Education for Digitalization of Energy

Deliverable 4.3

Report on Best Practice for University

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Status -Version: **V1.0**

Delivery Date (DOW): **31-12-2021**

Actual Delivery Date: **31-12-2021**

Distribution - Confidentiality: **Public**

Abstract:

European policy work and economic strategies should function coherently to produce a framework suited to redesigning higher level education (in university, vocational schools and lifelong professional development) in accordance with the industrial transition and digitalization, also in the Energy sector. Next to this, bridging and methodological transfer in university, vocational and lifelong education should exist to ensure the adaptation of curricula to the demands of the labor market. In this scenario, this deliverable is one of a triplet of “technical reports” on Best Practice for higher education, and in particular focuses on Best Practice for university. The BP is defined as a set of procedures aimed at reformulating the academic teaching offer and the academic learning process, directed to the Energy sector and the delivery of skillset demanded by its digitalization and transformation.

Keywords:

D4.3 – Best Practice, Digitalization, Energy transition, European Union, Industrial transformation, Teaching and Learning Procedures, University Education

DISCLAIMER

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ACKNOWLEDGEMENT

This document is a deliverable of EDDIE project. This project has received funding from the European Union's Erasmus+ under grant agreement Nº 612398.
The opinions expressed in this document reflect only the author's view and in no way reflect the European Commission's opinions. The European Commission is not responsible for any use that may be made of the information it contains.

Document History

Version	Date	Contributor(s)	Description
V0.1	**17/12/2021**	Claudia Battistelli, Martin Molnar, Anupama Vashishtha (RWTH) – Alvaro Lopez Lopez (COMILLAS) - Daniela Casiraghi, Susanna Sancassani, Bianca Santolini (POLIMI) - Andreas Stavrou (FOSS) – Hendrik Drier (EWI) - Alexandros Chronis, Georgia Saridaki, Maria Valliou (NTUA) - Genoveva Ponce Buenestado, Sonia Reventun Alegre (PADRE PIQUER) - Marta Sturzeanu, Carina Zidaru and Radu Plamanescu (CRE)	**Final draft of the deliverable, submitted for internal review.**
V0.2	**26/12/2021**	Claudia Battistelli, Martin Molnar, Anupama Vashishtha (RWTH) – Alvaro Lopez Lopez (COMILLAS) - Daniela Casiraghi, Susanna Sancassani, Bianca Santolini (POLIMI) - Andreas Stavrou (FOSS) – Hendrik Drier (EWI) - Alexandros Chronis, Georgia Saridaki, Maria Valliou (NTUA) - Genoveva Ponce Buenestado, Sonia Reventun Alegre (PADRE PIQUER) - Marta Sturzeanu, Carina Zidaru and Radu Plamanescu (CRE)	**Final deliverable ready for submission to the EU Agency.**
V0.3	**30/01/2023**	Amila Kaharevic, Berna Balci (RWTH) - Alvaro Lopez Lopez (COMILLAS) - Marina Zotaki, Katerina Tasidou (NOVEL) - Daniela Casiraghi, Susanna Sancassani, Bianca Santolini (POLIMI) - Andreas Stavrou (FOSS) - Radu Plamanescu (CRE) - Jakob Junkermann, Johanna Bocklet (EWI) - Konstantinos Michos (NTUA)	**Revised deliverable ready for submission to the EU Agency.**
V0.4	**07/05/2024**	Berna Balci (RWTH)	**Revised remarks in chapter 4.4**

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22/12/2021	**Ferdinanda Ponci**	**RWTH**
27/12/2021	**Juan Carlos del Real**	**COMILLAS**

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Acronyms

AI	Artificial Intelligence
ATI	Advanced Technology for Industry
BP	Best Practice
BSDE	Blueprint Strategy for the Digitalization of the Energy sector
DCF	Digital Competence Framework
DEAP	Digital Education Action Plan
DEH	Digital Education Hub
DMA	Digital market Act
DSA	Digital Service Act
DENSYS	Master Erasmus Mundus Decentralised Smart Energy Systems
EC	European Commission
EDSC	European Digital Skills Certificate
EERA	European Energy Research Alliance
EIT	European Institute of Innovation and Technology
ETIP	European Technology and Innovation Platform
EU	European Union
EUI	European University Initiative
HPC	High Performance Computing
ICILS	International Computer and Information Literacy Study
IEA	International Energy Agency
ICT	Information and communication Technology
JP	Joint Program
ML	Machine Learning
MOOC	Massive Open Online Courses
SET	Strategic Energy Technology
SETIS	SET Plan Information System
SP	Sub Program
STEM	Science, Technology, Engineering and Mathematics
VET	Vocational Education and Training

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Executive Summary

Deliverable, *"D4.3, Report on Best Practice for University"*, is one of a triplet of technical documents on Best Practice (BP) in higher education (i.e., university, vocational and lifelong education/training), and in particular it refers to university education. The document – the contents of which pertain to WP4 of the EDDIE project - presents the conceptual framework and the methodological approach for the redesign of a BP for teaching and learning in university, in the view of Energy Digitalization and of the corresponding demand for new professional skills in the sector. The conceptual framework is formalized through a meta-analysis of the current trends and issues emerged in university education, and it consolidates content, arguments, findings, and good practice as recommended in recent years by the European public authority and the industry. The methodological approach is formulated based on the targets and requirements set by the Digitalized energy sector and the industrial transformation.

Background and motivation

We are witnessing in these years a dramatic digital transformation of the European economy, and more generally, of the European society. The labor market calls for new technical and 'soft' skills that become also a means of participation and integration in the society. As a result, traditional roles, content and methods of education are being questioned. The education sector, today, must prepare students for changing tasks and roles both in the labor market and as European citizens. Simultaneously, today's policymakers and education providers need reskilling and upskilling opportunities to enable the students to tackle tomorrow's challenges.
Redesigning education for a digitalized society and economy should become a central matter for policymakers and public administration, as much as for students and parents, educators, and businesses and employers. Two are the main reasons:

1. Only education can develop a skilled workforce that is prepared for future jobs and a changing labor market. In this respect, rethinking and redesigning teaching and learning in university represents a prerequisite for Europe's future global competitiveness
2. Only education can deliver the prerequisites for the social inclusion and equal participation of European citizens in a digitalized democracy. In this other respect, rethinking and redesigning university education can make the difference when it comes to safeguarding European values such as equality, democracy, and the rule of law.

It must be noted that Education in the digital age includes - but is not restricted to - digital education, and encompasses the transmission of technical, 'soft' and citizenship skills, and must address both' formal and non-formal education throughout the entire life of European citizens.

Lots of policy work and economic strategies have been produced to redesign university education in the view of Digitalization. The importance of 'soft' and citizenship skills (e.g., entrepreneurship, leadership and teamwork, communication, work ethics, online etiquette, critical and computational thinking, competence building) is a consolidated matter of discussion, and from recent years different examples of 'iterative' and 'organic' approaches - in the form of small-scale experimental initiatives – have made their appearance to illustrate how good practice in education can be realigned to the needs of the digital era. These examples, if successful, could be reused, upscaled and mainstreamed. However, overall, the European university system still does not provide students with the effective and equitable employability that is required. For example:

- The implementation of digital infrastructure or topics in universities is at a good level across the European Union (EU), but not harmonically across the variety of technical fields and disciplines (e.g., important gaps must be filled in education for the Energy sector) or across the member states (constraints exist due to territorial legislation, or cultural and social barriers, or organization, or economic situation).
- The use of digital tools is gaining popularity among European teachers, but not often these tools are adopted in ways that are pedagogically meaningful. Most teachers do not, or only sporadically, participate in professional development focused on digital education.

Moreover, they often lack the training and the supportive framework that is needed to focus their teaching more strongly on the needed 'soft' and (digital) citizenship skills.

- Students in Europe have generally good digital skills, but differences persist based on educational background and country. Gender differences in acquisition and mastering of skills are negligible, but women remain by far less likely to turn their digital competences into a career.
- Studying abroad is a key element in students' development and it becomes even more important in the digital era, as it can – next to the skills that accompany physical mobility - have a significant impact on students' advancement. However, for students from low-income countries or poor socio-economic backgrounds, barriers persist for their plans to study abroad. This issue has become more severe since the start of the Covid pandemic.
- High work flexibility and a decreasing demand for mid-level qualifications are more and more establishing in professional contexts. Today's students need to be prepared for more flexible forms of work, a more flexible labor market, as well as more mobile and dynamic curricula and work biographies. In parallel, the existing workforce should undergo extensive upskilling and reskilling, increasing the relevance of lifelong learning and informal/non-formal education beyond the university studies.

Main scope and contribution of this document

With a focus on redesigning the teaching and learning procedures in university to align them to the requirements of the new digital world and energy sector, Deliverable D4.3 gives an overview of current guidelines, emerging strategies, and existing examples of good practice. After that, it lays out upcoming trends and opportunities for the identification of new recommendations and procedures that could redesign the academic offer. Practically, the scope and contribution of the document can be formalized into five major points:

1) It provides the framework of existing recommendations and strategies to rethink education and the energy industry in the view of digitalization. This framework is also populated by existing examples of good practice in education and training.
2) It presents the array of the current good practices that can be integrated within the framework of the EDDIE BP.
3) It identifies the trends and opportunities for development of a new BP for university education (thanks to points 1) and 2)).
4) It sets up the methodology for the practical development of the BP itself.
5) It sets the ground for identification of new recommendations and practices that will advance the existing ones.
6) It shows a set of good examples and best practices in university education and connected to university institutions.

The information in this report is complementary to the work undertaken in the twin deliverables *D4.2 'Report on Best Practice for Vocational Education'* and *D4.4 ''Report on Best Practice for lifelong learning and beyond'*. The outcomes of the three works will be used in the remaining of the EDDIE project for the practical development of a BP for higher education (in the form of procedures for teaching, training and learning) that ultimately will be consolidated part of the Blueprint Strategy produced at the end of the EDDIE project.

1. Introduction

In general, a Best Practice (BP) should be defined considering two contiguous perspectives linked to each other: the first refers to the market demand for trainers and specialists with a high level of both basic and specialized preparation; the second refers to the offer consisting of product and service solutions guaranteed by technical, methodological and application development of these trainers and specialists, as well as, when possible, to their transferability from role to role, or even more from sector to sector. Therefore, a BP is what is needed to close a “triangle of specialized skills” requirements, which defines and delimits the theoretical and practical contents of the knowledge for a profession, the soft and technical competences that this profession requires, and the learning processes that should guarantee their acquisition, so as to prepare students to integrate into the social sphere and above all into the labor market.

In the case of the Information and Communication Technology (ICT) and Energy sectors, the product and service solutions are practically unlimited, each being characterized by specific technical applications and functions, assigned to specific professional roles. The wide variety of functions and roles in these sectors has been accompanied over the last decades by a dramatic technological and market development, which has produced a spectacular typological expansion of knowledge requirements, with the consequent demand for education and training in Digitalization, as much as for reskilling and upskilling of previously acquired expertise.

The number and complexity of functions existing nowadays in the professions for the “Digital Energy” sector, correspond to an articulated demand for specialized knowledge and skills to carry out these functions and use the operational tools that they require. In this scenario, we introduce a BP for education and training that can meet the new demand for skills in the digital energy world. This BP is defined and identified by qualifications and contents, on the basis of the specific skills required by the market, and of the area of application/function in the development and production chain.

The evolution of the teaching model configures a new professional offer in which the new BP must be framed.

The progressive digitalization of all vital functions of the society gives users the access to a huge and ever-increasing mass of continuously updated information and knowledge.

In the field of education, specifically referred to higher level school, vocational training and university, digitalization introduces into the teaching and learning processes new study potentials as well as new operational interface tools and digital means, revolutionizing both methods and habits of both teachers and students. This in turn raises the challenge to consistently revise long-term coursework, teaching and learning contents. Emerging forms of self-education are expressing the potential to become an important pillar in the education system.

All these possible developments directly affect teachers’ education. Moreover, thanks to the new educational methods and tools, teachers can now be seen more as “knowledge facilitators” than as in their traditional role of "instructor and professor".

On the other hand, the learning process and the acquisition of knowledge and skills by students have changed fundamentally; for example, nowadays, the contents of a study no longer has to be learned by heart, but can be immediately accessed using mobile devices.

There must be matching between demand for specific competences and the skill offer, and rethinking the education practice should start from this pillar.

Digital skills are strongly demanded in different outsourcing activities of companies in many sectors, including the energy sector. The outsourcing to machines of information-processing and information-storage requires higher digital competence and media literacy. At the moment, it is not clear whether new occupations (and which new occupations) will emerge in the areas of software activity and algorithmic development, data analysis and management, monitoring and maintenance of robots and networks. Nor it is clear how sustainable the demand for such new occupations could be. However, some statistical surveys in progress indicate a huge growth of new types of jobs falling within the digital and energy fields. This trend should materialize especially in the case of strong growth of small and medium-sized enterprises operating alongside larger companies.

As a conclusive remark, a BP for education should take into great consideration the emerging application potential of digital technologies, especially in the perspective of the future, as it can be envisaged that this potential is going to be compatible to, and replicable in, an extremely wide sectoral range. Just in the education field, digitalization offers several references and starting points for the automated assessment of teaching/learning processes in the prospect of their improvement. Algorithms based on Educational Data Mining and learning analytics can increasingly take over the control and handling of learning processes. Developing digitalized learning tools in forms that be personalized to the users, can improve the teaching methods and consequently the education performance. Digitalization and automation, Artificial Intelligence (AI) and Machine Learning (ML) increase transparency in all basic or specific processes of teachers' education and schooling, but, at the same time, they also must respect and enhance all principle of personal and working privacy. In substance, whenever new forms of data misuse and identity theft may arise, this should also be addressed and resolved through technical or social innovation. This concepts either applies to learning analytics data that may raise questions about ownership and openness of data, as well as privacy. Tackling these concerns alongside all the other specific aspects that relate to rethinking education in the perspective of digitalization is the best way to ensure the appropriate use of data relating to the entire training cycle of anyone, adequately resolving the risk of improper use, and thus fully achieving the real and concrete objectives of a BP.

In this framework, the first step to develop a BP for reformulating university education in the view of digitalization and energy transition, is to understand WHAT this practice should deliver and HOW it should deliver it. Examples of existing good and best practice are important to evaluate to what extent the reformulation should happen, also considering the discrepancies in the local realities of a country (in the case of the EDDIE project, the extension should regard particularly the EU).

Structure of the document

The integral part of this document consists of three remaining chapters:

- Chapter 2 provides background information that should be taken into strong consideration in the effort to develop a BP for university, as it pertains to the most relevant European strategies, recommendations and roadmaps set by industry and policy makers to reach the objectives of the green economy across Europe in the near future.
- Chapter 3 describes the concepts and methodology underlying the development of a BP for university education, according to the vision and rationale of the EDDIE project and the objectives of its Blueprint. These concept and methodology will be used in the next stages of the project, which will be dedicated to the actual realization, validation and exploitation of the set of recommendation and tools that will form the BP.
- Chapter 4, which represents the Conclusions section, evaluates the European Union (EU) strategy for digital education presented in Chapter 2, with the aim of identifying those recommendations and examples that can be referred to, reused "as is" or improved in the EDDIE BP. With the same aim, this chapter presents examples of old or ongoing good and best practice in university education and connected to university institutions, to highlight the key factors for their success and to extrapolate information that can be useful for the EDDIE BP. All these lessons learnt will be finally used to draw some conclusive remarks and define the next steps of the development activity.

2. Background

This chapter provides background information that will be used to design an EDDIE BP for university education, and reviews relevant European strategies and roadmaps set for the energy transition and energy digitalization. This review encompasses all levels of professionalism, starting from the Education sector – where future professionals are "shaped" -, and then moving to the higher levels that are represented by Industry and Market with their demands and criteria. The review is complementary to any other relevant information already evaluated in EDDIE and presented in other project deliverables (i.e., D2.1 and D2.2).

In the following sections, we present existing policy work, recommendations and industrial strategies that should be "the reference point" for universities across Europe to digitalize the teaching and learning experience, and to deliver the technical and soft skills that are nowadays needed in the profession and social integration. Hence, these policies, recommendations and strategies represent the core information which the BPs of EDDIE should build upon.

2.1. Digital Education: EU Policies and Recommendations

The COVID-19 crisis has been having a strong impact on education and training, accelerating the digitalization process. It has also evidenced the need for developing an effective strategy to support and implement the digital transformation in education, and for supporting the upskilling and reskilling of both teachers and students. The digital transformation is important because it offers new or renewed learning patterns. [1 – 3] That said, there are some important challenges that the EU needs to consider, such as:

- The need for technological tools, platforms and pedagogy to be inclusive and to allow learners with disabilities to participate in the digital transformation;
- The development of digital capacities of education and training institutions;
- The need for individuals from disadvantaged backgrounds to have access to digital tools.

The European Commission (EC) has put in place a set of actions and initiatives to address these challenges, fostering the advancement of education and training, while defining a long-term vision for a European digital education.

At University level, two are the main strategies delivered by the EC and described in the European Education Area:

- The Digital Education Action Plan (DEAP)
- The European University Initiative (EUI)

Furthermore, it describes the main findings related to the COVID-19 emergency and the key findings and recommendations in terms of Higher Education Strategies developed by NESET.

2.1.1. Digital Education Action Plan 2021-2027

The DEAP 2021-2027 [1] is a renewed EU policy initiative aimed at encouraging and supporting the sustainable and effective adjustment of the education and training systems of the Member States to the digital age. It builds upon the previous DEAP 2018-2020 (which already discussed the digital transformation of education and training) but furthermore addresses some aspects and issues that have become clearer only during the Covid-19 pandemic, namely, that the switch to digital tools becomes a necessity to overcome the limitations of the "new normal" that the pandemic has established. In fact, the education sector has seen a disruptive switch to online teaching and learning, which indicates not only the need to adopt newer ways of imparting these skills but also a necessity for foundational skill-building to make everyone able to navigate the online world.

The priority areas and objectives called by the DEAP are two:

1. Fostering the development of a high performing digital education ecosystem.
2. Enhancing digital skills and competences for the digital transformation.

2.2. Fostering the development of a high performing digital education ecosystem

To achieve this broad objective, a detailed action plan has been formulated which relies on the cooperation among the Member States to prepare by 2022 a proposal for a "Council Recommendation" on the enabling factors for a successful digital education. This document will include guidelines on online and distance learning for primary and secondary education in addition to the development of a European Digital Education Content Framework for which a feasibility study on the creation of a European exchange platform will also be launched. Erasmus cooperation projects to support the digital transformation plans of primary, secondary, vocational education and training (VET), higher, and adult-education institutions, will be crucial to this end. A focus on the development of ethical guidelines on Artificial Intelligence (AI) and data usage in teaching and learning for educators is also in the works. Table 1 summarizes the Actions set to achieve this objective.

Table 1 - DEAP Actions to foster development of a high performing digital education ecosystem

Action	Description
Action 1	- Dialog with Member States in order to prepare a possible proposal for a Council Recommendation by 2022 on the enabling factors for successful digital education with stakeholders including governments, education and training institutes, private sector, public sector with the aim of tackling connectivity and equipment gaps and sharing knowledge on how to adapt and digitalize in an inclusive manner.
Action 2	- With the learning from the pandemic with respect to the need for online teaching, propose a Council Recommendation on online and distance learning for primary and secondary education by the end of 2021.
Action 3	- Development of European Digital Education Content Framework with more creative, engaging, and diverse content keeping in mind the long-term preservation of these educational resources along with addressing cybersecurity, data protection, and e-privacy risks.
Action 4	- Encourage Member States to include broadband in investment and reform projects in national recovery and resilience plans under the Recovery and Resilience Facility to facilitate high-speed internet connectivity for socio-economic drivers, such as schools.
Action 5	- Use Erasmus cooperation projects to support the digital transformation plans of primary, secondary, VET, higher, and adult education institutions. - Support digital pedagogy and expertise in the use of digital tools through the Erasmus+ Teacher Academies to support collaboration and provide

	professional development, and through the SELFIE for Teachers online self-assessment tool to identify strengths and gaps in digital competencies
Action 6	- Develop ethical guidelines on AI and data usage in teaching and learning for educators and teachers in addition to a training program for researchers and students on the ethical aspects of AI and data usage.
Action 7	- In order to promote responsible and safe use of digital technologies and increase digital literacy to identify facts from fake information and manage information overload, an informal commission expert group on addressing disinformation through education and training will be launched.

2.3. Enhancing digital skills and competences for the digital transformation

The other critical pillar of the DEAP is enhancing digital skills and competences for the digital transformation. Tackling disinformation through education and training, improved monitoring and support of the cross-national collection of data on student digital skills through participation in the ICILS (International Computer and Information Literacy Study) and encouragement of women's participation in STEM (Science, Technology, Engineering and Mathematics) will play a vital role towards achieving this goal. There is also a need to update the European Digital Competence Framework in addition to the development of a European Digital Skills Certificate (EDSC) that may be recognized and accepted by governments, employers and other stakeholders across Europe for increased mobility and flexibility within Europe for upskilling and reskilling opportunities. Incentivized advanced digital skills development through targeted measures including scaling up the Digital Opportunity Traineeship and establishment of a European Digital Education Hub will further benefit primary, secondary, vocational and educational trainees, learners and apprentices as well as support the cross-sector collaboration for seamless exchange of various digital education learning contents. Table 2 summarizes the Actions set to achieve this objective.

Table 2 - Enhancing digital skills and competences for the digital transformation

Action	Contents
Action 8	- Update of the Digital Competence Framework to include AI and data-related statements of skills, knowledge and attitudes along with development for AI learning resources for education and training. Stimulation of community practices for exchanging resources and discussions through two international online meetings for knowledge sharing and promoting digital literacy regarding AI.
Action 9	- Feasibility study exploring scenarios for the European Digital Skills Certificate to be conducted. The EDSC will help people have their digital skills quickly and easily recognized by employers, training providers and more by indicating the level of digital competence corresponding to the DigComp proficiency levels.
Action 10	- Update of the Joint Research Centre (JRC) report 'Developing Computational Thinking in Compulsory Education – Implications for policy and practice' and creation of Council Recommendations on improving the provision of digital skills in education and training through dialogue with industry on identifying and meeting new and emerging skills needs in order to ensure 65% of Europeans have at least basic digital skills by

	2025.
Action 11	- Monitoring and annual reporting on digital skills, expanded coverage of internationally comparable data on digital skills across EU Member States and at the European level supporting evidence-based policymaking through a more accurate picture of the state of young people's digital skills and the factors influencing the acquisition of digital skills within the EU.
Action 12	- Impart hands-on professional experience in digital fields demanded by the labor market to higher education students in varied disciplines including cybersecurity, big data, quantum technology, machine learning, web design, digital marketing and software development to higher education staff and VET learners, as well as recent graduates.
Action 13	- Make training in digital and sustainable entrepreneurship skills available to girls at secondary education level, enhance digital and entrepreneurial competences among girls and women through E-STEAM festivals to boost their confidence. By the end of 2027 – engage 40,000 young female students in training on the circular economy and digital skills.
Digital Education Hub	- Establish a European Digital Education Hub in order to improve cooperation on digital education at the EU level. - Member States to establish national advisories to exchange experience and good practice on the enabling factors of digital education, to link project and digital education initiatives internationally, to connect national authorities and other stakeholders. - Monitors the implementation of the Digital Education Action Plan, development of digital education in Europe through the results of supported projects - Supports cross-sector collaboration for seamless exchange of various digital education learning contents - Supports agile policy and practice development via user-driven innovation in the Digital Education Hackathon

2.3.1. European Universities Initiative

The transformation of our universities, accelerated by COVID, needs to address the need to prepare young people for the jobs of tomorrow in a fast-changing society. This requires a much deeper level of cooperation between universities. With its European Universities Initiative (EUI) [4], the European Commission aims at fostering excellence, innovation and inclusion in higher education across Europe, accelerating the transformation of higher education institutions into the universities of the future with structural, systemic and sustainable impact.

