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

D2.6 Learning goals catalogue for the energy sector. Final version

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

This deliverable is an enrichment of D2.3 which included the initial “Learning goals catalogue for the energy sector” and reports all the efforts of task 2.3 from M8 until the end of the project. As such, it reports:

a) Improvements in elements of the ASSET vocabulary (goals and outcomes) based on the experience gained through the delivery of the courses.
b) Additional learning outcomes which were defined during the creation of interdisciplinary courses and their mapping to Knowledge, Skills and Competences (KSCs).
c) Evaluation of the learning graph structures which was not explicitly stated in the DoA to be reported in this deliverable.

It is worth stressing that:

- The full version of the vocabulary is available on the project website.
- Part of the additional learning outcomes are not strictly related to the energy transition. Nevertheless, they have been included in this deliverable and in the ASSET vocabulary as the expansion of ASSET offering to other sectors is a key aspect for the sustainability of ASSET offerings.

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List of Acronyms

Abbreviation / acronym	**Description**
AI	Artificial Intelligence
BD	Big Data
CMS	Content Management Systems
DoA	Description of Action
EQF	European Qualifications Framework
FORD	Fields of Research and Development
KPI	Key Performance Indicator
KSC	Knowledge, Skills and Competences
LG	Learning Graph
PV	Photovoltaic
RES	Renewable Energy Systems
SET	Strategic Energy Technology
TOC	Table of Content
Tx.x	Task number
WPx	Work package number

1. Introduction

1.1 Purpose & Scope

This deliverable is part of WP2 "Energy transition skills identification and societal challenges". WP2 deals with the identification of needed skills and societal challenges in the energy transition and as a consequence on the definition of the ASSET learning model and learning goals that ensures replicability. As this deliverable is an enrichment of D2.3 [1], its aim is:

- to provide an **updated** vocabulary, which lists and explains the learning topics and outcomes in ASSET. We report only the updates to keep repetition to the minimum possible. The update relates mainly to the addition into the vocabulary structure (learning graphs) describing additional courses as well as improvements on existing ones.
- to **present results and experiences** from the use of the learning graph model and tool.

To be more specific, under Task 2.3, the structure of the following programmes was defined from M8 onwards:

- Software Defined Networks
- Mobile App Development
- New Materials for Solar Cell Applications – interdisciplinary version
- Ecological and Energy Efficient approach and thinking
- Energy transition made clear (For citizens)
- The technologies behind the energy transition (For citizens)

From the above programmes, the first two are programmes that were already prepared for technical departments and are now integrating SSH-materials generated in ASSET. For this reason, the relevant structure and learning outcomes are reported in section 2.2. The next two programmes are interdisciplinary programmes that were created in ASSET combining elements from previous single - discipline programmes and as such do not add elements (learning outcomes) to ASSET vocabulary while their structure has been reported in D3.4 [2]. The last two are programmes that were created for citizens re-using learning outcomes from already prepared ASSET programmes. Third, this deliverable aims to show the KSC needs covered by ASSET offerings. As such, the list of addressed KSCs has been updated.

1.2 Structure of the Deliverable

The deliverable is structured as follows:

- Section 1 provides the introduction to the document.
- Section 2 provides the updated ASSET vocabulary of topics and learning outcomes.
- Section 3 provides the final KSC needs covered.
- Section 4 presents the results and the experiences from the adoption of the learning graph concept.
- Section 5 concludes the deliverable.

1.3 Relation to other WPs & tasks

This deliverable reports the outcomes of Task 2.3. This task is tightly linked with the following tasks:

- Input from Task 2.2: Task 2.2 provides the KSC needs in the energy transition that were identified and defined.
- Inputs from WP3 and WP4 where interdisciplinary courses are designed and delivered.
- Output: to ASSET community as it is delivered at the end of the project.

2. ASSET Learning Outcomes – additions / improvements

2.1 Updated classification of ASSET learning topics

In the sequel, we present the classification of ASSET learning topics with emphasis on the programmes created from M8 till now. The rationale for selecting the two classification approaches has been thoroughly discussed in D2.3 [1].

The first classification framework is the SET plan [3], which includes the following ten key action areas:

1. integrating renewable technologies in the energy systems;
2. reducing costs of technologies;
3. new technologies and services for consumers;
4. resilience and security of energy systems;
5. new materials and technologies for buildings;
6. energy efficiency for industry;
7. competitiveness in global battery sector and e-mobility;
8. renewable fuels and bioenergy;
9. carbon capture and storage;
10. nuclear safety.

