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Education for Digitalisation of Energy

Deliverable 5.4

Recommendations on how to improve the educational frameworks

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Abstract:

This deliverable contains the list of actions identified to improve the educational frameworks, according to the work developed in other work packages within the EDDIE project. Initially, this report was intended to cover a set of focus countries in representative regions, but following the Agency's recommendations we have opted for proposing general recommendations applicable to most, if not all countries.

Keywords:

Recommendations, Actions, Conclusions, Best practices, Blueprint, Skills, Training, Digitalisation, Strategy, Stakeholders, Frameworks

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03	RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE	RWTH	Germany
04	FOSS Research Centre for Sustainable Energy – U. of Cyprus	FOSS	Cyprus
05	Politecnico di Milano – METID	POLIMI	Italy
06	Kungliga Tekniska Högskolan	KTH	Sweden
07	Fundación Obra Social y Monte de Piedad de Madrid – Escuelas Profesionales Padre Piquer	PIQUER	Spain
08	Centrul Roman al Energiei	CRE	Romania
09	REPSOL SA	REPSOL	Spain
10	IBERDROLA	IBERDROLA	Spain
12	DNV-GL	DNVGL	Spain
13	EDSO for Smart Grids	E.DSO	Belgium
14	NTT Data Italia SPA	NTT	Italy
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Definitions, Acronyms and Abbreviations

AI	Artificial Intelligence
BP	Best Practice
CEDEFOP	Centre Européen pour le Développment de la Formation Professionelle (European Centre for the Development of Vocational Training)
DigComp	Digital Competence framework for citizens
EC	European Commission
ECQA	European Certification and Qualification Association
ECTS	European Credit Transfer and accumulation System
ECVET	European Credit system for Vocational Education and Training
EDDIE	Education for the Digitalisation of the Energy Sector
EDUHub	European Digital Education Hub
EIT	European Institute of Innovation and Technology
EQAVET	European Quality Assurance in Vocational Education and Training
EQF	European Qualifications Framework
ESCO	European Skills, Competences, Qualifications and Occupations
EU	European Union
EUA	European University Association
GE	Good Example
IoT	Internet of Things
KSC	Knowledge, Skills and Competences
LEC	Low Energy Construction
LLL	Life-Long Learning
R&D	Research and Development
VET	Vocational Education and Training
WP	Working Package

Executive Summary

The transition to a digitalised Energy Sector requires Improving the educational frameworks to update the required skills of its workforce. This topic has been studied in the EDDIE project from several points of view. This document generalizes and summarizes the main recommendations provided in this project, in relation to:

1) The research carried out analysing the skill needs and the existing gaps,
2) The compilation of best practices in all the relevant EQF levels, from VET frameworks to university and Life-Long Learning, and
3) The definition of a strategy and a strategic network alliance, in order to seek the collaboration of all the stakeholders involved (i.e. training providers, industry, public sector and administration, as well as social actors and individuals).

The recommendations provided here are classified and grouped attending to the main stages of the life cycle of a training programme: specification, design, and implementation success/factors. In each stage, recommendations are further split into business and academic types.

Recommendations are also analysed with respect to the type of stakeholders involved or, in other words, the potential recipients of each recommendation.

Some of the recommendations provide indications on the methodology to identify and address skill supply-demand mismatches, with surveys turning to be useful tools for making a diagnosis. Best practices in the design and follow up of the surveys are identified.

There are also suggestions about the standardisation of descriptions for training programmes. They include the definition of a standard template and the use of a stable (although subject to improvements or extensions) “syllabus” of skills, as a useful tool for the specification and classification of training programs.

From the academic point of view, many tools are identified as useful for the design and implementation of programmes; for instance, training platforms, practical training, digital simulators, virtual scenarios, work-based learning, interactive learning, and multi-disciplinary training methods.

Some recommendations cover both academic and business-oriented aspects related to a successful implementation of training initiatives, such as:

- International/pan-European exchanges,
- Tight and fluent collaboration with the industry,
- The professional development of trainers,
- The development and provision of several services and marketplaces as catalysts to ensure the successful implementation, and
- The role of the administration in developing a coherent public policy and a homogenous framework to support and facilitate certification, quality assessment, and credentials.

Finally, it is a strong recommendation to promote the collaboration of all the stakeholders through the creation of strategic network alliances to ensure the continuity of the efforts over time, and to guarantee the long-term sustainability and ultimate success of the training efforts.

1. Introduction

This document compiles and provides a set of recommendations formulated to improve the education systems. Many of them are applicable to any field, but this project is focussed on the digitalisation of energy systems. This deliverable leverages the work and lessons learnt in previous work packages, in particular:

- WP2 in relation with the surveys conducted to address skill supply-demand mismatches and the diagnosis of the skill gaps to cover,
- WP3 in relation to the types of stakeholders and the networks or alliances suggested,
- WP4 in relation to the best practices in VET, university, and life-long learning, and
- WP5 in relation the strategy, the services to develop, the templates for training programs, and the establishment of alliances and a partnership in the European framework.

In this introduction, some classification criteria for the best practices and recommendations are presented. These are based on the training programme life-cycle and on the stakeholders involved. Chapters 2,3,4 provide recommendations related to WP2, WP4 and WP5 respectively. Finally, the conclusion section categorizes the main recommendations relating to the classification criteria set in the introduction.

1.1. Classification criteria for best practices and recommendations, based on a training-programme life-cycle

The first set of classification criteria are based on the training-programme life-cycle. This classification attends to the two main types of models that need to be developed (the business model and the academic model), as well as to the different phases of the life cycle.

Table 1 Life-cycle of a training programme

PHASE	BUSINESS MODEL	ACADEMIC MODEL
Specification	Methods of interaction with industry (energy and digital) for: technology trends, labour market, skill needs	Definition of target jobs, target skills. Taxonomies: skills, jobs, tools/systems.
	Methods for employees performance assesment	
	Methods for graduate-skill assesment, official education	
Design	Use of training-programmes templates: business	Use of training-programmes templates: academic
	Select facilities (virtual/physical) and resources	Definition of requirements/profiles for students
	Roles and functions of different stakeholders involved. Includes hiring mechanisms (if any)	Definition of skill-increments, target gaps. Contents and training goals.
	Financial structure: sponsorship, subsidies/grants, tuition, remuneration and costs	Develop detailed contents. Re-use of training modules. IPRs?
	Design of recruiting process: dissemination, marketing, recruiting procedures	Teaching and evaluation methods
	Digital tools licensing	Select digital tools
	Detailed operations planning	Detailed timetables academic planning
	Define certification entities and methods	Certification criteria (detailed)
	Define feedback and validation methods	Validation criteria (detailed)
Implementation success	Recruiting success (quantity)	Individual certification: results
	Financial success (profit, sustainability)	Programme certification: results
		Alumni feedback: results
		Employers feedback: results

The first step is the specification, where in the business model it is needed to define methods to interact with industry and other stakeholders, propose methods to assess the performance of employees and the skills of the students. At the same time, in the academic model it is needed to identify the target jobs, skills, programme scope and content.

Next, the design of the business model requires identifying facilities, resources, involved stakeholders, financial structure of the training, and other aspects like recruiting process, and tools licensing. Meanwhile, in the academic model it is needed to define requirements and profiles for students, define skill increments, and develop detailed content of the training.

For the implementation success it is needed to analyse the recruiting and financial success, while in the academic model validation criteria, certification, and both alumni and employer feedback are needed.

1.2. Characterisation of best practices and recommendations, according to the stakeholders involved

The identification of best practices is a good source to derive recommendations. Those practices involve specific types of stakeholders, and therefore the recommendations are addressed to those same types. In accordance with the work developed in WP3, and in particular the stakeholder mapping, the recommendations are directed to the following main categories of stakeholders:

- For the Administration (and Public Sector): European, National, and Regional levels. General policies, and educational policies. They are key in defining public policies and in defining the educational frameworks and regulations.
- For Industry, as direct or indirect beneficiaries of the training programmes.
- For training providers: VET, University, and Life-Long Learning. This includes formal and informal training, and the industry as a special training provider or partner. This is probably the key type of stakeholder, as the provider of training materials and courses.
- For “social” stakeholders, including associations and individuals (in roles like researchers, teachers, consumers, students or employees), that should also be engaged to collaborate in certain aspects, contributing also to increase the interest in digital energy through a multi-disciplinary approach that provides added value to the success of the training programmes.

2. Recommendations/best practices from WP2

This section deals with recommendations that have been derived from the efforts undertaken within WP2, which relate to the current and future skill needs in the Energy Sector. The goal was to define a methodology for identifying skill gaps in the process of digitalisation of the Energy Sector. This approach will lead to effectively monitoring the progress, as well as the changing dynamics of demand and supply of skills for the digitalization process.

