Education for Digitalization of Energy

Deliverable 6.3

Final report on the field test

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Abstract:

This report aims to provide updates of the piloting activities and presents the main findings of these. The report complements the preceding deliverables D6.1 and D6.2.

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D6.3, D6.2, D6.3, piloting activities, field test, main results

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	Participant organisation name	Short	Country
01	UNIVERSIDAD PONTIFICIA COMILLAS	COMILLAS	Spain
02	NATIONAL TECHNICAL UNIVERSITY OF ATHENS	NTUA	Greece
03	RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE	RWTH	Germany
04	FOSS Research Centre for Sustainable Energy – U. of Cyprus	FOSS	Cyprus
05	Politecnico di Milano – METID	POLIMI	Italy
06	Kungliga Tekniska Högskolan	KTH	Sweden
07	Fundación Obra Social y Monte de Piedad de Madrid – Escuelas Profesionales Padre Piquer	PIQUER	Spain
08	Centrul Roman al Energiei	CRE	Romania
09	REPSOL SA	REPSOL	Spain
10	IBERDROLA	IBERDROLA	Spain
12	DNV Business assurance Spain SL	DNV	Spain
13	EDSO for Smart Grids	E.DSO	Belgium
14	NTT Data Italia SPA	NTT	Italy
15	NOVEL Group	NOVEL	Luxembourg
16	University of Cologne Business School	UCBS	Germany
17	Institute of Energy Economics at the University of Cologne	EWI	Germany

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Definitions, Acronyms and Abbreviations

ACS – Institute for Automation of complex Power Systems

BSDE – Blueprint Strategy for the Digitalisation of Energy

EQF – European Qualifications Framework

EWI – Institute of Energy Economics at the University of Cologne

LEGOS – Lite Emulator of Grid Operations

LEM – Local Energy Markets

MQTT – Message Queuing Telemetry Transport

WP – Work Package

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Executive Summary

Energy sector's digitalisation process creates not merely several crucial challenges, but also great opportunities towards energy efficiency and sustainability. To take advantage of this opportunity, personnel with skills essential for this transformation is needed. EDDIE purpose is to develop an industry-driven Blueprint Strategy that will identify and try to cover the skill demand in European Energy sector digitalisation.

The project aims to create new profiles of engineers, researchers and technicians, trained and familiar with the new technologies, tools and methods to support and improve the digitalisation of energy sector. Additionally, the educational and research sector will fit in the new era and be in the spotlight of synergies with industry, policy makers and other relevant actors in this procedure.

The roll-out of Blueprint Strategy for the Digitalisation of Energy (BSDE) will take place in a central pilot site in Aachen and four smaller-scale pilot sites in Germany (Cologne), Greece (Athens), Italy (Milano) and Spain (Madrid). This deliverable is an update of the deliverable D6.2 and focuses on the main findings of the piloting activities. The main findings aim to convey the results, key learnings, and recommendations derived from the pilot activities. Besides, the program template from deliverables D5.2 and D5.3 is used to describe each of the 18 piloting activities additional to the program content. This draws a direct relation to the WP5 and the Blueprint Strategy of EDDIE. However, other parts of WP5 are also linked to the piloting activities. Various pilot activities that contain suitable training material will be placed in the Marketplace platform of the BSDE, developed in the context of EDDIE. Also, the identified trends in occupations related to the digital transformation of the energy sector in WP5 are being utilised in the design process of the pilot activities, targeting skills relating to these specific occupations. Besides the described relation to the central WP5, there are further links to the other work packages of the project. So, for example, the content development of the piloting activities will be affiliated to the skill needs and skill gaps identified in WP2. The stakeholder analysis of WP3 allows the pilot designers to define the educational content, based on the stakeholders' needs and reach out to the relevant stakeholders of each pilot activity. Lastly, the experiences of best practices in education, in the area of energy efficiency & transition, industrial transition & digitalization, as gathered in WP4, provide valuable insights regarding methodology, content, target groups and learning techniques.

The central pilot in Aachen will include learners from all EQF levels, proposing various activities. As the leader of the pilot is RWTH Aachen University, some of the actions focus on the education sector, from workshops at a secondary school to actions for university students. These activities will include lectures and a summer school about modern power systems and digitalisation, as well as the dissemination of EDDIE project's material and Blueprint, targeting not only students in the field of electrical engineering but also all students in an interdisciplinary setting. Other activities are aiming to raise synergies and appeal to a larger audience, the central pilot in Aachen plans workshops and experimental demonstrations in cooperation with the local communities and nationwide events. These activities are targeting to raise awareness about renewable energy and digitalisation to a larger audience, including the young generation in dissemination events, a summer vacation program and Girl's Day. In the same direction, stands the partnership with the city of Herne to propose a workshop, based on smart city initiatives, in order to achieve dissemination of EDDIE scope to wider audience, focusing on energy applications.

In coordination with Aachen pilot site and in the context of the BSDE directions, four other pilot sites will be developed in Cologne, Athens, Milan and Madrid. The Cologne pilot site will be mainly industry driven, aiming to reduce skills gaps in energy sector. This includes a program to train employees on new trends in the energy sector, a certificate program for mastering the energy landscape of the future and a course connecting companies as teaching entities with students. The Greek pilot site focuses on lectures and courses to university students in the field of new tools and mechanisms that will play crucial role in the digitalisation of the energy system. To raise synergies, NTUA also plans to participate in a summer school and a MOOC, organized by the H2020 project ERIGrid 2.0, aiming to stress the necessity of updating education programs, in the context of the transformation of the energy sector. In Italy, Politecnico di Milano will develop a MOOC targeted to digital energy management for real estates, aiming to match green skills with the real estate sector. Finally, Piquer is setting up a complementary training module on automation technology to improve the energy efficiency and control the energy consumption in private households as an educational offer in vocational training (VET) in Spain.

The implementation of the activities is followed by an assessment procedure, in order to measure the impact of the activities. The goal of the assessment is to achieve a continuous update of the Blueprint, and thus ensure the sustainability of the strategy, both during and after the end of the project. The end of this procedure will mean the determination of the Blueprint Strategy.