Error! Reference source not found. shows how each ASSET programmes map to the different SET Key Action Areas listed above.

Table 1: Mapping of ASSET learning topics to the SET Key Action Areas

ASSET Learning Topic	SET Key Action Area Addressed									
	1	2	3	4	5	6	7	8	9	10
Multi-terminal DC grids	✓			✓						
AC Microgrids	✓		✓	✓						
Power Quality in Microgrids	✓			✓		✓				
DC Microgrids	✓		✓	✓	✓					
Challenges and solutions in Future Power Networks	✓			✓						
Measurement Techniques and Distributed Intelligence for Power Systems	✓									
Implementation of automation functions for monitoring and control	✓			✓						
Maritime Microgrids	✓	✓						✓		
Power Systems Dynamics	✓									
Case study on distribution grid operation	✓									
Optimization Strategies and Energy Management Systems	✓	✓				✓				
Hydrogen as energy vector	✓							✓		
New Materials for solar cells applications	✓									
Renewable Energy Technologies	✓									
Energy and environment	✓					✓		✓		
Electrical heat pumps in the energy transition framework			✓		✓					
Corporate communication and Social Responsibility			✓							
Innovation and Diversity in engineering/Scientific Integrity			✓							
Understanding Responsibility in research and Innovation			✓							
Green professionalization and ethics			✓							
A holistic approach for Energy Transition: territory, networks, and sustainability			✓							
Innovation processes in the energy sector			✓							
Energy Efficient and Ecological Design of Products and Equipment	✓	✓	✓			✓		✓		

ASSET Learning Topic	SET Key Action Area Addressed									
	1	2	3	4	5	6	7	8	9	10
Economics of energy sources and the optimal integration of renewable energies and energy conservation measures	✓									
Behavioural change as a powerful drive to minimize the energy consumption while providing the same level of energy service			✓	✓						
Software Defined Networks			✓							
Mobile App Development			✓							
New Materials for Solar Cell Applications – interdisciplinary version	✓									
Ecological and Energy Efficient approach and thinking			✓							
Understanding Responsibility in the Energy Transition	✓		✓							
Energy transition made clear (For citizens)			✓							
The technologies behind the energy transition (For citizens)	✓		✓							
Innovation processes and technologies in the energy sector	✓		✓					✓		
Emerging technologies for the future smart grid	✓			✓				✓		

The second classification approach is based on the Frascati Manual [4]. Below is the list of the fields of research and development (FORD) covered by the ASSET programmes, as well as the subcategories covered:

2. Engineering and technology
    - 2.2. Electrical engineering, electronic engineering, information engineering
    - 2.3. Mechanical Engineering
    - 2.5. Materials Engineering
    - 2.7. Environmental Engineering
    - 2.11. Other engineering and technologies
5. Social Sciences
    - 5.3. Education
    - 5.4. Sociology
    - 5.9. Other social sciences
6. Humanities and arts
    - 6.3. Philosophy, ethics and religion
    - 6.5. Other humanities

The numbers for each field are identical to those used in the Frascati Manual 2015. Furthermore, **Error! Reference source not found.** shows the different fields covered by each ASSET programme.

Table 2: Fields of R&D covered by the ASSET learning topics

ASSET Programme	Engineering and Technology					Social Sciences			Huma-nities and arts	
	2.2	**2.3**	**2.5**	**2.7**	**2.11**	**5.3**	**5.4**	**5.9**	**6.3**	**6.5**
Multi-terminal DC grids	✓									
AC Microgrids	✓									
Power Quality in Microgrids	✓									
DC Microgrids	✓									
Challenges and solutions in Future Power Networks	✓									
Monitoring and distributed control for power systems	✓									
Implementation of automation functions for monitoring and control	✓									
Maritime Microgrids	✓									
Power Systems Dynamics	✓									
Case study on distribution grid operation	✓									
Optimization Strategies and Energy Management Systems	✓									
Hydrogen as energy vector	✓				✓					
New Materials for solar cells applications			✓							
Renewable Energy Technologies										
Energy and environment	✓	✓		✓						
Electrical heat pumps in the energy transition framework		✓								
Corporate and institutional communication and Social Responsibility							✓			
Innovation and Diversity in engineering/Scientific Integrity						✓	✓		✓	
Understanding Responsibility in research and Innovation								✓		✓
Green professionalization and ethics							✓			
A holistic approach for Energy Transition: territory, networks, and sustainability							✓			
Innovation processes in the energy sector						✓				
Energy Efficient and Ecological Design of Products and Equipment	✓		✓	✓	✓					
Economics of energy sources and the optimal integration of renewable energies and energy conservation measures					✓					
Behavioural change as a powerful drive to minimize the energy consumption while providing the same level of energy service					✓					
Software Defined Networks	✓									
Mobile App Development	✓									
New Materials for Solar Cell Applications – interdisciplinary version			✓							
Ecological and Energy Efficient approach and thinking				✓						
Understanding Responsibility in the Energy Transition	✓							✓		✓
Energy transition made clear (For citizens)							✓			
The technologies behind the energy transition (For citizens)							✓			