The methodology included in the first stage the design and distribution of surveys to assess the main challenges of the industry towards the digitalisation of the sector, as well as a review and analysis of several state-of-the-art education/training programs related to the energy systems. The later stage included surveys for the skills needed in the industry, surveys for the knowledge/skills provided by educational providers, and the analysis and comparison of the surveys that provided the identification of skill gaps.

This sector contains the main recommendations that have been derived from the designs and analysis of the surveys, organized in the following three categories:

1. General/policy recommendations
2. Survey on supply (training providers)
3. Survey on demand for digital skills (Energy-Sector companies)

2.1. General policy recommendations

A generic outcome from the surveys and the analyses is that the role of governments in the era of digitalisation of the Energy Sector is to develop a coherent public policy, arrange productive investment and create a framework for all participants: students, training providers, and employees.

The general key points towards advancing into a digital environment could be summarized as follows:

- Early digital energy adoption needs to be encouraged,
- Industry, governments and universities must advance digital energy R&D,
- Data privacy and security concerns need to be successfully addressed,
- Cybersecurity must be promoted, and
- The right environment should be provided for talents to emerge

Furthermore, the results of the analysis based on ESCO and CEDEFOP points out that one major suggestion is to follow the directions and guidelines set by the European directives and initiatives. To achieve the objectives of decarbonizing the energy sector and enhancing energy efficiency in buildings, transportation, and industries, it is crucial for the current and upcoming workforce to master both digital and green skills.

2.2. Survey on supply (training providers)

The recommendations raised from the design, distribution and analysis of surveys on supply, i.e. the training providers, focus on the general guidelines to attain optimal results. Surveys to training providers should not be too time-consuming, in order to motivate the participants to fill and complete the questionnaires. The questions should be kept relevant to the topic, and not require broad overview of the institution's overall positioning from the participants, maintaining the motive of completing the questionnaire.

The success of comparable surveys is highly related to ensuring that the collected data are of adequate quantity, in order to have a statistically significant sample. A practical and efficient way towards this direction is for the partners/colleagues to go through their contacts and then to approach the most relevant persons to respond to the survey.

A catalogue of already engaged stakeholders is very important to increase/stabilize the responses in repeated surveys. Keeping record of the adequate contact person and his/her job profile inside each organisation, would

serve the purpose of ensuring that future surveys will be answered and additionally that the compared data between 2 or more surveys have been gathered from the same people or people from the same professional positions inside organizations, in order for the results to be comparable.

2.3. Survey on demand for digital skills (Energy-Sector companies)

In accordance with the survey on supply, the main recommendations of survey on demand for digital skills are concentrated in the successful outcomes of the procedure. In this directions surveys to industry should not be too time-consuming, in order to motivate the participants to fill and complete the questionnaires.

There is an emerging need of creating a solid, continuous and flexible procedure for anticipating skill needs of the industry and feeding them to training providers. A systematic way to conduct this needs to be established.

The two main topics for the success of such a survey are the quality and quantity of the results. An important issue is to get valuable insights, without having excessive lists of relevant stakeholders. This can be addressed by focusing on associations and best-practices organizations.

In addition, to assure a statistically significant sample, the collected data have to be of adequate quantity. A practical and efficient way towards this direction is to utilize personal contacts and then approach the most relevant. The validation of the comparison for repeated surveys' results can be achieved by ensuring that the already engaged companies and the corresponding individuals within the companies are catalogued and reached in every survey.

2.4. Diagnosis of skill gaps to cover

The analysis and comparison of the surveys on supply and on demand highlights the most prominent skills gaps towards digitalization of the energy system, consistently pointing to the areas of data management and analysis, big data, cybersecurity, and programming & development competences. Moreover, the importance of transversal and green skills is also stressed.

The most significant skill gaps identified through the surveys in industry and training providers, include Big data, Data analytics, Cybersecurity, Artificial Intelligence, Blockchain and Internet of Things. Significant effort should be put in addressing these skill gaps. Focusing on Engineers/Researchers, the most significant mismatches appear in the areas of Analytical methods, Computing tools & platforms, and Programming & development related skills, and therefore engineering education providers should strongly consider addressing these topics when developing new courses and/or updating the already existing content. In that direction, the analysis conducted in WP2 also highlighted the importance of adding digital elements to already existing skills, ensuring that the already qualified professionals will continuously be up to date.

Considering digital technologies, the main gaps that have been observed are within Cloud services, Digital platforms, Cybersecurity, and Communication technologies. With respect to digital tools, the main gaps were observed in the use of Cloud servers and online-collaboration platforms.

Focusing on the source of the mentioned gaps, these can be caused either by a mismatch of demand from industry and offer of the education and training providers, or lack of coverage by already employed personnel. This is a significant insight since the mitigation of these mismatches can only be performed via targeted actions of either inserting new aspects in the education and training sector, or by re-skilling employees through several channels such as corporate universities and industrial training programmes. However, the surveys leave an open question of whether the focus of mitigating these skill gaps should be on the reskilling of employees/professional/students or on modification of the existing content in educational/training and VET programmes (and/or addition of new content).

The surveys and analyses also encompassed the implementation methods of education and training programmes, indicating that more attention should be paid to online training platforms, as a useful source of education and

training, as indicated by the interest in online courses, which is rising in the last few years, and it has been further increased within the social context of the Covid-19 pandemic.

A general remark arising from the work conducted during WP2 is that the topics related to digitalisation of energy should be well established in terms of classification/categorization of the respective knowledge and skills and have a system of credentials/qualification associated. To handle this, a system of mutually agreed and utilized syllabus elements is highly recommended, as a common language of keywords/descriptors for analysing and designing educational content.

An important recommendation to consider during the design stage of a survey is the need to separate various types of staff and job profiles within companies. The research encompassed three different categories of staff: managers/administration, engineers/researchers, and technicians/specialists. This segregation of outcomes yielded crucial insights that varied across the different staff categories. Consequently, it is imperative to introduce separate sections or blocks in the surveys to cater to the different types of staff and skillsets.

3. Recommendations/best practices from WP4

In this section the best practices (BP) and good examples (GE) identified in the deliverables D4.2, D4.3 and D4.4 of WP4 are presented in a comprehensive way. These BP and GE for the education in VET, universities and LLL are existing educational programs addressing the identified skill needs in EDDIE and are offering practical examples. In the framework of the EDDIE project the BP are the groundwork to understand the work that has already been carried out and can be considered as a good practice, to measure the extent to which each good practice could be transferred to other countries or contexts, and to learn from these.

Another part of this section are the recommendations driven from the BP and GE for the education in VET, universities and LLL. These recommendations consider also the lessons learned and problems identified during the research of the examples.

3.1. VET framework

3.1.1. Best practices and good examples

Although the sector of energy digitalisation in VET is yet to be developed, there are some key findings and commonly used methodologies that seem to have positive contribution to VET programs. After a comprehensive examination of various interventions that have been implemented in the field of VET provision in relation to the energy transition and digitalisation, six BPs as presented in Table 2 were identified. These best practices provide an analysis of the most innovative and successful approaches that have been implemented in the field and can serve as a model for future interventions. In order to identify strategies and methodologies that can give valuable insights for future practices, there was an analysis of the success factors and scalability of each BP.

The main findings of the research on BPs in the VET sector for energy digitalisation suggest that a strong emphasis on practical training and hands-on experience, coupled with customized learning and strong industry partnerships, are the keys to success. The six Best Practices identified include relevant and up-to-date curriculums that cover automated production systems, energy and environmental technologies, and strong industry partnerships. Other Best Practices involve active modernization of practical training opportunities to align with industry needs, and tailored programmes that address current challenges and opportunities in the energy transition field. It is also recommended that VET providers collaborate with industry and research stakeholders, utilize digital simulators and virtual scenarios to provide trainees with practical skills, and use interactive and multi-disciplinary training methods such as group discussions and project work.