European Universities are trans-national alliances of higher education institutions developing long-term structural and strategic cooperation with a minimum of 3 higher education institutions, from 3 EU Member States or other Erasmus program countries. At the moment, there are 41 Alliances working in Europe testing different models of the concept of European Universities and examining its potential to transform higher education. The EUI will be fully rolled out and scaled up under the next Erasmus program 2021-2027.

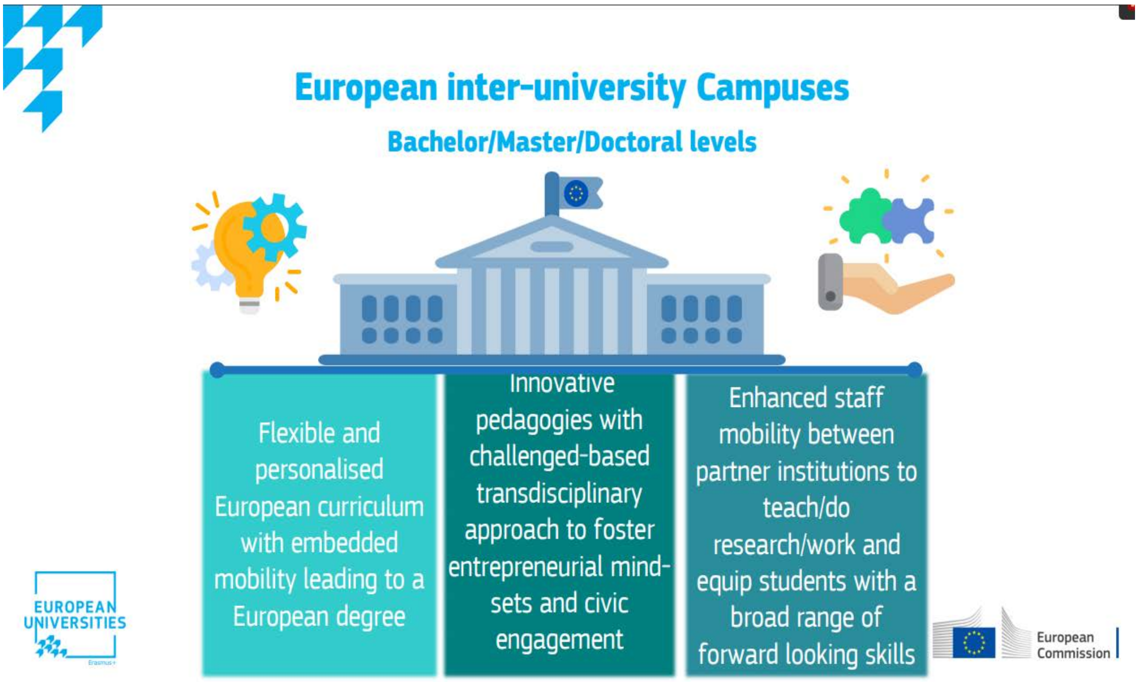


Figure 1 - European University Model (scheme presented at Info Session)

The European University Model (Figure 1) will be based on the following pillars:

- Deep level of inter-university cooperation with a joint long-term strategy.
- Structural, Systemic and Sustainable impact

Alliances will need a joint long-term strategy for education with, where possible, links to research and innovation to drive systemic, structural, and sustainable impact at all levels of their institutions

Alliances must create a European inter-university campus where:

- Students, staff and researchers enjoy seamless mobility (physical, virtual or blended);
- Transdisciplinary and transnational teams of students, academics and external stakeholders tackle big issues facing europe;
- Students can design their own flexible curricula, leading to a european degree;
- Practical and/or work-based experience is provided to foster an entrepreneurial mind-set and develop civic engagement;
- The student body reflects the social, economic and cultural diversity of the european population.

This Initiative could produce several results, such as interesting models for university cooperation to address skills shortages in different sectors. The outputs of these projects will be to be taken into strong consideration by the EDDIE project

2.3.2. The impact of COVID-19 on higher education: a review of emerging evidence and guidelines for planning higher education strategies

The Analytical report “The impact of COVID-19 on higher education: a review of emerging evidence” [2, 5] produced by the EC, Directorate-General for Education, Youth, Sport and Culture analyzes the impact of COVID 19 on university environment, taking into consideration the following aspects:

- Teaching and learning approaches
- Social dimension on higher education
- International student mobility

Each aspect is analyzed in relation to immediate impact (2019/2020 academic year), short-term impact (2020/2021 academic year) and medium-term impact (from now to 2025).

Teaching and learning approaches

In this context, the report evidences that universities have effectively addressed the crisis. They managed to transform face-to-face teaching into online teaching and the majority of university leaders confirm that transition online has been successful.

However, there is a difference between “online learning” and “emergency remote teaching”. Due to the sudden emergency, it was not possible to study or review the courses. In-person classes were simply "moved" online: there were no substantial changes to the curriculum or the methodology.

The report highlights that the switch to emergency remote teaching was more difficult in the fields which have a practical component. It also shows that most students responded well to the emergency remote teaching, but, for a non-negligible minority of students, the access to online communication tools and the internet remains a challenge, as does their level of digital skills.

Social dimension on higher education

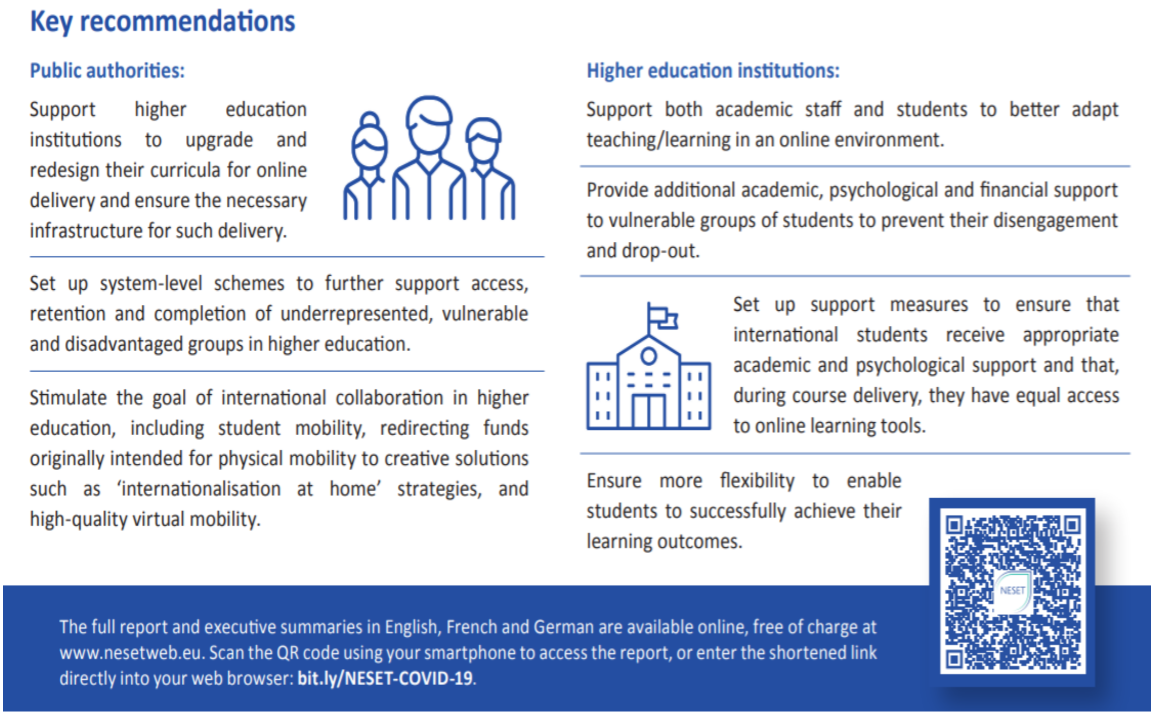
For social dimension on higher education, the report highlights the emergence of several new challenges for students, related to study conditions, study funding, and general well-being. Lots of students can’t count on a reliable internet connection and some of them don’t even have a quiet place to study. Many students worked to pay for study expenses: losing their jobs due to the pandemic, they would drop the study. Furthermore, many students experience prominent feelings of frustration, anxiety and boredom with academic activities.

International students’ mobility

Last but not least, the pandemic has heavily impacted international mobility. Many students and universities have been forced to cancel mobility programs. Many students were stuck in a foreign country and were exposed to high risk of isolation during periods of lockdown. Many other students, on the other hand, were unable to leave, but had to attend their host university's online classes from home. These students experienced significant disadvantages and a lower interaction with peers in their studies, thus removing a key element of learning mobility.

Guidelines to plan Higher Education strategies

With this document, the EC seeks to outline useful guidelines for planning Higher Education strategies in the coming years (Figure 2). These guidelines should be considered in EDDIE's development, in order to align the project with the EU perspectives.



Key recommendations

Public authorities:

Support higher education institutions to upgrade and redesign their curricula for online delivery and ensure the necessary infrastructure for such delivery.

Set up system-level schemes to further support access, retention and completion of underrepresented, vulnerable and disadvantaged groups in higher education.

Stimulate the goal of international collaboration in higher education, including student mobility, redirecting funds originally intended for physical mobility to creative solutions such as 'internationalisation at home' strategies, and high-quality virtual mobility.

Higher education institutions:

Support both academic staff and students to better adapt teaching/learning in an online environment.

Provide additional academic, psychological and financial support to vulnerable groups of students to prevent their disengagement and drop-out.

Set up support measures to ensure that international students receive appropriate academic and psychological support and that, during course delivery, they have equal access to online learning tools.

Ensure more flexibility to enable students to successfully achieve their learning outcomes.

The full report and executive summaries in English, French and German are available online, free of charge at www.nesetweb.eu. Scan the QR code using your smartphone to access the report, or enter the shortened link directly into your web browser: **bit.ly/NESET-COVID-19**.

Figure 2 – Planning Higher Education strategies in Covid era

In particular, regarding the teaching and learning approaches:

- Many institutions should rethink and conceptualize the nature and methods of teaching and learning, adapting their curriculum and methods to online teaching;
- Many universities should revise their assessment processes to maintain quality standards and academic integrity in the online learning environment;
- As a consequence of the first two points, many institutions should develop new online platforms, online proctoring, and data protection strategies;
- To ensure that all students have equitable access to the new educational tools, it is likely that universities will focus on the development of students' digital competences.

With regard to the social dimension on higher education, it is worth noting that:

- Many universities will aim to be more flexible in designing the organization and delivery of curricula (e.g., allowing students to easily change their course load, timing of assignments...)
- Government and European policies are likely to be committed to ensuring secure access to reliable, adequate and affordable internet connectivity for all students. Consequently, this could lead to even greater investment by universities in online learning:
- Increased focus on inclusion of underrepresented, vulnerable, and disadvantaged groups to prevent high dropout rates associated with the massive adoption of online education.

Finally, with respect to international students mobility, it should be considered that:

- If the emergence continues, many universities will begin to promote blended programs of physical and virtual mobility. They will likely revise their learning objectives and focus more on the exchange of ideas, rather than the experience of living abroad.

- New alternative "internationalization at home" programs will emerge (enriching on-campus learning by mixing intercultural elements in the home institution).

Many institutions are already responding to the changes brought about by the pandemic. Despite the difficulties, this opportunity could revolutionize the educational world. This is likely to lead to increased collaboration and exchange of best practices among European universities, which could be an incentive for the unification of educational programs.

2.4. European Strategic Energy Technology Plan (SET Plan) and SET Plan update

The SET Plan structure

The SET Plan was launched in January 2007 after acknowledging the need to reshape the European energy sector in order to make it possible to face the important challenges that come with the climate change. Its main objectives are to lower the cost of clean energy and to allow Europe to play a key role in the low-carbon technology scenario.

The SET plan is envisioned to be instrumental in funding Research and Innovation (R&I) activities by promoting a targeted and efficient spending, and by driving national and private financial sources.

It consists of the SET Plan Steering Group, the European Technology and Innovation Platforms (ETIPs), the European Energy Research Alliance (EERA), and the SET Plan Information System (SETIS). [6 – 10]

It is worth bearing in mind the composition and the roles that each of these groups play in allowing the SET Plan to be efficient:

- The SET Plan Steering Group consists of high-level representatives from EU countries, as well as Iceland, Norway, Switzerland, and Turkey. It ensures better alignment between the different research and innovation programs at EU and national level, as well as the SET Plan priorities. It also increases cooperation between national programs to avoid duplication and heightens the impact of public investment.
- The European Technology and Innovation Platforms (ETIPs) were created to support the implementation of the SET Plan by bringing together EU countries, industry, and researchers in key areas. They promote the market uptake of key energy technologies by pooling funding, skills, and research facilities. There are nine ETIPs.
- The European Energy Research Alliance (EERA) aims to accelerate new energy technology development by cooperation on pan-European programs. It brings together more than 175 research organisations from 27 countries, involved in 17 joint programs. It plays an important role in promoting coordination among energy researchers along the SET Plan objectives and in the technology transfer to the industry.
- The EU's SET Plan Information System (SETIS) provides information on the state of low-carbon technologies. It also assesses the impact of energy technology policies, reviews the costs and benefits of various technological options, and estimates implementation costs. This information is useful for the European industrial initiatives, private companies, trade associations, the European Energy Research Alliance, international organisations, and financial institutions.

As can be seen in the SET Plan infographic (Figure 3), the plan is articulated into 10 key actions:

- Integrating renewable technologies in the energy systems
- Reducing costs of technologies

- New technologies and services for consumers
- Resilience and security of energy systems
- New materials and technologies for buildings
- Energy efficiency for industry
- Competitiveness in global battery sector and e-mobility
- Renewable fuels and bioenergy
- Carbon capture and storage
- Nuclear safety

These actions are grouped into 6 domains, which to some extent reveal the strategic lines envisioned by the plan.

- Becoming world number one in renewables. Actions 1, 2.
- Delivering a smart consumer-centric energy system. Actions 3, 4.
- Develop and strengthen energy-efficient systems. Actions 5, 6.
- Diversify and strengthen energy options for sustainable transport. Actions 7, 8.
- Driving ambition in carbon capture, utilization and storage. Action 9.
- Increase safety in the use of nuclear energy. Action 10.

Finally, there are 13 implementation working groups, which reflect the same number of low-carbon energy sectors:

- Offshore wind
- Photovoltaics
- Deep geothermal
- Ocean energy
- Concentrated solar power / Solar thermal electricity
- Energy systems
- Positive energy districts
- Energy efficiency in buildings
- Energy efficiency in industry
- Batteries
- Renewable fuels and bioenergy
- Carbon Capture and Storage (CCS) – Carbon Capture Utilization (CCU)
- Nuclear safety

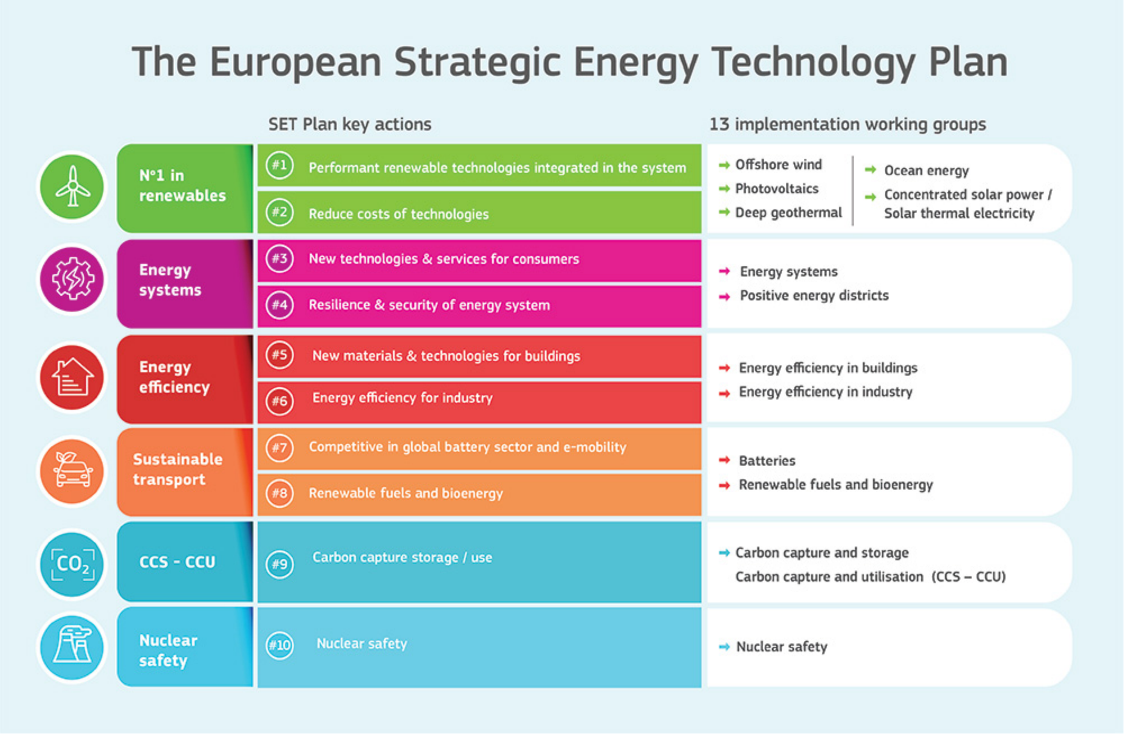


Figure 3 – SET Plan infographic
(source: https://ec.europa.eu/energy/sites/default/files/media/set_plan_bis_002.jpg)

Some reflections and roadmap for education and training

The SET Plan conducted a study on Energy Education and Training in Europe in 2014. Working Groups compiled assessment reports in twelve key low-carbon energy fields (such as “Electricity grids” and “Energy Storage”) and also on horizontal issues shedding light in four directions: “Current Situation”, “Ongoing Actions”, “Needs and gaps, in particular main barriers or bottlenecks for the different sectors and their markets” and “Recommendations at EU and Member State level within specific target dates”.

Those assessment reports were published autonomously under the title “SET Plan Study on Energy Education and Training in Europe, Assessment Reports of the Expert Working Groups”. They were also used to create the “Roadmap on Education and Training, Availability and mobilization of appropriately skilled human resources”. We make here an analysis of the main Recommendations/Best practices with an emphasis on digitalization.

One of the key pillars recognized by SET Plan in advancing the energy technology innovation is the availability and mobilization of appropriately skilled human resources.

The paradigm shift that happens in the energy field calls for multidisciplinary and system integration education. That means that the specialists need to understand how their work interacts with the other technical fields and the managerial decisions, and the planners and managers need to have a strong technical background.

The three objectives that the SET Plan Roadmap has, are the following:

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

Objective 1: Knowledge, Skills and Competences gap

For this objective the main recommendation is to fill the gaps via building networks, pooling resources and aim for all solutions to allow quick scale-up. So, it is encouraged to build Networks of Universities with links to Business and Research and Vocational Education and Training networks.

Network of Universities will help in the development of new curricula, the upgrade of the existing and the adoption of those changes. They will also facilitate the creation of joint degree programs that of course have as prerequisite the integration of the accreditation systems, the learning material etc . The connection between universities and research centers will open the way for a more advanced training for both the students and the staff.

VET Networks will involve many different actors like technical training centers, companies from related industries, vocational career guidance bodies, and bodies that handle the certification. They will have as key objective to enable the existing workforce to reskill and upskill by creating new and upgrade the existing curricula and strengthen the element of practical education preferably in the business setting.

The Master and PhD programs as outcomes of the networks, should follow the innovative educational methods that have a holistic approach and include not only technical but also human related skills. The Networks should involve as much as possible the European bodies with relevant expertise and create curricula that are open to neighbouring countries (through e-learning) especially to those that Europe has common practical objectives.

Objective 2: Reinforce the connection between the education and Business/Research

The two types of actions for this objective include Mobility and Cooperation Partnerships among Academia, Research institutes and Businesses and Infrastructure Support to Education and Vocational Training.

Through the Mobility and Cooperation Partnerships the students can have valuable practical experience and the teaching staff can exchange knowledge and know-how with the researchers and business staff. This procedure will also bring closer the curricula with the needs of the labor market.

Through Infrastructure Support to Higher Education and Vocational Training the aim is to give access to laboratories, demo sites, and research infrastructure facilities either standalone or as part of an industry. A platform can be created to enable practice in education in multiple levels, not only for the students but also for the research and business staff.

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

The types of actions under this objective include Virtual Learning and Information Platforms, KSC Recognition and Transfer Programs and Human Resources and Skills Observatories. Those actions are the more closely connected with the field of Digitalization.

The Virtual Learning and Information Platforms will enable few highly specialized experts reach not only the widespread group of students (either pre- or post- graduates) but also the general public that have an interest to be aware of the new energy technologies. The possibility of remote access is not only a way to better connect with infrastructures and data but it has become essential due to the Covid-19 crisis.

The Knowledge, Skills and Competences Recognition and Transfer Programs should define the learning outcomes for all the EQF levels and aim on the application of the ECVET and ECTS. In this way the mobility will be made easier and developing countries can have access to already established programs.

The Human Resources and Skills Observatories can be of many kinds with different focuses. They can include a database of what are the needed human resources and be a point of reference of learning outcomes thus enabling both the cooperation between different educational systems and the tracking of applied changes.

Other Recommendations and Best Practices

Energy efficiency and sustainability with respect to the environment should be a core part of all the educational programs of the future. In order to inspire younger generations to be part of the energy field workforce, informational campaigns can be used that can also be used to let the general public know how they can implement locally the new technologies.

Transition from analysis to action

In 2016, 154 umbrella organizations were involved in the formulation of a set of targets for the low-carbon energy sectors aforementioned and other energy topics. The commitment to meeting these targets has then been framed into 13 implementation plans, each of which is devoted to the low-carbon energy sectors.

The implementation plans are participated by a subset of the participant countries, being one or two of them chairs of the working group. They specify the volume of investment to be mobilized, and a clear list of R&I activities where the R&I efforts are to be focused.

Goals and implementation plans can be accessed on the SETIS system, aforementioned.

Considerations in the perspective of university

The transition to a clean energy sector is leading to a new employment scenario in the EU. As a result, new profiles at all EQF levels are required. Universities, mainly in charge of the education of EQF levels 6-8, must be involved in the implementation plans, and should work on designing an efficient system that allows the seamless conversion of the knowledge generated in the R&I activities into education programs.

To optimize the talent/skill generation process, programs must be flexible, thus otherwise they will not be able to adapt to the rapidly changing needs of an energy industry in transition to a still-to-be-defined to-be scenario.

In addition, as already highlighted by the reports on education by the SET plan, it is of paramount importance that universities across Europe promote networks or alliances, which will be translated into more rational and standardized curricula, easier interaction and thus knowledge transfer between European regions, etc.

2.5. Advanced Technologies for Industry (ATI) project

The ATI project has been created as a solution for developing a competitive European industry by giving an overview of the current situation regarding technological trends and data on advanced technologies. Those type of technologies will enable and help industries to successfully manage a shift towards a low-carbon and knowledge-based economy. The report includes information available through the new Advanced Technologies for Industry Website within the relevant sections (Policy Briefs, EU Reports, International Reports, Sectoral Watch and Technology Watch). The Policy Briefs analyses national and regional policy measures focused on a specific policy challenge, technological area or mode of implementation and explore policy tools that have been designed and implemented with the aim of fostering the generation and uptake of advanced technologies. [11].

In June 2016, the New Skills Agenda for Europe reaffirmed the need for digital skills, and in particular for ‘digitally smart people’, who are not only able to operate digital technologies, but can also innovate and provide leadership in terms of their use. Among other initiatives, the new skills agenda launched the Digital Skills and Jobs Coalition to mobilise companies, not-for profit organisations, educational providers, social partners and Member States in Europe to work together to tackle the lack of digital skills in Europe. The Coalition also encourages Member States to develop national digital skills strategies aimed at training more digital experts and offering more reskilling and upskilling solutions to the labor force and citizens in general. After its launch early in 2017, 18 National Coalitions were established, with a total of 300 members, and activities have been implemented which have involved more than 7 million EU citizens.