Overall, several of the elements of the BSDE are tested through the pilots by assessing the possible impact they may have on the transition to the digital era of the energy system. In particular the skill gaps identified will be used as a starting point to develop educational material. In addition, the developed templates and best practice analysis will be utilized in the development process, while using the common language of syllabus elements that is being identified in WP5. The developed programs will be distributed and disseminated through the training programs marketplace and the dissemination portal of the BSDE.

1. Introduction

The digitalisation of the energy sector has a central role in the transition towards a sustainable future. The European Green Deal, along with other initiatives, positions the European Union as a global leader in this challenge. Europe has a unique opportunity to establish global leadership in the energy transition and to shape the future energy systems. Driven by technology innovations, as well as by the decarbonisation ambition set by the Paris Agreement and the EU 2050 target, this new architecture enables and supports increasing shares of renewables, energy storage and demand response management, all of which can increase grid flexibility.

The purpose of the EDDIE project is the foundation and establishment **of a Sector Skills Alliance to develop an industry-driven Blueprint Strategy for the education and training in the energy sector, which is continuously affected by digitalisation. This Blueprint is an industry-driven strategy that will meet and anticipate the skills' demands for the sustainable growth and digitalisation for the European Energy sector.** The ongoing digitalisation procedure of the energy sector causes major technological, economic and social challenges, creating new skills demands that need to be met in order to ensure the sustainable future of the energy sector. Providing adequate training and fostering cooperation among all stakeholders throughout Europe is vital towards that direction. Thus, the Blueprint strategy will establish a sustainable framework that allows to define and update educational programs responding to industry changes and to increase the attractiveness of the energy sector as a career choice. It will also take into consideration, in an interdisciplinary way, green and soft skills, social sciences humanities, economics and gender dimension.

All the effort implemented in WP2, WP4 and WP5, to identify the skills gaps in the Energy Sector and develop best practices and the Blueprint Strategy for the Digitalisation of Energy (BSDE), will be the roadmap for the design of the pilot demonstration activities. EDDIE's main target in WP6 is the BSDE rollout in different pilot demonstrators. Identifying and categorizing skill gaps and the corresponding job profiles is of high importance to determine the appropriate content and activities of the pilot sites. The piloting contents and activities will also consider and reflect the best practices identified and developed in WP4. The relation of the pilot activities to the other WP of the project and the blueprint strategy is described in detail in deliverable D6.2.

The main pilot will be deployed in the city of Aachen, including all courses and tools and focusing on addressing all the considered EQF levels and stakeholders. Pilot activities of smaller scale and more targeted EQF levels will also be deployed in Germany (Cologne), Greece (Athens), Italy (Milano) and Spain (Madrid). The coordination between the five pilot sites is ensured through regular meetings and a joint repository on the project website. The meetings are used to exchange experiences and decide on joint deployment method of the piloting activities. The implementation of these piloting activities will be followed by an assessment procedure, measuring the impact of the activities. The goal of the assessment is to continuously update the Blueprint, in order to ensure the sustainability of the strategy, both during and after the end of the project. In deliverable D6.1, there is a detailed description of the tools and measures of the assessment mechanism, along with the preliminary KPIs. As for the outputs and conclusions of the current WP6, these will provide feedback for the update of the Blueprint, ensuring the strategy sustainability, both during and after the completion of the project and fostering the long-term and large-scale replication and continuous updating of the training programs.

This deliverable is the third and final report on the piloting activities, following the preceding deliverables D6.1 and D6.2. In this deliverable an update of the piloting activities and the main findings of these is provided. These updates include the revision and finalization of the program description, program template and program content of the individual piloting activities as well as the integration of a new pilot activity in Aachen. By using the program template for the training marketplace of deliverable D5.3 the general information, business and operational model as well as the learning and teaching model of the pilot activity is described. The assessment that leads to the main findings after the deployment of the piloting activity, includes input from the survey of participants, feedback from the presenters, as well as findings that occurred during the design and deployment stages of the field activities. The assessment procedure, that aims to measure the impact of the activities and provide feedback to the Strategy is described in detail in deliverable D6.7.

1.1. Structure of the document

The integral part of this document consists of 6 remaining chapters. Chapter 2 presents the activities that will take place in the central pilot in Aachen, including an overview, a detailed description of the pilot activities. The detailed description of the piloting activities is structured into the following parts:

- General description
- Program template: Program fact sheet, Business and operational model, Learning and teaching model
- Program Content
- Main Findings

Following the structure of chapter 2, chapter 3 presents the pilot in Athens, Chapter 4 covers the pilot in Milan, Chapter 5 details the pilot in Cologne, and Chapter 6 addresses the pilot in Madrid. Finally, in a conclusion the main points of the document and the main findings of the pilots are summarized.

1.2. Overview of Piloting Activities

In total there are 18 individual piloting activities distributed over five field test sites. The central pilot in Aachen coordinated by RWTH consists of nine piloting activities. In Athens, there are four piloting activities organized by NTUA, while the field test site in Cologne has three activities supervised by EWI. Lastly, there is one activity in Milan and one in Madrid planned by POLIMI and PIQUER respectively. To get an overview, see the table below.

Table 1 Overview of piloting activities

Site	Partner	EQF Levels	Piloting activities
Aachen, Germany	RWTH	1-8	9
Athens, Greece	NTUA	6-7	4
Milan, Italy	POLIMI	5-6	1
Cologne, Germany	EWI	4-6	3
Madrid, Spain	PIQUER	4	1
			Total 18

2. Field Test Aachen

The design and implementation of the Aachen pilot is being tailored to the needs of education/training providers and of the community (both governing bodies and citizens) in terms of (re)building knowledge, competence and skills, as identified in WP2 and related deliverables. The design and implementation also consider the rationale and the objectives of the Blueprint Strategy that is being developed in WP5. Consequently, several piloting activities have been conceived and planned, each addressing (and "testing") one or more components and aspects of the BSDE value chain.