ASSET Programme	Engineering and Technology					Social Sciences			Humanities and arts	
	2.2	2.3	2.5	2.7	2.11	5.3	5.4	5.9	6.3	6.5
Innovation processes and technologies in the energy sector						✓	✓		✓	
Emerging technologies for the future smart grid	✓			✓						

2.2 ASSET Learning Graphs and Vocabulary- enrichments /improvements

The vocabulary consists of words, phrases, and terminologies that give more detail about the learning outcomes and the learning topics. Recall that in ASSET, each programme has one learning topic, and this learning topic is the title of the programme itself. Therefore, the keywords provided for a programme are also the keywords provided for the learning topic.

To make reading easier, in section 2.2.1 we present the elements of the vocabulary that are completely new (were not included in D2.3) and in the subsequent sections (from 2.2.2 onwards) we provide the modifications.

2.2.1 Additional elements from D2.3

The new elements refer (as mentioned in the introduction) to the programmes “software defined networks”, “mobile application design” and “the technologies behind the energy transition”.

Table 3: Program Overview: Software Defined Networks

Educational Programme Title	Software Defined Networks
SET Area	New technologies and services for consumers
EQF level	7-8
Learning outcomes	• Possess knowledge of SDN basic concepts • Understand the concepts of NFV architectures • Deeply understand the distinction between the data and control planes • Analyse the operation of OpenFlow protocol and programme networking SDN devices • Understand the architecture of the SDN controller • Combine design methodologies of advanced networking systems to achieve specific QoS • Understand how innovation is created and managed as well as the benefits it can bring to professionals and businesses • Learn how to focus of issues that can be solved with novel processes or products
Other relevant keywords	Software Defined Networking, Network Function Virtualisation, Network function chain, quality of service, innovation, creative thinking.
Notes	

Table 4: Learning Outcomes and Learning Materials: Software Defined Networks

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Possess knowledge of SDN basic concepts	Understand the concept of Software Defined Networking, as well as the rationale behind the approach and be able to present the fundamentals of this approach	Slides
Understand the concepts of NFV architectures	Understand the terminology of network function virtualisation, the role of the building blocks, their location in the network and the targets of each one of them	Slides
Deeply understand the distinction between the data and control planes	Understand how SDN and NFV concepts interoperate and distinguish between the data flows and the control messages and their orchestration	Slides
Analyse the operation of OpenFlow protocol and programme networking SDN devices	Be capable of experimenting with SDN-enabled devices that realise the OpenFlow protocol as a first and widely recognised implementation of SDN concept	Slides
Understand the architecture of the SDN controller	Study and understand the architecture and operation of the SDN controller (which inputs it collects, how it makes decisions, etc..)	Slides
Combine design methodologies of advanced networking systems to achieve specific QoS	Use design thinking and technical knowledge to specify advanced networking	Slides

Table 5: Program Overview: Mobile App Development

Educational Programme Title	Mobile App Development
SET Area	New technologies and services for consumers
EQF level	7
Learning outcomes	• Conceive and specify a mobile app • Explain and compare different gender and diversity approaches • Discuss the context between diversity and innovation • Collect user requirements • Design the mobile application • Implement a mobile application • Test with the users the mobile application
Other relevant keywords	Mobile app design, diversity and innovation in design, user requirements collection
Notes	