In July 2017, the European Commission launched the multilingual database, 'European Classification of Skills, Competences, Occupations and Qualifications' to support the dialogue between European employment services (EURES) and the education sector, and as a reference for job-specific skills, job search and job matching algorithms. In October 2017, the European Council called for EU Member States' training and education systems to be 'fit for the digital age'. In November 2017, at the Gothenburg Summit, the European Parliament, the Council and the Commission announced the European Pillar of Social Rights, which reaffirmed the right to high-quality and inclusive education, training and life-long learning. In relation to this, the Communication 'Strengthening European Identity through Education and Culture'47 sets out a vision for a European Education Area and announced a dedicated Digital Education Action Plan for the period 2018–20. As a result, in January 2018, the European Commission launched a new Digital Education Action Plan48, covering three priorities: (i) making better use of digital technology for teaching and learning; (ii) developing relevant digital competences and skills for the digital transformation; and (iii) improving education through better data analysis and foresight. The plan sets out 11 actions, including one that intends to scale up the self-reflection tool SELFIE for the use of one million teachers, trainers and learners in the EU and the Western Balkans49. The new European Commission's working group DELTA (Digital Education Learning, Teaching and Assessment 2018–20) will start in September 2018 and will play a key role in the implementation of the new digital education action plan.

Germany

At 35.5% in 2019, the tertiary education attainment rate is increasing slowly, by 6.1 pps since 2009. Germany is the only EU country with practically no gender gap (0.8 p.p.). Tertiary attainment varies widely between regions, from 51.3% in Berlin to 21.1% in Brandenburg. The number of new entrants to higher education at bachelor level is broadly unchanged since 2015. The participation of students from disadvantaged backgrounds remained stable at around 30% for over a decade (Autorengruppe, 2018). In contrast did foreign-born students increase their participation in ten years by over 10 pps to 34.2% in 2019, very close to the average and a much lower gap than throughout the EU. At 35%, Germany continues to have the highest proportion of science, technology, engineering and mathematics (STEM) graduates in the EU: 40.1% at bachelor, 30.1% at master and 47.3% at PhD level. The share of female graduates in STEM subjects amounts to 28% compared to 51% in all subjects, with a STEM gender gap around the EU average (Eurostat). The number of annual new STEM entrants decreased slightly in 2013-2018, particularly in engineering, but increased in ICT (Eurostat). Recent tertiary graduates integrate very well into the labor market (94.7% in 2019), marginally higher than recent VET graduates (ISCED 3-4) at 93.4%20, both well above the EU average employment rates. [12]

Fraunhofer and a selected group of universities have developed a modular concept for cybersecurity training. This collaborative approach enables the latest theoretical or practical research findings to be immediately incorporated into the teaching program. Students work in modern laboratories equipped with simulation tools allowing real threat scenarios to be tested. [13]

"Industrie 4.0" (I40) is a national strategic initiative from the German government through the Ministry of Education and Research (BMBF) and the Ministry for Economic Affairs and Energy (BMWI). It aims to drive digital manufacturing forward by increasing digitisation and the interconnection of products, value chains and business models. It also aims to support research, the networking of industry partners and standardisation. As a leading supplier of industrial equipment at the global level, the digital restructuring of industry offers plenty of opportunities to boost international competitiveness of German production and better conditions for job creation. [14]

Spain

Skills mismatches are significant. Higher education attainment (44.7%) is one of the highest among EU countries (above the average of 40.3%), but graduates are concentrated in fields which are not the most in demand in the labor market. Business, administration and law (19%), education (17%), and health and welfare (17%) are the most popular fields of study; while ICT (3.9%), mathematics and statistics (0.5%) and manufacturing and processing (0.8%), where there are skills shortages, are less popular (Cedefop, 2016; Adecco, 2018). University graduates have a hard time finding jobs that meet their qualifications and are forced to accept middle- or low-skilled jobs. In 2019, the employment rate of recent tertiary graduates in Spain (77.2%) was below the EU-27 average (85.0%). Of those who graduated at university in 2014, 27.2% were not in work in 2018 (MEFP, 2019b). On the same year, 30.6% of tertiary graduates had a job that did not require a tertiary diploma, above the EU-27 average (28.1%).

Student guidance and orientation on career opportunities is needed to reduce mismatches. Closer cooperation between universities and business could help reduce skills shortages by better aligning education programs and providing on-the-job traineeships. Educational guidance prior to university does not sufficiently focus on pathways to the labor market. A survey indicates that low enrolment in STEM degrees (25% of total) may be largely due to a lack of guidance (65% of upper secondary respondents) and the perception that these degrees are very challenging (40%) (DigitalES, 2019).

Spain is developing a tertiary graduate tracking mechanism. At national level, the existing method for tracking graduates is based on the administrative data sets from public employment services (PES), the National Institute of Statistics (INE) and higher education statistics. A system to track skills is under development in Spain, in cooperation with the business sector. PES is producing a methodology to detect training needs in cooperation with regions, social partners and national reference centres (European Commission, 2020a). At regional level, 3 out of 17 regions implement systematic graduate tracking measures and in another 2 conduct less systematic ones. For the remaining territories, there is no evidence on the existence of such measures. At University level, most universities have regular measures to track their graduates, bur these measures differ in content and methodologies and thus, results are not comparable across universities. [15]

From a policy design perspective, it was rapidly agreed that the best formula to establish the model of the initiative would be in the form of a public-private-partnership supported by the Ministry of Industry and the Directorates of Industry and SMEs as well as Telecommunication and Information Society.

A central theme of the initiative is to provide industrial companies with information and implementation support to exploit the opportunities provided by Industry 4.0 in Spain. Furthermore, digital enablers play a key role in Spain's Industry 4.0 model. Divided into three main categories - intra and interenterprise application, communication and data treatment and hybridisation of the physical and the digital – digital enablers refer to the main digital technologies driving industry digitisation forward. The initiative prioritises intra and inter-enterprise enablers, e.g., digital platforms, big data, collaborative applications, etc. [16]

Romania

Although the demand for higher skills is increasing, the number of tertiary educated graduates is low and graduates' skills do not match labor market needs. Having enough higher education graduates is important for productivity growth, innovation and competitiveness. However, according to EUROSTAT, in 2019, only 25.8% of Romanians aged 30-34 had a university degree, significantly below the EU average of 40.3% and the lowest in the EU. Nevertheless, the rate has increased significantly compared to 2009 (16.8%), even though it is still below Romania's national Europe 2020 target of 26.7%. A look at graduating cohorts shows that, in 2018, for every 1 000 people aged 20-29 there were 45 higher education graduates combined at bachelor's, master's and doctoral level. This number is significantly below the EU average of 60. In 2018, 28.1% of graduating students graduated in science, technology, engineering or mathematics (STEM), of which 5.8% in ICT. Although these proportions are among the highest in the EU, the actual number of professionals ready to enter the labor market is low. Furthermore, graduates' skills often do not meet the expectations of employers.

The number of students in higher education is shaped by demographic, educational and socio-economic factors. At the start of the 2019/2020 academic year, the total number of students enrolled in higher education had increased slightly compared to the previous year (by 1.8%). Still, this number was 38% lower than in 2011, and has dropped particularly in private universities, whose number has decreased sharply from 52 to 27. Influencing this downward trend are demographic factors, including emigration, but also high early school leaving rates, the low percentage of high-school graduates that pass the baccalaureate exam (64.5% in 2020), and a certain preference for studying abroad, whereas the number of foreign students is rather low (5.7% in 2018/2019). Among the 15-year-olds that sat the PISA test in 2018, 60% expect to complete higher education (EU average: 62.4%). However, only 33% of the poorest students expect to do so, compared to 87.3% of their more advantaged peers, which and is one of the biggest gaps in the EU. [17]

Politehnica University of Bucharest - Student drop out is an important topic for Romanian universities. One of the past and current challenges at Politehnica University of Bucharest is to deal with fewer financial resources than in the past and to deliver quality education and training to the students. The University designed an effective institutional framework to deploy financial resources for increasing student performance. These activities focused on curriculum design, teachers' continuous training, and learning experiences design. In addition, it works on developing appropriate tools to measure quality, effectiveness, and efficiency.

Ovidius University of Constanta (OUC) - OUC aims to increase effectiveness by better preparing graduates for the labor market. The key way to address this goal is by strengthening the entrepreneurial and intrapreneurial education. OUC has partnered with University of Rochester (Ein Center for Entrepreneurship), in a project initially funded by the Romanian-American Foundation and the US-Romania Fulbright Commission, to set up a cross campus entrepreneurial approach. Under this program, OUC academics and top administrators were trained and top UoR experts in entrepreneurship visited OUC to guide the transition. Additionally, in a partnership with Junior Achievement Romania, set up within the Entrepreneurial University program, OUC used a self-evaluation tool, prepared jointly by the European Commission and OECD, called HEInnovate (https://heinnovate.eu/), and is now in the process of training academics and involving students in pre-accelerator programs. Finally, OUC partnered with Google to establish a co-working space called “Atelierul Digital Google” to better prepare graduates for future jobs. The program started in 2016. [18]

Greece

Employment of tertiary graduates has risen, but their lack of soft skills affects their job prospects. In 2019, 43.1% of adults aged 30-34 had attained tertiary education, above the EU-27 average of 40.3%. However, among foreign-born people, only 16.1% had a tertiary degree, the lowest share in the EU (EU average: 35.3%). The employment rate among recent graduates (20-34 years-old) was 64.2% in 2019. Though still the lowest rate in the EU (EU average: 85.0%), it has exceeded 2010 levels for the first time. The employment of people with secondary education, on the other hand, trails behind the EU average for both general (51.3%) and vocational (50.9%) profiles. Employers have observed a significant lack of skills related to communication, teamwork, flexibility and adaptability among job candidates in general (Adecco, 2018). Greek students, while apparently less aware of the relevance of soft skills than students in other countries, also feel they lack skills in areas they consider essential for job performance, including communication, teamwork, self-confidence and work ethic (Pereira et al., 2019).

Greek higher education caters mostly to undergraduate studies. Greece has by far the EU’s highest share of students enrolled in undergraduate programs (86% v EU-27 average of 60%). But at master’s level the share is only 10% (EU average: 29%). Many students leave the country for post-graduate studies. In 2017, 25.8% of master’s graduates obtained their degree abroad (EU average: 5.3%). Inward degree mobility by contrast is one of the lowest in the EU. Through legislation introduced in 2020, universities are now allowed to offer undergraduate programs in foreign languages, joint degrees and double degrees between Greek and foreign HEIs. [19]

France

In 2019, 47.5% of 30–34-year-olds had a tertiary education, above the EU average of 40.3%. The number of students enrolled in tertiary education grew by 12% from 2013 to 2018, among the highest growth rates in the EU. However, numbers in PhD studies fell (-4.9%). The employment rate of recent graduates (82.0% in 20195) was the fifth lowest in the EU (EU average 85.0%). Adults with a master, doctorate or equivalent qualification have a higher earnings premium in the labor market than in many other Member States - +110% more than individuals whose highest attainment is upper secondary in 2017 (+74% more in the EU-23) (OECD, 2019b). France has announced reforms to increase the use of administrative data for graduate tracking in HE and VET (European Commission, 2020a).

The Choose France strategy aims to welcome 500 000 foreign students by 20276. French universities perform strongly in International Orientation and Teaching & Learning (U-Multirank, 2020). HEIs attracted 358 000 foreign students in 2019, of whom 75% were from outside Europe, mainly from Africa and Asia. Among PhD students, 40% were foreigners in 2017. However, 58% of mobile doctorate holders are employed abroad 3 years after obtaining their doctorate (MESRI, 2019b). The draft research programming Law for 2021-2030 will aim to make the research profession more attractive for doctorate holders. Employers' surveys show that a lack of skills is the main barrier to hiring. According to the 2018 CEDEFOP Skills forecast, 54% of new job openings in France in 2016-2030 will require a high level of qualification, compared to 43% at EU level. Nevertheless, the share of science, technology, engineering, and mathematics (STEM) tertiary graduates slightly declined from 27.7% in 2010 to 25.4% in 2018. [20]

Higher education clustering in France (*Communautés d'universités et d'établissements*, COMUE) - Clustering in France are driven by recent reforms aimed at consolidating universities and restructuring the higher education landscape (2007 law on autonomy and responsibilities of universities, followed by 2013 law on higher education and research). Over the period 2000-2019, nine full mergers took place in France while 20 "communities" were set up, gather universities, other HEIs as well as research centres. In some cases, the COMUE prepared ground for a full merger or served as a vehicle towards more in-depth collaboration among French universities, while also structuring cooperation with other types of institutions. Merger and clustering activity continue in recent years up to 2020, but the general regrouping of the educational system seems under consolidation. [21]

The cross-cutting "*Industrie du Futur*" (Industry of the Future) [22] program was launched by the French government in April 2015. IdF consists of several objectives. It aims to modernise the French production base and production tools and support the use and integration of digital technologies to transform companies and business models. This in turn is expected to create new sources of growth and jobs. The IdFA platform's objectives are to make France a leader in the world's industrial renewal.

IdF's is structured around five pillars: technological offerings, business transformation, training, international cooperation and IdF promotion. The first pillar focusses on developing cutting-edge technology. This activity supports companies with research funding, subsidies and loans and by developing a network of platforms for pooling and testing new technologies.

Secondly, IdF offers financial and personalised support for companies to invest in production and to engage in projects. It also seeks to identify 550 experts to help SMEs identify transformation projects. Its ambition is to support at least 2000 companies by 2016. The third pillar concentrates on upskilling the workforce. This is pursued by creating joint future visions with unions and developing training programs and curricula. The fourth pillar targets international cooperation on standards and alliances. A bilateral approach is taken, in particular with Germany (*Industrie 4.0*) through cooperation on standardization and technology projects.

Italy

Italy's tertiary educational attainment rate declined slightly in 2019 and is one of the lowest in the EU. At 27.6% in 2019, the share of 30–34-year-olds with tertiary education is above the Europe 2020 national target of 26%-27%, but well below the EU average of 40.3%. At 13.9 % (EU average

35.3%), the attainment rate is particularly low among foreign-born people. Science, technology, engineering and mathematics (STEM) graduates make up 24% of all graduates, only slightly below the EU average of 25.4%. At 19 pps, the STEM gender gap is significantly lower than the EU average of 25 pps. The share of female graduates is higher than the EU average across STEM disciplines, most notably in engineering, where women make up 32% of graduates (EU 28%).

While a tertiary degree represents an advantage on the labor market, transition into employment remains difficult. The employment rate of recent tertiary graduates10 has been steadily recovering over the past 5 years, reaching 64.9% in 2019, up 8 pps compared to 2014. While it is considerably higher than the employment rates for VET and general upper school graduates, it remains well below the EU average of 85%. Low demand from a productive sector characterised by small and medium-sized firms is a factor in graduates' poor employment prospects. [23]

Based on the national strategy for digital skills the educational system and advanced digital education are essential elements of the digital transformation of the public sector and the economy as a whole. The training system must contribute to support the processes of investment in human capital, which require new organizational and production processes through innovative methodologies and technologies. 'Digital thinking' should be combined with fostering the skills that are needed to develop cutting-edge technologies.

Participatory approach to the design of the university strategic plan - The University of Trento designed its strategic plan for 2017-2019 based on a broad consultation of all governing bodies and representatives of the entire university community. All academic and administrative units were asked to submit a "project for improvement" addressing operational and practical issues through a call for proposals. Top 35 projects in line with the university's priorities were selected and integrated in the strategic plan. The University of Trento pursues the process of continuous improvement by: - Fostering a culture of quality, quality methods and tools; - Self-assessment, critical approach and continuous improvement in the management of all processes that contribute to quality improvement; - Timely action to correct the existing actions and policies. [24], [25]

The Italian Ministry of Economic Development has launched the *Industria 4.0* National Plan (I4.0), a strategy aiming at supporting industrial change through a series of conjunctional measures. The measures seek to promote investments in innovation, technology and skills development while taking into consideration principles set by the fourth industrial revolution. The Government intends to design a framework for effective and suitable operation.

The main objective is to support innovative investment and empowerment of skills related to the fourth industrial revolution by setting the framework for attracting private investment in technologies, support to research, development, and innovation and the promotion of investment in venture capital and start-ups. On the other hand, the initiative seeks to contribute to the empowerment of skills by promoting I4.0 education programs, strengthening vocation training, skills development, Competence Centres, Digital Innovation Hubs and the financing of I4.0 Technology Clusters and Industrial PhDs. [26]

The Netherlands

Tertiary attainment and graduate employment rates are well above the EU average. 51.4% of the population aged 30-34 holds a tertiary degree (EU average 40.3%). The attainment rate among the EU-born population from outside the Netherlands (53.4%) surpasses that of the native population (52.7%) and it is also relatively high among the non-EU-born (42.1%; EU average 34.2%). The employment rate of recent tertiary graduates was very high: 94.0% in 2019 (EU average 85.0%). The first 15 quality plans were approved in 2019 (OCW, 2019b). In 2014, the previous partly grant-based student finance system was replaced by low-interest loans provided by government. The aim was to invest the savings resulting from this reform in the quality of tertiary education. In 2018, the Minister of Education, Culture and Science signed an agreement with the Association of Research Universities, the Association of Universities of Applied Sciences and student organisations about shaping the quality agreements for 2019-2024, which link the release of the performance-related part of the budget for each higher education institution to approval of their quality plan. The plans of all 54 institutions were assessed by the Accreditation Organisation of the Netherlands and Flanders (NVAO) in the first half of 2020. The quality plans are linked to EUR 2.3 billion of funding in the years 2019-2024. [27]

Open access materials, not surprisingly, do not automatically provide credit towards a qualification but rather have the broader purpose of supporting education. For example, the Open Courseware initiative of the Delft University of Technology in the Netherlands is explicitly designed not to replace degree-granting higher education or for-credit courses but to exist alongside them, to provide content that supports education, whether it be for academic staff, enrolled students or self-learners. [28]

The Smart Industry (SI) initiative was launched in November 2014 by the government and industry stakeholders. The objectives are to strengthen the Dutch manufacturing industry position and increase industrial productivity. SI is structured around three main action lines that seeks to capitalise on existing knowledge, accelerate and introduce ICT in companies and strengthen knowledge, skills and ICT conditions.

The core activities concentrate on agenda setting, building multi-actor eco-systems and executing support actions and research. SI is organised around three key lines of action, respectively capitalising on existing knowledge, accelerating in field labs and strengthening the foundations. The first action line concerns the use of existing knowledge and focusses on the gathering and dissemination of knowledge to businesses. This is carried out by providing companies with technological and market understanding, best practices and tools. Specific activities cover presentations, a website, online training modules and business team trainings. The second action line, acceleration through field labs, is assumingly the most visible part of SI. It seeks to create national and regional ecosystems and interrelated networks of companies and knowledge institutions with a basis in SI principles.

The field labs present practical environments for design, testing, experimentation and deployment of technology solutions. The labs work as operational environments where people can join for discussion, meetings etc. It is basically a location with a program that is made up of multiple try-out innovation projects and planned training within projects. The third action line is of a more long-term nature and aims to improve knowledge, skills and ICT conditions. In terms of knowledge, it is focussed on strengthening R&D incentives in field labs and to develop a long-term SI research agenda together with top sectors and universities. Human capital conditions are sought upgraded through adapting relevant educational courses and programs – ranging from primary education to scientific education and dual education - to the needs of SI. It seeks to offer modular educational blocks and to organise courses on sustainable production. ICT conditions are targeted by a vision to develop an increasingly solid and secure ICT infrastructure and by a research program for the development of software tools that cover chain collaboration, interoperability and standardisation. [29]

Slovakia

Slovakia has reached the EU benchmark on tertiary attainment, but disparities are widening. Following years of steady growth, in 2019 Slovakia's tertiary educational attainment rate reached 40.1%, in line with the EU-27 average (40.3%). However, the gender gap in favour of women has quadrupled over the past decade from 4.3 pps in 2009 to 16.1 pps in 2019 (EU-27 10.5 pps). The attainment rate for Slovak men thus remains below the EU-27 average (32.2% v 35.1%). The attainment gap between individuals living in rural areas and cities has also widened from 18.2 pps in 2009 to 35.5 pps (EU-27 22.1 pps).

The employment rate of recent tertiary graduates has increased, while the proportion of science, technology, engineering and mathematics (STEM) graduates remains unchanged. In 2019, the employment rate of recent tertiary graduates (aged 20-34) reached 83.4%, reducing the gap to both the EU average (85.0%) and the higher employment rate for upper secondary VET graduates (84.6%). The proportion of STEM graduates remains limited at 22.6% in 2018 (EU-27 25.4%), essentially unchanged since 2013. The proportion of women among graduates in natural sciences, mathematics and statistics (65%) is one of the highest in the EU; however, it is among the lowest in ICT, at 15%. The 2020 national reform program aims to increase the number of professionally oriented bachelor programs, including with ESF support, which should improve the overall employability of graduates. During the COVID-19 lockdown, higher education institutions (HEIs) switched to digital learning, but its effectiveness is not yet known.

Slovakia continues its reform measures to boost the quality of higher education. Slovak HEIs rank low internationally (Times Higher Education, 2020). Weaknesses result from factors such as fragmentation, low teaching quality, and limited internationalisation and job market orientation (European Commission, 2019b). Based on the legal framework adopted in 201813, Slovakia is establishing a new system of accreditation and aims to increase the importance of quality assurance. The new Slovak Accreditation Agency for Higher Education, which is operational since January 2020, is developing internal quality assurance system standards, study program standards for accreditation, and standards for awarding the degrees of ‘docent’ and ‘professor’. The Student Council for Higher Education presented four pillars to improve higher education: social support, education, infrastructure, and science and research. The Council advocates bringing quality assurance into line with Standards and Guidelines for Quality Assurance in the European Higher Education Area. [30]

Inspired by similar initiatives implemented in Germany and the Netherlands, the Ministry of Economy first presented the Smart Industry concept for Slovakia at a high-level conference in March 2016. The government adopted the strategic direction of the paper on the 29th of October 2016, and with the decision to pursue the development of local smart industry. The Smart Industry Platform was established to act as a central authority coordinating the various efforts and is comprised of a working group of multidisciplinary experts from industry, academic and government.

The Smart Industry Platform was formed as a first step in the implementation of the overall initiative, as a working group of experts designed to bring together representatives from key stakeholders. These included various ministries of the Slovak government, as well as industry associations (IT Association, National Union of Employers, Federation of Employers' Associations, Automotive Industry association, Klub 500), R&D agencies (Slovak Innovation and Energy Agency), academic and educational institutions (Slovak University of Technology, Technical University of Kosice, Slovak Academy of Sciences), businesses (Embraco, Siemens, SOVA Digital, Matador, Microsoft, Volkswagen), and industry clusters (Cluster for Automation Technologies and Robotics AT+R). [31]

Finland

The Vision for Higher Education and Research 2030 is being implemented. The government set three main objectives for higher education by 2030: providing 50% of the total young adult population (aged 25-34) with a tertiary degree; playing a major role in adult learning; and increasing access to and equality in university studies. In 2017, 55% of first-time entrants to universities of applied sciences had a vocational degree, 9% for other universities (MEC, 2019c). 47.3% of adults (30-34) in Finland hold a tertiary level degree (EU-27 average 40.3%). This rate has increased by 1.4 pps since 2009 (45.9%). Higher education institutions are encouraged via the new funding model to develop adult education through continuous learning possibilities. The number of available student places at universities must meet the needs of society and be based on employment forecasts for each sector and region. The limited number of places in certain regions make it particularly difficult to enter university there. For instance, in the Uusimaa region (i.e., the extended Helsinki metropolitan area) there is a major shortage of study places and a growing demand (European Commission, 2020b). Around two thirds of university applicants are rejected annually; this delays tertiary education for several years for many students. Higher education policy needs to incentivise their role in knowledge transfer more strongly.