The Institute for Automation of Complex Power Systems (ACS) of RWTH Aachen University delivers courses in BSc and MSc and participates in various EU-funded and regional programs. The piloting activities cover a range of EQF levels from 1 to 8. Thus, different target groups are addressed in order to increase knowledge, experience, and (re)skilling in the energy sector. The activities are carried out in different settings such as in the education sector with workshops, lectures, or dissemination events in an interdisciplinary setting. Other activities are aiming to raise synergies and appeal to a larger audience with workshops and experimental demonstrations in cooperation with the local communities.

2.1. Overview of activities

Table 2 Overview of pilot activities in Aachen

Piloting Activity	Target group	EQF Level	Duration	Main stakeholders	Part/s of Blueprint Strategy tested	Results delivered to EC	Energy sector	Contents
Archimedischer Sandkasten with city of Aachen	10-14 years, general public	1, 2	June '22	RWTH, Stadt Aachen, Bleiberger Fabrik	Levers to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts	Power, IT	Introduction on topics related to smart grids, energy transition challenges and digitalisation, supported by practical demonstration. Tailored to kids.
Girl's Day at ACS	10-14 years	1, 2	27.04.23	RWTH	Levers to raise awareness and to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts	Power, IT	Introduction to digitalisation of the energy grid, energy grid demonstrator, dissemination events and material
Smart Milano	High school students in 12th grade	1, 2	Oct 23 – Dec 23	RWTH, Gymansium Würselen, Liceo linguistico d'Arconate	Levers to raise awareness and to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts	Power, IT	Introduction on topics related to smart grids, energy transition challenges and digitalisation, supported by practical demonstration. Including a bilingual and pan-European cooperation element..

Gymnasium Workshop	High school students	2, 3	April '23	RWTH, Anne Frank Gymnasium Aachen	Levers to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts	Power, IT	Introduction on topics related to smart grids, energy transition challenges and digitalisation, supported by practical demonstration. Tailored to high school students and teachers.
Science Night at RWTH	High school students, Bachelor students, Master students, general public	3 to 8	11.11.22	RWTH	Levers to raise awareness and to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts	Power, IT	Introduction to digitalisation of the energy grid, energy grid demonstrator, dissemination events and material
Workshop on Data Platforms for the Energy Infrastructure	Industry, municipality, citizens	3 to 8	May '23	RWTH, City of Herne, Hochschule Bochum	Levers to raise awareness and to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Computing tools and platforms	Power, IT	Workshops on open source data platform for smart cities
Leonardo lecture on energy transition	Bachelor students, Master students	6, 7	Dec '23	RWTH	Levers to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts	Power, IT	Lecture on Digital Energy Revolution, Lecture on Urban Electrical Energy Systems
ACS lecture on automation of complex systems	Bachelor students, Master students	6, 7	Summer semester 2023 (from April '23)	RWTH	Levers to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Computing tools and platforms Learning Outcomes, in terms of skills and knowledge, will be in line with ESCO and EQF framework	Power, IT	Introductory course of current research topics in modern power systems, use of interactive computation sheets
Future energy systems lecture on energy digitalisation	Bachelor students, Master students	6, 7	Summer semester 2023 (from April '23)	RWTH	Levers to reduce skill gaps, Design of recommendations and overall action set, general templates, best practices	Teaching/learning material on renewable energy and Smart grid concepts, Learning Outcomes, in terms of skills and knowledge, will be in line	Power, IT	Lecture on Digitalization of the Energy System

						with ESCO and EQF framework		

2.2. Presentation of activities

In this section the piloting activities in Aachen are presented individually following the same structure as described in chapter 1.1. It should be noticed that the used program template from deliverable D5.3 to describe the piloting activities is developed for the EQF levels 4-8. Therefore, only the applicable parts of this program template are filled for the piloting activities with an EQF level of 1-3.

2.2.1. Archimedischer Sandkasten with city of Aachen

The “Archimedean Sandbox” event is a 3-week summer vacation program for school children from 9 to 16 years old organized by the city of Aachen and supervised by the local educational institution Bleiberger Fabrik in Aachen. Children can sign up for the program on individual days, weeks or the full period. Topic of the program is the energy generation through wind power. ACS is one of the technical supporters of the program next to other institutes of the RWTH. As a Kick-Off event, the children visit ACS on the first day and interact with a small wind park and energy grid model. This is a starting point for the children to design and build their own wind setup. ACS will consult the children in two meetings on their own wind setup project in the city center of Aachen. Furthermore, part of the program is an open fair for the general public. At this event, ACS presents the same wind park and energy grid model to interested pedestrians.

<u>**Program fact sheet**</u>

1. **Name of program:** Archimedischer Sandkasten
2. **Program format:** on-campus/ on-site
3. **Program language:** German
4. **Length of program:** 3 weeks
5. **Student´s estimated effort in working hours:** 3-30
6. **Industrial challenges addressed 1. - Economic and organizational:** N/A
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Technology integration (compatibility with existing processes/ technologies)
9. **Industrial challenges addressed 4. - Energy system:** N/A
10. **Industrial challenges addressed 5. - Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** Promoting young talent / labour shortage
12. **Skill gap area:** N/A
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** Public funding
17. **Target groups:** Students (Pre-career stage)
18. **EQF level:** 1-2
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? No
    b. Does the program provide credits (ECTS)? No
    c. Is it modularized? No
    d. Does it provide any certification per module? No
20. **Certification:** N/A

<u>**Business and operational model**</u>

1. **Relevance of program:**

   a. **#1:** raising interest and awareness around the young generation, on modern power systems engineering and energy transition topics
   b. **#2:** Promoting young talent in engineering and IT professions
2. **Definition of targets:**
   a. Name the skills you target: electricity and energy
   b. Enter their ESCO codes: N/A
   c. Name the occupations you target: N/A
   d. Enter their ESCO codes: N/A
   e. Name the tools and systems that you target: N/A
3. **Financial structures: N/A**
4. **Use of resources:**
   a. **#1:** physical facilities at ACS, seminar room
   b. **#2:** research assistant from ACS as a lecturer
   c. **#3:** wind park and energy grid model
   d. **#4:** dissemination material
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
   a. **#1:** Dissemination by the City of Aachen in the press
   b. **#2:** Dissemination by the City of Aachen in the Future Lab Forum
   c. **#3:** Dissemination at local schools
7. **Employer feedback:** N/A
8. **Alumni engagement:** N/A

