study for North-Germany performed gap-analysis to compare the demand and offers for training relevant to Germany's future energy scenarios.

The figure below summarizes the resulting comparison:



Notes on the figure:

- Topics were selected via voting in the project consortium
- Although the focus of the study is north Germany, the survey for the programs were done nationwide.
- The survey for the need of further education was conducted with companies within the NEW 4.0 consortium.

The main findings of the study are outlined below:

- There is a big gap between the demand and offers in the area of digitization, data science, IT-security, and information and communication technology. Meeting this demand should be prioritized.
- In addition to ICT, IT security and data science, there is also a high demand for programs on storage technologies, load management, control engineering as well as modelling and simulation. These disciplines are necessary to enable efficient control of our complex energy system.
- There is also a need to establish programs that deal with converting surplus renewable generation into other energy forms, such as heat (sector coupling).
- There is already a wide range of training courses available for the common types of production from wind, sun and biomass.

The other findings in the report, which is not represented in the graph above are as follows:

- In addition to the gaps in learning contents, there was also a clear lack of modular and part-time continuing training courses.
- There is a need to provide training to people who wish to work in the energy sector but are coming from another field of expertise (lateral entry)
- Institutions should not only expand BS and MS programs, but also provide continuing education in a flexible and modular way for lifelong learning.
- Manufacturers of standard technologies should be involved.
- Continuous vocational training should be provided.
- Available in the annexes of the study are the sources/websites for finding offered programs, including distant learning and MOOCs. The annexes also list down the institutions (regional and nationwide) that offer them. http://www.new4-0.de/?wpdmdl=981

Source 2: Wide range of courses offered for renewable energies (Große Vielfalt an Studienangeboten für erneuerbare Energien)

http://www.energiewende-schaffen.de/wp-content/uploads/2015/10/Studienangebote_EE_WS2012-2013_NEU.pdf

This report from Wissenschaftsladen Bonn e. V. contains a collection of university programs in 2012 from different states of Germany that included topics on renewable energy. These programs are further classified into its type and specialization in the table below. Furthermore, several details about each program (which university offers it, duration, and web link to program) are also included in the report.

Studienangebote für Erneuerbare Energien

	EE übergreifend		Windenergie		Wasserkraft		Geothermie		Bioenergie		Photovoltaik/ Solartechnik	
Bachelor/Diplom	30	104	1	4		5		4	5	8	1	15
Master/ Aufbaustudium	29	72	3	1		2	2	7	6	9		15
Fernstudium	13	9	2	1							3	1
Ausbildungsintegriertes duales Studium	5	19									1	
Wissenschaftliche Weiterbildung/Summer Schools	7		1									
Summe	84	204	7	6	0	7	2	11	11	17	5	31
385	288		13		7		13		28		36	

Stand: 2012

Quelle:
Wissenschaftsladen Bonn e.V.

Legende:
Studium vollständig auf EE ausgerichtet
Studium mit Schwerpunkt/Vertiefung EE

Translation of terms for the table:

- Studienangebote – Study offers
- Erneuerbare Energien – Renewable Energies
- EE übergreifend – Renewable Energies comprehensive
- Windenergie – wind power
- Wasserkraft – hydropower
- Geothermie – geothermal energy
- Bioenergie – bioenergy
- Photovoltaik/Solartechnik – Photovoltaics/Solar technology
- Aufbaustudium – postgraduate studies
- Fernstudium – distance learning
- Asubildungsintegriertes duales Studium – Dual study integrated into education
- Wissenschaftliche Weiterbuildung – Further scientific education

Source 3: A website for finding program offers in renewable energy
http://www.studium-erneuerbare-energien.de/

This website allows the user to find different programs based on program type, focus, and location in Germany:

- Type of programs include:
  - Bachelor / Master / Diploma Degree Courses
  - Training / Dual studies
  - Part-time continuing education and distance learning

Source 4: News article: Germany's vaunted vocational training programme strains to meet Energiewende's demand for skilled workers, 08 August 2017, Clean Energy Wire
https://www.cleanenergywire.org/news/germanys-vaunted-vocational-training-programme-strains-meet-energiewendes-demand-skilled-workers

Remark: An English version of this article is available online.