From spring 2020, students will be mainly selected based on national matriculation examination grades, which is a biannual, high-stakes final `test´ that takes place at the completion of general upper secondary studies. Student selection to universities of applied sciences already changed in 2019: applicants can apply to different study field with the same entry test and select up to six destinations (Arene, 2019). An applicant can also apply to different universities and disciplines via either the matriculation examination or through a single institutional entrance exam specific to certain universities and studies. While entrance exams are being modified so that they do not require lengthy preparation, upper secondary students seem to still prefer to attend private training courses to get better prepared for them. In addition, since students do not know their matriculation examination outcomes early enough, they may also have to prepare for the entrance exam as well, just in case.

The new funding model for higher education institutions will be applied from 2021. Universities of applied sciences will receive 6% (currently 4%) of their basic funding based on the number of graduates that enter into employment and the quality of their employment. For the other universities, it will be 4% (currently 2%). This will increase funding based on continuous learning indicators for universities of applied sciences from 5% to 9%, and for the universities from 2% to 5%. In 2019, the employment rate of recent tertiary graduates (1-3 years after graduation), aged 20-34, was 89.1%, above the EU-27 average (85.0%), and higher than in 2018 (88.3%). [32]

The Digital Finland Framework highlights the importance of intelligent and clean energy, climate neutral industrial processes and smart mobility services. Finland recognises the need for sustainable, resource-efficient solutions and the promotion of the circular economy. The policy strategy is to combine the material and process strengths in Finland with digital capabilities and support the circular economy through AI, the platform economy and digital design. With recent advances in smart energy, electricity costs for data centres remain relatively low and Finland allows the selling of recovered heat from data centres. Digitalization is considered a cross-cutting topic and treated as such in particular in the domains of bioenergy, waste-to-value, smart grids, energy storage and smart buildings. [33]

International analysis

Besides all the inputs from the European countries presented above, here are some highlights from outside Europe, related to best practices on University Education. In 2019, **Russia** approved the ”National Strategy for the Development of Artificial Intelligence (AI) for the period until 2030”. This strategy ensures the accelerated development of AI in the Russian Federation through conducting research in the field of artificial intelligence the availability of information and computing resources for users and improvement of the training system in this area. Training programs have been launched in artificial intelligence in 100 universities in Russia in 2019. These initiatives are free for students and teachers. In addition, a separate work will be carried out with researchers. [34]

In July 2020 the **South Korea’s** government announced a major new policy – the Korean New Deal [35], with the goal to transform the country from a fast follower into a first mover and to address the structural changes driven by the pandemic. The New Deal is structured in 3 pillars, the Digital New Deal, the Green New Deal and the Stronger Safety Net. The government announced plans to invest KRW 114.1 trillion (approximately €84.5 m) over 5 years to support the creation of 1.9 million jobs, of which 903 000 jobs from the Digital New Deal.

With the Digital New Deal, Korea aims to further strengthen its digital capacity based on its competitive edge in ICT, thereby promoting innovation and dynamics throughout the economy. The goal is to promote the data-driven economy including the collection, standardisation, processing and combining of data, and ultimately to secure a competitive advantage for the country by creating new industries and accelerating the digital transition of key industries. The Digital New Deal is articulated in the following main domains implemented through leading projects:

- Stronger integration of Data, Network and AI (DNA) throughout the economy
- Digitalization of education infrastructure
- Fostering the ”contact-free” (contactless) industries

Canada was established the ”Digital Literacy Exchange Program” which was funded with Budget 2017. The Budget 2017 foresees CAN$29.5 million (€25 million) over a period of 5 years starting in 2017-2018. With this program Canada aims to support basic and advanced education on digital skills to fill the digital divides, especially for seniors, low-income Canadians, Indigenous people and for people living in the not yet properly connected Northern regions. This will not only fill the gap around skills, but it will enable Canadians to make more informed decisions especially when asked consent to collect and tread data. [36], [37].

The United Kingdom is on the right path to success in delivering innovation at scale as it is continuously updating its ”Digital Strategy”, adding new technologies or related projects and funding. The United Kingdom Government published in March 2017, its last Digital Strategy Document under the name ”UK Digital Strategy 2017”, following the previous Autumn Statement 2016. [38]. In terms of Government policies towards technology development and adoption, one of the pillars of the Digital Strategy Document is willing to give everyone access to the digital skills they need. The pillar envisions changes in the education system to improve children’s digital skills and knowledge. However, this is not only about future generations: the UK government aims to fill the gap in digital skills for people already accounted in the workforce to harness productivity benefits that the digital innovation brings. [39]

Japan has always pursued proactive industrial and technology policies. In the last years, however, the prime minister’s cabinet has made science and technology policy a key component of its development strategy, with a view to leverage innovation to kick-start faster growth. To deal with current issues, Japanese policies have expanded to encourage digital and societal innovation through targeted policies such as the Society 5.0 strategy, the Smart Japan ICT strategy and Healthcare 2035. In terms of, Society 5.0 strategy is a central component of the Abe government’s growth strategy, a way to leverage innovation to propel Japan beyond the low growth trap of the last decades. Society 5.0 is a vision of a super smart society that can resolve various social challenges by incorporating the innovations of the fourth industrial revolution (including the Internet of Things, Big Data, Artificial Intelligence, Robotics and the sharing economy) into every industry and social life. [40]

The universities in the **United States** and higher education institutions fuel this ecosystem by providing a large supply of AI talent and skills. The tech giants and the start-up AI ecosystem are strongly connected with universities and higher education institutions. University Industry collaborations and AI spin-offs are facilitated by corporate funding of universities. The governance structure and the VC fund (E14 fund) of the MIT Media Lab and the MIT-IBM Watson AI Lab are prime examples of the corporate-academia-entrepreneurship linkages that characterises the US AI ecosystem. The birth of the AI giant Google is a story of university-industry symbiotic relationships. Moreover, the American universities are key producers of AI technologies. For example, the East Coast is leading the number as producer of AI technologies. [41]

The Shenyang Institute of Automation, Chinese Academy of Sciences (SIACAS) was established in 1958 and is regarded as the national leading institute in the development of automation science and technology in China. It focuses on the three fields of Robotics, intelligent manufacturing and opto-electronic information technology. The research centre supports more than 10 national and provincial central laboratories and technical centres, as well as an educational facility for master's degree programs, doctoral programs and postdoctoral programs. SIACAS operates various exchange and cooperation programs with research institutions and high-tech companies, at the international level as well. Internet Plus Proposed in 2015, the grand action plan 'Internet Plus' aims at the comprehensive digitalization of the economy and society beyond the conventional internet, which is to be integrated into various areas such as e-commerce, education and manufacturing. Big Data is one of the relevant technologies promoted by Internet Plus. [42]

2.6. The European Energy Research Alliance and the Program on the Digitalization of the energy sector

The European Energy Research Alliance (EERA) [43] is an energy research community in Europe that brings together universities and public research centers in 30 countries. The "Digitalization of Energy" Joint Program (JP) of the EERA will produce documents, position papers etc. on:

- SP1: High Performance Computing (HPC): One of the main parts in which this digitalization can be achieved is by linking together, through a multi-disciplinary platform of High-Performance Computing and Numerical Mathematics, a network of experts in computational and energy sciences
- SP2: Data Science & Artificial Intelligence: One of the main parts in which this digitalization can be achieved is by linking together, through a multi-disciplinary platform of High-Performance Computing and Numerical Mathematics, a network of experts in computational and energy sciences
- ESI tSP: Technology: The Interactions are driven by a desire to improve performance, increase efficiency, and are enabled by ubiquitous cheap data and control infrastructure and political and economic cohesion (e.g. European Union). The SP is devoted to model, simulate, and operate integrated energy systems.
- AMPEA tSP: Multiscale modelling of materials, processes, and devices: The goal of this SP is to coordinate a concerted effort to identify current challenges and forthcoming trends in multiscale modelling and simulation.
- Hydropower tSP: Digitalization: The scope of this tSP is to find solutions and answers related to Digitalization of Business Processes in Hydropower. Digitalization provides new opportunities in many sectors, and hydropower is no exception
- Nuclear Material tSP: The performance of Nuclear Materials used in structural components is essential for the development of sustainable Nuclear Energy

The Joint Program Energy Systems Integration is organised in 5 sub-programs (SP) that target different aspects of Energy Systems Integration. Given the nature of Energy Systems Integration, the SPs are strongly interlinked.

- SP1: Modelling
- SP2: Forecasting, aggregation & control
- SP3: Technology
- SP4: Consumer
- SP5: Finance & regulation

The Smart Grids JP is organized in the following structure:

- SP1 Technologies and tools for the management of future power systems
- SP2 Storage Integration
- SP3 Distribution Network Flexible operation
- SP4 Consumer and Prosumer Engagement through Digitalization and ICT
- SP5 Flexible transmission network

Regarding the Energy Efficiency in Industrial Processes JP, The EU Industrial Strategy of May 2021 sets out an approach to drive the transformation to a more sustainable, digital, resilient, and globally competitive economy in Europe. This strategy includes supporting industries towards climate neutrality, outlining that reducing emissions across the sector will depend on an 'energy efficiency first' principle and a secure and sufficient supply of low-carbon energy at competitive prices.

2.7. The European digital strategy and digital roadmap

The core of the European Digital strategy lies in the creation of the Digital Single Market, which was first proposed May 2015. It is one of the European Commission's 10 political priorities. It should enhance the benefits of scale given by the digitalization on a European Level. All European costumer and businesses should be able to access and offer digital services in every member state. Complementary to the Digital Single Market, the EU aims to be the global driver of consumer and data protection mitigating the effects of big platforms. Therefore, the Digital Single Market is accompanied by the Digital Services and Digital Markets act, which curbs market power and ensures a level playing field for small businesses. Within the framework of the EDDIE, the focus on digital skills and jobs are in particular relevant. The Commissions is intendent to address the digital skill gap of many in the workforce by introducing the Digital Education Action Plan.

Digital Single Market

The Digital Single Market was proposed in 2015 and focuses on three core domains.

- The Digital Single Market strategy aims to give consumers and businesses better access to online goods and services across Europe, for example by lifting barriers to cross-border e-commerce and access to online content, while improving consumer protection.
- The improvement of networks and services by providing high-speed, secure and trustworthy infrastructures and services shall be given by the right regulatory conditions. The focus lies on cybersecurity, data protection/e-privacy, and the fairness and transparency of online platforms.
- Maximizing the growth potential of the European digital economy so that every European can fully reap its benefits - in particular by improving the digital skills that are essential for an inclusive digital society.

Artificial Intelligence

The European Commission has proposed to invest €2.5 billion to the deployment of computing platforms and AI applications. The framework aims to mobilize resources to achieve an "ecosystem of excellence" and create a unique "ecosystem of trust." The Commission stresses several requirements for high-risk AI applications. There will be regulations on Training data, data and records, information to be provided, robustness and accuracy, human supervision. More narrow requirements for certain sensitive AI applications, such as remote biometric identification are discussed.

Competition Policy

The main drivers of the competition policy, which intends to create a level playing filed are the Digital Services Act and the Digital Markets Act. Both will be covered in more detail in the next subchapter.

IT/Data security

A robust regulatory framework is already in place both in the field of data protection and cybersecurity. The former sees the General Data Protection Regulation (GDPR) and the Free Flow of non-personal Data Regulation in force. The EU is intended to monitor the development of technology and markets closely and adjust accordingly.

Role Model

The EU Commission aims to be a role model and has its own in-house strategy for its internal digitalization. The goal is to have a common, cloud-based, platform for all EU institutions and agencies. This should improve the system security, the accessibility but also the transparency of the commission's work. Successful applications are intended to be shared the member states thereafter, pushing e-Governance on all levels. Furthermore, it is planning to co-create its IT solutions with private businesses and more importantly it should play an incubator role for new emerging technologies. By using its scale, this would foster innovation.

2.8. The Digital Services Act and Digital Markets Act

2.8.1. The Digital Services Act (DSA)

Since 2000, the E- Commerce Directive has been the main legal framework for the provision of digital services in the EU. However, in 20 years the digital environment has changed and the rules need to be updated. Due to the nature of the platform economy, some very large platforms have become quasi-public spaces for information exchange and online commerce. On the one hand, they offer great benefits to consumers and constantly encourage innovation and commerce. On the other hand, they are abused to distribute illegal content or sell illegal goods or services online. They induce a particular risk to users' rights, the flow of information and public participation.

To counteract these developments, the Digital Services Act (DSA) regulates networks, which are considered intermediaries in their role as a link between consumers and goods, services and content. These digital services transmit or store content of third parties. Specific due diligence requirements apply to hosting services and in particular to online platforms, a sub-category of hosting services. Examples of online platforms include social networks, content sharing platforms, app stores, online marketplaces, online travel and accommodation platforms.

However, the main target group of this regulation are the few very large online platforms that have a significant social and economic impact with at least 45 million users (10% of the EU population). More and stricter rules apply to them.

The aim is to improve protection against hateful or illegal content and to create a harmonised and more powerful framework for transparency and accountability of online platforms, leading to fairer and more open digital markets. In general, the Digital Services Act mitigates current problems and can be seen as an ex-post regulation.

What are the major Changes due to the DSA?

The set of changes can roughly be divided into two sub-categories:

1. **Prevention of Illegal Content**
    - All hosting providers (including online platforms) are required to implement measures to counter illegal content online, including goods and services.
    - Among the obligations is a “Notice and Take Down“ mechanism for users to flag such content, and for platforms to cooperate with “trusted flaggers”.
    - In addition, the draft regulation specifies what the content of such a notification must contain in order for the hosting provider to have positive knowledge of illegal content that triggers liability. Hosting providers must provide sufficient justification to the user for their decision to block or remove a particular piece of content. The definition of what constitutes "illegal" content is governed by national law.
    - Hosting providers are only liable for third-party content if they fail to remove illegal content after becoming aware of it.
    - Rules for traceability of commercial users should improve finding sources of illegal goods.

2. **Enhance Transparency**
    - New rules on traceability of business users in online market places, to help identify sellers of illegal goods;
    - Effective safeguards for users, including the possibility to challenge platforms' content moderation decisions;

- Transparency measures for online platforms that are wide-ranging, including on the algorithms used for recommendations
- Obligations for very large online platforms to prevent abuse of their systems by taking risk-based action, including oversight through independent audits of their risk management measures.
- The main parameters of recommendation systems on very large online platforms need to be explained in the respective Terms and Conditions. Additionally, all options to change or influence these parameters need to be announced. The users need to have the possibility to actively and directly influence the displayed content and at least one of the options should not be based on so-called profiling, i.e., automated processing of personal data. The operator must integrate such functions into the user interface of its website or app.
- Researchers will have access to internal data of key platforms, which allows to audit how platforms work and how online risks evolve. The audit result can be published.
- New oversight structure in Member States, supported by a new European Board for Digital Services. For the very large online platforms, the European Commission has an enhanced supervision and enforcement role.

What are the concrete implications?

The energy industry itself is not in the target group of this regulation. However, if an institution hosts a cloud service, that cloud service will be regulated by this framework. However, most of these services will have fewer than 45 million customers and therefore will only have to deal with the lighter regulatory package.
Moreover, most institutions are passively affected by the regulation passively. The large platforms must disclose who and how their commercial customers advertise. Since all common digital marketing channels are operated by large platforms, companies in the energy industry also use these channels. Therefore, their marketing history will be made publicly available so that competitors can see how they advertise.

Which Best Practice could emerge?

1. Implement new regulatory framework on all platforms
2. Learn from the best: Analysis of large datasets is possible since the platforms are required to make public who and how large costumer used them.

2.8.2. The Digital Markets Act (DMA)

Since 2000, the E-Commerce Directive has been the main legal framework for the provision of digital services in the EU. However, in 20 years the digital environment has changed and the rules need to be updated. Due to the nature of the platform economy, some very large platforms have become quasi-public spaces for information exchange and online commerce. These large platforms have accumulated a great deal of market power, which reduces the business opportunities for new entrants and thus harms competition in the long-term.

The Digital Market Act (DMA) is designed to regulate not the entire digital economy but these very large corporations in specific. It calls them “Gatekeeper”, which are offering either online search engines, online intermediation services, online social networking services, video-sharing platforms, operating systems, interpersonal communication services, cloud computing or advertising.

The criteria to be defined as Gatekeeper are:

1. Has a strong economic position, significant impact on the internal market and is active in multiple EU countries;
2. Has a strong intermediation position, meaning that it links a large user base to a large number of businesses;

3. Has (or is about to have) an entrenched and durable position in the market, meaning that it is stable over time.

Moreover, the quantitative thresholds for the core platform service provider are 45 million monthly active end users in the EU (10% of EU population), more than 10,000 yearly active business users in the last three year and annual turnover within the European Economic Area of at least EUR 6.5 billion in the last three years (or an average market capitalisation of at least EUR 65 billion). If a Gatekeeper meets the quantitative thresholds, the first three criteria are presumed to be satisfied.

The intention of the DMA is to addresses future market power problems and can be seen as an ex-ante regulation. The act went through the ordinary legislative procedure. It is directly applicable as a regulation throughout the EU. The aim here is apparently full harmonization, i.e. member states may not provide for a stricter or less stringent framework.

To characterise the spirit of the regulation, the DMA favours innovation by business users and new entrants over innovation by existing gatekeepers. This decision in turn leads to a preference for long-term competition over short-term efficiencies.

What are the major Changes due to the DMA

The regulations aim to prevent or mitigate market abusive behaviour of Gatekeeper. In general, the measures are divided into practices the gatekeepers are forced to do, which they would otherwise abstain from and practices they no longer allowed to carry out.

Practices Gatekeeper are required to carry out:

- Allow third parties to interoperate with the gatekeeper's own services in certain situations.
- Allow their business users to access the data they generate when using the Gatekeeper platform
- Provide businesses that advertise on their platform with the tools and information necessary to allow advertisers and publishers to self-verify their ads run by the Gatekeeper
- Enable their business users to advertise their offerings and enter into contracts with their customers outside of the Gatekeeper's platform

Practices Gatekeeper are prohibited to carry out:

- Treat services and products offered by the gatekeeper itself more favourably in rank order than similar services or products offered by third parties on the gatekeeper's platform
- prevent consumers from engaging with businesses outside their platforms prevent users from uninstalling pre-installed software or apps if they wish to do so
- In particular the ban to self-promote own services is considered to harm the Gatekeepers market power.

If the EC detects wrongdoing it can fine of up to 10% of the gatekeeper's total turnover in the preceding fiscal year. For serious misbehaviour, under Article 27(1) of the DMA, the EC may impose daily penalty fines of up to 5% of the average daily turnover of the gatekeeper in the preceding fiscal year.

In the event of systematic and repeatedly violations by gatekeepers, additional remedies may be imposed on gatekeepers following a formal investigation. Such remedies shall be proportionate to the committed misbehaviour. As a last resort, non-financial measures such as the divestment of (parts of) a business may also be imposed.

What are the concrete implications?

Energy Institutions are most likely not defined as Gatekeepers, thus only affected indirect through the regulation. However, it improves the market chances for digital business models such as Smart Energy systems.

Since there is no impact on Energy Institutions, there are no Best Practices to define.

2.9. Existing policies on Digitalization in Energy (and energy education)

In recent years, the digital evolution along with the new tools and technologies that have been developed all across the world, paved the way for a new era in which digitalization plays a major role in many aspects of our world, including the energy sector. The COVID-19 pandemic has accelerated this transition and made abundantly clear that with the good use of these technologies, set goals in societies and economies can be more easily achieved. In response to these challenges related to digital technologies, global organizations and research institutions have released documents with proposed guidelines and policies.

The International Energy Agency (IEA) has produced a document entitled 'Digitalization and Energy' covering a wide range of topics starting from the impact and the goals of digitalization in the energy sector to guidelines and policies for its effective use. It provides a valuable insight in the areas which can be significantly improved with the use of technological advancements and highlights the related risks:

- *Energy access:* In some developing countries in Africa, mobile phones are the most ubiquitous of consumer-electronic appliances while at the same time energy supply is limited. Some companies took this opportunity to develop new business models that will allow these people to access the energy services. More specifically, two services were offered to the citizens of rural areas: the rent-to-own service in which consumers pay a fee up-front and complete the payment in instalments and the solar-as-a-service in which the consumer never owns the device. Cloud services and software platforms as an alternative are also currently being investigated. It is important to note that lack of standards and policies along with lack of transparency may possibly discourage investors and stakeholders.
- *Environmental sustainability:* Digital tools can enhance the energy efficiency and minimize the carbon footprint which is detrimental to the environment. Although, these tools should be used wisely in order to prevent implications such as increased travel by self-driving vehicles, high energy consumption from smart devices and electronic waste.
- *Energy security:* Although cybersecurity risks pose a threat to energy security, the digitalization can possibly add to the system's resilience. For instance, mechanical failures can easily be prevented with the use of smart electronic devices and reduce outages.

It is evident that these risks can be prevented or mitigated, only by establishing effective, well informed, policy frameworks. The document presents policy recommendations that possible stakeholders should consider before releasing a policy.

More specifically one should:

- Build expertise and be updated in terms of new technology
- Facilitate easy and quick access to data
- Release flexible policies that can be adopted to technological changes
- Put the planned activities into action
- Be involved and take part in broad inter-agency discussions
- Take into account the benefits for the whole system and not only for its components
- Monitor and record the results produced from the digitalization of the system
- Take into account security risks in the design of the system

- Provide a common ground for different actors to compete in the development of new tools, platforms and models
- Learn from other stakeholders

A shining example that encompasses the aforementioned guidelines and can be used as a case study is Singapore's Smart Nation Vision, released in 2014, aiming to create "the world's first smart nation". The action plan focuses not only on the infrastructures but also on active research and development of new technology tools. More specifically, Singapore has fully invested in building concrete digital platforms and accumulating electronic resources such as high-speed broadband network to improve connectivity rates and sensors gathering data all across the island. To bridge the gap between different technologies and enhance the interoperability, it produces standards for network system architecture, communication and security protocols for sensors and the IoT that are tested outside the country. Furthermore, the government provides training seminars to 10 000 public servants in data science, in an attempt to expand the data analytics and cybersecurity skills of its employees. The country puts a strong focus on the research and development activities by investing approximately USD 14 billion in funds through to 2020. Finally it strengthens the communication and data exchange between the public and private sector by releasing public data. For instance the "Bus Uncle", a Facebook Messenger chatbot tells the waiting time for the next bus in the distinct local creole Singlish. It is worth mentioning that this action plan cannot be easily applied to every country: each government has a different starting point and should adapt the guidelines accordingly taking into account elements such as existing digital and energy infrastructures.

Following the release of the document entitled "An EU strategy for Energy System Integration", which stresses out the importance of building integrated, efficient, flexible power networks, the European Commission launched a roadmap in July 2021 in preparation for a new action plan regarding the digitalization of the energy sector. The action plan will focus on five axis: the creation of a common infrastructure for data sharing which will enable the exchange of information between different stakeholders, the active involvement of the citizens in this transition, the integration of digital technologies in the energy sector, the protection of the systems focusing on the cybersecurity and the incorporation of green technologies in the ICT sector. It is important to note that different policies have been published over the years regarding key elements of the digitization process: the 'Electricity Directive - (EU) 2019/944' for data exchange, the 'Regulation on the internal market for electricity – (EU) 2019/943' and the 'Energy Efficiency Directive – (EU) 2018/2002' for data protection with strong focus on the smart meters of the energy sector.