<u>**Learning and teaching model**</u>

1. **Admission requirements:** No requirements
2. **Training goals:**
   a. Training goal #1: wind energy is not a constant energy producer due to weather dependencies
   b. Training goal #2: electricity supply and electricity demand in the energy grid must match
   c. Training goal #3: without conventional energy producers and volatile renewable energy sources in the energy grid of the future, energy storages are needed and the energy grid is getting complex
   d. Training goal #4: complex energy grid provides new challenges and needs new skills
   e. Training goal #5: Generate interest in STEM subjects and promote young talent
3. **Program content - Syllabus elements in ICT/ Digital:** N/A
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** BASIC ELECTRICITY – Electricity theory, Current, voltage & components
   b. **#2:** ELECTRICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS – RES (Solar Energy, wind energy)
   c. **#3:** ENERGY MANAGEMENT & GREEN SKILLS – Regulation & new Business Models
   d. **#4:** Electrical Engineering - configuration of RES Installations
   e. **#5:** Electrical Engineering - Electrical design
   f. **#6:** Electrical Engineering - Electrical engineering
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS –Teamwork
   b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Problem solving
   c. **#3:** HUMANITIES & ETHICS – Critical thinking
   d. **#4:** HUMANITIES & ETHICS – Volunteering & cooperation
7. **Program content - Re-use of training modules:** Yes – Reuse of the landscape model for the Girl's Day at ACS
8. **Program content - Intellectual Property Rights:** All material are open to public**.**
9. **Methodologies:** Practical learning, Problem-based learning, Worked examples, Interactive lecture, Discussion-based learning
10. **Teaching methods:** Practical exercises, Problem solving
11. **Evaluation methods:** Other - no

12. **Internships:** No
13. **Scheduling:** Self-paced

Program Content

The main teaching object is the wind park and energy grid model, demonstrated to the participating children in the beginning of the vacation program at the ACS institute visit, and to the pedestrians during the dissemination event in the city center of Aachen. A picture of the model can be found in Figure 1.

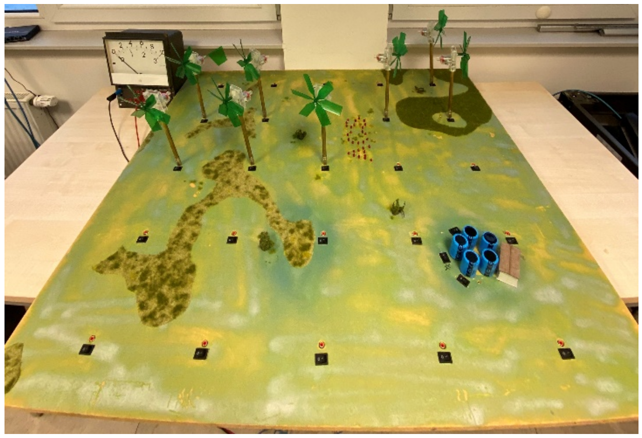


Figure 1 Picture of the wind park and energy grid model

The model is a landscape, where small wind turbines can be plugged in at destined connection points. Also, part of the landscape are fixed capacitors representing energy storages and LED lights representing consumers. With the help of ventilators, wind is generated and directed on the wind turbines. Consequently, the LED lights are turned on. Based on the number of wind turbines and the rotation speed, the LED lights might fluctuate, which provides an understanding of the principle of load and generation. To stabilize the fluctuation, the energy storages can be activated, which explains the principle of energy storage. Additionally, the voltage can be observed in a voltmeter.

Main Findings

The "Archimedischer Sandkasten" activity for children, focused on energy generation through wind power. The survey results from the open fair for the general public indicate that the children have a basic understanding of climate-neutral electricity generation, the necessity of energy storage devices, and the complexity of the energy grid with renewable energy. The use of a demo during the activity enhanced the children's understanding of the integration and impact of renewables into a grid. The demo showed the impact of electricity produced by wind energy on the grid and how storage devices can stabilize the electrical grid if renewable energy is present. The positive response to the demo led to the development of a new demo, integrating topics identified as skill gaps such as Energy Management Systems. This new demo, used in another pilot activity, the Girls' Day, was adapted to children's age but still demonstrated the increased complexity of future energy systems, necessity for flexibility, automation, and advanced control of such systems. An additional survey conducted with parents and interested adults showed a high level of interest in the energy transition and the importance of digitalization for the progress of the energy transition. Most respondents reported learning new things with digital tools. However, only 60% agreed that they are aware of how digital processes are used in the energy network, indicating a potential area for further education and awareness raising. Also the conductors noticed the high interest of participant to discuss the overlying topic of the demo (integration of renewable energy sources in the energy grid), indicating a need for further educational events to create the possibility for discussions.

In conclusion, the "Archimedischer Sandkasten" activity successfully engaged children, their parents and interested adults in understanding the complexities of renewable energy and the role of digitalization in the energy transition. The activity's approach of using interactive demos and targeted surveys proved effective in both imparting knowledge and identifying areas for further development and learning.

Table 3 Summary of Archimedischer Sandkasten with City of Aachen

Summary	Main remarks
Success factors	• Reach of broad audience including children of all ages and adults • Enhancement of understanding of volatile integration of wind energy into the grid
Areas of improvements	• Adjustment of wind park and energy grid model to include new functionalities
Recommendations	• Consistent involvement in this and similar established programs

2.2.2. Girl's Day at ACS

Girls' Day is a nationwide project for career and study orientation for girls. On this annual day of action, female students learn about professions or fields of study in which the proportion of women is less than 40 percent. Girls from grade 5 are addressed. The main component of this pilot activity is a workshop for lower secondary female students at the Institute for Automation of Complex Energy Systems. In the workshop, the female students explore the balance between generation and consumption in the energy grid using a plug-and-play energy grid demo.