This news article talks about the need for the vocational education and training system of Germany to provide the needed skilled workers to meet Energiewende's demand. The main points of the article are outlined below:

- Germany must train and retrain its workforce to handle the transitions involved in the evolving energy system.

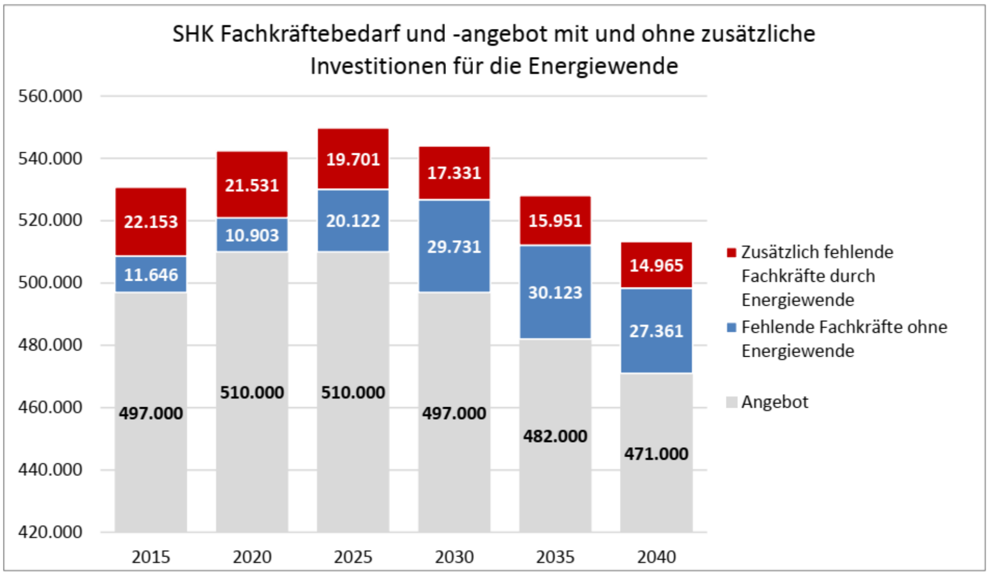
- "According to a study conducted by the think tank Bonn Science Shope (WILA Bonn) for 2014-15, which analysed job vacancies requiring dual-system vocational training, the demand stems above all from the wind power industry, which accounts for almost half of the new jobs on the market, followed by building services, solar PV, solar thermal, transmission technology, and bioenergy, respectively."
- Expertise in combined energy and IT are needed.
- An important part of the adaptation process is the specialization courses that can last from one week to a year (called as *Weiterbildung* or *Fortbildung* in German)
- The need to avoid labour gaps was pointed out, citing that work in small business should be an attractive alternative to work in large companies or public service.

Source 5: Demand for skilled workers for "Energiewende" in buildings (Fachkräftebedarf für die Energiewende in Gebäuden)
https://www.vdzev.de/heizungswirtschaft/fachkraefte/

A study was conducted by Prognos, as commissioned by VdZ e.v. to investigate the future skill-shortage in the discipline of building sanitation, heating, and air conditioning (SHK). The figure below shows the need for skilled workers in this area. The grey part shows the forecasted number of available skilled workers. The blue part shows the forecasted shortage in skilled workers if Germany's Energiewende is not followed. The red part show the forecasted additional shortage in skilled workers if the Energiewende is followed.

The main findings of the study are outlined below:

- Even without "Energiewende" there will be a shortage in skilled workers for SHK, i.e. building sanitation, heating, and air conditioning. If Energiewende will be followed, then a larger shortage is expected.



- The decrease in total demand after 2025 is due to the increase in productivity and the reducing demand based on demographics.
- The supply of skilled workers after 2025 is due to the aging of population

Remark: This shortage must be met through the delivery of training (vocational or university) programs and attracting more people to pursue careers in SHK.