In September 2021, the EC published the '2030 Digital Compass: the European Way for the Digital Decade', a document highlighting the key role that digitalization plays in our society and the challenges associated with vulnerabilities that have been revealed in different sectors such as limited access to digital technologies, interconnections with non-EU based companies and social divisions. As far as the energy sector is concerned, it is stated that digitalization can contribute greatly to the achievement of European Green Deal objectives. More specifically, digital tools and platforms along with the collected data can provide solutions and assist in building an independent, resilient and sustainable green economy. Limited transportations, virtual meetings and smart digital technology applications, will enhance the reduction of emissions contributing to Europe's goal of reducing greenhouse gas emissions by at least 55% by 2030 and thus ensuring the protection of our planet. Continuous research efforts may also lead to the design and the implementation of more efficient digital tools. These tools may also be applied in the industrial energy sector and result in lower emissions and better outcomes in terms of production and efficiency. It is also mentioned that the transition to this new economy requires the collection, the processing and the distribution of all the product related data. For instance, the information about storage devices for electric vehicles and industrial applications will be distributed as part of the Sustainable Products Initiative in order to enhance the information exchange between the manufacturers, improve the resources efficiency and support the customers in the Decision-Making process.

It goes without saying that this transition requires digitally empowered citizens who will be perfectly capable to undertake these challenges. Strong focus will be given to digital skills which are vital to this aim and a prerequisite for the Digital Decade. The European Pillar of Social Rights Action Plan sets the target for adults with at least basic digital skills to 80% in 2030 with the launch of life-long learning programs in these areas of expertise. Citizens equipped with more specialized digital skills shall trust digital products and online services, identify possible threats, crossover the received information and rely on trustworthy sources. Finally, people should expand their advanced digital skills, in order to get quality jobs and move up the career ladder. As of 2019, the number of ICT specialists was 7.8 million, with a prior annual growth rate of 4.2% and thus it is expected that the EU will be far below the projected need of 20 million experts for key areas, such as cybersecurity and data analysis. Moreover, more than 70% of businesses claims that the staff has inadequate digital skills while also a significant severe gender imbalance is reported (only one in six ICT specialists and one in three STEM graduates are women). These challenges should be addressed with big investments in training programs in these areas in order to bridge these gaps and equip the future generations with the essential skills, in order to shine in the Digital Decade.

In the same month, the European University Institute published the RSC Working Paper 2021/73 entitled “An energy system model to study the impact of combining renewable electricity and gas policies” authored by Martin Roach and Leonardo Meeus. In this work, it is stated that it is currently debated whether the policies that have been successful at bringing down the costs for renewable electricity can be replicated for renewable gas, i.e., hydrogen and biomethane. It is worth mentioning that the European Union (EU) aims for 40 GW of electrolyzers domestically by 2030, there aren’t any support schemes for this. There are specific targets concerning biomethane, although many have support schemes. In the same working paper, it is mentioned that France aims for 10% of gas consumption to be supplied by biomethane in 2030. The support of biomethane may be limited by a link to its end-use consumption. Biomethane is supported in Germany when designated for electricity generation and in Italy for transport.

With the upcoming revision of the EU renewable energy directive, some stakeholders have advocated for a gas target to support low-carbon and or green gas technologies. If the recent experience in the electricity sector is regarded as largely successful in deploying renewable electricity generation technologies, then such a policy tool may have provided some inspiration for a gas target as is pointed out in the working paper. As one mechanism to promote decarbonized and renewable gases at the EU level there are proposals for guarantees of origin. The working paper advances an energy system model to help policy makers design renewable energy policies that combine support for renewable electricity with support for renewable gas. There is a so called by the authors “Stylized model” which includes demand for electricity, heating, and hydrogen in industry that is supplied by competing technologies where renewable gas policies can support the investment in electrolysers to produce green hydrogen as well as the investment in biomethane production which is subsequently injected into the gas network.

Usually, countries are considering introducing a renewable gas policy or increasing the ambition of the policy that is already in place. Such a policy typically consists of a target in combination with direct support to achieve the target. As the energy system is becoming increasingly integrated and the number of policy instruments is increasing, we expected to find significant interaction effects. This is confirmed by the working paper results. As further indicated, policy makers therefore need to be aware of these effects when they design their policies to avoid surprises regarding the costs of the policies and/or the effectiveness of these policies in supporting renewable gas technologies.

2.10. Existing skills offer and the future Energy labor market

The EDDIE project tried to identify the current skill offer by education and training providers as part of its activities, and the results are thoroughly presented in the report D2.2 Current and future skill needs in the energy sector [ref]. Through a dedicated survey targeting the education sector, mainly universities, interviews, and several reviews of reference university curricula, it was possible to get an overview of the digital skills and competences offered by education providers. Several insights were drawn from this work, that stress the importance of aligning academia with the labor market to foster the digital transformation of the energy sector.

The current education system in Europe still needs to improve in providing good employability to graduate students in relation to the knowledge and skills demanded by the ongoing transformation of the Energy sector. Alignment of academia with the labor market is needed to teach students both theoretical and practical, hands-on skills directly applicable in the work environment. To this end, significant effort in this direction is already being made by some universities and European initiatives. Areas such as Smart Grids, Information & Communication Technology, Innovative methods of simulation & analysis (machine learning, artificial intelligence, big data analytics) appear to be more and more present in several academic programs throughout Europe.

Given the importance of an organization's human capital to business success, aligning training and competence development with business needs has become a key challenge. Thus, in the last 10 years, many companies created corporate universities (CU) to face this challenge. Corporate universities really come into place when companies see the education of their employees as a strategic instrument to create competitiveness and support overall corporate strategy and culture. They are generally dedicated units acting as partners with senior leadership to develop strategic skills and capabilities.

Another useful source of education and training is indicated by the interest in online courses and MOOCs which is rising in the last few years, and it has been further increased within the social context of the covid-19 pandemic. Consequently, it is possible to find several high-quality platforms that play the role of education marketplaces where providers and consumers meet, leveraging the powerful network effect of a learners' community in action. One of the main takeaways from the benchmarking analysis is that topics related to digitalization of energy are not well established yet, especially in terms of classification / categorization of the respective knowledge and skills. Nevertheless, there is a variety of target audiences not only in terms of training/education level, but also in terms of cross-sectoral domains. Moreover, the credentials / qualifications awarded as well as related reference standards such as EQF are seldom specified.

Vis-à-vis interviews with education stakeholders indicated that the *demands and trends in the educational* offering can be summarized as a strong increase in need of well-trained engineers with a transversal, specifically energy and digitalization technologies, skillset. The multi-disciplinarity extends also into fields such as cyber-security and business aspects such as management skills and market models for energy systems. In addition, the trends are towards shorter more flexible offerings including self-paced offerings, which can cater also to needs from industry stakeholders. With regards to the *trends in skills with regards to digitalization*, there is a clear need to provide more education in data analytics and artificial intelligence, with automation coming up as a close second. Additionally, needs related to digitalization tools to enable modeling and simulation of energy consumers and markets is an emerging trend. The *content presently covered in offerings* map, at a high level, relates well to the identified trends. However, the bulk of education is still provided within traditional electrotechnical or energy related topics and the digitalization topics are offered as add-ons, or electives in later years of studies. There are a few examples of educational offers in terms of new formats for continuing education, and most are adapted to a university context addressing mainly students in universities. Admittedly, this is biased due to the group of respondents representing mainly industry. The responses from the VET sector indicate a larger focus on use of digital tools rather than basic technologies. To some extent this maps well with requirements of allowing a self-paced format.

Regarding *objectives of the educational offering*, the interviews highlighted the importance of providing employable trained professionals to society to impact the development of the energy system. Again, depending on the type of organization, for example university of VET, different emphasis is placed on fundamental theory as opposed to tool-based teaching to reach this goal.

Also, the importance of educating individuals to have awareness and provide a critical mindset in a rapidly changing environment as the energy sector is stressed.

Diving deeper into the knowledge and skills offer by education and training providers through the dedicated survey (Figures 4 and 5), one can identify if specific skills and skillsets are covered through different study programs and the level of expertise the knowledge is provided. Most education and training providers (mainly Universities) indicate that they provide an adequate coverage of data related skills which are crucial for the digital transformation since data is the key element in digital technologies. Nevertheless, analytical methods and way of thinking for example when conducting statistical analysis or mathematical optimization are not provided at an expert level by a significant number of institutes. The least covered skills or the skills that are not provided at the highest expertise levels, refer to computing tools, such as simulation tools, and more ICT specific knowledge related to programming and development. The importance of transversal skills, that are interdisciplinary and needed regardless the specialization, as well as green skills that are becoming crucial for a sustainable future is validated and stressed by the industry who is aware of their importance.

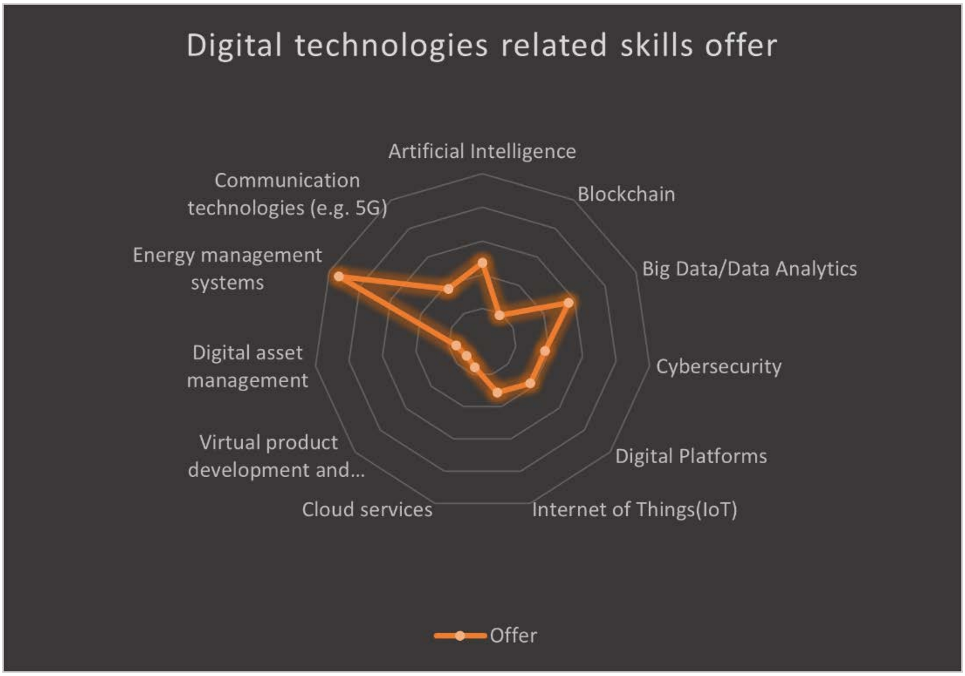


Figure 4 - Results from EDDIE's survey on skill offer - digital technologies

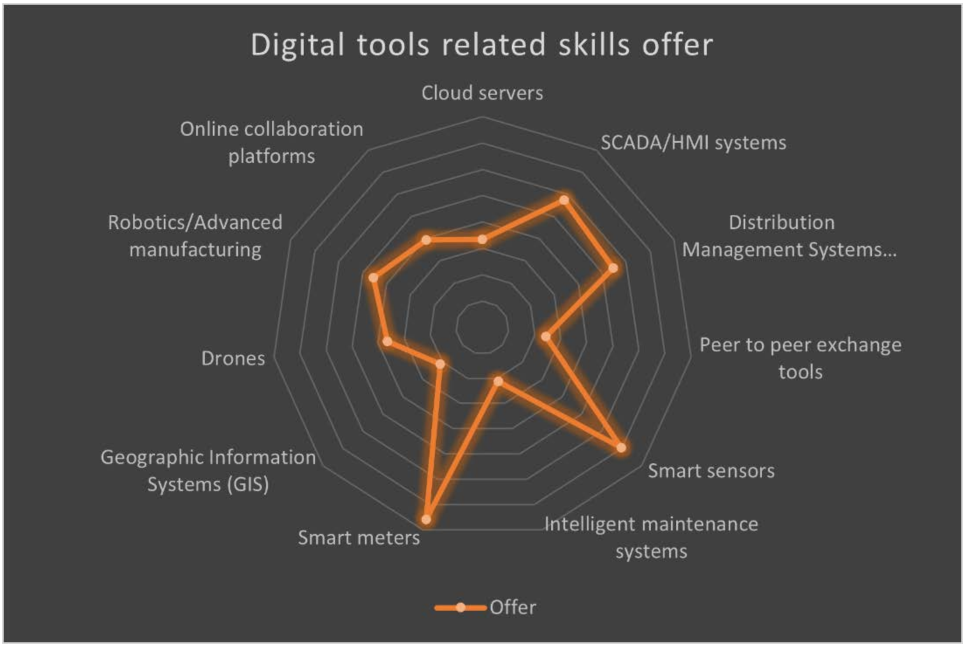


Figure 5 - Results from EDDIE's survey of skill offer - digital tools

3. Methodology: definition, classification and bottom-up approach for the development of a Best Practice

This Chapter presents concepts and methodology underlying the definition and development of the EDDIE BP, according to the vision and the objectives of the EDDIE Blueprint Strategy for the Digitalization of the Energy sector (BSDE). Conceptual definition and methodology will be used in the next stages of the project, for the practical development and validation of the set of procedures that will form the BP.

3.1. Definition of Best Practice

The definition of Best Practice (BP) is a highly debated topic of discussion; however, within the context of higher education, it is generally recognized that a practice is “best” when it is making the most positive contribution, adding the highest possible value to the students learning experience, and when it is worth of wider dissemination. A BP is then any practice that goes above and beyond the standard good practice, and it should give a particularly positive contribution in terms of: guaranteeing the academic standards of an education provider; quality and/or enhancement of the learning opportunities provided to students; quality of the information delivered about a higher education offer.

Four stages are necessary for the definition and successful establishment of a BP, namely: identification, verification, dissemination and embedding:

- *Identification,* that is to say, the BP should be easily traceable. Too often good practices pr examples exist but are not put forward and promoted. Mechanisms should be available, such as periodic review, validation, module enhancement plans, and program appraisal and enhancement, to identify examples of best practice and potential areas of best practice worthy of investigation.
- *Verification:* a practice must be checked, validated and approved by others in a program team, subject area or faculty, in order to ensure that it meets its requirements and

specifications and that it fulfills its intended purpose. If as a result of this it is agreed that practice is solid working practice rather than good or exceptional practice, this is still a good outcome and worthy of recognition as it is endorsement of appropriate practice.

- *Dissemination* varies depending on circumstance; nevertheless, whatever methods are agreed upon need to be *proactive and systematic*. Examples of agreed good practice won't become known unless they are communicated effectively and widely thereby increasing opportunities for enhancement. Simply placing examples on a website or in a file for colleagues to look through when they find the time will not work effectively.
- *Embedding.* Identifying, verifying and disseminating examples of good practice is important, but all this remains questionable if it has no positive impact on the practice of others. A good practice is thereby successful and considerable as a "best practice" if and only if it becomes embedded into educational programs. Embedding should be accompanied by continuous monitoring, periodic reviews and enhancement plans, in order to see how areas of identified good practice are taken forward, disseminated and embedded within programs, departments and faculties.

The BP defined in EDDIE refers to these general principles. This BP is intended to be any *process* defined by a set of procedures (i.e., recommendations, lessons learned, examples of existing good practices, new practices that advance them, practical tools) for the redesign and methodological validation of teaching and learning, directed to the Energy sector and the delivery of the skillset demanded by its digitalization and transformation. The setup of a BP will also consider the area of operation and impact (e.g., teaching/learning procedures, teaching offer, study contents and programs, examination and certification, international mobility, supporting actions, etc.).

3.2. Bottom-up approach for the development of a Best Practice

For the design and development of a BP, we propose and follow a *bottom-up approach*: the BP is the result of an analysis and evaluation of the current labor market, market and industry specifics as well as of the EU strategy set to achieve a digital transformation of the economic sector (including the Energy sector). We look at and delve into inputs from market, stakeholders involved in the energy sector, public authorities (to define the demand, as it is seen in the EDDIE ecosystem), and we look at and delve into other inputs on the current offer from university. From this information, it can be defined WHAT has to been done in terms of BP (procedures) and HOW this should be achieved. Figure 6 provides a graphical representation of this methodology.

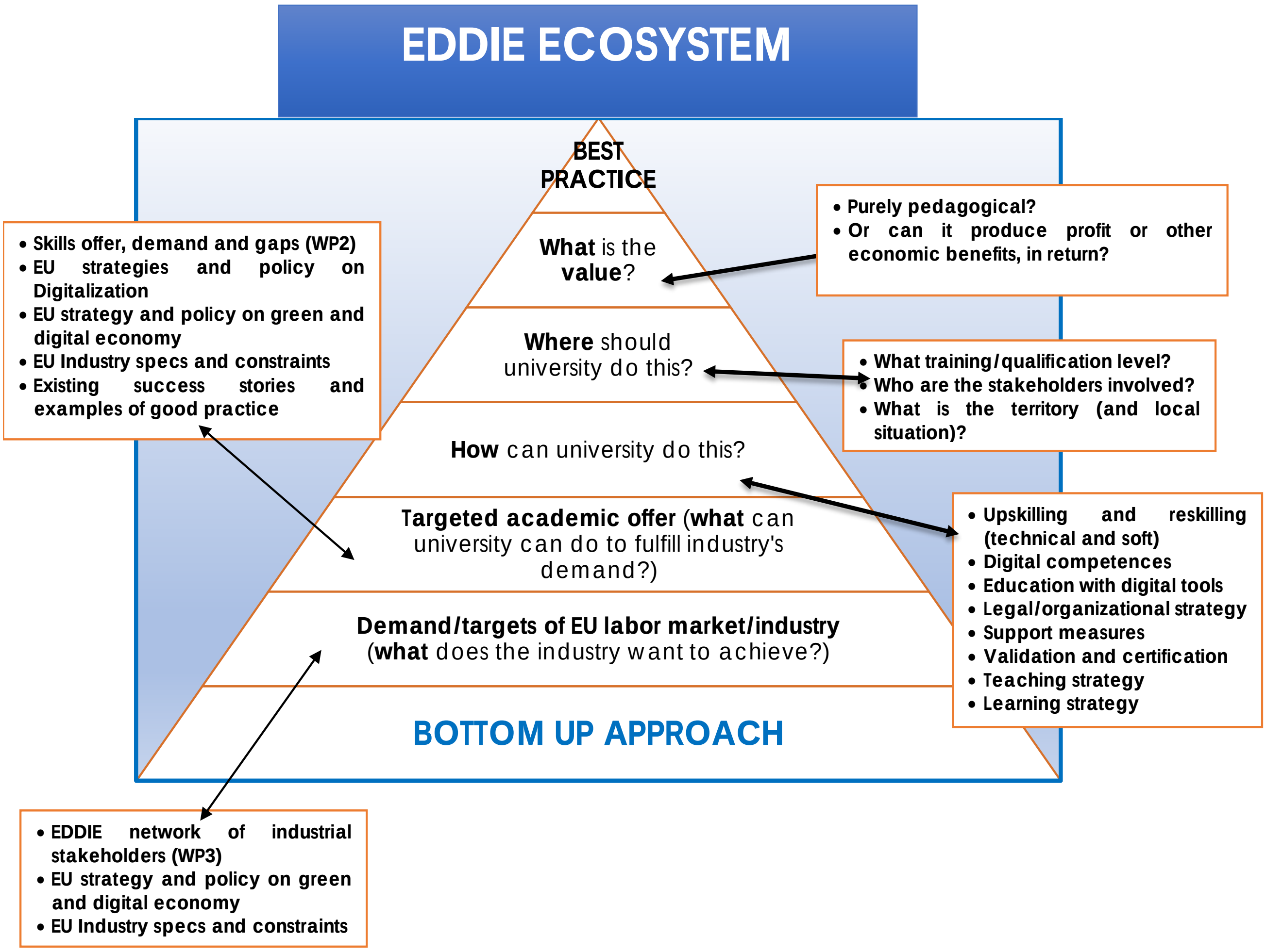


Figure 6– Bottom-up approach for the definition and development of Best Practice in university.

Some aspects that will be taken into account in the design and development of BP, are:

- The BP must be targeted to specific levels of education and certification, specific stakeholders (industry, public authorities, teachers or students), specific area of application and industrial/labor market's sector (in the EDDIE project, the focus is on the Energy sector).
- The BP should take into consideration the territoriality (i.e., the specific social, political, economic situation and the specific education system across the different EU countries)
- Examples of existing good practice (success stories, ongoing projects, strategies and initiatives around EU) should be used as references for the development of a BP.
- The BP should be developed in synergy with the EU frameworks for education and professional qualification.
- The BP should address purely pedagogical purposes or also bring opportunities for added economic value.
- The BP could target a variety of aspects, such as the technical or 'soft' upskilling and reskilling, the acquisition of digital competences, the application of digital tools for teaching/learning, but also organization and legal aspects of the education, support measures, instruments of examination or certification.

The review, design and development of BP (for university but also for vocational education and lifelong learning) in WP4 is in part made to guide the works in WP5, where the Blueprint strategy is designed. For this reason, it is important that the methodology in WP4 bears in mind the structures that are being used in WP5 to analyze existing education programs, which stresses not only their academic suitability, but also their economic long-term sustainability. For this reason, we follow a list of items to be reviewed in additional to those already mentioned, in the design of good practices at the different stages of the academic and business models of new (or existing) education initiatives. Table 1 presents these items.

Table 3 – Items common to Best Practice model in WP4 and WP5

PHASE	BUSINESS MODEL	ACADEMIC MODEL
Specification	Methods of interaction with industry (energy and digital) for: technology trends, labor market, skill needs	Definition of target jobs, target skills. Taxonomies: skills, jobs, tools/systems.
	Methods for employees performance assessment	
	Methods for graduate-skill assessment, official education	
Design	Use of training-programs templates: business	Use of training-programs 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 academic planning
	Define certification entities and methods	Certification criteria
	Define feedback and validation methods	Validation criteria
Implementation success	Recruiting success (quantity)	Individual certification: results
	Financial success (profit, sustainability)	Programme certification: results
		Alumni feedback: results
		Employers feedback: results

3.3. Requirements for Best Practice

The consortium has established the following requirements for the Best Practices for a university education:

1. Relevant to digitalisation and energy
2. Use of digital tools and solutions
3. Links with industry/research stakeholders
4. University or scientific exchange program

In order to specify the relevance of the Best Practice to digitalisation and energy, and based on the preliminary research for WP5 – Job Profiles analysis, the digital skills that were found most important for the development and implementation of new technologies and systems in energy digitalization are:

- **Artificial Intelligence and Machine Learning:** used for a wide range of applications, such as optimizing the operation of power plants, predictive maintenance for equipment failures, and analyzing energy usage data to improve efficiency.
- **Cybersecurity:** used for protecting control systems, networks, and data while ensuring the integrity and availability of energy systems.
- **Internet of Things (IoT):** used to monitor and control energy systems, track equipment performance, and optimize energy usage.
- **Robotics:** used to automate tasks such as drones for inspecting power lines and solar panels, and robots for cleaning and maintenance.
- **Big Data/Data Analysis:** analyze big data and extract insights to improve energy systems.
- **Blockchain:** used for a wide range of applications, such as monitoring transactions, managing energy trades, controlling energy and storage flows and tracking renewable energy credits.
- **Augmented reality:** used to improve the efficiency of the design, training, and maintenance of the systems,
- **Energy modelling:** used mainly for optimizing the performance of energy systems.
- **Simulation and optimization:** used to simulate the performance of energy systems and optimize their operation.
- **Cloud services:** used mainly to access resources, store, and analyze large amounts of data.
- **Advanced control systems in the energy grid:** used to optimize the performance of the grid, improve system stability, and manage the integration of renewables.
- **Measurement techniques:** used to measure, monitor and control the energy systems in real-time.

Apart from the Best Practices, during our research, some other examples that support the analysis of the university education were identified, while not directly related to energy digitalization or not fulfilling the requirements completely. To expand our research and provide a more comprehensive view, these are also presented and analysed in the next section as good examples. These examples complement both our research and the identified Best Practices and include also different type of programs connected to universities. They provide valuable insights on methodology and important lessons learned that can be applied in the university sector.