<u>**Program fact sheet**</u>

1. **Name of program:** Girls Day
2. **Program format:** On campus / On-site
3. **Program language:** German
4. **Length of program:** 1 day
5. **Student´s estimated effort in working hours:** 6h
6. **Industrial challenges addressed 1. – Economic and organizational:** N/A
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. – Technical and regulatory:** Technology integration
9. **Industrial challenges addressed 4. – Energy system:** N/A
10. **Industrial challenges addressed 5. – Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** Promoting young talent / labor shortage
12. **Skill gap area:** Programming and development competences
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (lower secondary education)
18. **EQF level:** 1-3
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? No
    b. Does the program provide credits (ECTS)? No
    c. Is it modularized? No
    d. Does it provide any certification per module? No
20. **Certification:** N/A

<u>**Business and operational model**</u>

1. **Relevance of program:**
    a. **#1:** Vocational orientation project for female pupils

   b. **#2:** Promoting young talent in engineering and IT professions
2. **Definition of targets:**
   a. Name the skills you target: energy and electricity
   b. Enter their ESCO codes: N/A
   c. Name the occupations you target: N/A
   d. Enter their ESCO codes: N/A
   e. Name the tools and systems that you target: N/A
3. **Financial structures:** N/A
4. **Use of resources:**
   a. **#1:** Wind turbine model to study the generation of electricity
5. **Licences for digital tools:** No
6. **Marketing and student recruiting procedures:**
   a. **#1:** Nationwide Girls' Day website
   b. **#2:** Posters in schools
   c. **#3:** RWTH website
7. **Employer feedback:** N/A
8. **Alumni engagement:** N/A

Learning and teaching model

1. **Admission requirements:** No requirements
2. **Training goals:**
   a. Training goal #1: Generate interest in STEM subjects
   b. Training goal #2: Raising interest and awareness around the young generation, on modern power systems engineering and energy transition topics
   c. Training goal #3: Impart knowledge about wind power and renewable energies and arouse enthusiasm for the topics
   d. Training goal #4: Promoting young talent in engineering and IT professions
3. **Program content - Syllabus elements in ICT/ Digital: /**
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** BASIC ELECTRICITY – Electricity theory, Current, voltage & components
   b. **#2:** ELECTRICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
5. **Program content - Syllabus elements in Energy:**
   a. #1: ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS – RES (Solar Energy, wind energy)
   c. **#3:** ENERGY MANAGEMENT & GREEN SKILLS – Regulation & new Business Models
   d. **#4:** Electrical Engineering - configuration of RES Installations
   e. **#5:** Electrical Engineering - Electrical design
   f. **#6:** Electrical Engineering - Electrical engineering
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS –Teamwork
   b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Problem solving
   c. **#3:** HUMANITIES & ETHICS – Critical thinking
7. **Re-use of training modules:** Yes – Reuse of the landscape model for the Girl's Day at ACS
8. **Intellectual Property Rights:** No
9. **Methodologies:** Practical learning, Problem-based learning, Worked examples, Interactive lecture
10. **Teaching methods:** Practical exercises, Problem solving
11. **Evaluation methods:** No evaluation necessary
12. **Internships:** No
13. **Scheduling:** Half-day event

Program Content

Female students from the fifth grade from different schools in the German state North Rhine-Westphalia come to RWTH EON Research Center every year where they have the opportunity to learn about the integration of renewable energy, soldering the charger, energy savings, and general knowledge about energy. This year, 2023, the activity started at 08:30 where the students got an overview of the day's activities and greetings from all institutes of the center. Afterwards the girls were separated into two groups going to different stations of the institutes one after another in the predefined schedule:

Table 4 Girls' Day schedule

Time	Group 1	Group 1
09:35	Station 1: Soldering, Institute for Power Generation and Storage Systems	**Station 2: Integration of renewable energy, ACS Institute**
10:25	**Station 2: Integration of renewable energy, ACS Institute**	Station 1: Soldering, Institute for Power Generation and Storage Systems
11:25	Station 3: General knowledge about energy, Institute for Future Energy Consumer Needs and Behaviour	Station 4: Energy savings, Institute for Energy Efficient Buildings and Indoor Climate
12:05	Station 4: Energy savings, Institute for Energy Efficient Buildings and Indoor Climate	Station 3: General knowledge about energy, Institute for Future Energy Consumer Needs and Behaviour

The teaching object of this pilot activity offered by the ACS institute in Station 2 is based on the wind park and energy grid model, which was already used in the "Archimedischer Sandkasten" activity. A picture of the plug-and-play energy grid demo is in Figure 2. This model was extended to form a modular wind turbine model for the Girl's Day. It now consists of individual modules that can be connected to each other in any way. As before, small wind turbines can be connected to specific connection points within the individual modules. The individual modules represent different areas in the energy system; in addition to the previous onshore wind turbines, the model has been expanded to include a module representing an offshore wind park. In addition, LED lights representing consumers are grouped into different consumer groups. Also part of the landscape are the capacitors as energy storage and newly integrated PV systems. The fans generate wind and direct it to the wind turbines. The PV systems react to light sources. The generated wind and PV power switches on the LED lights. Depending on the number of wind turbines and the rotation speed as well as the emulated solar irradiation, the LED lights might fluctuate. This provides an understanding of the principle load equal to generation. To stabilize the fluctuations, the energy storage units can be activated, to explain the principle of energy storage. In addition, the voltage can be observed in a voltmeter. By the end of the activity, a survey was conducted.