Table 6: Learning Outcomes and Learning Materials: Mobile App Development

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Conceive and specify a mobile app	Conceive a novel mobile application and start specifying it in detail so that these can be delivered to the developers	Learning material 1: Lecture slides from the professor Learning material 2: Exercise: reports from the student
Explain and compare different gender and diversity approaches	Understand the different gender and diversity approaches and be able to explain and compare them and use them in the context of mobile application design	Learning Material 3: Video lecture: Gender and diversity approaches Learning Material 4: Video lecture: Innovation and diversity
Discuss the context between diversity and innovation	Being familiar with the diversity approaches, the students are expected to be able to connect this with innovation in the perspective of mobile application design	Learning Material 5: Text work and workshop during a lecture
Collect user requirements	Learn the user requirement collection methods and be able to apply them	Learning material 6: Lecture slides from the professor
Design the mobile application	Learn to use wireframes techniques to design the mobile applications and understand the involved technological choices (mobile native, web-based and hybrid)	Learning material 7: Lecture slides from the professor Learning material 8: Exercise: reports from the student
Implement a mobile application	Learn and code mobile application both native and web based using the most widely deployed framework like android studio.	Learning material 9: Lecture slides from the professor Learning material 10: Hands on in the lab
Test with the users the mobile application	Understand and apply user testing techniques	Learning material 11: Lecture slides from the professor Learning material 12: Actual events Learning material 13: Questionnaires

Table 7: Program Overview: The technologies behind the energy transition

Educational Programme Title	Software Defined Networks

SET Area	Integrating renewable technologies in the energy systems; New technologies and services for consumers
EQF level	4-5
Learning outcomes	• Understand the role of renewable energy for the energy transition • Acquire basic knowledge about the operation of different renewable technologies • Get a basic understanding about other technologies needed to enable the energy transition
Other relevant keywords	Renewable energies, CO2 pollution, electrical grids, photovoltaic system, wind farms, biomass generation, hydropower generation, smart grids
Notes	

Table 8: Learning Outcomes and Learning Materials: the technologies behind the energy transition

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Understand the role of renewable energy for the energy transition	Understand how renewable energies impact our lives, contributing to reduce the CO2 pollution and mitigating the associated global warming issues	Video
Acquire basic knowledge about the operation of different renewable technologies	Understand the basic concepts behind the most common types of renewable generation, such as photovoltaics, wind, biomass and hydropower	Video
Get a basic understanding about other technologies needed to enable the energy transition	Understand how renewable energies impact the management of the electrical infrastructure and the associated needs for digitalization and automation of future power systems.	Video

2.2.2 Improved version of "Challenges and solutions in Future Power Networks"

The vocabulary elements of this programme have been improved to include new modules on cybersecurity and on multi-terminal DC grids. The modifications are shown in bold green fonts.

Table 9: Program Overview: Challenges and solutions in Future Power Networks

Educational Programme Title	The Economics of renewable energy sources including externalities
SET Area	Integrating renewable technologies in the energy systems
EQF level	7-8
Learning outcomes	• List and explain the challenges in future power systems • Explain and analyse how new control techniques can be used for addressing the challenges • Explain how monitoring systems enable key functions in future power systems • Explain how real time simulations help in testing new solutions for future power systems • **Describe cyber threats for power systems and possible cybersecurity solutions** • **Determine and establish the objectives of converter-level and system-level control in multi-terminal DC grids**
Other relevant keywords	Control engineering, Frequency control, Voltage control, Automatic voltage control, Power system stability, Power system dynamics, Power system monitoring, Real-time systems, Measurements, ICT, resilience, cybersecurity, DC grids
Notes	

Table 10: Learning Outcomes and Learning Materials: Challenges and solutions in Future Power Networks

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
List and explain the challenges in future power systems	• Technical issues in power systems caused by distributed generation, power-electronic based grids, low-inertia systems, and other new technologies.	• Lecture Slides and Video: Today's and Tomorrow's Networks
Explain and analyse how new control techniques can be used for addressing the challenges	• Understand how power electronics affect voltage stability • Understand the role of impedance measurements for designing voltage control strategies • Describe different solution for voltage stability control	• Lecture Slides and Video: New voltage control techniques
Explain how monitoring systems enable key functions in future power systems	• Classical state-estimation • State-estimation as applied to distribution systems • Multi-area state estimation approaches	• Lecture Slides and Video: Monitoring of Power Systems