Source 6: Article: Skilled Professional for Germany
https://www.bmwi.de/Redaktion/EN/Dossier/skilled-professionals.html

Remark: This article may be viewed in English

The Federal Ministry for Economic Affairs and Energy of Germany released an article about securing skilled professional in the future.

The relevant points are as follows:

- "Greater use can particularly be made of the potential of women, older people, people with an immigrant background, young people without vocational qualifications, and people with disabilities. Diversity is an important element of corporate success. In occupations facing a skills shortage, it is also important to approach qualified professionals from around the world."
- "Companies that want to be able to compete need a skilled workforce. This also applies to German companies abroad. This is why the 'Skills Experts' support German small and medium-sized companies, in particular, as they provide vocational training to young locals."

Source 7: (not yet used for identifying gaps, but might be useful later for designing programs)
https://www.wilabonn.de/images/PDFs/Serena/Analyse_Ausbildung_Erneuerbare_Energien.pdf

This report shows the considerations when designing training programs for the field of renewable energy

Source 8: Responsible Research and Innovation as a required process in policy making.
https://www.tab-beim-bundestag.de/de/pdf/publikationen/berichte/TAB-Hintergrundpapier-hp022.pdf

This background paper from the Office of Technology Assessment at the German Bundestag (TAB) offers a review of a RRI (Responsible Research and Innovation)-Approach in research an innovation policies. A better coordination of the many activities in innovation assessment in the different German sectors is pointed out.

»Responsible Research and Innovation« als Ansatz für die Forschungs-, Technologie- und Innovationspolitik – Hintergründe und Entwicklungen

Source 9: Civil Society Organisation

https://www.forschungswende.de

Forschungswende works at the national level to promote science policy expertise, create a forum for those interested in politics, governance and science policy, and increase demand for and promote improved participation and transformation orientation in the science system. Forschungswende is changing how R&I is approached to help shape social – ecological transformations and science policy democratization. It has organized workshops and conferences to outline priorities and working structures and has published the study, 'Participation and Transparency in Energy Research'.

Source 10: Energiewende in Region Ahrweiler as an example of local multiperspective development and participative innovation.

https://enahrgie.de/inhalt/?no_cache=1

Source 11: Serious Game to increase vocational competences in the field of renewable energy technologies for female adolescents.

This is a positive example of a pedagogical project. More creative examples and a more intensified distribution are needed

https://serena.thegoodevil.com/projekt/serenaproject/

Source 12: Example of independent think tanks offering public policy consulting and training on climate, environment and development to different societal sectors.

Adelphi https://www.adelphi.de/de

Remark: This article may be viewed in English

Web links

Eurofound. *European company survey (ECS) 2013.*
http://eurofound.europa.eu/surveys/data-visualisation/3rd-european- companysurvey-ecs

Eurofound. *European company survey (ECS) 2009.*
http://staging.eurofound.europa.eu/surveys/ecs/2009/european-companysurvey-2009

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IMD World Competitiveness Centre. *World competitiveness yearbook.*
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IMD World Competitiveness Centre. *World competitiveness online (database).*
http://www.imd.org/wcc/wcy-world-competitiveness-yearbook-online/

ManpowerGroup. *2014 talent shortage survey.*
http://www.manpowergroup.com/talent-shortage-explorer/

OECD. OECD skills surveys: *PIAAC: public data and analysis.*
http://www.oecd.org/site/piaac/publicdataandanalysis.htm

PricewaterhouseCoopers. *PwC's annual global CEO survey.*
http://www.pwc.com/gx/en/ceo-survey/about-the-ceo-survey.jhtml
Social Sciences and Humanities for Advancing Policy in European Energy (SHAPE-ENERGY)

http://www.eskills-guide.eu

http://www.ecompetences.eu

http://www.eskills-lead.eu

https://shapeenergy.eu/

9. Annex 2: Overview of Technical Skills and Competencies (TSC) for Energy

Hereinafter you may find a very extensive, even if not exhaustive, selection of topics and specialisations related to sustainable energy Discipline Engineering Specialisation.