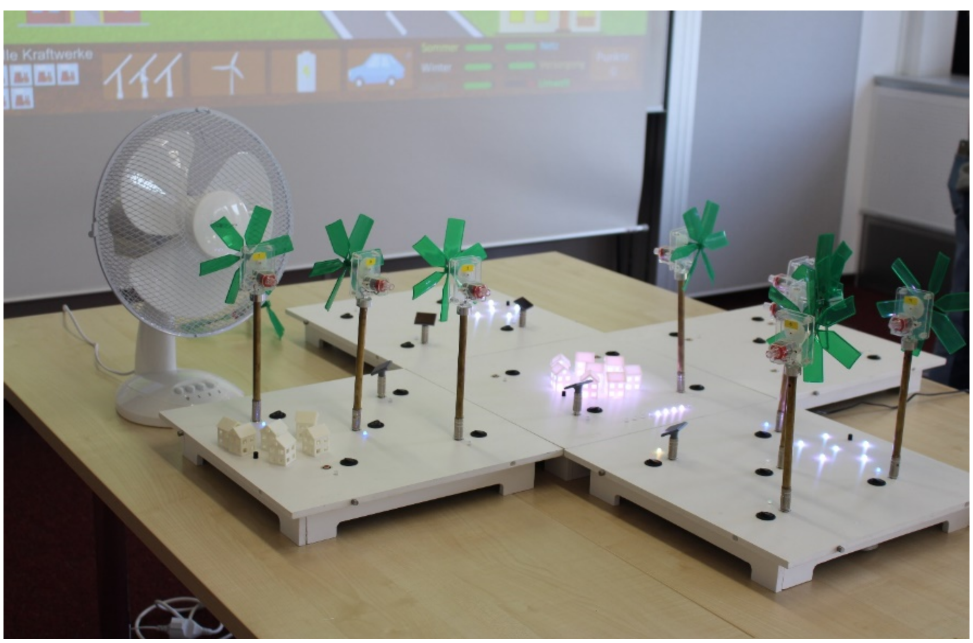


Figure 2 Plug-and-play energy grid demo

Main Findings

The main teaching object was a Plug-and-play energy grid model, which was an extension of the model used in the "Archimedischer Sandkasten" activity. The model, consisting of individual modules representing different areas in the energy system, provided an understanding of the principle of load equal to generation and the role of energy storage. The use of fans to generate wind and light sources to emulate solar irradiation made the model interactive and engaging. The area of improvements to address the topic of smart grids could be integration of more digital functions.

The survey results revealed a positive response to the activity. All participants agreed or fully agreed that the model of the energy grid was well described. Most participants agreed or fully agreed that their awareness of the digitization of energy transition had been enhanced and their interest in the topic of energy and energy networks had been awakened or increased. Most participants also found the activity motivating and expressed a desire to do further research on the topic. All participants expressed a desire to learn more about energy networks and the digitalization of the energy transition, and 86% were interested in learning more about specific job descriptions to work in the field of energy technology and be part of the energy transition. This indicates that the "Girls' Day" activity not only enhanced the participants' understanding of energy systems and the digitalization of the energy transition but also sparked their curiosity about potential career paths in this field.

In addition to the main findings, the survey results also provided valuable insights into the participants' prior knowledge and future interests. Notably, 71% of the participants reported that the topic of energy grids or electrical engineering had not been covered in other school subjects. This underscores the importance of initiatives like the "Girls' Day" activity in introducing these topics to students at an early stage. Furthermore, when asked about their willingness to participate in similar workshops in the future, 57% of the participants expressed a preference for university-based workshops, while 43% preferred school-based workshops. This suggests a keen interest among the participants in exploring university-level education and research environments. Aside from that, the observations of the conductors indicate that the female participants need more encouragement to express their prior knowledge and questions in the workshop.

Table 5 Summery of Girl's Day at ACS

Summary	Main remarks
Success factors	• Motivation of female student to follow STEM topics • Enhancement of understanding of the current and future energy grid
Areas of improvements	• Integration of more digital functions into the plug-and-play demo
Recommendations	• Expose more young female students to the topic of digital energy • Continuation of participation in this and similar established programs

2.2.3. Gymnasium Workshop

The Gymnasium Workshop is a workshop provided by the Institute for Automation of Complex Power Systems to pupils of the lower secondary level in a STEM group at the Anne Frank Gymnasium in Aachen. The aim is to provide the students a first understanding of digitalization in the energy sector. This is achieved through interactive presentations and the use of the Lite Emulator of Grid Operations (LEGOS) demonstrator.

Program fact sheet

1. **Name of program:** Gymnasium Workshop
2. **Program format:** On campus / On-site
3. **Program language:** German
4. **Length of program:** 1,5h (29.03.2023)

5. **Student´s estimated effort in working hours:** 10 h
6. **Industrial challenges addressed 1. - Economic and organizational:** N/A
7. **Industrial challenges addressed 2. – Social:**
    a. **#1:** Lack of citizen engagement
8. **Industrial challenges addressed 3. - Technical and regulatory:**
    a. **#1:** Technology integration
9. **Industrial challenges addressed 4. - Energy system:**
    a. **#1:** Network operation – Automation and fault clearance
    b. **#2:** Network operation – Automatic fault indic**ators**
10. **Industrial challenges addressed 5. - Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Programming and development competence
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
    b. **#2:** 0714 Electronics and automation
14. **Starting point of program design:** Energy program with ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (Pre-career stage)
18. **EQF level:** 2-3
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? No
    b. Does the program provide credits (ECTS)? No
    c. Is it modularized? NO
    d. Does it provide any certification per module? No
20. **Certification:** N/A

Business and operational model

1. **Relevance of program:**
    a. **#1:** Raising interest and awareness around the young generation, on modern power systems engineering and energy transition topics
    b. **#2:** Promoting young talent in engineering and IT professions
2. **Definition of targets:**
    a. Name the skills you target: energy and electricity
    b. Enter their ESCO codes: N/A
    c. Name the occupations you target: N/A
    d. Enter their ESCO codes: N/A
    e. Name the tools and systems that you target: N/A
3. **Financial structures:** N/A
4. **Use of resources:**
    a. **#1**: Lite Emulator of Grid Operations (LEGOS) Demonstrators
    b. **#2:** Whiteboard
    c. **#3:** Classroom at school
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
    a. **#1:** Marketing via the Gymnasium
7. **Employer feedback:** N/A
8. **Alumni engagement:** N/A