Table 2- Best Practices from VET education

Best Practice	Organization	Objectives	Practice
The electricity and energy programme	Swedish National Agency for Higher Vocational Education	Upskilling workforce related to energy digitalisation in order to improve employability in the sector	1. Relevant and up-to-date curriculum: automated production systems, energy and environmental technologies etc. 2. On-the-job training and practical skills 3. Strong industry partnerships
VET program for Automation Technicians	Burckhardt Compression AG	Workforce upskilling with on-the-job training in energy digitalisation	1. Strong emphasis on digital tools and solutions 2. Collaboration with industry/research stakeholders 3. On-the-job training and practical skills
Vilnius Vocational Training Centre of Technologies	Vilnius Vocational Training Centre of Technologies (VTMC)	Knowledge transfer between industry and academia in energy digitalisation	1. Active modernization of practical training opportunities to align with industry needs 2. Strong partnerships and networks with local companies, other VET providers, and universities, 3. Sector-based practical training centres
Dual VET training system (GE)	Germany	Practical workforce upskilling of professionals	1. Strong industry partnerships 2. Hands-on training and practical expertise combined with theoretical classes 3. Customized learning that is tailored to the needs of the energy and digitalisation sectors
Schneider Electric	Schneider Electric SE	Promote the continuing vocational education and training of workers in technical occupations	1. Customized solutions that are fully tailored to the needs of the company's electrical distribution system 2. Utilizes digital simulators and virtual scenarios to provide trainees with hands-on experience and practical skills 3. Collaboration with industry/research stakeholders, which ensures that the training remains relevant and up-to-date with the latest industry trends and practices
EnerTracks	Agora Energiewende and RENAC	Foster knowledge transfer in energy digitalisation	1. Tailored to address the current challenges and opportunities in the energy transition field 2. Interactive and Multi-disciplinary Training: group discussions, project work etc. 3. The programme uses digital tools and technologies such as virtual study tours, online learning modules, and digital platforms for communication and collaboration

Due to the limited number of references on the subject of energy digitalisation, additional research was conducted to provide a more comprehensive view. These also provide valuable insights on methodology and important lessons learnt that can be applied in the VET sector. Overall, they align with the main findings on Best Practices in the VET sector. In Table 3 these examples are presented. To clarify how relevant those examples are to energy digitalisation, their focus is mainly on the broader concept of the energy transition, taking well into consideration the context of digital transformation. The majority of the examples emphasize the importance of providing VET education that aligns with the needs of the sector and includes practical, on-the-job training. Some examples, such as the

dedicated structure for combining traditional training with work-based learning and the upskilling and reskilling schemes applicable across the EU, focus on enhancing the employability of VET learners and stimulating job growth. Additionally, the professional development of VET trainers and the integration of the curriculum into VET provision are highlighted as important factors for providing high-quality education that aligns with industry needs.

Overall, the methodologies identified from Best Practices and Good examples provide valuable insights into successful strategies. If implemented in the VET sector, the trainees could be better trained for the challenges and opportunities of the energy transition and digitalisation sectors.

Table 3 Good examples from VET education

Program Name	Organization	Objectives	Practice
From Stump to Boiler (FI)	REDU	Workforce upskilling in the bioenergy sector	Provision of VET education in alignment with the needs of the sector Dedicated structure for combination of traditional training with work-based learning Integrates theoretical knowledge with hands-on applications in biomass energy production
Towards near Zero-Energy Buildings (nZEB) Training in the Southern EU countries (EL)	SouthZEB project	Develop training and assessment programs for professionals involved in nZEB building process, focusing on knowledge transfer from front runner countries	Provision of VET education in alignment with the needs of the sector Collaborative project with strong industry links Training modules combine theoretical knowledge with practical exercises and use digital tools (portal and e-learning)
Geothermal and Solar Skills-GSS-VET (EL)	GSS–VET project	Design and deliver a demand-driven Vocational and education training for Geothermal, Photovoltaics and Solar Thermal energy systems installers	Provision of VET education in alignment with the needs of the sector Incorporates ICT and interdisciplinary skills in the training content, preparing learners for the digitalisation of the energy sector Promotes partnerships between public and private institutions, engaging VET providers, sectoral organizations, and regional authorities to ensure alignment with industry needs
NE(W)AVE-Renewable e-VET Learning (EL)	NE(W)AVE project	Test and implement a comprehensive learning model for the future professionals in the renewable energies Contribute to increasing the employability and inclusion of NEETs and VET learners developing VET business partnerships in the renewable energy field based on work-based learning	Promotes VET business partnerships and close cooperation between education and business fields Offers work-based learning opportunities and practical training for VET learners Development of an e-toolkit for education professionals and training to help VET trainers modernise and diversify their educational offer
CraftEdu (SK)	CraftEdu project	Development of innovative qualification and VET schemes for	Provision of VET in alignment with the needs of the sector

		craftsmen and on-site workers in the field of energy efficiency and use of renewable energy sources in buildings	Addresses the skills gap by providing targeted training and supporting the development of practical skills for energy efficiency and use of renewable energy sources in buildings
Education close to zero energy constructions: “Energy lift” (SE)	Swedish Energy Agency	Preparation of the construction sector for future requirements for near-zero energy buildings (NNE standard)	Provision of VET in alignment with the needs of the sector Collaboration with regional energy agencies and professionals to provide tailored training in the sector
Improve Skills and Qualifications in the Building Workforce-WE-Qualify (CY)	WE-Qualify project	Promote the continuing vocational education and training of workers in technical occupations in the Construction sector, as well as other relevant sectors related with the installation and maintenance of energy saving and renewable energy systems	Provision of VET education in alignment with the needs of the sector Integrates specialized and high-quality training programs for improved skills and knowledge Collaboration with WE-Qualify consortium and Cyprus Productivity Centre for organizing training programs
VET4LEC-Inclusive Vocational Education and Training for Low Energy Construction (Multi-Country, including Finland, Slovenia and Spain)	VET4LEC	Development of a trans-European network for VET in low energy construction	Upskilling and reskilling schemes applicable across the EU (Integration of the curriculum into VET provision) Collaborates with VET providers, social partners, LEC contractors, and site personnel in various countries for knowledge exchange and assessment Develops core knowledge, skills, and competences (KSCs) applicable to new build and retrofitting in LEC through a construction VET transparency tool

3.1.2. Lessons learnt and recommendations

1. **Strong emphasis on practical training and hands-on experience**

Professionals in the sector of energy are required to show practical knowledge and approach of digital skills in order to be competitive in the field. Thus, it is important for these training programmes to offer the opportunity for students and professionals to gain hands-on experience and practical skills through on-the-job training and apprenticeships. This not only helps to ensure that students are well-prepared for careers in the industry, but also helps to keep the VET sector relevant and responsive to changing industry needs.

Practical recommendations:

- Develop training programmes that provide hands-on experience in areas such as automated production systems and energy and environmental technologies.
- Provide trainees with access to modern equipment and technology to simulate real-world scenarios.
- Develop partnerships with local companies to provide trainees with opportunities for work-based learning.
- Offer apprenticeships and internships to provide trainees with hands-on experience in the industry.

2. Customized learning and strong industry partnerships

In order to ensure that the VET programme is aligned with the industry needs and trends, the establishment of strong links with industry partners is really important. This can help bridge the gap between theoretical and practical knowledge and align the program with the technological advancements and changes in the energy sector. VET providers need to work closely with industry partners to understand their needs and develop tailored programmes to meet those needs.

Practical recommendations:

- Develop partnerships with local companies to gain insights into their needs and requirements.
- Offer customized training programmes that are tailored to the needs of individual sectors, or even to the needs of individual companies.
- Provide trainees with access to industry experts and mentors to gain real-world insights and experience.
- Collaborate with industry and research stakeholders to stay up-to-date with the latest trends and practices in the energy transition and digitalisation sectors.

3. Utilize digital tools and virtual scenarios

In the context of energy, the use of digital tools has become increasingly important within the VET sector in order to keep up with the rapidly evolving industry. Digital tools can be used to simulate real-world scenarios, provide interactive learning experiences, and enable students to gain practical skills and experience in a safe and controlled environment. This is especially important in the field of energy, where students need to understand complex systems and technologies, and be able to troubleshoot and solve problems quickly and efficiently. Even when real-world opportunities are limited, digital tools and virtual scenarios can provide trainees with practical skills and experience. Overall, they can help trainees gain a deeper understanding of complex systems and technologies.

Practical recommendations:

- Develop digital simulators and virtual scenarios that replicate real-world scenarios in areas such as electrical distribution systems or renewable energy sources.
- Use online learning modules to provide trainees with access to learning materials anytime and anywhere.
- Use digital platforms for communication and collaboration among trainees and between trainees and industry experts.
- Provide training and support to VET trainers and instructors on how to effectively use digital tools in teaching.
- Provide courses and tailored training for using digital tools relevant to energy digitalisation, such as:
    - Virtual and augmented reality simulators
    - Digital twins
    - Energy management software
    - IoT devices and sensors
    - Computer-aided design and manufacturing tools
    - Data analytics and visualization software
    - Cybersecurity tools and protocols
    - Cloud computing platforms
    - Machine learning and artificial intelligence tools
    - Robotics and automation systems.