3.4. Analysis of Best Practices and Good Examples

Best practices at a university education level are obtained considering the requirements set by the consortium. These requirements are explained in detail in the section above. To elaborate further on obtained best practices, each practice and example is analysed through the following steps:

- **General presentation of the practice:** a general description of a best practice/good example
- **Relevance/Importance:** why a best practice/good example is chosen and what is its relevance/importance.
- **Aims and objectives:** a description of the aims and objectives of the best practice/good example.
- **Structure and organisation:** a description of the target group, program type, certification, duration of the program, evaluation, teaching method etc.
- **Scalability and Transferability:** a description of a best practice's ability to increase/decrease in performance and to be replicated from one organisation or country to another.
- **Impact and success factors:** a description of provided knowledge and skills, outcomes and results, and lessons learnt from the best practice/good example.

These steps will be used to describe and analyse the best practices/good examples in order to identify key elements that have led to their success and to determine how these elements can be replicated and adapted in other countries and organisations.

4. The framework for a Best Practice in university education: lessons learnt, trends and opportunities, and final remarks

This final part of the deliverable presents the results of the conceptual and methodological systematization of the previous chapters, providing:

- In Section 4.1: an insight on trends and opportunities to redesign university Education in the view of Digitalization and considering Industrial transition, by evaluating - in the perspective of university - the DEAP (2021-2017) (ref. Section 2.1), and selecting from it the actions that can be referred to, or integrated into, the EDDIE BP.
- In Section 4.2: an array of successful examples of existing good practices that can be integrated into the framework of the EDDIE BP, or used as a reference/lesson learnt.
- In Section 4.3: comprehensive examination of various best practices that meet the requirements previously described in chapter 3.3 and are directly relevant to energy digitalization. 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 Section 4.4: the groundwork for the practical development of a BP (which will constitute the next step of work of WP4), with concepts, recommendations and final considerations.

4.1. Best EU policies and strategies for the academic education

This section presents an interpretative assessment of the EU Roadmap on Digital Education, aimed at identifying the Actions that seem particularly relevant for the redesign of academic education (and training in general), in line with the upskilling and reskilling requirements that are following the changes of labor market and industry.

4.1.1. Assessment of the EU Roadmap on Digital Education in the perspective of university

The success of guiding principles of the Action Plan is heavily dependent on the whole sector, thus all participants are equally responsible for taking action in addressing modern, up-to-date and digital education. One of the major roles is played by universities since academia establishes a direct link between industry, researchers, engineers, and students participating in higher education. Furthermore, the university is a foundational institute in the education and training system and has a direct effect on both the demand and offer side of the labor market. Based on the aforementioned main action pillars, the following sections highlight the key challenges, tasks, and possibilities universities may have throughout the implementation of the Action Plan.

1. **Fostering the development of a high-performing digital education ecosystem**

The first priority goal of the action is to foster the development of a high-performing digital education ecosystem relying on the exploitation of enabling factors for digital education, the European Digital Education Content Framework, accessible high-speed internet connection, digital pedagogy and expertise, and the exploitation of AI and data usage in both learning and teaching. As a key player in the education and training sector, universities must represent higher education and academia, and must also actively participate in assessment and development processes.

Table 4 – University-related assessment of DEAP objective 1

Action	University-related considerations
Action 1	- the strategic dialogue includes governments, education and training institutes, the private sector, and the public sector, thus, universities must also be represented - the enabling factor of tackling connectivity and equipment gaps might be more severe within university terms due to high software and hardware requirements in information technology and engineering fields
Action 2	- universities gained vast experience in adapting virtual teaching during the COVID-19 pandemic, and their transformation was dominantly successful - primary and secondary schools might be guided and supported by higher education institutes via sharing know-how's and best practices on online learning
Action 3	- universities may serve as testbeds for novel learning platforms or contents, they may also take a major part in the design and development of new content or technologies in digital education - higher education courses relying mainly on virtually accessible materials may be developed and extended further for a broader audience - in the certification process, universities and their experience and knowledge must be considered as a baseline for the assessment of skills and courses
Action 4	- universities should be equipped with robust and efficient digital technology such as schools.
Action 5	- universities may provide digital professionals to deliver hands-on learning workshops or in-person live courses on digital platforms
Action 6	- in the development of the training program for researchers and students, the experiences and knowledge from universities must be considered - universities may also take an active part in course design and material development

2. Enhancing digital skills and competencies for the digital transformation

The guidelines are also aiming the enhancement of digital skills and competencies for the digital transformation via updating the European Digital Competence Framework, developing a European Digital Skills Certificate (EDSC), proposing recommendations, improving cross-national monitoring and support, incentivizing advanced digital skills development, and encouraging women's participation in STEM. Since universities are highly subject to the problems addressed by this priority area, they must not be just well-represented, but they also must take high effort actions to deliver a short-term impact on the sector. In addition, to improve cooperation on digital education at a European level, the action plan sets the goal to establish a novel European Digital Education Hub (EDEH).

Table 5 - University-related assessment of DEAP objective 2

Action	University-related considerations
Action 7	- Universities might consider integrating the teaching of the top 3 essential digital skills in a compulsory soft-skill course

	- This hybrid course may serve as a pilot for an eu-level standardized course (e.g., In English, and the same contents everywhere; maybe online, maybe in-person, or virtual)
Action 8	- High-quality AI courses of universities with more experience within the field can serve as basics for learning resource and material design - Cooperation with existing online learning platforms, such as edx, Coursera, and Udemy, might be considered
Action 9	- Universities should actively take part in this action as they have great experience and knowledge on the assessment of learning competencies, outcomes, and acquired skills - They can also help to design an assessment procedure for measuring digital skills
Action 10 and 11	- Universities should clearly communicate the level of inclusion of digital skills in compulsory courses - A comprehensive survey must be carried out to identify the digital skills needed for computer-based labs
Action 12	- Universities must highlight the importance of digital skills, such opportunities must be advertised, motivation via scholarships or elite industrial placements exploiting the well-established relationships between academia and industry
Action 13	- Soft skills and gender equality should be more strongly transmitted by European universities, and career guidance will have to play an increasingly important role. - Universities should promote women's access to STEM careers.
EDEH	- Flagship universities should be encouraged to participate in setting up a multi-level international hackathon on selected digital energy topics

4.1.2. Selection of Actions in the perspective of University

The actions that seem particularly interesting for the EDDIE project at University context are the following.

ACTION 1: Launch a strategic dialogue with Member States in order to prepare a possible proposal for a Council Recommendation on the enabling factors for successful digital education by 2022.

In particular, the main goal is to define the steps supporting education and training institutions at all levels by sharing knowledge that needs to be taken in order to make digital education available for everyone. This, for example, by encouraging Member States to develop guidelines for digital pedagogy.

It is expected that this strategic reflection process, together with several thematic meetings, will increase the commitment and the awareness of the Member States.

This ACTION will strengthen the digitalization of education at all levels in Europe thus indirectly supporting the activities of the EDDIE project.

ACTION 3: Develop a European Digital Education Content Framework by 2023 and launch a feasibility study on the creation of a European exchange platform by the end of 2021.

Specifically, in 2022 will be launched a dialogue which will address issues such as digital innovation and technological transformation, as well as the impact that the COVID-19 pandemic has had and is having on education, taking into account the needs of all parties involved in education.

Thanks to this dialogue it will be possible to create a European Framework for Digital Education Content and a European Exchange platform focused on certified online education resources and platforms.

This ACTION will produce two outputs particularly relevant for the EDDIE project.

1. The European Framework for Digital Education Content could support the EDDIE project in evaluating its outputs in terms of contents, and in setting new goals and processes to produce digital contents.
2. The European Exchange Platform could be used by the entity to share the education resources and platforms produced by the project itself

ACTION 5: Use Erasmus cooperation projects to support the digital transformation plans of primary, secondary, vocational education and training (VET), higher, and adult-education institutions, as well as support digital pedagogy and expertise in the use of digital tools.

This action has two main objectives: the first one is to ensure that educational institutions develop and strengthen their digital capabilities and capacity; the second one is to support teachers, working in different educational levels, in the development of their digital skills.

The Action will be implemented through several funded projects. The first funding was opened in April 2021, and will be made available annually until 2027, through the Erasmus+ call.

This ACTION will develop and align the development of the digital skills of all the educational institutions of the Member States thus indirectly supporting the educational Actions put in place by the EDDIE project.

ACTION 8: Update the European Digital Content Framework to include AI and data-related skills.

The aim of this action is to enable EU citizens to acquire technological knowledge so that they can use the new tools securely and at the same time acquire awareness of related issues such as privacy, ethics, sustainability and discrimination.

Specifically, during 2021 and 2022, Artificial Intelligence will be added to the Digital Competence Framework so that it can be implemented in education and training.

This ACTION will produce an important output for the EDDIE project, that is the compilation of Digital Competence Framework 2.2 by March 2022. The Digital Competence Framework could be used as a valuable reference in the programs and courses implemented and supported by the EDDIE project.

ACTION 9: Develop a European Digital Skills Certificate (EDSC) that may be recognised and accepted by governments, employers and other stakeholders across Europe, by 2023.

The objective of this action is to develop a European Digital Skills Certificate because in Europe there is a wide range of digital skills certifications that need to be recognized, in order to allow the citizens to indicate their digital skills level according to the DigComp.

This ACTION will align the Member States in the recognition of the digital skills, furthermore it will ensure that by 2025 70% of people aged 16-74 will have basic digital skills and that by 2030 at least 80% of the population will have basic digital skills.

The main outcome will be the European Digital Skills Certificate (EDSC) recognized and accepted by governments, employers, and other stakeholders in Europe.

The output of this action will be relevant for EDDIE which could use the digital certificate as a requirement for specific training experiences focused on the digitalization of energy.

ACTION 13: Encourage women's participation in STEM.

The European Commission has decided to encourage the participation of women in STEM studies and careers, in fact data show that only 24 out of 1,000 graduates of tertiary education in the European Union (EU) ICT-related subjects and only 18% of ICT specialists in the EU are women.

New higher education programs for engineering and information and communications technology based on the interdisciplinary STEAM approach will be offered, E-STEAM (Equality in Science Technology Engineering Arts Math) Festivals organized in different EU Member States will be organized to increase confidence and creativity, and online learning platforms will be used to increase the participation and the development of digital skills also at secondary education level. This ACTION is expected to engage 40,000 young female students in STEM disciplines by the end of 2027.

The support to higher education programs for engineering and information and communications technology based on the STEAM approach and supporting Equality has to be considered valuable for the EDDIE project: the project has to strongly consider this aspect too.

European Digital Education Hub: The Commission will establish a European Digital Education Hub by 2022, to improve cooperation on digital education at the EU level.

The European Digital Education Hub will be focused on three main actions:

- Creating and developing a community of practice for cooperation (cop)
- Creating a network of National Advisory Services (NAS)
- Collecting best practices through the new Support, Advanced Learning and Training Opportunities (SALTO) resource center for digital education

In particular, the CoP will:

- Provide a cross-sectorial space;
- Encourage knowledge and information sharing, cooperation and mapping;
- Support the acceleration of digital innovation in education.

The NAS will foster the 'Strategic Dialogue on Enabling Factors in Digital Education'.

The SALTO will train the staff of the National Agency; will guide beneficiaries and applicants providing them with all the necessary tools; and will also take charge of the best practices.

European Digital Education Hub could be considered by the Eddie consortium as an important source of tools, information and expertise.

4.2. Examples of good practice

4.2.1. Re-Generation

General presentation of the practice

The International Telematic University UNINETTUNO with the collaboration of the company ENEL, has created an online platform that offers short training courses for students. These courses are offered in e-learning mode using the UNINETTUNO model and technology.

Relevance of the programme

We consider the programme to be a good example because we can highlight how all training courses focus on the development of digital competences such as digital economy, law in the digital society or IT and digital technologies. However, although the knowledge is perfectly applicable to the energy sector, the courses do not present specific subjects related to the energy industry. The courses cover topics such as Digital Technologies for companies, Big Data and company databases, Advanced Web-based Technologies, Basics of Big Data, Artificial Intelligence.

Aims and objectives

One of the fundamental objectives is to update the professional skills of the students who enrol on these courses. The courses aim to provide training in three strategic thematic areas of training in the Digital Society with the professional skills most in demand in the world of work today.

Structure and organization

During enrolment, each student will be able to choose only one of the following short term programmes with each five dedicated online courses:

- Digital Economy Area

- Law in the Digital Society

- IT and Digital Technologies Area

The training courses, if successfully completed by the students, will give the possibility to obtain ECTS, which can be used for enrolment in new full training courses as degree courses at UNINETTUNO University and at all European Universities.

Scalability and Transferability

It is a project that can be replicated in other countries and universities. With this e-learning format and short courses, students can deepen their digitization-related skills that will be of great relevance for their professional future.

Impact and success factors

What makes this Re-Generation Project of online short courses a successful experience is the possibility of using a digital platform, with the structure and technology of a prestigious university such as UNINETTUNO University in collaboration with a company in the energy sector such as ENEL. These short courses are essential to make up for some of the digital skills gaps that are observed in university students when it comes to entering the world of work.

4.2.2. NPI–DIGIKOALICE: The project ENERSOL

General presentation of the practice

The ENERSOL project initiated on 2004, targeting schools of the Czech Republic on the topics of energy efficiency, RES and saving of fuel. The project involves several Czech ministries, educational agencies & institutes, association of regions and industry association.

Relevance/Importance

The relevance of the project stands mainly on the collaboration of different stakeholders, including public authorities and industry. Moreover, some of the actions utilize digital tools and solutions and include initial applications of digitalization of energy (e.g. construction of smart houses)

Aims and objectives

The project aims mainly at secondary school students and their teachers, working on topics of RES, energy efficiency, emission reduction and furthermore on digital technologies, regarding web design, smart houses, remote control data gathering. During the project, there is the opportunity of partnership between students of secondary and higher vocational schools, teachers and industry professionals.

Structure and organisation

Every year The Kroměříž Education Agency is preparing the draft rules and topics of the project, requesting the approval of the partners. The prime minister, related ministers, heads of unions of school founders accept the responsibility of the project.

The highlights of each year are the regional, national and international shows, where the students with the highest evaluations perform.

Scalability and Transferability

The project demonstrates high transferability, taking into account that the topics or RES, energy savings, and fuel savings have a common ground and therefore, the program can be replicable to the other European countries, educating and triggering students' interest about these topics.

Impact and success factors

Every year 80 secondary schools participate in the project, varying along the country of Czech Republic.

4.2.3. Centre for Digital Energy

General presentation of the practice

The Centre for Digital Energy is the interdepartmental structure of the Fraunhofer Institute for Applied Information Technology. The Centre works closely with RWTH Aachen University, and together they offer the bundling of expertise from the fields of energy systems, digitisation, IT security, and business models. Through their application-oriented research, they can support regional companies in maintaining and sustainably developing their competitiveness in a rapidly changing energy supply environment.

Relevance/Importance

The Centre for Digital Energy is a **Good Example** because it shows the symbiosis of academic and applied research for the industry in digital energy. Furthermore, by offering various positions for students on Bachelor, Master, and PhD level, they educate future generations in applied research on numerous topics related to digital energy. By offering several training programs, the Centre can serve as an example of life-long learning, which are also considered in the scope of the EDDIE project.

Aims and objectives

The aim of this Centre is to have an impact on research and development for industry in digital energy in the following areas:

- digital support in planning methods and operating methods of energy systems,
- innovative market approaches,
- new business models,
- solutions for constant data exchange,
- IT security, and
- sovereign networking in the energy supply.

Structure and organization

The Centre for Digital Energy is based on three pillars:

1. research and development of new technologies and business models,
2. the training of future experts, and
3. testing and verification activities to ensure that research results can be successfully integrated into products and services.

The research and development in this Centre are divided into the following categories:

1. **Energy systems**: research and development of cross-sectoral and climate-neutral energy systems of the future,
2. **Digitalisation**: more efficient network usage through automation or intelligent network control technology, and research about the potentials of digitisation in the energy sector,
3. **IT Security**: the investigation of threats and the development of required IT security technologies, and
4. **Business Models**: test the old business models and find new possibilities.

In addition, the Centre offers four services:

1. **Municipal energy system planning**: simulation tools and methods for the digital inventory of buildings and infrastructures,
2. **Modular network control systems**: development of micro-services-based control systems,
3. **IT security development**: concepts and IT security technologies for critical infrastructures, and
4. **Energy data and visualization**: tools for data preparation and visualisation of energy data.

In the scope of the Modular network control systems service, following trainings exist:

1. training related to SOGNO architecture, deployment in (local) cloud environments or individual SOGNO components, and
2. training for standards, technologies and tools used in SOGNO (e.g. CIM).

These trainings are examples of life-long learning, which are also considered in the scope of the EDDIE project.

Scalability and Transferability

The Centre enables the efficient and sustainable transfer of scientific knowledge into commercial use. The research focus and results are transferable into education by integrating them into the curricula.

Impact and success factors

The research at the centre has a positive impact on teaching at higher education institutions. A good example is the integration of “hot topics” in current research into the curriculum of related courses at universities. This gives the students insights into state of the art research topics and a glance at the application of these topics in research and industry

4.2.4. Summer School Energy Technology, Policy and Politics

General presentation of the practice

The "Energy Technology, Policy and Politics" is a summer school for early-stage researchers from around the world who want to gain an in-depth understanding of the energy sector. The summer school is jointly organized by the Energy Science Center (ESC) and the Institute of Science, Technology and Policy (ISTP) of ETH Zurich.

Relevance/Importance

The newly created Swiss summer school with the title "Energy Technology, Policy and Politics" will provide for the first time a comprehensive overview of the technical, socio-economic and political challenges and opportunities of creating a sustainable energy supply for the future, under the premise of net zero (or even negative) GHG emissions.

The summer school will address the following topics from a technical, economic and policy perspective:

- How does the energy supply system function today and potentially in the future?
- What are the main challenges and opportunities in achieving a net zero greenhouse gas (GHG) emissions energy supply system?
- How can needed investments in the energy system be realized?
- How can policy accelerate the transition to a net zero energy system?
- How can political ambition be increased or implement such accelerating policies?

Aims and objectives.

The "Energy Technology, Policy and Politics" summer school is aiming to present an in-depth understanding of the energy sector to early-stage researchers from around the world. The scientific program will strongly build on inputs from renowned experts. Participants will actively take part in workshops that allow them to dive more deeply into relevant scientific aspects. Due to the highly interdisciplinary nature of the topic, the proposed summer school will attract early-stage researchers from the engineering and natural as well as social sciences (including economics).

Structure and organization

To this end, the conference will use different formats including keynote lectures, poster sessions, case studies and panel discussions to convey information as well as create a space to develop strategies and test ideas. This will provide an opportunity to get an interdisciplinary and broad overview of the topics and look at specifics more closely. In this sense, the conference will enable young scientists to contribute towards the transformation and decarbonization of the energy system, which will ultimately help solve the challenge of climate change. The five-day summer school is structured around keynote presentations, poster sessions, workshops and a concluding panel discussion involving lecturers and participants.

Scalability and Transferability

The school is open to early-stage researchers (PhD students and postgraduate students) from around the world, who want to gain an in-depth understanding of the energy sector.

Impact and success factors

The ESC and the ISTP are both interdepartmental scientific units of ETH Zurich that promote a sustainable energy system that is responsive to the central challenges of the energy transition. The ESC and ISTP both offer a platform for nourishing the exchange of information between the engineering sciences, the social sciences, policy-makers and other members of society. Moreover, they both foster productive transdisciplinary research collaborations.

4.2.5. SEEEP PhD Summer School

General presentation of the practice

The Hybrid School on Energy Transition is a yearly 2-week Energy PhD school organized by KTH Stockholm and TU Eindhoven, as part of the SINO-EU Engineering Education Platform.

Relevance/Importance

The PhD Summer School is organized as a part of cooperation between the European network of technical universities, CLUSTER and the Chinese Network, Sino European Engineering Education Platform (SEEEP). It takes place every year, alternately in China and Europe and managed jointly by KTH Royal Institute of Technology, Eindhoven University of Technology, Zhejiang University and Shanghai Jiao Tong University. For example, in 2019 the topic was "*Affordable Energy Transition: technological solutions and socio-economic constraints",* in 2021 "*Energy Transition: Pathways towards net zero",* and in 2022 *"Energy Transition: Resilient Energy Systems".*

Aims and objectives.

The school aims at developing multi-disciplinary skills of PhD students related to system engineering, design thinking, team working, presentation skills and peer learning.

Structure and organization

The workload is 3/4 ECTS. The participants will have a schedule with lectures and project work in an international working environment where other students from European Universities as well as Chinese Universities will take part. There will be selected lectures by expert Professors from Shanghai Jiao Tong University, Zhejiang University, KTH Royal Institute of Technology and TU Eindhoven on topics encompassing resilient production and storage, renewable energy technology, sustainability, energy demand flexibility and energy grids and conversion.

Scalability and Transferability

This summer school for PhD students from diverse programs is a good example for upskilling in challenging multidisciplinary and multicultural projects.

Impact and success factors

The School is free of charge and don't require participation fee. Accommodation is provided and paid by the School organizers. The participants are able to grow their network and exchange valuable experiences.

4.2.6. Iberdrola University Programme

General presentation of the practice

Iberdrola has signed a series of collaboration agreements with the main universities in which Iberdrola collaborates, as proof of its constant support and relationship with education and entrepreneurship.

Relevance/Importance

Iberdrola U, Iberdrola's University Programme, is a meeting point for university students, grant recipients, teachers, researchers, and Iberdrola employees with a common goal: to contribute to defining the energy of the future using innovative solutions. It is a programme that gives opportunities to young talent, making them a part of the change in the energy sector and the challenges of the energy transition.

Aims and objectives.

Iberdrola U, the Iberdrola Universities Program, aims to support the transfer of knowledge, talent and social contribution. It strengthens the link between universities and companies with the goal of teaching young talents the skills to develop innovative solutions to the energy sector's challenges. To make these aims a reality Iberdrola is working with nine leading global universities. Iberdrola, through its constant support and collaboration with education and entrepreneurship with the goal of developing students' skills and proficiencies in business, research, and innovation, is undertaking a number of lines of action:

Structure and organization

Currently, the nine agreements of the University Program connect over 300,000 members, including students, teachers, and scholarship holders. Some relevant example for EDDIE work are summarized below:

- Iberdrola and the MIT (the Massachusetts Institute of Technology) have signed an agreement to boost innovation in clean energies. The agreement will focus on energy and environmental innovation, training the company's employees and helping students develop entrepreneurial skills.
- Collaboration agreement with the Comillas Pontifical University - Chair in Energy and Innovation. Persisting in its unwavering commitment to the academic world, Iberdrola has signed the Iberdrola Chair in Energy and Innovation at the Comillas Pontifical University. The purpose of this Chair is to formalise the stable collaboration agreement between the University and Iberdrola for not only creating and transferring knowledge, but also implementing research, innovation and educational activities.
- The collaboration agreement between Iberdrola and the University of Salamanca will promote education, research, innovation and entrepreneurship. The main objective of this Chair is to promote University/Business technology transfer and establish a framework for collaboration in the launch of R&D projects and training initiatives.

Scalability and Transferability

Through their nine global agreements and other collaborations with universities, Iberdrola U created a network that drives training, entrepreneurship and research that currently connects 300,000 students, 20,000 teachers and 1,500 grant recipients with a shared goal: to be leaders in the future of energy. The same approach is feasible for EDDIE in terms of skills and curricula updates towards innovative solutions to the energy sector's challenges.

Impact and success factors

The collaborations established by Iberdrola folds into many objectives such as training the company's employees and helping students develop entrepreneurial skills, creating and transferring knowledge, but also implementing research, innovation and educational activities, development of R&D projects, contribution to innovation in strategic sectors through specialised training, new research projects in the areas of energy digitalisation and storage etc. All those collaborations strengthen Iberdrola ties with the academic world and research community. This can be applied in EDDIE for the strategic network building and stakeholders' engagement.