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Explain how real time simulations help in testing new solutions for future power systems	• Commercial and customized simulation tools • Simulation tools for developing new control techniques for future power systems	• Lecture Slides and Video: Introduction to real time simulation tools
Describe cyber threats for power systems and possible cybersecurity solutions	• **Understand how cyber-attacks are typically planned and executed** • **Identify the requirements for security at the different levels of the energy infrastructure** • **Describe cutting-edge solutions to guarantee cybersecurity**	• **Lecture Slides and Video: Cybersecurity for Critical Infrastructures**
Determine and establish the objectives of converter-level and system-level control in multi-terminal DC grids	• **Determine and establish the objective of converter and system level control** • **Explain the mean features of advanced control methods applied for converter level control** • **Describe different control strategies for system level control of MTDC grids**	• **Lecture Slides and Video: Multi-terminal DC grids**

2.2.3 Improved version of "Measurement Techniques and Distributed Intelligence for Power Systems"

The vocabulary elements of this programme have been improved to include a case-based module that provides a concrete mapping of the theoretical concepts to a practical scenario. The modifications are shown in bold green fonts.

Table 11: Program Overview: Measurement Techniques and Distributed Intelligence for Power Systems

Educational Programme Title	The Economics of renewable energy sources including externalities
SET Area	Integrating renewable technologies in the energy systems
EQF level	7-8
Learning outcomes	• Investigate and apply the basics of uncertainty propagation in measurements • Assess the applications of measurements in power systems • Examine and appraise the application of distributed measurements in power systems • **Describe an automation solution for monitoring based on an actual implementation on a distribution grid** • Investigate and apply the fundamentals of distributed intelligence in power system
Other relevant keywords	State Estimation, Measurement uncertainty, Measurement errors, Substation automation architecture, Phasor Measurement Unit, Synchrophasor

Notes	

Table 12: Learning Outcomes and Learning Materials: Measurement Techniques and Distributed Intelligence for Power Systems

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Investigate and apply the basics of uncertainty propagation in measurements	• Identify the basic principles of measurement and its uncertainty. • Recognise the challenges in measurements in power systems. • Analyse how uncertainties propagate in power system measurements • Arrange simple statistical evaluation of measurements • Evaluate measurement compatibilities	• Lecture slides: Introduction and features of the evolving power system • Lecture slides: Fundamentals of metrology and measurement uncertainty, GUM standard • Exercise: uncertainty calculation and propagation
Assess the applications of measurements in power systems	• Describe how transducers (voltmeter, ammeter) are used for measurements • Investigate how to perform power measurements in multi-phase systems • Examine the synchrophasor concept and how it is implemented via PMU • Examine the function of the different parts of the PMU	• Lecture slides: transducers for power systems • Lecture slides: digitization of monitoring chain • Lecture slides: Synchrophasor measurement, PMUs • Exercise: Calculation of synchrophasors
Examine and appraise the application of distributed measurements in power systems	• Analyse how state-estimation works • Apply distributed measurements for state-estimation • Employ quantities measured by the PMU to improve the	• Lecture slides: State Estimation - Static centralized state estimation • Lecture slides: Integration of PMU data in state estimation • Exercise: Computation of state estimation
Describe an automation solution for monitoring based on an actual	• **Understand why there is a need to integrate monitoring devices in distribution grids**	• **Lecture Slides - The Automation Architecture for**

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
implementation on a distribution grid	• **Introduce the test site (LV+MV grids)** • **Understand the specifications of the monitoring devices utilized in the example distribution grid** • **Examine the implemented automation architecture** • **Verify the application and operation of state estimation in the test case distribution grid**	**Monitoring the grid** • **Lecture slides: The grid topology from Unareti** • **Video: a demo shows sending and storing the measurements**
Investigate and apply the fundamentals of distributed intelligence in power system	• Identify the advantage and need of using agents in power system. • Examine the use and significance of the FIPA standard	• Lecture slides: Agents in power systems: an introduction. • Demo: Agents sample application

2.2.4 Improved version of "Economics of energy sources and the optimal integration of renewable energies and energy conservation measures"

The vocabulary elements of this programme have been improved to facilitate their re-use. The modifications are shown in bold green fonts.