- Instrumentation and Control System Maintenance Management

TSC Description	Interpret and implement maintenance regimes, processes and procedures for programming, configuration and maintenance of control systems to ensure optimal availability and reliability of process plant and equipment			
TSC Proficiency Description	**Level 1**	**Level 2**	**Level 3**	**Level 4**
		Interpret maintenance regimes, processes and procedures for the programming, configuration and maintenance of control systems to maintain control systems in a safe and reliable manner	Facilitate the implementation of maintenance regimes, processes and procedures for the programming, configuration and maintenance of control systems to manage control system maintenance tasks in a safe and reliable manner	

- Mechanical Field Maintenance Management

TSC Description	Perform routine and non-routine mechanical field maintenance work to ensure optimal availability and reliability of mechanical rotating and static equipment in process plants			
TSC Proficiency Description	**Level 1**	**Level 2**	**Level 3**	**Level 4**
	Recall fundamentals of mechanical rotating and static equipment and systems to assist in mechanical maintenance tasks in a safe and reliable manner	Identify and apply mechanical maintenance procedures and work instructions to perform mechanical maintenance tasks at field in a safe and reliable manner	Interpret mechanical maintenance and inspection regimes, work instructions and procedures to coordinate mechanical maintenance tasks at field	Develop mechanical field maintenance and inspection regimes, workflows and procedures to reduce likelihood of failure and to ensure maintenance tasks are performed correctly and consistently

- Mechanical Rotating Equipment Engineering Management

TSC Description	Manage the design, technical specification, selection, modification and troubleshooting of mechanical rotating equipment, structures and systems to provide mechanical engineering discipline support to production, maintenance and project teams			
TSC Proficiency Description	**Level 3**	**Level 3**	**Level 4**	**Level 5**
		Manage the design, technical specification, selection, modification and troubleshooting of mechanical rotating equipment, structures and systems to provide mechanical engineering discipline support to production, maintenance and project teams	Manage the design, technical specification, selection, modification and troubleshooting of mechanical rotating equipment, structures and systems to provide mechanical engineering discipline support to production, maintenance and project teams	Manage the design, technical specification, selection, modification and troubleshooting of mechanical rotating equipment, structures and systems to provide mechanical engineering discipline support to production, maintenance and project teams

- Mechanical Static Equipment Engineering Management

TSC Description	Manage the design, technical specification, selection, modification and troubleshooting of mechanical static equipment, structures and systems to provide mechanical engineering discipline support to production, maintenance and project teams			
TSC Proficiency Description	**Level 2**	**Level 3**	**Level 4**	**Level 5**
		Interpret designs, technical specifications, modification designs, constructability methods, maintenance procedures, and asset integrity techniques to provide mechanical static engineering support to production, maintenance and project teams	Facilitate the development and implementation of designs, technical specifications, modification designs, constructability methods, maintenance procedures and asset integrity to manage mechanical static engineering support to production, maintenance and project teams	Evaluate designs, technical specifications, modification designs, constructability methods, maintenance procedures and asset integrity to drive standards of mechanical static engineering support to production, maintenance and project teams

- Process Analyser Maintenance Management

TSC Description	Interpret and implement maintenance regimes, processes and procedures for maintenance and configuration and inspection of process analysers to ensure their optimal availability and reliability			
TSC Proficiency Description	**Level 2**	**Level 3**	**Level 4**	**Level 5**
		Identify and apply maintenance regimes, processes and procedures to perform maintenance and configuration for process analysers	Interpret maintenance regimes, processes and procedures to perform monitoring, inspection, configuration and maintenance for process analysers	Facilitate the implementation of maintenance regimes, processes and procedures to supervise monitoring, inspection, configuration and maintenance for process analysers

- Reliability Engineering Management

TSC Description	Manage life cycle costing, root cause failure analyses, reliability modelling and assessments, fit-for-purpose analyses and failure patterns of plant and equipment to provide reliability engineering technical support to production, maintenance and project teams			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Interpret reliability engineering techniques, methods and standards, life-cycle analyses and equipment risk analyses to provide reliability engineering support to production, maintenance and project teams	Investigate reliability engineering techniques, methods and standards, life-cycle analyses and equipment risk analyses and reliability modelling techniques to manage reliability engineering support to production, maintenance and project teams	Set direction for reliability engineering strategies to drive high availability, integrity and reliability of plant equipment and systems