4.2.7. HHL Energy Conference

General presentation of the practice

The HHL Energy Conference in Leipzig is an annually student organized which provides university students and young professionals with an interdisciplinary view on a current topic or trend of the energy sector.

Relevance/Importance

The HHL Energy Conference is a Good Practice Example since it is a scientific exchange program which is relevant towards the twin-challenges of digitalization and energy as it links industry, politics, and research stakeholders. Due to its interdisciplinary nature and competitive case study, digital tools and solutions are favored as well as efficient practice skills are likely to be developed. However, for a further integration of digital skills workshops that focus on this topic would be needed.

Aims and objectives

The aim of the conference is to create new ideas and knowledge for the present and future developments in the energy sector through the exchange of multiple stakeholders, like politicians, leaders from energy driven industries, consultants, and students at leading universities. Furthermore, it helps students and young professionals to develop problem-solving skills through the case study competition that are relevant for working in the German energy industry.

Structure and organization

The conference targets students and young professionals that are interested in the German energy sector. It has a big range of different activities and program points over the course of 2 days to diversify the exchange and learning opportunities for all participants.

- Case study competition by a practice partner (typically a consulting firm)
- Key-note speeches
- Panel discussions
- Career fair and network building
- Practical workshops

The case study competition is the central program point and includes workshops, feedback rounds as well as a presentation of the results and winners' ceremony. It allows participants to develop hands-on skills and a closer connection to professionals in the industry. The conference excels in the representation of the biggest energy producers, start-ups, consulting firms, and leading private firms in different sectors with an intersection towards the energy sector.

Scalability and Transferability

The conference could be easily expanded to other countries in the EU since it is for now restricted on the German context and its energy industry. Additionally, it could be scaled up by inviting more attendees and presenters or expand the duration of the conference. The knowledge, skills and experiences obtained at the conference can be transferred into career context of the participants.

Impact and success factors

The conference has a significant impact on the shortage of specialists in the energy sector as it connects students / professionals with important players on every level of the German energy industry.

4.2.8. International Workshop on Energy Data and Analytics e-Energy Workshop

General presentation of the practice

The International Workshop on Energy Data and Analytics by the Karlsruhe institute of Technology is a virtual conference / workshop that focuses on the interrelation of digitalization, mainly data management / analytics, and energy systems.

Relevance/Importance

The workshop is highly focused and relevant to the topics of digitalization and energy system as well as their interrelation. The scientific exchange is specifically designed to include digital tools, skills, and solutions. While it provides links with research stakeholders it does not provide links with industry stakeholders in particular due to its theoretical nature.

Aims and objectives

The workshop aims to inform a broad audience about collected data and new results in research, bringing professional in the energy industry / academic close to the state-of-the-art on what data-oriented research could advance or improve the present energy system. It wants to provide support to individuals who want to broaden up methodologically and give researchers in databases/KDD communities the opportunity to subject their ideas, concepts, and solutions to a critical audience.

Structure and organization

The online workshop presents over the course of one day different researchers and their prepared and in advanced selected contributions. Each presentation includes a discussion at the end. The contributions must stem from the field of energy data or energy systems. The format of the contributions is open and includes research papers, vision papers, and comparative studies, descriptors of energy data sets and case studies and experience reports. Additionally, the workshop serves as a potential networking platform for researchers and funding opportunities. However, it is targeted towards a broad audience, not only researchers and academics that wants to learn about new data sets or trends, to expand their methodological knowledge.

Scalability and Transferability

The workshop could be made into an in-person event which is further specified topic- or country-wise. However, it would lose its international character of knowledge exchange. It could be scalable to more participants, countries, sessions in its online format. The knowledge obtained is very specific and mostly transferrable into the academic context.

Impact and success factors

The workshop has a high potential impact since it addresses a relevant and novel topic for research. Exchange between academics and others can advance this topic and results that are highly critical to solve the present energy challenges. A critical success factor is the active participation and networking among the researchers but also the broader audience, which highly depends on the participants and incentive building through different activities by the organisers.

4.2.9. Digital Energy Conference

General presentation of the practice

The Digital Energy Conference is an onsite conference which was part of the “Smart Country” Convention in Berlin. It is focused on all topics surrounding the combination of digitalization and energy for politics and businesses.

Relevance/Importance

The conference offers a broad spectrum of topics regarding digitalization and energy system as well as their interrelation. It is a Good Practice Example since the transfer of knowledge is designed to be very practice based and following includes real-life digital tools, skills, and solutions. While it provides links with industry and politics stakeholders it did not provide a lot of connection with academics and researchers.

Aims and objectives

The conference aims to connect specifically big players of the energy industry and public sector and to discuss different economically viable solutions for the energy sector. The topics in 2022 included:

- Smart Grids & Smart Metering
- Renewable Energies & Sector Coupling
- IT Security & Resilience
- Efficiency & Sustainability
- Big Data & Artificial Intelligence
- Digital Buildings

Structure and organization

In 2022, the one-day conference hosted 27 speakers and over 500 participants mainly from the energy industry and public sector, like the Federal Ministry of Economic Affairs and Climate Action (BMWK). The conference offered different expert-panels, key-note speeches as well as interactive skill- and knowledge-based workshops. The different formats and opportunities for knowledge transfers promote an exchange between the represented stakeholders and allowed for network building.

Scalability and Transferability

The conference could not easily be changed into a different format since it is part of the bigger "Smart Country" Convention which hosts different conferences with the intersection digitalization. Nevertheless, it could be scaled up to offer more spots for participants or expand the duration of the conference with an extra day for workshops or similar activities. The knowledge obtained at the conference is highly transferable into the real-life context.

Impact and success factors

The conference can have a big impact on the public sector and the private sector as well as their work in solving the challenges of the energy sector and industry together. One factor for success is how well the knowledge and experiences of the participants are taken into account and transferred.

4.2.10. IEEE International conference on Energy Technologies for Future Grids

General presentation of the practice

The IEEE International conference on Energy Technologies for Future Grids is organized by Australian Research Council (ARC) Industrial Transformation Training Centre in Energy Technologies for Future Grids in Collaboration with Universities and Industries in Australia. The main topic of the conference is "Challenges, Solutions, and Opportunities for Industrial Transformation".

Relevance/Importance

The conference has a high relevance with the digitalization of energy, addressing various of the skills linked to the digitalization procedure. One of the conference tracks is dedicated to "IoT and Communication for Energy Technologies" relevant to IoT skill gap. Various sub-tracks are highly relevant to digitalization of energyskills gaps, for example "Distributed control in power systems" & "Volt/VAr optimisation, control and coordination" are relevant to Advanced control systems in the energy grid skill, "Application of AI to power systems" is relevant to Artificial Intelligence and Machine Learning skill, "Advanced optimization techniques, and energy policies" is relevant to Simulation and optimization skill. The use of digital tools will be a key topic of the conference, engaging stakeholders both from the industry and research (academic) sectors.

Aims and objectives

The main aim of the conference is the presentation of scientific papers, regarding the following tracks:

- Future Grid Energy Technologies
- Power and Energy Transformation and Utilisation
- Power and Energy Enabling Technologies
- Power Grid Planning and Operation
- Future Grids with Electric Vehicles
- IoT and Communication for Energy Technologies

Structure and organisation

The conference will be taking place biennial, with the first conference on 3-6 December 2023 in Australia. It will be hosted by School of Electrical, Computer and Telecommunications Engineering, Faculty of Engineering and Information Sciences, University of Wollongong, Australia and will be financially sponsored by IEEE Industry Applications society (IAS), USA.

The review process of the submitted papers for the conference is been designed to be rigorous, with at least two independent and unbiased reviewers will evaluate the quality of the submitted paper. The review process is single blind and we are using Microsoft CMT for handling the submissions electronically. Based on their research interests and expertise a large database of well-known academicians and industry personnel is available to act as. The Technical Program Committee includes well-known senior professors and professors from all over the globe. All the papers will be screened for quality.

Scalability and Transferability

The conference will be posted to IEEE Xplore digital library and the presented papers will be published on the the IEEE Xplore subject to the IEEE standards and quality check and will be eligible for further review for publication in IEEE Transactions on Industry Applications and IEEE Industry Applications Magazine. This access opportunity demonstrates a high transferability potential, providing with research, technical and business content, in the context of challenges, solutions, and opportunities for industrial transformation

Impact and success factors

The conference aims to gather professionals from the Industry and Universities, raising the topics of Challenges, Solutions, and Opportunities for Industrial Transformation.

The conference ensures its success, due to:

- The validity and global range of IEEE as the organizer of the conference
- The emerging / trending conference tracks for the energy sector and industrial transformation

4.2.11. Future Energy Systems

General presentation of the practice

Future Energy Systems was established in 2017 by the University of Alberta, in the context of the Canada First Research Excellence Fund (2016-2023). FES funds researchers to develop and integrate new energy technologies into the existing energy system, building a broad and integrated research program.

Relevance/Importance

Future Energy Systems links the university with the industry, policy makers and public institutions. Furthermore, the program contributes to the in-depth understanding and research in various topics of the digitalization of energy.

Additionally, through the program various skill gaps, arise from the digitalization of energy, are addressed, regarding:

- Machine learning: to increase organic photovoltaic cell efficiency
- optimization techniques, systems engineering and controls
- Advanced control systems in the energy grid: smart grids capable of managing any potential renewable or conventional input are being developed, with work encompassing software control systems, and the actual design, prototyping, and testing of control equipment in partnership with utilities and energy producers

Aims and objectives

The main aim of FES is to develop a research program to unite researchers from various sectors and answer the critical questions linked to energy generation, uses, transportation, regulation, and their environmental, economic and societal impacts. This support extends to researchers targeting to environmental impact mitigation and understanding the influence of energy transition in a holistic way.

Structure and organisation

FES includes four research areas:

- Developing Hydrocarbons Responsibly
- Improving Environmental Performance
- Enabling Sustainability
- System Wide Enablers

facilitated by 9 faculties of University of Alberta and supported by 135 researchers of the university. The research topics vary from energy generation, energy transport & access, energy use & regulation, energy monitoring, mitigation strategies for carbon footprint and land & water reclamation,

The FES has established partnerships and collaborations with private industries, government and institutions, focusing on its research outcomes to benefit the society, both nationally and internationally. Its currently 369 partnerships ensure FES connection with academic peers, industry users, academic institutions and government regulators.

Impact and success factors

The success of the program relies on its interdisciplinary structure, connecting researchers from different scientific sectors, to deliver holistic research projects for the energy systems.

Another parameter that ensures the sustainability and thrive of the project refers to its strong collaborations with the government, institutions and industry, facilitating the researchers to share their expertise with decision makers, public authorities and industry professionals.

The impact of FES is tangible through:

- More than 2,300 research outputs from FES researchers on FES projects
- 167 masters and 249 doctoral students trained through FES research
- 115 masters and doctoral graduates to date
- 619 publications by program researchers
- 3,055 citations of published research

Scalability and Transferability

FES program demonstrates a high transferability potential, showing a pathway of collaboration between universities including students and researchers, states and industries.

4.2.12. European Master in Renewables Energy

General presentation of the practice

The master program is an initiative proposed and developed by The Association of European Renewable Energy Research Centers (EUREC). The program is active since 2002, led by the partnership European universities (members of EUREC) consisting of Mines Paris – PSL, University of Zaragoza, Oldenburg University, Hanze University of Applied Sciences, NTUA, University of Northumbria, University of Perpignan and IST Lisbon.

Relevance/Importance

The collaboration between universities, research centers and the industry achieved through the master program is of high importance. Moreover, the renewable energy resources are a crucial sector at the digitalization of energy process, and therefore relevant to the scope of EDDIE project.

Aims and objectives

The international and European directives aiming to reduce the CO2 emissions, dictate and ensure the further expansion of the renewable's installations. In this direction, the need for young professionals skilled in the renewable energy technology is emerging. EUREC responded to this challenge, aiming to mitigate the skill gap of post-graduate professionals in the renewable energy sector, through the development of the European Master in Renewables Energy.

Structure and organisation

The Master course lasts for 3 semesters and is divided in three sections equally:

- Solid foundation in the key energy technologies (wind, solar, bioenergy, hydropower)
- Specialization in a particular technology (photovoltaics / wind energy / Grid Integration / Solar Thermal & Associated Renewable Storage / Ocean Energy / Sustainable Fuel Systems for Mobility
- Practical or research experience in an industry or a research laboratory. The practical project is accompanied by a master thesis

Impact and success factors

The Master is considered as a success due to the following factors:

- It addresses the industry skill needs in the area of renewable energy resources
- It links the academic knowledge with the practice in the industrial environment
- It ensures the up-to-date content of the Master courses, through the collaboration of different universities and research centers that participate in the program

Scalability and Transferability

The Master program demonstrates a high transferability potential. It can be easily adopted at many European countries, considering that the framework and technologies in renewables is similar across the EU. Furthermore, it can serve as a successful example of a program that aims to mitigate skill gaps in a specific sector (in this case, renewable energy).

4.2.13. Joint Programme in Digital Transformation

General presentation of the practice

Students enrolled in the Joint Programme in Digital Transformation can design their studies individually and flexibly in accordance with their ideas and preferences. Three out of seven courses offered by the various partner institutions of ENGAGE.EU can be chosen: Platform Strategies, Digital Strategy, Competing in the Age of AI, Digital Technologies, Leading in the Digital Age, Cultural and Behavioral Changes, Digital Ethics. All courses are taught as virtual block courses over two weekends.

The Joint Programme in Digital Transformation is topped off by a mandatory in-person summer seminar taking place at the University of Mannheim in summer 2023.

Relevance/Importance

The program is of interest and well designed. It is powered by an alliance of relevant European Universities and it educates European students in digital topics, thus mitigating the general skill gap problem when it comes to digital. In addition, it is linked with Industry by the partnership of SAP. However, we do not find an explicit link with the energy system.

Aims and objectives

The Joint Programme in Digital Transformation addresses the world's greatest digital transformations, technologies and solutions, offering students the opportunity to enhance their skills and prepare for a digital future through cutting-edge courses.

Structure and organization

The ENGAGE.EU Joint Programme in Digital Transformation is targeted toward students of any citizenship who are enrolled in a bachelor's (advanced students) or master's programme at an ENGAGE.EU alliance university (University of Mannheim, Luiss University, NHH Norwegian School of Economics, Tilburg University, University of National and World Economy, Université Toulouse 1 Capitole, Vienna University of Economics and Business).

There are no prerequisites for this interdisciplinary programme, and students from diverse backgrounds (such as business, economics, law, social sciences) are encouraged to apply, as long as they have a significant interest in:

- Exploring digital transformation as a major driver of societal change in Europe
- Analyzing the impact of this transformation in the areas of business, law, and political society
- Gaining new skills and tools pertinent the digital paradigm shift
- Developing solution approaches for complex issues arising from digital transformation.

Some other relevant information:

- Degree: Add-on certificate (honours programme), suitable for advanced Bachelor's students in their final year as well as Master's students in their first or second year
- Standard period of study: 1 semester
- ECTS credits: 24 ECTS (3 virtual block courses plus summer seminar in-person)
- Language of instruction: English
- Programme timeline: Application in Fall Semester, Kick off and Courses in Spring Semester from February to May + summer seminar in July

Scalability and Transferability

This program has a relatively low impact on the overall Bachelor or Master program of students, and therefore it can be a good means to endow students of different disciplines with digital skills. However, for the moment it is restricted to the universities in the alliance aforementioned.

Impact and success factors

Reduction of skill gap, and general overview of digital trends and topics, thus expected to have wide adoption.

4.2.14. International conference on energy, environment and digital transition

General presentation of the practice

The E_2DT conference is organized on an annual basis by AIDIC, the Italian Association of Chemical Engineering. The conference discusses the positive and negative environmental effects of energy and digital transformation and the opportunities for new technologies to drive innovation. Each year it focuses its attention on the topics of energy, greenhouse gases, climate and human risks, and digitization for the energy transition.

Relevance/Importance

The E_2DT conference can be considered a good example as it delves into the macro-topic digitization of energy. It's an excellent place for exchange between public and research entities and private/corporate realities. However, the subtopics of the conference are not fixed and are variable yearly under the macro topic of energy, environment and digital transition.

Aims and objectives

The conference aims to bringing together researchers, engineers, senior executives, policy makers and opinion formers to map the transition towards net zero carbon and fully renewable energy to meet the COP26 Glasgow Agreement. The objective is to provide a view on available, up-to-date evidence on positive and negative environmental effects of the energy transformation in a holistic way and on the opportunities for new technologies to drive/accelerate the transition. The focus will be on energy, GHG aspects, climate/human related risks, and digitalization.

Structure and organization

The target audience for the conference are engineers, senior managers, policy makers and opinion leaders eager to outline the way forward for the transition to zero carbon emissions and fully renewable energy to meet the COP26 Glasgow Agreement. The Conference is structured in plenary lectures given by selected, high-profile speakers, who showcase their work with lectures and/or posters presented in the various sessions. Posters stay throughout the duration of the Conference, promoting author presentations and spontaneous discussion.

Scalability and Transferability

This case is highly transferable and scalable to other contexts and/or professional groups that need to gather and share new ideas in the field of energy transition and energy digitization.

Impact and success factors

The first edition of the conference was held in October 2022 in Milan, Italy, and featured more than 100 papers from 23 countries on energy and environmental issues. A second edition is already on the calendar for fall 2023.

4.2.15. Workshop Modeling and Simulation of Cyber-Physical Energy Systems

General presentation of the practice

The yearly workshop Modeling and Simulation of Cyber-Physical Energy Systems (MSCPES) brings since 2013 researchers and industrialists together to exchange ideas and newest research results on the following (not exhaustive) list of topics: Hybrid modeling and simulation, Co-Simulation of multi-domain systems, Ontologies for CPES, Applications of CPES, Distributed algorithms and control, Formal languages for CPES, Smart Grid and Smart Cities modeling, Design of simulations/experiments for CPES, Data generation using CPES simulation for big data analytics.

Relevance/Importance

Automation and digitalization have become important topics in the energy sector in recent years, as modern energy systems increasingly rely on communication and information technology to combine smart controls with hardware infrastructure. With the emergence of cyber–physical systems as a transdisciplinary field, such modern energy systems can be classified as cyber–physical energy systems, integrating the related research and development within a broader scope. We have labelled this initiative as a best practice because it covers this important topic of relevance, as it is to fill the gap between traditional engineering domains, with focus on energy, and computer science. In addition, is puts together Academia and Industry, which is a desirable characteristic to speed up progress.

Aims and objectives

Digitalization needs an acceleration to facilitate an evolution towards an integrated energy system to reach Carbon neutral Europe in 2050: further RES integration, H2, Power to X, electrical vehicles, flexibility, automaton, etc. with an increasing level of EU interconnections. RTE, the French TSO, defined a new R&D program last year to answer to these evolutions. The necessity of multi-partner and open source collaborations is highlighted because system planning, system operation and system stability in an interconnected system need a common work between different sectors and TSO, DSO, academics...

Structure and organization

The workshop is part of the Cyber-Physical Systems and Internet-of-Things Week hosted at different locations every year with the IEEE Industrial Electronics Society as a technical co-sponsor. The workshop chairs are currently Peter Palensky (TU Delft, The Netherlands) and Anurag Srivastava (Washington State University, USA). As part of the MSCOES Workshop the participants can present papers and submit them to IEEE Explore. During the workshop, a dedicated session for demos is reserved for developers with academic and industrial background.

Scalability and Transferability

These workshop initiatives are easily scalable. Leveraging local experts of digital energy in Academia and Industry.

Impact and success factors

Its impact depends on reaching a critical mass of participating companies and universities. If this is the case, it can be a good lever to allow both parts to understand the potential of digital technologies to improve the energy sector. Moreover since the first workshop in 2013 there have been 120 published papers on IEEE Explore.

4.3. Best Practices

4.3.1. Specializing Master in Smart Grids

General presentation of the practice

The Second level Specializing Master in Smart Grids is promoted and coordinated by Enel Group in collaboration with Politecnico di Milano. It aims at forming highly qualified professionals able to face complex design problems and foster technological innovation in the field of electrical power systems. The program investigates renewable energy, energy storage, e-mobility, big data, and digitalization.

Relevance/Importance

The participation of a university institution and a large private company in writing the program ensures high-quality training. In fact, students can benefit from university expertise and corporate know-how: this also enables them to learn by practicing on real case studies, to be in contact with the stakeholders and to acquire many of the skills required in the job market. The path is structured in a win-win perspective: students participate in high-profile training and the company can select the best talents and integrate them into its staff. Moreover, the activities proposed in the programme includes also the use of digital tools and the topic analysed are in line with the topic-of-interest for EDDIE project (energy modelling, simulation and optimization, advanced control systems in the energy grid).

Aims and objectives

The main aim of the Second level Specializing Master in Smart Grids is to explore in depth the technical aspects of the Electric Power Systems design, operation, and control, as well as their real-life implementation (an essential share of the classrooms is dedicated to experimental training in advanced laboratories). It also aims to develop student's soft skills, driving the students toward a 360° growth of their professional-wise attitude.

Structure and organization

The Specializing Master is aimed at master's graduates in engineering, mathematics, physics, and statistics who have not yet turned the age of 30. It is arranged in theoretical classes of 330 hours plus 100 hours for laboratories (both numerical and experimental). The program lasts one year, and classes and workshops are held twice a week. During the academic year, students are subjected to specific examinations. Those who adequately complete the curriculum are awarded the title of Master's degree specializing in Smart Grids.

The Specializing Master focuses on the study of the evolution of electricity systems needed to enable a significant supply from Renewable Energy Sources (RES). In this perspective, it focuses on the impact of RES on the electricity system (market & networks). Market rules should ensure that conventional power stations are suitably operated even in the presence of large contributions from renewable generation. Distribution networks play a key role to enable the Energy Transition, to allow the full integration of the Distributed Energy Resources (DER) and the development of new services to customers and market, moving towards a decarbonised, decentralized, and sustainable energy system.

The evolution of distribution network will be addressed in the context of smart grids perspective to which distribution systems are gradually moving. Finally, some case studies and real-life implementations will be described, with the relevant costs and benefits. The course is divided into six modules:

- Module 1: Energy Outlook - 108 h + 4 h labs
- Module 2: Smart Grids - 80 h + 28 h numerical labs
- Module 3: Health and Safety - 34 h + 12 h labs
- Module 4: Smart grid implementation - 60 h + 56 h labs
- Module 5: Soft skills & Innovation lab - 48 h
- Module 6: Project Work - 200 h + 10 h tutorship

Scalability and Transferability

This program is effectively scalable and transferable. Collaboration between public education and private companies, in fact, can be considered by other universities and companies as well. Moreover, it could also be proposed in smaller "dimensions": for example, a collaboration between vocational training schools and local companies could be implemented.

Impact and success factors

Through the program, 30 students each year have been trained. Enel Group selects 20 talents who work in the Enel Group for at least 3 days a week and who are hired under a contract of advanced training and research apprenticeship (Level 3 apprenticeship).

4.3.2. Master's Degree in Smart Grids

General presentation of the practice

The Master's Degree in Smart Grids is a Master of Science Degree with 90 ECTS credits, taught by the University of Strathclyde in Scottland and the Universidad Pontificia de Comillas in Spain, in close collaboration with Iberdrola, Minsait/Indra and UFD Distribucion Electricidad S.A.. The main objective of the program is to respond to the growing demand for engineers, needed to lead the ongoing process of the digitalization of the electric grid.

This program provides students with a detailed understanding of the operation and planning of grids under this new paradigm, along with new business opportunities and models that are arising in this constantly changing field. It has been developed in close collaboration with Iberdrola. This alliance guarantees both the practical component, thanks to the participation of industry, and the academic rigor of the courses.

One of the most interesting features of the program is the intensive international experience offered. Students not only spend one semester in both Spain and Scotland, but also carry out internships at any of the international offices of Iberdrola in Spain, Scotland, the USA and Brazil.