Table 13: Program Overview: Economics of energy sources and the optimal integration of renewable energies and energy conservation measures

Educational Programme Title	The Economics of renewable energy sources including externalities
SET Area	Integrating renewable technologies in the energy systems
EQF level	6
Learning outcomes	• Describe what the energy transition is and why it is needed; what are the driving factors and challenges related to this new energy transition; and analyse what are the impacts of the energy transition on economic and social issues. • **Identify and describe the most significant criticalities and the constraints affecting the organizational structures and the functioning of the energy markets.** • Explain the different forms of energy: renewable electricity generation technologies; illustrate Renewables Energy Technologies market evolution in the decade 2010-2019. • Explain the rationale for implementing RES economics; Understand the "fundamentals" of economics of low-carbon energy. • Apply methods to determine comparative "Levelized cost of energy" for various technologies on a €/MWh basis • Analyse perform sensitivity of RES

	• Identify the Economics of Renewable Energy Mix and Energy Efficiency. • Evaluate the impact of pricing scheme (e.g. cost-reflective tariff vs progressive tariff of kWh) and subsidies on management and new installations • Identify and analyse factors influencing the dynamics of the renewable energy transition: cost reduction of RE&EE technologies, Internalising Externalities and Non-Energy Benefits
Relevant keywords	RES Integration, Levelized Cost of Energy, Net Energy, EROI, Economy, Efficiency, Marginal Cost of energy technologies, Externality Costs
Other relevant keywords	Dynamics of the energy transition, Sustainable energy, Components of the energy system, Economics of energy, Energy market, Pricing scheme, Energy Subsidies
Notes	Sources used to prepare the learning outcomes (e.g. other courses offered and organised around the same topic, etc.)

Table 14: Learning Outcomes and Learning Materials: Economics of energy sources and the optimal integration of renewable energies and energy conservation measures

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Describe what the energy transition is and why it is needed; what are the driving factors and challenges related to this new energy transition; and analyse what are the impacts of the energy transition on economic and social issues	• Introduce the new energy transition and illustrate the main driving factors and related challenges. • Overview the environmental and social impacts of energy production, distribution and end-use.	• Seminar slides • MOOC
Explain the different forms of energy: renewable electricity generation technologies; illustrate Renewables Energy Technologies market evolution in the decade 2010-2019	• Examine several technologies for generation of renewable electricity • Describe enhancing technologies for electricity system operation	• Seminar slides • MOOC
Explain the rationale for implementing RES economics	• Analyse the rationale for renewables • Analyse the dynamics of the low-carbon energy transition by applying the "fundamentals" of the energy economics	• Seminar slides • MOOC

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
	• Illustrate renewable energy sources potential	
Apply methods to determine comparative “Levelized cost of energy” for various technologies on a €/MWh basis	• Determine comparative “Levelized cost of energy” for various technologies on a €/MWh basis (plus Exercise) • **Modelling and integration of RES system with the existing energy system**	• Seminar slides • MOOC
Analyse perform sensitivity of RES	• Analyse global weighted-average Cost of Electricity • Explain net energy, intermittency • Describe options for the supply-demand matching problem, flexibility • Illustrate options for the supply-demand matching problem • Explain capital intensity	• Seminar slides • MOOC
Identify the Economics of Renewable Energy Mix and Energy Efficiency	• Describe The equimarginal costs principle • Determine optimum mixtures of renewable-energy sources and energy efficiency • Assess the potential for Energy Efficiency (plus exercise, calculate economic indicators (i.e. NPV, IRR, PBT)) • Analyse the potential for energy efficiency	• Seminar slides • MOOC
Identify and describe the most significant criticalities and the constraints affecting the organizational structures and the functioning of the energy markets	• **Identify and explain the components of the energy system (sources, vectors and end-uses) and the technical determinants of the production, transport, conversion and use of energy sources** • **Illustrate how EE improvements relate to improvements in quality of life (focus on the Rebound effect)**	• **Seminar slides**
Evaluate the impact of pricing scheme (e.g. cost-reflective tariff vs progressive tariff of kWh) and subsidies on management and new installations	• Describe the various forms of energy Subsidies • Internalize the environmental Externalities	• Seminar slides • MOOC

Learning Outcome	Definition/explanation of the Learning Outcome	Learning Materials
Describe and discuss the dynamics affecting the speed of the renewable energy transition: cost reduction of RE&EE technologies, Internalising Externalities **and Non-Energy Benefits**	• Understand environmental externalities • Analyse the renewable energy transition • Explain rising FF Costs & declining RE costs, accounting for Fossil Fuel Externalities • Describe policies for the green energy transition	• Seminar slides

3. Additional Knowledge, Competences and Skills covered by ASSET

The programmes built from M8 onwards address a set of KSCs which include KSCs already covered by previous programmes and additional ones. The additional ones are shown in the following table with light pink and mainly refer to “lead interdisciplinary staff” and “information security manager role”.