Learning and teaching model

1. **Admission requirements:** No requirements
2. **Training goals:**
    a. Training goal #1: Generate interest in STEM subject
    b. Training goal #2: First introduction to the energy system

   c. Training goal #3: Introduction to the operation and issues of the energy grid
3. **Program content - Syllabus elements in ICT/ Digital:** N/A
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** CONTROL – Control systems
   b. **#2:** CONTROL – Distributed Control
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ELECTRICAL ENGINEERING - configuration of RES Installations
   b. **#2:** ELECTRICAL ENGINEERING – Electrical instrumentation
   c. **#3:** ELECTRICAL ENGINEERING - Electrical Substations
   d. **#4:** ELECTRICAL ENGINEERING - Electrical design
   e. **#5:** ELECTRICAL ENGINEERING - Electrical engineering
   f. **#6:** ELECTRICAL POWER SYTEMS – power plants, lines and substations
   g. **#7:** ELECTRICAL POWER SYTEMS – RES (Solar Energy, wind energy)
   h. **#8:** ENERGY MANAGEMENT & GREEN SKILLS - Energy transition
   i. **#9:** ENERGY MANAGEMENT & GREEN SKILLS – RES (Solar Energy, wind energy)
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS - Teamwork
   b. **#2:** HUMANITIES & ETHICS - Critical thinking
   c. **#3:** TRANVERSAL PROFESSIONAL SKILLS - Problem Solving
7. **Program content - Re-use of training modules:** Yes – Science night
8. **Program content - Intellectual Property Rights:** Material is open to public.
9. **Methodologies:** Practical learning, Interactive lecture, Discussion-based learning
10. **Teaching methods:** Practical exercises, Problem solving
11. **Evaluation methods:** No
12. **Internships:** No
13. **Scheduling:** Part-Time

Program Content

In the first part of the workshop, the students familiarize themselves with the topics of energy transition and digitalisation by means of an interactive lecture. Firstly, through an introduction to the topics of digitalisation and the energy transition itself. Subsequently, the students will work out together how digitalisation in the energy sector supports or enables the energy transition. This is done based on future strategies, such as load management or small island grids as DC-neighbourhood using IoT.

In a second part, the participants will have the chance to visually see the effects of small changes in the power grid using the Lite Emulator of Grid Operations (LEGOS) developed by RWTH. LEGOS is a multi-layered learning platform for demonstrating use cases of smart energy services. It consists of nodes that allow the connection of up to 6 branches and one unit (generator, consumer, storage, ...). Each branch is an active component that enables measurement and control of the energy flow between two units. The LED strips on the branches allow visualization of the magnitude and direction of the current flow through their activation patterns. Each unit can be controlled remotely through haptic interaction or as an IoT device.

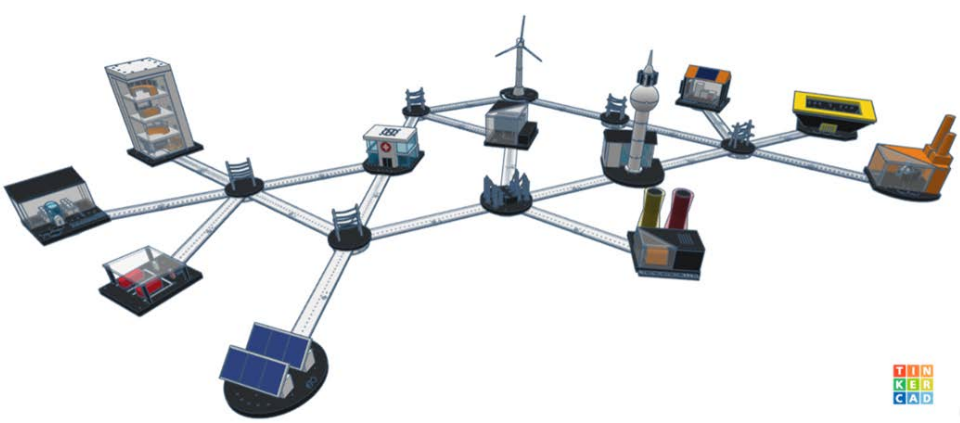


Figure 3 LEGOS Platform developed by RWTH Aachen University

With the help of some simple tasks, the pupils will learn independently about the basic interrelationships in the electrical grid. First, they should set up a simple power supply by connecting the individual nodes and branches with each other. In doing so, they should identify the relationship between voltage, current and resistance and determine the generated and consumed power. After this introduction, they will gain an initial understanding of the stability of the power grid by simulating short circuits at various points and working together to find the best solutions to ensure reliability of supply in the event of a short circuit. The last part deals with the integration of renewable energies as decentralized power plants.

Figure 4 LEGOS Node

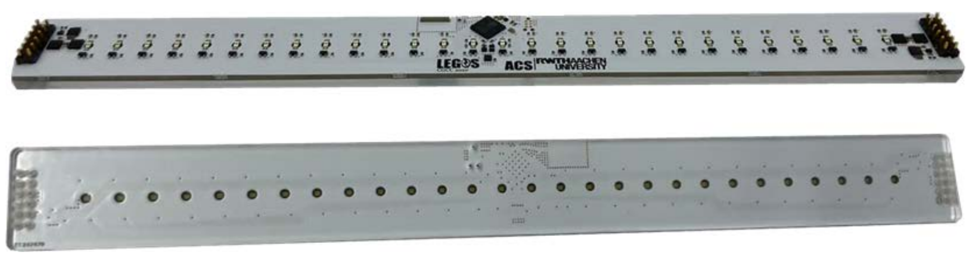


Figure 5 LEGOS Branch

Figure 6 Connected nodes and branches

<u>Main Findings</u>

The “Gymnasium Workshop” activity aimed to enhance participants’ understanding of the energy grid and the digitalization of the energy transition. The survey results from the event indicate that the activity was successful in achieving these objectives, but also highlighted areas for further improvement.