Relevance/Importance

This program actively promotes the education of engineers with the skills required in the new energy sector’s context. The double degree programme aims to develop knowledge in both the energy systems and telecommunications dimensions of Smart Grids. Academic excellence, together with internships in real-life projects taking place in a leading multinational energy company, Iberdrola, enable you to acquire new skills, which are in demand in the energy industry.

Overall, its curriculum covers skills that are relevant for the digitalization of energy (e.g. artificial intelligence and machine learning). This type of professional profile is already in high demand in the energy industry around the world.

Aims and objectives

This course responds to the growing demand for engineers needed to lead the process of digitalisation of the electricity grid. It is specifically designed for graduates in the fields of electrical, electronic or telecommunications engineering.

These engineers will need to master both the Power Systems and the Digital Telecommunication technologies present in this new energy paradigm. The present master program deepens on these two main subjects and their interdependencies.

Structure and organization

Applicants to this master must hold a Bachelor's Degree in Electrical Engineering or in Telecommunications Engineering. It is a Master of Science program Students who complete the master successfully receive two degree certificates for the Master in Smart Grids, one issued by Universidad Pontificia Comillas and another one by the University of Strathclyde.

The course is structured over a year in which

- the first term will be spent at the ICAI School of Engineering of the Comillas Pontifical University
- and the second term at the Department of Electronic & Electrical Engineering of the University of Strathclyde,
- followed by a paid internship offered as part of the master's degree with *Iberdrola*, *Minsait/Indra* and *UFD Distribución Electricidad S.A.* at one of their offices in Spain, the UK, the USA or Brazil.

Besides it can be performed in two years if it is combined with the Industrial of Telecommunication M.Sc. programs of ICAI School of Engineering.

Scalability and Transferability

Leveraging local experts of both energy and digital sectors in Academia and Industry, this program may be replicated in different locations. Its alumni are expected to be highly demanded by Industry in the coming decades. Its concept is in fact already being replicated in seven universities offering the programme through EIT InnoEnergy.

Impact and success factors

This type of professional profile is already in high demand in the energy industry worldwide. Academic excellences, together with internships in real projects that take place in a leading multinational company in the energy sector, allow students to acquire new skills, which are in high demand in the energy industry.

4.3.3. Master's Degree in Digital Energy and Business

General presentation of the practice

The Digital Energy and Business master's degree by the Albstadt-Sigmaringen University in Germany is a hybrid, on-site and online learning, program which includes theoretical courses and practical projects about digital transformation, increasing networking of systems, technology innovations, and smart process control within the energy industry.

Relevance/Importance

The Digital Energy and Business master's degree focuses on the intersection of digitalisation and the energy industry. It is a scientific program which combines theoretical knowledge and practice skills involving digital tools. It represents a direct linkage of research and industry stakeholders.

Aims and objectives

The master program aims to further educate students on the very specific intersection of energy and digitalization. It prepares students for a career in this field by providing theoretical knowledge and practical skills regarding management and digital tools. Further, it connects students and academics with private sector companies in the energy industry.

Structure and organization

The master program targets bachelor graduates with a background in energy, economics, business or information systems. It offers different methods of learning, theoretical courses and practical projects, within its curriculum. The following courses are available: Project: Digital Transformation and Innovation, Project Management, Business Process Management, IT Management, IoT and IoT Engineering, Technology and Efficiency, Business Intelligence, Management Skills, Advanced Analytics, Digital Networks and Smart Energy, Digital Energy Markets. Additionally, it generates research on the topic through a mandatory master thesis at the end of the program.

Scalability and Transferability

The knowledge obtained by the students within their master studies can be easily transferred into the energy industry and direct work experience. Due to its practical nature and the need for a sufficient number of business partners as well as professors, the scalability is limited.

Impact and success factors

The conference has a significant impact on the shortage of specialists in the energy sector as it prepares for and directly connects students with companies in the German energy industry. The program is likely to be successful due to its targeted, specific, and practical nature.

4.3.4. Master's Degree in Decentralized Smart Energy Systems

General presentation of the practice

The joint Erasmus Mundus master's programme in Smart Electrical Networks and Systems covers smart electric grids, a critical component in the creation of a sustainable power supply. Students develop the engineering and entrepreneurial skills needed to understand, design, implement and manage smart grids. Graduates have a unique understanding of the role played by new technologies and new businesses in a changing landscape. Seven universities offer the programme through EIT InnoEnergy.

Relevance/Importance

The program with the specialisation track decentralised Smart Energy Systems is considered as best practice as is relevant to digitalisation and energy. It uses digital tools it has links with industry/research stakeholders and the context is relevant to skills like artificial Intelligence and Machine Learning, Cybersecurity, Big Data/Data Analysis, energy modelling, Simulation and optimization, advanced control systems in the energy grid Measurement techniques.

Aims and objectives

Decentralised smart energy systems (e.g. isolated villages, small cities, urban districts, rural areas connected or not to the electric grid, etc.) play an increasing role in the perspective of a transition towards a low carbon society and then of a massive integration of renewable energy sources within the global energy system. Accordingly, the overall goals of the proposed Erasmus Mundus Joint Master Degree in Decentralized Smart Energy Systems are the following:

- To educate top skilled engineers with multiphysics approaches,
- To train future researchers in decentralized energy systems
- To offer a broad opening on the human and social sciences
- To provide to students an international network as well as a genuine European learning, an integrated multicultural and language experience

Structure and organization

The Master Degree is a two year program with 120 ECTS. The first two semesters consist of a core curriculum in Engineering at the University of Lorraine (UL) in France. In the third semester there 3 different specialisation tracks:

- Decentralised Smart Energy Systems in a global energy system at the Royal Institute of Technology (KTH) in Sweden, which is considered as a best practice for EDDIE
- Power-to-X, innovative pathways for energy storage at the Polytechnic University in Turin in Italy
- Thermal Energy Management at the Polytechnic University of Catalonia in Spain

The fourth semester corresponds to an internship/MSc thesis particularly offered by associated partners, either in the industry sector or in a research institution.

Two joint summer schools will be organized for networking and to expand students' transferable skills like business and entrepreneurship, or more technical skills like energy storage, hydrogen or energy systems modelling. In addition, an immersive week in University of Liège (Belgium) will provide sound knowledge in the use of artificial intelligence to manage energy networks. To expand students' vision, a large range of breadth courses will be proposed, including social sciences and humanities dealing with energy policy-making, geography, social acceptance, risk perception, finance, business, together with an integrated cultural and language experience. A significant part of the pedagogy will rely on case and challenge based modules (large multidisciplinary and multi-objective projects), taken from real life and involving partners from the industry and civil society (policy makers, local stakeholders, associations…).

For students choosing to carry out the 3rd semester at KTH, double master degrees will be awarded from UL and KTH.

Scalability and Transferability

The concept of this Erasmus Mundus joint Master Program with connections to the industry is transferable to other university for digital energy degrees, since the framework is promoted by Erasmus+. It offers a collaboration between different educational institutions and industrial stakeholders and builds a European network for students. Although the scale is limited to a reasonable number of students and associated partners.

Impact and success factors

The program has been inspired by the completed UNI-SET project. Coordinated by the European University Association (EUA), this project direct at supporting the participation of universities in the SET Plan process and in EU energy research in general as part of the Energy Action Agenda. The graduates of this program report s

4.3.5. Master's Degree in Smart Electrical Networks and Systems

General presentation of the practice

The joint master's programme in Smart Electrical Networks and Systems offered through the European Institute of Innovation and Technology EIT InnoEnergy covers smart electric grids, a critical component in the creation of a sustainable power supply. Students develop the engineering and entrepreneurial skills needed to understand, design, implement and manage smart grids. Graduates have a unique understanding of the role played by new technologies and new businesses in a changing landscape. Seven universities offer the programme through EIT InnoEnergy.

Relevance/Importance

This is considered as best practice as is relevant to digitalisation and energy, it uses dgital tools it has links with industry/research stakeholders and the context is relevant to skills like artificial Intelligence and Machine Learning, Cybersecurity, Big Data/Data Analysis, energy modelling, Simulation and optimization, advanced control systems in the energy grid Measurement techniques.

Aims and objectives

Graduates participating in the program develop a holistic and pan-European understanding of electric power engineering in combination with entrepreneurial skills. Moreover the program provides an international network as well as a genuine European learning. Through their studies graduates are able to design and implement smart grids, manage and control power quality, apply data science skills and battery storage applications to electrical solutions.

Structure and organization

The master degree is structured as a two year program with two universities to attend for the students. In Year 1, all students follow their first year of studies at KTH: Royal Institute of Technology, in Stockholm, Sweden or at UPC Universitat Politècnica de Catalunya. The focus in this year are the fundamentals of electric energy systems, including: smart grids, power system analysis, power electronics, electrical machines, and high-voltage engineering. During Year 2, the students choose an area in which to specialise at one of four universities:

- Energy Management in Smart Grids Buildings at Grenoble INP: Institute of Technology, France
- Power Distribution and Storage, at KU Leuven, Belgium
- Power Electronics as Enabling Technology for Renewable Integration, at UPC: Universitat Politècnica
- de Catalunya · BarcelonaTech, Spain
- Sustainable Electrical Energy Systems, at TU/e: Eindhoven University of Technology, the Netherlands
- Smart Power Grid Technology, at KTH Royal Institute of Technology, Sweden

After successfully completing the two-year programme, the students receive a degree from each of the two chosen universities:

- Grenoble Institute of Technology. International Master of Science in Electrical Engineering for Smart Grids and Buildings
- KTH Royal Institute of Technology. Master of Science (Teknologie masterexamen)
- KU Leuven. Master of Science (Burgerlijk Ingenieur)
- Eindhoven University of Technology. Master of Science in Electrical Engineering
- Universitat Politècnica de Catalunya. Master's degree in Energy Engineering (Máster en Ingeniería de la Energía)

Additionally the students receive receive a certificate from ESADE Business School and a EIT label certificate.

Scalability and Transferability

The course has very good replicability and its concept is in fact already being replicated in seven universities offering the programme through EIT InnoEnergy.

Impact and success factors

The program poseses the EIT Label which is a quality seal awarded by the European Institute of Innovation and Technology (EIT) to a KIC educational programme that has been assessed positively by the EIT on the implementation of the EIT Quality Assurance and Learning Enhancement (EIT QALE) system.

4.4. Wrap-up and conclusive remarks

Before drawing the lessons learnt and recommendations derived from reviewing the DEAP 2021-2027 and the examples of good practice, it is worth presenting some ideas that are under development in EDDIE WP5 for the BSDE.

The BSDE aims at designing a sustainable system that is able to sense and react to unbalances between the skills and competences built in the Education System and those that the industry actually requires. Figure 7 presents a high-level concept of the process in which different education providers of the EU member states “generate” new professional skills or upgrade existing skills. However, the current gap in digital skills evidenced by the work of EDDIE WP2 - even only accounting for the Energy Sector - suggests that education providers are not reacting to the swift-changing needs of industry at the pace they should. This fact, if continued in time, may have undesirable effects for the European transition to the digital economy.

The result of the BSDE design must be therefore a sustainable entity which monitors mismatches between what the Energy Sector requires in terms of workforce competences to foster the "reactions" required by the different stakeholders in charge of education to correct them.

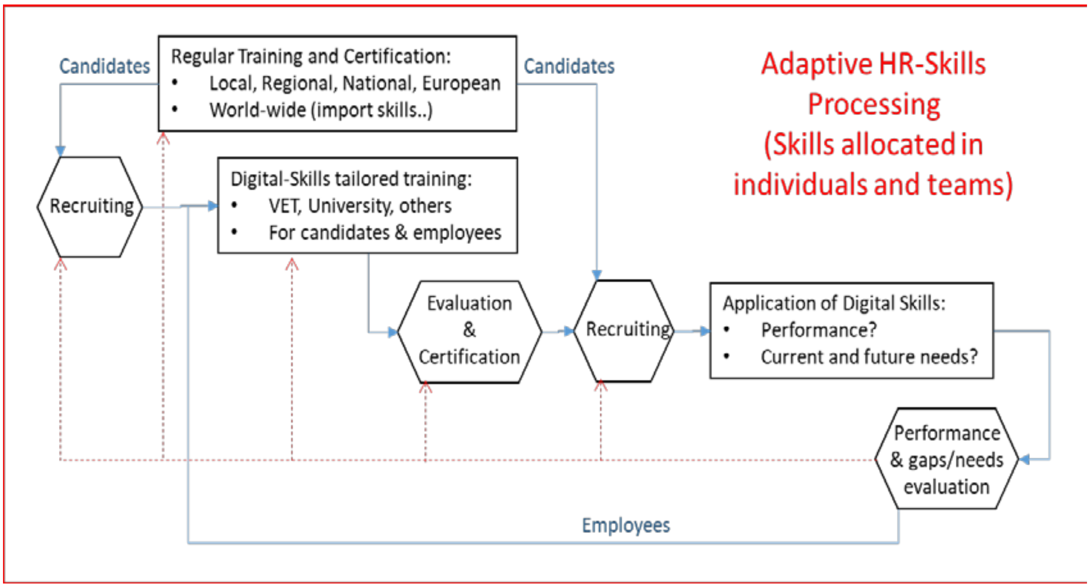


Figure 7 - High-level representation of the adaptive process of education and training as a response to industry needs

The critical review of the DEAP performed in Section 4.1 has revealed, to a certain extent, the accuracy of the BP and BSDE design to attain its objectives. In this line, reviewing policies and stakeholders' strategies comes as essential when observing the large number of initiatives fostered by the EU. Similarly important is the cooperation between the huge number of actors in the Energy scenario to meet the goals set by EU.

With respect to fostering the development of a high-performing digital education system, we can extract three points where Universities must actively contribute: procedures, contents, connectivity and competences. More concretely, the list of actions in the DEAP shows that there is a process of review and definition of the factors that could optimize the transition of the education system to a new digital one. There is a reflexive dialogue process between the Member States that is sharing time and space with a bunch of practical experience on digital teaching emerging from the contour conditions that the pandemic has set to the Education system. Europe is in a good position to combine these two theoretical and practical streams of experience and finds a fine blend to set the guidelines to transition to the digital education system. It is however fundamental to regard the emergency digital teaching dynamics of the pandemic social isolation not as the desired digital 'to be', but as a large set of digital experiences that may ease the assessment of the potential of the different digital levers available, and of their possible combinations.

Still related to structuring the new digital learning and teaching technologies, we have found the European Framework for Digital Education Content very relevant, for it could support the EDDIE project in evaluating its outputs in terms of contents, and in setting new goals and processes to produce digital contents. Then, the European Exchange Platform could be used by the entity to share the education resources and platforms produced by the project itself

It is clear that we are in a moment of re-design of the education system, and therefore we have a good opportunity to prevent the new system from exhibiting some of its current biases. However, it is not clear that Universities are called to play a fundamental role in, for example, the correction of the gender bias in STEM. They can definitely act as a sensor of the share of women joining them, but it seems clear that corrective actions should be implemented at earlier education levels (indeed, they should take place as early as possible). The situation when it comes to other biases related with the new AI hyper-automation trends is different. In this point, Universities as the main centers of knowledge creation, reflection and critical thinking, must be active in guiding the Ethics dialogue for all this inclusion of technologies in society to be person-centric.

Then, we find that the DEAP encourages leveraging the current cooperation projects (mainly the Erasmus ones) to optimize the digital transformation plans. When it comes to digital, the scale is fundamental, and therefore it is very important to have a clear view and understanding of these cooperation projects for the different stakeholders and initiatives to be aggregated in a natural way. With this aggregation approach, Europe may harmonize the resources placed in the digital transition of the Education system both by preventing us from doing several times similar things and by optimizing knowledge and good-practice sharing, which will eventually lead to an optimized digital transformation pipeline. In this point, the Digital Energy stakeholder map which is being created in the EDDIE project may well be an important asset, and the BSDE entity design must leverage it to foster collaboration.

With respect to enhancing digital skills and competences for the digital transformation, it seems straightforward that Universities must play a pivotal role. We find extremely important to make updated standards like the Digital Competence Framework (DCF) or the European Digital Skills Certificate (EDSC) be recognized by all stakeholders as references to structuring skills and competences and to assess the digital maturity of individuals. Only having an efficient mechanism for measuring digital maturity in a massive way (like the EDSC) can we be proficient in making the European society transition to the desired digital to be scenario. Regarding the DCF, the EDDIE project can contribute in different dimensions, especially by enriching the competence framework with its findings from WP2.

The recommendation of promoting hands-on experience in fields demanded by the labor market is definitely at the core of the EDDIE's BSDE approach. The marketplace approach which is tentatively proposed in the current version of the BSDE entity can make it easy for industry to efficiently convey these demand signals to all education providers.

Finally, the DEAP promotes the Digital Education Hub (DEH) to improve cooperation, which is, again, fundamental to make it possible to properly scale initiatives. The EDDIE project can clearly find synergies with this DEH which, indeed, may play a pivotal role in making the entity resulting from the BSDE design be sustainable.

In total there are 20 practices with different types of programs connected to the university education and university institutions identified. The best practices differ from the good examples thought their fulfillment of all the defined requirements in the methodology. Overall, the identified best practices consist of 5 master programs in majors with the needed skills for the digitalization of the energy sector. The applied practices in theses master programs can serve as a guidance and recommendation for the design and development of further programs aimed at university-level education. Particularly, the recommendation includes the pan-European orientation of master programs facilitated through student exchanges or partnerships with other universities, fostering connections with energy sector companies to establish early career networks, incorporating digital tools into curricula, and ensuring the preservation of additional eligible certificates. These practices, in combination with the acquisition of necessary skills, ensure the successful integration of the students into the energy sector.

Apart from the Best Practices some other examples that support the analysis of the university education were identified. 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. Noticeable is the need for extracurricular activities for students to increase their interest and knowledge in digital energy. This will increase the likelihood of students perusing a path which is leading into the energy sector and participating in the digitalisation of it. In order to foster a new generation in the digital energy sector, it is recommended to even 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. The pilot activities in Aachen such as Archimedischer Sandkasten with the City of Aachen, Gymnasium Workshop, Science Night, and Girls' Day serve as an example of this.

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1. Annex 1: **Examples of Good Practice (ref. § 4.2)**

Project/Website link	Type of program	Digital tech/specialisation	Target group	Energy sector focus	Organisation
Re-Generation	Certifed online course with ETCS	Advanced Web-based Technologies, Basics of Big Data, Artificial Intelligence	Life Long Learning, Higher VET and University level	Energy in general	ENEL Italia; UNINETTUNO, Italy
NPI – DIGIKOALICE: The project ENERSOL	Higher School Program	Use of digital Technology in general	graduates	Renewable energy sources, saving energy consumption and reducing emissions.	Masaryk University, Czech Republic
Centre for Digital Energy	Research Institute with different type of projekts and research connected to university	Industry 4.0, IoT, automation or intelligent network control technology	PhD students, students, professionals	Energy systems, Digitalisation, Municipal energy system planning, Modular network control systems, Energy data and visualization	Fraunhofer Institute for Applied Information Technology (FIT), Germany
Summer School Energy Technology, Policy and Politics	Summer school	Energy modelling, Advanced control systems in the energy grid	PhD students, postgraduate students	a comprehensive overview of the technical, socio-economic and political challenges and opportunities of creating a sustainable energy supply for the future, under the premise of net zero GHG emissions	ETH Zurich, Switzerland
SEEEP PhD Summer School	Summer school	Energy transition	PhD students	resilient production and storage, renewable energy technology, sustainability, energy demand flexibility, and energy grids and conversion	KTH Royal Institute of Technology, Eindhoven University of Technology, Zhejiang University, and Shanghai Jiao Tong University

Iberdrola University Programme	Universities Program	Optimisation of the distribution network, occupational safety, environmental aspects and supply quality	University students, grant recipients, teachers, researchers, the company's employees	Smart grids, Environment and biodiversity, Utility of the future, Substations and high voltage, HVDC, Nuclear technologies, Energy markets, Wind resources	Iberdrola University, Massachusetts Institute of Technology, Comillas Pontifical University, University of Salamanca, University of Strathclyde, Tecnológico de Monterrey, Hamad Bin Khalifa University of Qatar, Yale University, University of New Mexico, Federal University of Rio de Janeiro
HHL Energy Conference	Conference	Depends on the year, for 2023: The twin-challenges of digitalization and energy	university students, young professionals	Depends on the year, for 2023: Sustainability, Affordability and Resilience in energy systems	HHL (Uni), Leipzig, Germany
International Workshop on Energy Data and Analytics e-Energy Workshop	Online Workshop	Internet of things, Big Data/Data Analysis, Energy modelling, Simulation and optimization, Measurement techniques	PhD students, students, professionals	Energy system design and operation	Karlsruhe Institute of Technology, Germany
Digital Energy Conference	Conference	Artificial Intelligence and Machine Learning, Cybersecurity , Internet of things, Big Data/Data Analysis, Cloud services	PhD students, students, professionals	Smart Grids, Smart Metering,Renewable Energies, Sector Coupling,IT Security, Resilience, Efficiency, Sustainability, Big Data, Artificial Intelligence, Digital Buildings	Bitkom, Germany

IEEE International conference on Energy Technologies for Future Grids	Conference	Smart sensing, IoT, wireless power transfer and smart grid communications, and many others skills in different areas of energy	PhD students, students, professionals	Energy in general	IEEE Industry Applications Society; Australian Research Council Industrial Transformation Training Centre, Australia
Future Energy Systems	Funding for researchers	Developing Hydrocarbons Responsibly, Improving Environmental Performance, Enabling Sustainability, System Wide Enablers	PhD students, students, professionals	Current and future energy systems	University of Alberta, Canada
European Master in Renewable Energy	Master program-University level	Photvoltaics, Wind Energy, Grid Integration, Solar Thermal and associated Renewable Storage, Ocean Energy, Sustainable Fuel Systems for Mobility	Master students	Renewable energy	National Technical University of Athens, Greece
Joint Programme in Digital Transformation	Add-on certificate (honours programme)	Artificial Intelligence and Machine Learning, Big Data/Data Analysis, Simulation and optimization	University students	Digital transformation	University of Mannheim, Luiss University, NHH Norwegian School of Economics, Tilburg University, University of National and World Economy, Université Toulouse 1 Capitole, WU Vienna University of Economics and Business
International Conference on Energy, Environment & Digital Transition	Conference	Energy modelling, Advanced control systems, Simulation and optimization	PhD students, students, professionals	Renewable and sustainable energy	The Italian Association of Chemical Engineering

Workshop Modeling and Simulation of Cyber-Physical Energy Systems	Workshop, Conference	Energy modelling, Simulation and optimization	PhD students, students, professionals	Cyber–physical energy systems	IEEE

2. Annex 2: **Examples of Best Practice (ref. § 4.3)**

Project/Website link	Type of program and target group	Digital tech/specialisation	Country	Energy sector focus	Organisation
Specializing Master in Smart Grids	Master Program-University level	Big Data/Data Analysis, IoT	University students	Smart grids	Politecnico di Milano, Italy
Master's Degree in Smart Grids	Master Program-University level	Advanced control systems in the energy grid	University students	Smart grids	Comillas Pontifical University, Spain
Master's Degree in Digital Energy and Business	Master Program-University level	Energy modelling, Big Data/Data Analysis	University students	Energy management, renewable energy, decentralized energy generation, smart process contrl	Hochschule Albstadt-Sigmaringen, Germany
Master's Degree in Decentralized Smart Energy Systems	Master Program-University level	Smart Grids, Energy modelling,	University students	Decentralized smart energy systems	KTH, Sweden
Master’s Degree in Smart Electrical Networks and Systems	Master program-University level	Digitalization of the electric grid	University students	Smart grids	Royal Institute of Technology, Sweden; Eindhoven University of Technology, Netherlands; KU Leuven, Belgium; Grenoble INP Institute of Technology, France; Universitat Politècnica de Catalunya, Spain