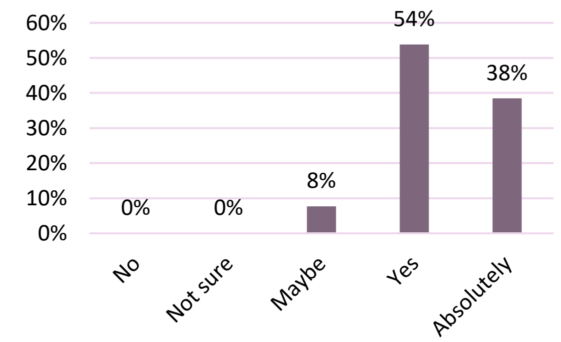
Table 15: Addressed cross sectoral KSCs

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

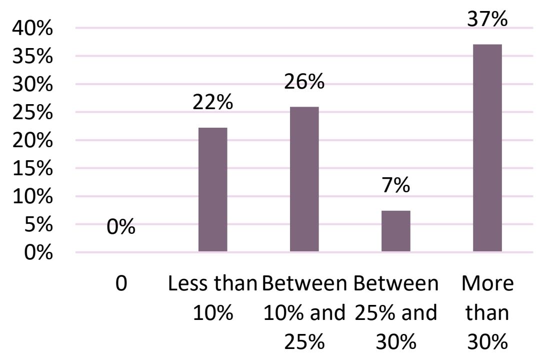
4. Assessment and experiences from the use of the learning graph concept and tool

To evaluate the proposed model and tools, **two** workshops with tutors/professors were organised: one in the framework of the 16th International Conference on Intelligent Tutoring Systems (ITS2020 2020), which attracted 50 attendees reporting 14 different affiliations across Europe, most of them coming from universities and vocational training organisations, and another one in Spain (held in October 2020) which attracted more than twenty people. During the first workshop, instructors from academia and training organisations received a ten-minute introduction and then experimented with the presented models and tools for one hour during which they created new programs with the tool and then announced them in the marketplace. At the end of the workshop, they filled in an anonymous questionnaire providing their comments. After that, a group interview followed that allowed us to capture comments and collect feedback in a descriptive narrative way. During the second workshop, which followed the same structure but with more lengthy sessions (reaching a two-hour workshop), a group interview was conducted. Next, we present, first the results from the questionnaires and then from the interviews. It is pointed out here that in the instance of the tool used in the workshops, twenty-two educational programmes -with targeted duration of 3-months- were available covering topics from the energy sector (fourteen courses), social sciences and humanities and entrepreneurial and business aspects (eight courses).

With respect to the validity of the concept of the learning model, as shown in the left-hand side of Figure 3: 1, 92% consider that the concept is valid and only 8% did not like the learning graph approach. With respect to "the time they estimate that could be saved through the use of the learning graph concept and the accompanying tool", nobody declared that no time would be saved. A small percent (namely 22%) considers they will save time but this will be less than 10%, while a significant percentage of 44% considers they will save more than 25% as shown on the right-hand side graph of figure 1. This is considered a major success, as this was one of the main targets of our work. Saving time in the preparation and development of a new educational programme is anticipated to release significant part of the professors/tutors/instructional designers' effort, which can be devoted to delivering the programmes to additional or larger audiences.



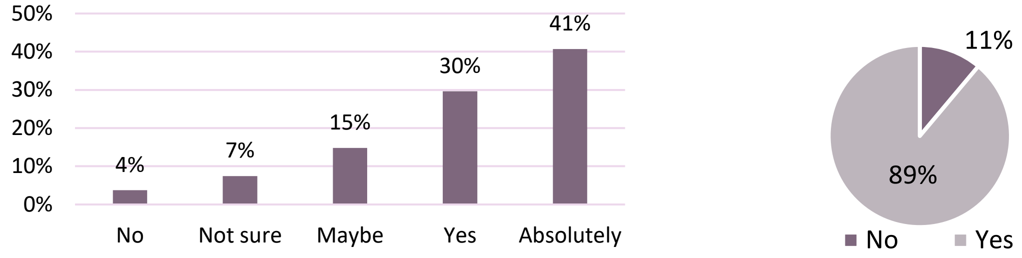
Response to the question: "Do you consider the learning graph model valid? "



Response to the question: "How much time do you estimate could be saved through the use of the presented model and tool?"