4. Interactive and multi-disciplinary training methods

Traditional classroom lectures and theoretical lessons may not be enough to equip students with the practical skills and knowledge they need to succeed in such a specialized industry. As such, VET providers should incorporate interactive and multi-disciplinary training methods into their curriculums to provide students with a comprehensive understanding of the sector. These methods can also help trainees develop critical thinking, problem-solving, and collaboration skills. Skills are critical for success in the rapidly evolving energy transition and digitalisation sectors, where new challenges and opportunities are constantly emerging.

Practical recommendations:

- Use group discussions and project work to encourage collaboration and critical thinking among trainees.
- Offer training in multiple disciplines such as engineering, data analytics, and business management to provide a comprehensive understanding of the energy transition and digitalisation sectors.
- Develop training programmes that address not only technical skills but also soft skills such as communication, leadership, and teamwork.
- Use case-studies and real-world examples to illustrate the practical application of theoretical concepts.

Apart from the above, to improve the effectiveness of vocational education and training (VET) programs, it may be beneficial to offer short-term training cycles that combine theoretical learning with on-the-job practice. This approach would help students develop practical skills and competencies while also gaining valuable work experience. It is also important to incorporate certification schemes into VET courses to ensure that professionals are well-prepared for the workforce. In addition, it is essential to investigate the necessary skills for specific jobs and develop holistic programs that address both labor market needs and relevant EU directives. To facilitate this, mobilizing a network of stakeholders to provide apprenticeships and training opportunities for both students and trainers can be helpful. Offering professional development opportunities for VET trainers and mentors can also equip them with appropriate methodologies and digital tools to upgrade VET provision. Finally, including professionals with experience and expertise in curriculum development can directly address mismatches of workforce supply to labour market demands.

3.2. State of the art within the University sector

3.2.1. Summary of the Best practices identified

The identified best practices in deliverable D4.3 consist of 5 master programs targeting Bachelor students in Europe. These master programs stand out on one hand through their educational content addressing the identified skills needed for the digitalisation of the energy sector. On the other hand, the programs include interesting structural and transferable practices. These practices focus mainly on educational programmes with industrial connections and programmes within the framework of pan-European exchange like EIT InnoEnergy and Erasmus Mundus. In Table 4 provides an overview of these best practices.

Table 4 Best Practices from University Education

Master Program	Universities	Involved Stakeholders	Practice
Specializing Master in Smart Grids	POLIMI	Enel Group	1. Industry collaboration to enhance the development of digital competences 2. Implementation effective talent recruiting strategies for companies 3. Utilization of cutting-edge digital tools to cultivate and expand digital competences. 4. Use of hands-on laboratory work
Master's Degree in Smart Grids	UOS, COMILLAS	Iberdrola, Minsait/Indram, UFD	1. Industry collaboration to drive innovation and maximize the impact of international education 2. Double degree program that fosters the integration of global perspectives and enhances the acquisition of digital competences
Master's Degree in Digital Energy and Business	HS-Albsig	Companies in the German energy industry	1. Implementation of a hybrid teaching approach 2. Project work with industry partners to bridge the gap between theory and practice, enriching the energy business education experience
Master's Degree in Decentralized	KTH, UL	EIT InnoEnergy, EUA, PoliTO, UPC	1. Maximize digital tools to empower learners with unparalleled access and resources

Smart Energy Systems			2. European network for cross-border collaboration, driving innovation in education and digital competences 3. Double degree program promoting a global mindset and advanced digital competences 4. Strategic industry-research partnerships for a dynamic ecosystem 5. Educational certificate for mastering digital competences
Master's Degree in Smart Electrical Networks and Systems	KTH, TU/e, KU Leuven, Grenoble INP, UPC	EIT InnoEnergy, ESADE Business School	1. Utilization of digital tools to enhance teaching and learning 2. European network to foster collaboration and knowledge exchange in energy business education 3. Promote industry/research collaboration to drive innovation and relevance in the energy sector. 4. Develop a comprehensive energy business education program 5. Implementation of a global double degree program for advanced skills and a broad perspective. 6. Introduction of an education certificate to validate energy business competencies

Apart from the Best Practices, during the research for D.4.3, some other examples that support the analysis of the university education were identified, while not directly related to energy digitalisation or not fulfilling the requirements completely. To expand the research and provide a more comprehensive view, these are also analysed and presented as good examples. These examples complement both our research and the identified Best Practices, and include also different type of programs connected to universities. In Contrast to the Best Practices, the Good Examples other program types that target a wider range of audiences. These programs include workshops, conferences, research institutions and cooperation, summer schools targeting students, PhD students, researchers, young professionals and lectures. Overall, the Good Examples provide valuable insights into methodology and important lessons learned that can be applied in the university sector. Table 5 provides an overview of these good examples.

Table 5 Good Examples from the University sector

Program Name	Organizer	Involved Stakeholder	Program type	Target	Practice
Re-Generation	International Telematic University Uninettuno	ENEL	Short E-Learning courses	Students	1. Emphasize digital economy, digital society's law, and IT and digital technologies 2. Facilitating practical implementation in the energy sector
The project ENERSOL	NPI DigiKoalice	Several Czech ministries, educational agencies and institutes, association of regions and industry association	Higher School Program	Graduates	1. Collaboration opportunities created through partnerships between secondary and higher vocational school students, teachers, and industry professionals. 2. Focus on RES, energy efficiency, emission reduction, and digital technologies like web design, smart houses, and remote data gathering

Centre for Digital Energy	Fraunhofer Institute for Applied Information Technology (FIT)	RWTH Aachen University	Research projects, PhD program	PhD students, students, professionals	1. Application-oriented research supporting regional companies in maintaining and enhancing competitiveness in a changing energy supply landscape 2. Academic and applied research symbiosis emphasizes digital energy's role in industry innovation and sustainability
Summer School Energy Technology, Policy and Politics	Energy Science Center (ESC); Institute of Science, Technology and Policy (ISTP)	ETH Zürich	Summer school	PhD students, postgraduate students	1. Comprehensive interdisciplinary exploration of technical, socio-economic, and political challenges and opportunities for achieving a sustainable energy supply with net zero (or negative) GHG emissions.
SEEEP PhD Summer School	Royal Institute of Technology (KTH), Eindhoven University of Technology (TU/e)	European network of technical universities (CESAER), CLUSTER and the Chinese Network, **S**ino **E**uropean **E**ngineering **E**ducation **P**latform (SEEEP)	Summer school	PhD students	1. Lectures by global experts cover resilient production, renewable energy technology, sustainability, energy demand flexibility, and energy grids and conversion
Iberdrola University Programme	Iberdrola University	MIT, Comillas, USAL, UOS, ITESM, HBKU, YU, UNM, UFRJ	University-industry agreement	Students, grant recipients, teachers, researchers, employees	1. Bridging universities and companies to equip young talents with skills for innovative energy solutions 2. Iberdrola collaborates with nine top global universities
HHL Energy Conference	HHL Leipzig Graduate School of Management	Energy industry sector	Case study competition, workshop	students, young professionals	1. Interdisciplinary and competitive case study utilizing digital tools and solutions
International Workshop on Energy Data and Analytics e-Energy Workshop	KIT	University and industry partners	Virtual conference/ workshop	PhD students, students, professionals	1. Open call for contributions including research papers, vision papers, comparative studies, energy dataset descriptors, case studies, and experience reports 2. Networking platform for researchers and potential funding opportunities
Digital Energy Conference	Bitkom	DKB, Enpal., PPC, techem	Conference	PhD students, students, professionals	1. Broad spectrum of topics regarding digitalisation and energy system 2. Connecting energy industry leaders and public sector entities

IEEE International conference on Energy Technologies for Future Grids	ARC, ITTC	IEEE IAS, IEEE IES, and IEEE PES, ITRP, Universities and Industries	Conference	PhD students, students, professionals	1. Highly relevant to energy digitalisation, addressing various digital skills
Future Energy Systems	University of Alberta	Canada First Research Excellence Fund	Collaboration of universities, industry, policy makers and public institutions	PhD students, students, professionals	1. Multisectoral collaboration of researchers addressing critical questions on energy generation, usage, transportation, regulation, and their environmental, economic, and societal impacts
European Master in Renewables Energy	EUREC	EUREC EEIG, NTUA, Mines Paris, University of Zaragoza, Hanze UAS, IST, UOL, Northumbria University, UPVD	Master program	Master students	1. Addressing the skill gap in renewable energy through the European Master in Renewable Energy program
Joint Programme in Digital Transformation	University of Mannheim	SAP	Add-on certificate (honours programme)	Students	1. Focusing on global digital transformations, technologies, and solutions to enhance students' skills
International conference on energy, environment, and digital transition	AIDIC	UniPa, UCL, EPFL, ENGIE Research & Innovation	Conference	PhD students, students, professionals	1. Updated perspective on environmental impacts of energy transformation
Workshop Modeling and Simulation of Cyber-Physical Energy Systems	IEEE	TU Delft, WVU, AIT	Workshop, Conference	PhD students, students, professionals	1. Open-source collaborations with multiple partners. 2. Special focus on advancing RES integration, H2, Power to X, electric vehicles, flexibility, automation, etc., with increased EU interconnections