Discipline Engineering Support Management

- Engineering Support Management

TSC Description	Provide discipline engineering technical support and expertise in technical specifications, modifications, asset integrity and troubleshooting of engineering equipment and systems, to production, maintenance and project teams			
TSC	**Level 2**	**Level 3**	**Level 4**	**Level 5**

Proficiency Description			Interpret technical specifications, modification designs, constructability methods, maintenance procedures, and asset integrity techniques to provide discipline engineering support to production, maintenance and project teams	Evaluate technical specifications, modification designs, constructability methods, maintenance procedures, and asset integrity techniques to manage discipline engineering support to production, maintenance and project teams

- Technology Road Mapping

TSC Description	Plan short-term and long-term goals for the implementation of new and emerging process plant and equipment technologies, to continuously improve plant performance and to make capital out of future market needs			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
			Drive the organisation's processes using strategic technology and operations road-mapping	Exploit the organisation's strengths to enhance its business competitiveness through strategic technology and operations road-mapping

Engineering Design and Project Management

- Commissioning and Start-Up Management

TSC Description	Manage the commissioning, start-up, and operationalisation of new or modified process plants and equipment			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
	Interpret commissioning and start-up work processes and procedures including systematic integration, testing and initial process operations to conduct commissioning and start-up activities	Establish commissioning and start-up work processes and procedures including systematic integration, testing and initial process operations to coordinate commissioning and start-up activities with internal and external stakeholders	Drive strategic planning and implementation of commissioning and start-up work processes to ensure the safe and reliable commissioning and start-up of new or modified process plants and units	

- Engineering Project Management

TSC Description	Manage engineering projects and coordinate with project teams and stakeholders to achieve project outcomes and objectives			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Interpret project management workflows and practices including project execution plans, scheduling, critical milestones, front-end engineering designs, procurement, commissioning, start-up and quality assurance, to support an engineering project	Establish project management workflows and procedures including project execution plans, scheduling, critical milestones, front-end engineering designs, procurement, commissioning, start-ups and quality assurance to achieve project outcomes and objectives	Drive the achievement of project outcomes, objectives and quality with stakeholders, including strategic project development and planning, project finance management, conflict management and project risk management

Health, Safety and Environment Management

- Environmental Management System Framework Development and Implementation

TSC Description	Develop Environmental Management System (EMS) frameworks and implement procedures and practices to ensure compliance with legal and organisational requirements as well as commitment to environment protection		
TSC Proficiency Description	**Level 1**	**Level 2**	**Level 3**
	Identify Environmental Management System (EMS) policies, procedures and practices in the planning, preparation and execution of work activities	Apply Environmental Management System (EMS) procedures and practices in the planning, preparation and execution of work activities	Interpret Environmental Management System (EMS) policies, standards, procedures and practices in the workplace to ensure compliance with EMS
	Level 4	**Level 5**	**Level 6**
	Facilitate the development and implementation of Environmental Management System (EMS) frameworks and procedures to ensure compliance with legal and organisational requirements and for commitment to environmental protection	Review Environmental Management System (EMS) policies, standards, procedures and practices to ensure effective implementation and continuous improvement of EMS	Set direction of Environmental Management System (EMS) framework and system to meet the organisation's health safety and environmental objectives

Learning and Development Management

- Continuing Professional Development Management

TSC Description	Facilitate the implementation of continuing professional development plans within the organisation to extend, update and maintain the technical competences of professionals			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Establish continuing professional development (CPD) plans by undertaking training, coaching and assessments, and arrange courses and programmes to extend and update knowledge	Drive continuing professional development (CPD) plans through alignment of professional standards and improving CPD methodologies	

- Learning and Development Framework Management

TSC Description	Develop and apply a learning and development framework to manage competency and capability development for the organisation			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Implement and contribute to the development of the organisation's learning and development frameworks	Lead the development and implementation of learning and development frameworks and procedures in the organisation	Drive the organisation's strategic plans in learning and development to foster a culture of lifelong learning and skills mastery in the organisation