Figure 1 Feedback collected from tutors with respect to the validity of the concept and the estimated time reduction

The workshops' attendees were also asked if they would be interested in joining the established community and sharing their own learning materials and structures openly. The results (shown in figure 2) indicate that more than 70% are willing to join and share their materials and structures. This is important since as more structures and content are injected in the web-based tool, the number of attracted users is expected to raise accordingly. The more valuable resource they find, the more they will come back and contribute. With regards to the "validity of the concept in other sectors" outside the energy transition sector, 89% answered "Yes" and 11% answered "No", as shown in the pie chart of Fig 2. The audience included people from engineering, agro-food, sociology and bio-medicine disciplines.

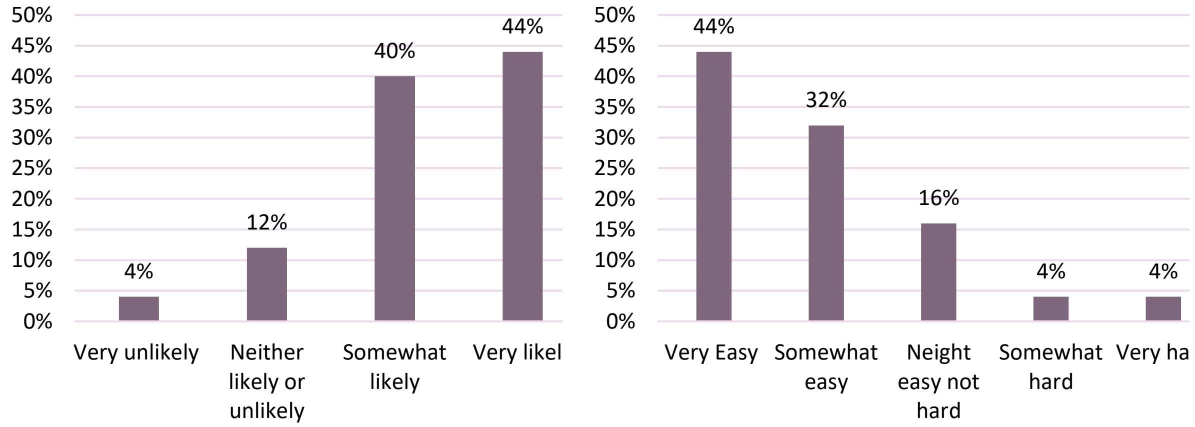


Responses to the question: "would you be interested in joining the established community and sharing your own learning materials and structures openly?"

Responses to the question: "do you consider the approach valid in other sectors?"

Figure 2: Results from the feedback collected from the tutors regarding their intention to engage with the approach and to apply in other sectors

Another interesting result was that, despite the limited volume of available materials at the time of the workshop, (as shown in figure 3a) 84% of the respondents declared they consider likely or very likely to update their current educational programmes with learning materials already available in the tool. This shows that there is strong interest in incorporating learning outcomes in educational programmes that are already in place or in the phase of preparation. Additionally, assuming that the number of the learning graphs and learning materials included in the tool will increase, the interest is expected to increase as well. Figure 3: 3b shows the opinion of the attendees regarding the easiness to use the learning graph tool which was a tool developed using a widely deployed CMS (Content Management System). The higher percentage of 44% declared they found it quite easy to use, with another 32% declaring somewhat easy. A really low percentage considered it somewhat hard or very hard to use.



a) *Response to the question: "How likely do you consider to use the existing materials in your courses?"*

b) *Responses to the question: "How easy-to-use is the learning graph tool?"*

Figure 3: Results from the feedback collected from the tutors with respect to value proposition and willingness to use the existing materials.

Finally, attendees were also asked to express how satisfied they were from the holistic proposition including the learning graph model, the learning graph tool and the educational programme marketplace. They all declared to be satisfied, with the majority of them (67%) declaring to be "very satisfied". The collected results and the comments showed that people need such tools and they are ready to use them.

5. Conclusion

This deliverable reported the additions and improvements that the consortium decided from M8 onwards. These mainly refer to additional programmes that were quite easily created combining elements from already existing programmes (from ASSET or from the participating universities curricula). These covered additional topics whose classification has been reported in chapter 2 and satisfy additional KSC needs as reported in chapter 3.

Chapter 4 finally includes the assessment of the learning graph model and tool from external experts recruited through workshop organisations. The results are very satisfying and provided us with valuable inputs to improve ASSET offerings.

6. References

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