3.2.2. Lessons learnt and recommendations

1. **University programs targeting the necessary skills for digital energy**

Through the analysis of best practices and good examples, it was concluded that the following skills for digital energy that were identified in WP 2 are still not covered in depth in many bachelor or master studies: Artificial Intelligence and Machine Learning, Cybersecurity, IoT, Robotics, Big Data, Blockchain, Augmented reality, Energy modelling, Simulation and Optimization, Cloud services, Advanced control systems in the energy grid, Measurement techniques. To give a broader perspective of job opportunities to future students and to fill the gaps in job markets, it is necessary to integrate these topics in regular curricula, or develop new programs to include them.

2. **University programs supporting international/pan-European exchange and collaboration with other universities**

In order to support the pan-European and encourage a pan-European view on digital energy, it is necessary to enhance the exchange and collaboration between university programs that support international/pan-European with other universities. It could be done through designing double-degree programs or by encouraging exchanges through joint projects/seminars/workshops.

3. **University programs with strong connections to the energy industry**

In order to enable a smoother recruiting process and keep education up to date in terms of technology development and the skill gaps identified by energy industry, it is recommended to establish a symbiotic relationship between industry and universities. By offering different internships and project work, industry would be able to attract talented students who could be potential workers later on. In this way, students would get the benefit of dealing with real application scenarios and job opportunities.

4. **Extracurricular activities for students to increase interest/knowledge in digital energy**

In order to increase interest/knowledge in digital energy through university, it is recommended to organize extracurricular activities. This could be done by organizing different workshops and case studies that would focus for example on the topics and skills that are identified in WP2 and listed in the first recommendation point. Furthermore, it is recommended to organize thematic competitions, such as “hackathons” or “ideathons”, where students would have the possibility to actively contribute to the development or brainstorming of relevant topics in digital energy. It is recommended to encourage students to participate in digital energy thematically based conferences.

5. **Increase the interest in the topics of digital energy already on primary/secondary education level**

In order to foster a new generation in the digital energy sector, it is recommended to start familiarization with digital energy from an early age (on primary/secondary education level). This will increase the interest of students in an early stage in the topics. For this purpose, it is recommended to organize workshops and events that would attract children and teenagers to be involved in digital energy topics. The pilot activities in Aachen such as Archimedischer Sandkasten with the City of Aachen, Gymnasium Workshop, Science Night, and Girls’ Day could serve as an example and a good basis to promote and organize more workshops and events in this direction.
It is also recommended to incorporate the topics more into the curriculum and create space to teach skills

3.3. State of the art of Life-Long-Learning frameworks

3.3.1. Summary of the Best practices identified

The identified best practices in deliverable D4.4 consist of eight initiatives targeting mainly professionals working in the field.

Several common factors emerge from these best practices in the energy sector:

- **Skill Development:** All the practices emphasize training and upskilling to address the needs of the ever-evolving energy sector. They focus on a range of skills, including:
  - maintenance management,
  - smart grid principles,
  - energy digitalisation,
  - digital transformation,
  - intelligent technology deployment.
- **Industry Orientation:** The programs are typically oriented towards meeting specific industry needs. This ranges from introducing new technologies like smart grids, and promoting digitalisation in the power sector, to enabling companies to realize value from digital transformation investments.
- **Collaboration and Networking:** Many of the programs are built on partnerships with other institutions or networks of companies, leveraging collective knowledge and resources to offer a comprehensive learning experience. Collaboration is also essential and useful to gather data on the skills to address.
- **Flexible Learning:** These practices offer flexibility, which is increasingly important in modern learning environments. They often provide online access to training and make learning easily accessible and

affordable for a wide audience. This is particularly important for the addressed target which needs to get a personalized experience.

- **Tailored Content:** The content of these training programs is often customizable or tailor-made for the target audience. Whether it's for the general public, engineers, or professionals and executives in the energy sector, these practices provide content that best suits the learner's needs. For sure, we will see an important development in the personalization of learning experiences due to the massive introduction of tools based on Artificial Intelligence (a context to be taken into strong consideration).
- **Application of Emerging Technologies:** A key commonality is the focus on the application of new and emerging technologies. This includes:
  - digital tools,
  - smart technologies, and
  - and intelligent systems.

Best Practice	Organization	Objectives	Practice
Predictive Maintenance	Maintenance Manager HQ	Provide training in maintenance management, including predictive maintenance for the general public	• Reskilling workforce in real-world case studies and mentorship • Huge global network of companies
Professional Certificate of Competency in Smart Grids Industrial Automation	EIT (Engineering Institute of Technology)	Introduce engineers to the principles of smart grids in power system application under various network conditions	• Highly specialised in the sector of energy digitalisation and • New emerging digital technologies are applied and taught.
Digitalisation and smart technologies for the power sector	Renewables Academy AG (RENAC),	Contribute to decarbonisation while maintaining a high level of digital solutions training people involved in the energy sector	• Aimed at an industry audience that wants to approach new topics: they can do it easily online, at an affordable price
The Energy Training Centre	ETC (The Energy Training Center)	Provide training for clients (technical and non-technical professionals) who are undertaking a transition in the energy sector	• Partnerships with world-renowned institutions • Specialized training in energy digitalisation
Siemens Xcelerator Academy	Siemens	Provide specific trainings for professionals and companies in the energy sector to enable companies to secure value realization from the investment in digital transformation	• Customizable and scalable training to digital tools
Energy Academy	DNV	Provide a wide range of courses for the electricity supply chain for the general public	• Upskilling the workforce • Support industries in energy transition
Intelligent and Integrated Energy Systems	TU-Delft with DNV and IBM on edx	Enable professionals in the energy sector to deploy intelligent technology, strategy and business models to adapt to significant changes in the energy field	• Tailor-made by professors and industry experts • Partnerships with world-renowned institutions •
Digital Transformation in Energy and Utilities	IEEC (Institute of Executive Careers)	Targeted to professionals and executives in the energy sector and focused on the Utilities Industry and support the	• Industry-oriented • Use if digital tools

Best Practice	Organization	Objectives	Practice
Certification Course		digitalisation of conventional power generators	

Beside the Best Practices, during our research for D.4.4, some other success stories were identified. They target professionals, but also students and the public. These success stories continue to prioritize skill development, industry orientation, application of emerging technologies, and collaboration. However, they also bring in additional focal points:

- **Reskilling in Renewable Energy Sources:** Both European Energy Manager-EUREMnext and SMART-UP stress the importance of reskilling the workforce in the field of renewable energy sources. This is becoming increasingly vital as the world shifts towards cleaner, more sustainable forms of energy.
- **Training for Construction Professionals**: ingREeS focuses on the knowledge gaps in the construction industry regarding energy efficiency and renewable energy sources. It looks at revising skills and delivering this necessary knowledge to construction professionals.
- **Deep Energy Renovation:** Fit-to-nZEB aims to develop large scale training schemes and programs on deep energy renovation. This focus on energy-efficient retrofitting is a crucial component of sustainable building practices.
- **Quality Certification and Assurance:** Practices like QualitEE and PROF/TRAC emphasize the development of qualification standards and certification mechanisms. These tools ensure consistent, high-quality service provision in energy efficiency services.
- **Focus on Energy Consumption and Efficiency:** ENERGISE, eTEACHER, and KeepWarm aim to encourage energy-efficient behaviors and decisions at both individual and community levels. This can range from raising awareness about energy consumption to modernizing district heating systems for better efficiency.
- **Empowerment Tools:** The eTEACHER program uses tools to drive users towards informed decisions for energy saving and indoor environment quality optimization.
- **Digital Transformation:** The Digital Energy and Optimization practice prepares professionals for the digital world and Industry 4.0, a clear indication of the growing importance of digital technologies in the energy sector.