- Staff Development Management

TSC Description	Manage staff capabilities and competency-based development through learning and development activities to build a skilled workforce			
TSC	**Level 3**	**Level 4**	**Level 5**	**Level 6**

Proficiency Description	Implement staff development plans to support the development of staff competency and capability	Manage staff competency and capability development plans	Evaluate staff development strategies, processes and progression pathways and opportunities for all staff to ensure the alignment of staff development with the organisation's objectives and business needs	Influence human resource (HR) strategies to build a highly skilled, motivated and innovative organisation

- Trainer and Assessor Development Management

TSC Description	Develop and apply a learning and development framework to manage competency and capability development for the organisation			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Facilitate the development and implementation of trainer and assessor development plans	Evaluate trainer and assessor development plans to ensure workplace learning and assessment programmes are in place	

- Training, Coaching and Assessment Management

TSC Description	Deliver competency-based on-the-job training, coaching and assessment in line with the processes and procedures of the learning and development framework			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
	Apply processes, procedures and plans of learning and development frameworks to deliver training, coaching and assessment for staff	Facilitate the implementation of learning and development frameworks including on-the-job training, coaching and assessment for staff	Guide the development of learning and development frameworks to manage the delivery of on-the-job training, coaching and assessment for staff	

Data Analytics

- Data Analytics System Design

TSC Description	Integrate the use of data analytics within the manufacturing environment for identification of bottlenecks and opportunities for process improvement			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
	Interpret data requirements for big data analytics to cleanse and transform data to support data analytics projects	Review requirements of statistical models to ensure alignment with business needs and deploy models to the manufacturing environment for operational use	Formulate hypotheses for business problems to select big data technologies and tools for implementation in the organisation, based on data requirements	

- Data and Statistical Analysis

TSC Description	Interpret and analyse data using statistical techniques to uncover trends and patterns to locate and define new process improvement opportunities		
TSC Proficiency Description	**Level 1**	**Level 2**	**Level 3**
	Identify data collection procedures to assist in basic data collection and processing activities	Apply data analytical techniques to process and interpret data of limited complexity	Analyse data using statistical techniques to identify trends and patterns
	Level 4	**Level 5**	**Level 6**

	Facilitate the development of new analytics solutions to address existing gaps in analytical tools	Devise the next generation of data science, with the use of big data analytics, to discover new process improvement opportunities	Transform the organisation through the use of big data analytics and data synthesis to drive solutions and improve business processes

Research and Development Management

- Applied Research and Development Management

TSC Description	Manage applied Research and Development (R&D) projects and activities to innovate and develop new products and processes			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Interpret Research and Development (R&D) aims and objectives to execute R&D projects that are aligned with the organisation's business direction and strategies	Devise Research and Development (R&D) project scopes and objectives to manage R&D activities and ensure alignment with the organisation's business direction and strategies	Establish strategies and methodologies for Research and Development (R&D) and product innovation activities to achieve the organisation's strategic aims and objectives

- Innovation Management

TSC Description	Integrate creativity and innovation into the design and development of products and processes while ensuring compliance and non-infringement of existing Intellectual Property (IP) regulations and patents rights			
TSC Proficiency Description	**Level 3**	**Level 4**	**Level 5**	**Level 6**
		Interpret and determine the feasibility of innovation initiatives and strategies	Review innovation initiatives and strategies to translate selected innovation initiatives to organisational plans	Inspire a culture of innovation and lead innovative practices at the organisational level

Technology Application Management

- Internet of Things Management

TSC Description	Integrate data from computing devices, equipment and machines in a networked environment to provide specific solutions			
TSC Proficiency Description	**Level 2**	**Level 3**	**Level 4**	**Level 5**
	Apply interfacing techniques in computer systems for networking and use of dashboard information	Analyse information provided by networks and dashboards to apply and sustain operational needs	Manage manufacturing operation execution using Internet of Things (IoT) solutions for manufacturing improvement	Formulate Internet of Things (IoT) direction and platforms to drive operational efficiency and effectiveness