Best Practice	Organization	Objectives	Practice
European Energy Manager-EUREMnext (Multicountry)	EUREM	Train and certify energy managers, while creating a network of certified professionals worldwide	• Reskilling of the workforce in the field of renewable energy sources • Provision of training in alignment with the needs of the sector
ingREeS -Scheme for Middle and Senior Level Construction Professionals on Energy Efficiency and Use of Renewable Energy Sources in Buildings (SK)	EASME	Analysis of the construction industry's knowledge about energy efficiency and using renewable energy sources in buildings. Revision of the skills that were lacking and what needed to be done to deliver these skills to construction professionals	• Development of qualification standards • Development of certification mechanism • Upskilling of the workforce
Fit-to-nZEB-Innovative training schemes for retrofitting to nZEB-levels (EL)	Center for Energy Efficiency EnEffect	Develop large-scale training schemes and programmes on deep energy renovation for trainers in the field of deep energy	• Capacity building of trainers • Improvement of training provision in the deep energy sector

Best Practice	Organization	Objectives	Practice
QualitEE-Quality certification frameworks for Energy Efficiency services to scale up responsible investment in the building sector (EL & SK)	E7 ENERGIE MARKT ANALYSE GMBH	Develop tools for quality assessment, financial assessment and procurement for companies that undertake energy efficiency services projects	• Establishment of mechanisms to implement quality assurance schemes for energy efficiency services • Establishment of cooperation structures among the different stakeholders in the energy efficiency sector
ENERGISE-European Network for Research, Good Practice and Innovation for Sustainable Energy (FI)	Multipartner	Develop a social science programme to enhance understanding of changes in energy consumption in the households	• Establishment of mechanisms to mainstream energy consumption • Fostering individual and community initiatives to achieve energy efficiency
eTEACHER-end-users Tools to Empower and raise Awareness of Behavioural CHange towards EneRgy efficiency (FI)	Multipartner	Encourage and enable energy behaviour change of building users by means of continuous interventions displayed through a set of empowerment tools to drive informed decisions in order to save energy and optimise indoor environment quality	• Digital tools for energy behavioural change • Fostering individual and community initiatives to achieve energy efficiency
PROF/TRAC (multi-country including Slovenia)	Multipartner	Development of a training programme aimed at overcoming market barriers towards a successful design and construction process of nearly Zero Energy Buildings for professionals with a higher education degree in the construction sector	• Upskilling of the workforce • Development of a certification mechanism
KeepWarm: Improving the performance of district heating systems in Central and Eastern Europe (multi-country)	Multipartner	Modernise DHS around the whole region and reduce greenhouse gas emissions by improving system operations and promoting a switch to less-polluting sources, like renewables	• Provision of capacity building activities to promote change • Establishment of mechanisms to accelerate energy efficiency
SMART-UP (multi-country)	Multipartner	Encouragement of vulnerable customers to actively use their Smart Meters and In-House Displays to achieve energy savings	• Reskilling of the workforce in the field of energy consumption • Establishment of cooperation structures to promote energy efficiency
Digital Energy and Optimization	GLOMAC	Prepare professionals for the digital world and Industry 4.0	• Upskilling of workforce related to energy digitalisation

3.3.2. Lessons learnt and recommendations

Some of the general key lessons learnt from both these best practices and good examples in LLL are the following:

1. **LLL programs and courses focused on upskilling and reskilling for digital transformation:**

The main keywords of the best practices and success stories identified are related to the need for constant upskilling and reskilling. Given the rapidly evolving nature of digital technologies, there is a continuous requirement to update knowledge and skills to stay relevant. The focus has to be on a range of skills: maintenance management, smart grid principles, energy digitalisation, digital transformation, smart technologies, and intelligent systems. Furthermore, there's an increasing emphasis on reskilling in the field of renewable energy sources, Energy Consumption and Efficiency.

Practical recommendations:

- create strong partnerships with industry experts and global stakeholders provide specialized training and effective knowledge transfer,
- link to key companies in the field for a complete understanding of the main skills to address, and
- link to key companies in the field for a complete understanding of the kind of professionals/workforce to involve in the training activities.

2. **LLL programs and courses focused on Specialized training (with Quality Assurance processes)**

The practices stress the importance of capacity building in relation to digital skills also through Specialized Training. This ensures the sector has the capability to adopt, manage, and advance digital transformation. Specialized and personalized training in digital technologies and their application in the energy sector is crucial. This is demonstrated by practices focusing on areas like smart grids, digital tools for energy behavioural change, and digital transformation in the energy sector. Furthermore, the practices emphasize the importance of developing certification mechanisms, demonstrating that validation and recognition of digital skills in the energy sector are vital. This is particularly true for professionals willing to demonstrate their expertise, and for companies wanting to hire staff with specific competencies.

Practical recommendations:

- create relevant and cost-effective training solutions for professionals to grow and develop;
- develop industry-oriented initiatives with links to professionals, industries and global stakeholders;
- focus on practical training from real-world professionals and experts is crucial for success;
- create tailor-made courses, short and focused on specific topics, mixing diverse format: online and in-presence; theory and practice; synchronous and asynchronous;
- use tolls based on artificial intelligence to easily create small updated modules of contents;
- follow quality assurance mechanism to ensure the quality of the courses provided;
- provide certification or credentials to support the visibility of the skills acquired by professionals.

3. **LLL programs and courses created through Collaboration and Networking:**

Several practices are built on partnerships and networks, indicating that collaboration and the sharing of knowledge and best practices are key in the digitalisation of the energy sector. This theme is crucial due to the rapidly evolving nature of digital technologies: strong contact among academia and research centers, training providers, industries and professionals could guarantee the overcoming of market barriers and the alignment between training and sector needs, in order to support the adaptation of the workforce to market trends and requirements in digitalisation. This could also be useful to disseminate the results of the initiatives: reaching a large audience is key to making a meaningful impact on the industry and society and to guarantee the sustainability of the Entity.

Practical recommendations:

- reach a large audience and raise awareness on the topic through dissemination activities (social networks, conferences, etc..),
- create courses involving actors from different sectors (e.g.: companies, professionals working in the field, etc), and

- make the courses available on different international platforms (open or not) in order to guarantee the involvement of different targets.

3.4. Conclusions of WP4

3.4.1. General Recommendations for VET, University and LLL

In this section, the recommendations developed for VET, University and LLL valid for educational programmes are generalized and summarized:

- Educational programmes should be targeting the necessary skills for digital energy and constantly update the curricula adequately. In this way, the development of the needed knowledge and skills in the energy sector is ensured. For increased effectiveness of the programmes industry perspectives and experienced professionals should be included in the curriculum development. In particular, for targeted and contained programs as in LLL and VET, the training programs should be in line with the needs of the labour market and incorporating work-based learning to respond to fast-paced changes.
- International and local exchange as well as collaboration with different stakeholders from industry, research and communities should be an integral part of educational programmes. Effective and consistent collaboration of all stakeholders in the energy efficiency sector is imperative.
- More focus should be placed on the engagement of the local communities, especially vulnerable groups, through the design and implementation of initiatives which aim at their awareness, education and engagement in actions targeting digital energy topics. For instance, addressing children at primary/secondary education level and creating the base for their future path into the energy market is vital.
- The integration of work-based learning structures, digital tools (simulators and virtual scenarios) for practical skill development, interactive and multi-disciplinary methods, and hands-on experience into the traditional curricula is essential to meet successfully the skill needs of the digital energy sector.
- The engagement and mobilisation of different stakeholder categories is a parameter of utmost importance to be fostered through different types of actions, including lifelong learning programmes. Tackling energy digitalisation is not a challenge that affects only the policy level, or the industry. It is an endeavour which requires the involvement of everyone, let alone one requiring significant investments.

3.4.2. Analysis of European educational tools, frameworks, and standards

Synergies with European educational tools, frameworks, and standards will be elaborated in deliverable D4.5 which is due end of July. Deliverable D4.5 will present the following frameworks:

- European Skills, Competences, Qualifications and Occupations (ESCO),
- European credit system for vocational education and training (ECVET),
- European Qualifications Framework (EQF),
- Europass,
- European Credit Transfer and Accumulation System (ECTS),
- European Quality Assurance in Vocational Education and Training (EQAVET),
- European Certification and Qualification Association (ECQA),
- European Institute of Innovation and Technology (EIT),
- European University Association (EUA),
- Digital Competence Framework for Citizens (DigComp), and
- European Digital Education Hub (EDUHub).

The following synergies between EDDIE and the considered frameworks have been identified:

- Provision of a standardized method to define and classify the digital skills and competencies needed in the energy sector.
- Facilitation of the recognition of prior learning and experience and encourages a higher level of completion and wider participation in LLL of individuals.
- Use in assessing and improving all forms of digital competences.

Recommendations that can be drawn are the following:

- Facilitate the collaboration between EDDIE and frameworks in order to accelerate the development of a skilled workforce.
- Establish a shared online community or platform that promotes communication, collaboration, information exchange, and mapping while accelerating the adoption of digital innovation in education.

4. Recommendations/best practices from WP5

This section covers recommendations and best practices, related to the Blueprint (strategy) defined within WP5. The strategy involves the creation of a Large-Scale Partnership (LSP), which is one of the tools proposed in the "Pact for Skills" European framework. The primary objective of this LSP is to facilitate training and education for the digitalisation of the Energy Sector. In the context of this alliance, a non-profit association (the "Entity") will be created to provide a legal support to the coordination activities of the LSP. This section addresses the conclusions drawn from the design of the strategy, offering recommendations and lessons learned from best practices that can be beneficial for the LSP and other similar initiatives. The recommendations are organised into three categories, related respectively to:

1. Services that the Entity could provide,
2. Description of features of training programmes, and
3. Alliances and partnerships to be developed within the European Framework.

4.1. Services to be provided - strategy

First of all, it is important that the activities and services offered are based on an **analysis of the actual needs of the target stakeholders**. The services should be practical and efficient; ensuring tangible **improvements** in the training and education products. It is important to identify skill gaps as they start to emerge and develop, addressing them in a timely manner to meet both present and future needs.

The next consideration is whether the services should be **specialized** or **general-purpose**. While general-purpose services can reach a wider audience, specialized services provide added value to the digitalisation of energy systems. They allow a more focused approach, deepening more into the specificities of this field, while capturing the attention of the relevant stakeholders.

In order to select which candidate services should be deployed, a **cost-benefit analysis** and a **business model** is needed for each potential service. This includes analysing its relevant stakeholders, its added value, and the long-term sustainability of the concept. This is the approach applied in the EDDIE project.

In the EDDIE project, four specialized web marketplaces have been selected and analysed, each focusing on different aspects of education for the digitalisation of energy systems

1. **Research and dissemination** contents. This marketplace serves as a platform to disseminate news, relevant findings, and prospective studies through various mediums such as papers, reports, events, talks, and conferences. Its purpose is to keep stakeholders informed about the latest developments in the field.
1. **Training programmes**. This marketplace acts as a forum to collect and showcase best practices in specialized training programs for individuals, both employers and potential students, interested in the digitalisation of energy systems. It provides a centralized resource for accessing high-quality educational opportunities in this field.
2. **Jobs.** Working in conjunction with the training programs marketplace, this platform helps companies find suitable candidates to fulfil their skill requirements. It serves as a bridge between companies seeking talent and individuals who have undergone specialized training in the digitalisation of energy systems.
3. **Tools and systems.** With contributions from industry and academy, it would gather and disseminate technology options and tool-oriented training. It benefits from contributions by both industry and academia, offering a comprehensive resource for individuals and organizations seeking knowledge and practical tools related to energy system digitalisation.

Another interesting type of service was identified, related to **certification** and **quality assessment** on training programmes. However, it was not included within the EDDIE framework because of its high cost, not compatible with the strategy. At least in the initial stages of the Entity, since there is room for providing added value in the future (for example in terms of homogenization of the systems across Europe).

4.2. Templates for Training Programmes, including syllabus elements

The training-programmes marketplace has a special relevance within the context of education, and as such, EDDIE has prioritized its development. One critical aspect identified in the development of this marketplace is the definition of a standard **template** for training programmes. This template has a direct impact on the design of the databases and the web marketplaces, and provides added value in terms of homogenisation, standardisation, classification, filtering, and selection, as well as in usability and the application of analytics.

From the work done in EDDIE developing a training programme template (as outlined in deliverables D5.2 and D5.3), the following recommendations and best practices have been derived for **defining the template**:

- Use of standard keywords: Employ standardized keywords to describe the program contents, utilizing a syllabus structure and referring to recognized classifications such as ESCO.
- Use of standard European frameworks. Align the template with established European frameworks like ECTS and EQF.
- Adaptation to the web format. Design of the template to suit the practical purpose of a web-based marketplace, ensuring that users can easily search and filter through available options.
- User-friendly and semi-automated interface: Development of an interface that is intuitive and semi-automated, allowing multiple training providers to upload their programs onto the platform easily.
- Two levels of description: Provide both critical details stored within the marketplace and links to external sources with more detailed information. This enables users to make informed selections
- Address both academic and business models: Clearly separate and address both the academic and business aspects of the training programs within the template.

By implementing these recommendations, the training-programmes marketplace can offer a standardized and user-friendly experience, making it easier for users to find and select suitable training options. The template ensures consistency and facilitates the comparison and analysis of different programs, benefiting both learners and providers within the digitalisation of energy systems domain.

The **syllabus** is a core part of the definition of a training programme, both for requirements (initial profile of target students) and for learning goals and contents (expected acquired profile). In the EDDIE project, a syllabus has been drafted, but it is expected to evolve in the future. Based on the lessons learned in EDDIE, the following considerations have been identified for driving the definition of the syllabus:

- Combination of pre-defined and flexible formats: It is essential to provide a combination of pre-defined formats and flexibility for the content of the programs. The pre-defined format allows for classification, and selection of options, and provides a general description of the field. However, as some programs may cover specialized topics that are challenging to define in advance, incorporating flexibility is necessary to accommodate specific keywords related to the field.
- Structure the syllabus with blocks and categories: The syllabus should be organized into blocks and categories, which are non-exclusive since knowledge and skills are inherently interconnected. This structure aids in easily finding the most relevant keywords by starting from any block or category related to that keyword. It facilitates navigation and improves the search and selection process for users.
- The syllabus should include a mix of several domains, like transversal, knowledge and functional skills. Transversal skills are applicable across different sectors, such as languages, leadership, and teamwork. Knowledge skills are domain-specific, such as telecommunications or cybersecurity. Functional skills are associated with the type of activities for which the acquired knowledge will be utilized, such as maintenance, design, or documentation.

4.3. Alliances and partnerships in the European framework (relation with the Pact for Skills and the Entity)

Regarding the creation of a strategic network alliance (Sector Skills Alliance) in this field, which has been since the beginning of the project a clear objective since the beginning of the project, along with the commitment to ensuring its sustainability, it is important that the networking and the alliance are based on specific activities, targets, and the services to be developed. The alliance should not be an end in itself, but rather a means to drive meaningful change. Securing funding from various sources is essential to carry out these activities, including direct European support, specific calls and projects, as well as fees for the services provided (including membership fees). A database of stakeholders is needed, and it must reflect the different types of institutions and their specific needs and interests. The goal is to gather and map all the relevant stakeholders, in order to involve them in the activities that may benefit them directly or indirectly.

During the course of the project, two relevant facts happened. In 2020 it was announced the EU Pact for Skills was announced as a principal policy action to address the future of education and skills, bringing together Industry and training providers in the same economic/industrial sector. In 2022 the EC issued the Digital Action Plan for Energy where a clear commitment was established to create a Large-Scale Partnership for Skills (LSP) in The Digitalisation of the Energy System, within this year of 2023, under the umbrella of the aforementioned Pact for Sills.

Therefore, it is recommended that the Sector Skills Alliance, targeted at the beginning of the EDDIE project, should be oriented to become the Large-Scale Partnership committed by the EC, which has to be aligned with strategic plans to facilitate funding and visibility. Currently, the Pact for Skills offers a great opportunity to frame this alliance, aligning it with the long-term vision of the European Commission, Also, the alliance should be framed within the Green Deal and the EU plans for digitalisation and employability.

The Partnership should rely on and make use of the already existing infrastructure (e.g. CEDEFOP, ESCO, other EU projects, or other related platforms). Relying on the work already done is essential to avoid duplications and leverage what is already known or available for improvement and adaptation to new skills needs. Within the EDDIE project, there have already been success stories in collaboration with other European projects that frameworks in similar topics in order to find out synergies and enhance the results of the analyses carried out in the field of skills gaps in the digitalisation of the energy sector. As an example, EDDIE has cooperated with ESCO on updating the process of the European database of occupations related to the Energy sector by providing the results related to the skills gaps to add new occupations and skills related to green and digital skills in the Energy Sector. EDDIE project has also been taken into account through ETIP-SNET the projects that are being covered by BRIDGE, especially its EIRIE platform.

Finally, the creation of an Entity, as a non-profit association, adds value to the Partnership enabling the development of the activities mentioned above by providing managerial and legal support for handling funding and resources. The Entity could be the core of the LSP, carrying out fundamental activities and coordination, and setting the grounds for the up-skilling and re-skilling that is needed in Europe in the context of the digitalisation of energy systems.

5. Conclusions: structured summary of recommendations.

Table 6 summarizes the main recommendations that have been provided, classifying them according to the type of model (business or academic) and phase of the training programme where they have an impact. Some recommendations affect the two types of models or several phases of the training programmes, and the most relevant have been kept as belonging to several phases/models.

Table 6 List of main recommendations classified per type of model and phase

PHASE	BUSINESS MODEL	ACADEMIC MODEL
SPECIFICATION	Address workforce supply-demand mismatches and establish a systematic way of continuously anticipating skill needs	Define a standard template for training programs.
	Good practices in the surveys (short and concise, selection of stakeholders, track of contacts)	Develop a syllabus with transversal, knowledge, and functional skills for educational content.
	Tackle skills mismatches through innovative education, re-skilling programs.	Include training on digital transformation, smart technologies, and intelligent systems
	Programs supporting international/pan-European exchange and collaboration	Address workforce supply-demand mismatches and establish a systematic way of continuously anticipating skill needs
DESIGN	Address workforce supply-demand mismatches and establish a systematic way of continuously anticipating skill needs	More attention to be paid to online training platforms
	Good practices in the surveys (short and concise, selection of stakeholders, track of contacts)	Emphasize practical training and hands-on experience
	Foster collaborations with the (energy) industry and engage with research stakeholders	Utilize digital simulators and virtual scenarios for practical skill development
	Provide professional development for VET trainers and mentors	Combine traditional training with work-based learning structures
		Incorporate interactive and multi-disciplinary training methods
		Tackle skills mismatches through innovative education, re-skilling programs.
		Foster collaborations with the (energy) industry and engage with research stakeholders
IMPLEMENTATION SUCCESS	Offer specialized services offered based on the actual needs of stakeholders.	Increase interest/knowledge in digital energy (e.g. primary/secondary education, extracurricular activities, etc.)
	Create specialized web marketplaces to increase visibility and commercial success.	Policy makers to develop a coherent public policy updating training contents and compatible frameworks (qualification and certification)
	Conduct a cost-benefit analysis and develop a business model.	Provide certification, quality assessment and credentials to support the visibility of the learnt skills
	Establish a strategic network alliance with specific activities.	
	Alignment with European initiatives and frameworks.	
	Provide certification, quality assessment and credentials to support the visibility of the learned skills	

Regarding the specification phase, and in particular the business models, it is necessary to identify and address supply-demand mismatches and establish a systematic way of anticipating skill needs. Surveys are needed to

identify these mismatches, and as a result of the surveys that have been carried out in EDDIE, we highlight the importance of following good practices in the design of the surveys, such as having short and concise questions, pre-selecting the stakeholders to which the survey will be directed and keeping track of the institutional contacts. Innovative education and re-killing programs should be considered for tackling skill mismatches. Finally, programs should support international/pan-European exchange and collaboration.

Regarding the specification of the academic model, a standard template for training programmes and a syllabus with transversal, knowledge, and functional skills are very useful tools for specifying educational content allowing standardizing formats and contents. In particular, in the domain of the digitalisation of the energy sector, digital transformation, smart technologies, and intelligent systems are identified as key areas that should be further explored and where the education institutions should contribute to form new students and professionals.

In the design phase of the business models, there is also a need to address supply-demand mismatches, based on surveys that should follow good practices. In addition, the collaborations between educational institutions and the industry, in particular with the energy industry in this field, provide great added value for students, and should have high priority when designing new courses. For this to be possible, it is not sufficient to design new training materials for students, but also education trainers will need a re-skilling. In particular, VET trainers should be provided with professional development, making this a pre-requisite to extend this to students.

For the design of the academic model, from the best practice analysis, many tools have been identified as relevant to successfully achieving this transition:

- Online training platforms.
- Practical training and hands-on experience.
- Work-based learning, in combination with traditional training.
- Interactive and multi-disciplinary training methods.

For implementation success, in the business models, there are two major groups of recommendations. Firstly, to create and offer specialized web marketplaces and services, to increase the visibility and commercial success of the training programmes. The business models should be based on the actual needs of the stakeholders, and in order to analyse their feasibility, a cost-benefit analysis and related business model should be developed. Secondly, the creation of a strategic network alliance, (the Large-scale Partnership) is key to monitoring and fostering the activities in the field. This alliance should leverage and be aligned with other European initiatives.

Finally, for the implementation success of the academic model, it is needed to increase interest and knowledge on digital energy. This is key to motivating students, professionals, and professors. This should start as early as in primary/secondary education, and extracurricular activities are identified as having the potential to play an important role in this matter. In education, the recognition procedures for the training courses play an important role. In order to support the visibility of the learned skills, certification, quality assessment, and credentials should be provided. To achieve these goals, policymakers should develop a coherent public policy, update training contents and design compatible frameworks (qualification and certification).

Table 7 identifies the stakeholder involved in each recommendation. Training providers are key and they need to be involved in most of the recommendations. In a few recommendations (standard template, syllabus, and training platforms) they are the only involved stakeholders.

There are many recommendations that require mainly intervention of training providers and the industry. This is the case of the web marketplaces needed to increase visibility and commercial success and the related recommendations (specialized services, cost-benefit analysis, business model development). Tackling skill mismatches, as well as training on digital transformation, smart technologies, and intelligent systems will also require the collaboration of the industry and the training providers. The same is true for some of the practical recommendations, like the hands-on experience, the work-based learning, and the interactive and multi-disciplinary training methods.

On the other hand, the administration (or public sector), and in particular policymakers, should be the ones providing coherent public policy updating training contents and compatible frameworks. In collaboration with the training providers and/or the industry, they should foster the international and/or pan-European exchange and provide professional providers for trainers. In relation to the strategic network alliance, they should seek alignment with European initiatives, and support the anticipation of skills needs, while providing a homogenous and stable framework that enables cross-border certification and credentials, while ensuring a proper quality assessment.

Social and other stakeholders should also be involved in the collaborations with the industry, seeking their participation in the strategic network alliance, and supporting the objectives of developing surveys and increasing interest in digital energy.

Table 7 List of main recommendations with the involved stakeholders

List of recommendations	Training providers	Industry	Administration	Social & others
Define a standard template for training programs.	X			
Develop a syllabus with transversal, knowledge, and functional skills for educational content.	X			
More attention to be paid to online training platforms	X			
Offer specialized services offered based on the actual needs of stakeholders.	X	X		
Conduct a cost-benefit analysis and develop a business model.	X	X		
Create specialized web marketplaces to increase visibility and commercial success.	X	X		
Tackle skills mismatches through innovative education, re-skilling programs.	X	X		
Include training on digital transformation, smart technologies, and intelligent systems	X	X		
Emphasize practical training and hands-on experience	X	X		
Utilize digital simulators and virtual scenarios for practical skill development	X	X		
Combine traditional training with work-based learning structures	X	X		
Incorporate interactive and multi-disciplinary training methods	X	X		
Policymakers to develop a coherent public policy updating training contents and compatible frameworks			**X**	
Programs supporting international/pan-European exchange and collaboration	X		**X**	
Provide professional development for VET trainers and mentors	X		**X**	
Alignment with European initiatives and frameworks.	X	X	**X**	
Address workforce supply-demand mismatches and set a systematic way of continuously anticipating skill needs	X	X	**X**	
Provide certification, quality assessment and credentials to support the visibility of the learned skills	X	X	**X**	
Foster collaborations with the (energy) industry and engage with research stakeholders	X	X		X
Establish a strategic network alliance with specific activities.	X	X	**X**	X
Good practices in the surveys (short and concise, selection of stakeholders, track of contacts)	X	X	**X**	X
Increase interest/knowledge in digital energy (e.g. primary/secondary education, extracurricular activities)	X	X	**X**	X

Overall, the recommendations respond to the questions of how the mismatches of skill supply-demand should be addressed, while providing tools for the specification (template, syllabus) and design (training platforms, practical training, digital simulators and virtual scenarios, work-based learning, interactive and multi-disciplinary training methods, etc.) of training programmes, and following best practices (international/pan-European exchanges, collaboration with the industry, professional development of trainers, etc.).

Finally, for implementation success, the provision of specialized services/marketplaces provides added value but should be properly substantiated, while the role of the administration is critical to develop a coherent public policy and a homogenous framework, to support and facilitate certification, quality assessment and credentials. The creation of a strategic network alliance realised through a Large-Scale Partnership, is the best option in order to ensure the continuity of the efforts over time and to guarantee the long-term sustainability and ultimate success of the ongoing project developments.