The majority of participants reported gaining a better understanding of the energy grid after the workshop. This suggests that the workshop content was effective in conveying complex concepts related to the energy grid. Furthermore, most participants agreed that their awareness of the digitalization of energy transition had been enhanced, indicating that the workshop successfully highlighted the role of digitalization in modern energy systems. However, the survey results also revealed a lack of interest among participants in working in the field of energy technology, with more participants disagreeing than agreeing when asked if they could imagine themselves working in this field. This suggests that while the workshop was effective in enhancing understanding and interest in energy networks and the digitalization of the energy transition, it was less successful in inspiring participants to consider careers in energy technology. It may be also due to a lack of understanding of what energy technology and energy transition covers topic wise, or a lack of exposure to these topics in school, as indicated by majority of participants reporting that the topic of energy grids or electrical engineering had not been covered in other school subjects.

It was noticed by the conductors that the LEGOS demo could has some areas of improvements to address the topic of smart grids. This could include the integration of a smart house entity into the smart grit to show younger participants the influence they can have on the energy grid by being a prosumer.

In conclusion, the “Gymnasium Workshop” activity successfully engaged participants in understanding the complexities of the energy grid and the role of digitalization in the energy transition. However, the activity was less successful in inspiring interest in careers in energy technology. These findings suggest that future iterations of the workshop could benefit from a greater focus on career exploration and a clearer explanation of the breadth of topics covered by energy technology and energy transition. Despite these challenges, the positive response to the structure and organization of the workshop, with 100% of participants expressing satisfaction, indicates that the workshop’s approach is fundamentally sound and provides a strong foundation for future improvements.

Table 6 Summary of Gymnasium Workshop

Summary	Main remarks
Success factors	• Enhancement of understanding of the current and future energy grid • Motivation of student to follow STEM topics • Collaboration between university and high school
Areas of improvements	• Integration of more digital functions into the LEGOS demo
Recommendations	• Expose more students to the topic of digital energy • Presentation of studies and job opportunities in digital energy

2.2.4. SmartMilano

SmartMilano is an educational project between the students of the school Gymnasium Würselen in Würselen, Germany and Liceo linguistico d’Arconate e d’Europa in Arconate MI, Italy. ACS is the expert in this program and provides the students the LEGOS demonstrator. In this program German and Italian students work in tandem groups to create materials for a digital EduBreakout (created with Genial.ly) published on the European eTwinning platform on the topic of sustainable energy supply in cities focusing on the city Milan. The project schools are guided by the EU's 2022 Competence Framework for Sustainability (GreenCOMP). The EduBreakout is intended to be available for future students.

<u>**Program fact sheet**</u>

1. **Name of program:** SmartMilano
2. **Program format:** Blended
3. **Program language:** German and Italian
4. **Length of program:** 3 months
5. **Student´s estimated effort in working hours:** 10-20
6. **Industrial challenges addressed 1. - Economic and organizational:** Goals/ target-tracking
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Technology integration (compatibility with existing processes/ technologies)

9. **Industrial challenges addressed 4. - Energy system:** Network planning: Digital tools for network planning, Network operation: Automatic fault indicators
10. **Industrial challenges addressed 5. - Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** Promoting young talent
12. **Skill gap area:** N/A
13. **ISCED code of program content:**
    - **a. #1:** 0713 Electricity and energy
    - **b. #2:** 0714 Electronics and automation
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (Pre-career stage)
18. **EQF level:** 2-3
19. **Lifelong learning and certification:**
    - **a.** Is it possible to combine the program with a job? No
    - **b.** Does the program provide credits (ECTS)? No
    - **c.** Is it modularized? No
    - **d.** Does it provide any certification per module? No
20. **Certification:** N/A

Business and operational model

1. **Relevance of program:**
    - **a. #1:** raising interest and awareness around the young generation, on modern power systems engineering and energy transition topics
    - **b. #2:** promoting young talent to work in a pan-European setting
    - **c. #3:** pointing out solutions for a sustainable and secure energy supply in a bilingual setting
2. **Definition of targets:**
    - **a.** Name the skills you target: electricity and energy
    - **b.** Enter their ESCO codes: N/A
    - **c.** Name the occupations you target: N/A
    - **d.** Enter their ESCO codes: N/A
    - **e.** Name the tools and systems that you target: N/A
3. **Financial structures:** N/A
4. **Use of resources:**
    - **a. #1:** physical facilities at ACS, seminar room
    - **b. #2:** research assistant and Professor from ACS as experts
    - **c. #3:** LEGOS
    - **d. #4:** Availability of needed IT-tools for students and teachers
5. **Licenses for digital tools:** Yes
6. **Marketing and student recruiting procedures:**
    - a. **#1:** Dissemination in schools by teachers
7. **Employer feedback:** N/A
8. **Alumni engagement:**
    - **a. #1:** Participants and teachers can use the eTwinning platform for future educational purposes

Learning and teaching model

1. **Admission requirements:** No requirements
2. **Training goals:**
    - **a.** Training goal #1: Awareness-raising on the topic of the energy transition and renewable energies
    - **b.** Training goal #2: Introduction to digitalisation of the energy grid
    - **c.** Training goal #3: Introduction to the operation and issues of the energy grid
    - **d.** Training goal #4: Bilingual exchange between students
    - **e.** Training goal #5: Generate interest in STEM subjects and promote young talent
3. **Program content - Syllabus elements in ICT/ Digital:** N/A

4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
    a. **#1:** CONTROL – Control system
    b. **#2:** ELECTRICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
5. **Program content - Syllabus elements in Energy:**
    a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
    b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS – RES (Solar Energy, wind energy)
    c. **#3:** ENERGY MANAGEMENT & GREEN SKILLS – Regulation & new Business Models
    d. **#4:** Electrical Engineering - configuration of RES Installations
    e. **#5:** Electrical Engineering - Electrical design
    f. **#6:** Electrical Engineering - Electrical engineering
6. **Program content - Syllabus elements in transversal skills:**
    a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS –Teamwork
    b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Problem solving
    c. **#3:** HUMANITIES & ETHICS – Critical thinking
    d. **#4:** HUMANITIES & ETHICS – Volunteering & cooperation
    e. **#5:** FOREIGN LANGUAGES – French, German, others
7. **Program content - Re-use of training modules:** Yes, use of produced educational materials
8. **Program content - Intellectual Property Rights:** All material are open to public**.**
9. **Methodologies:** Practical learning, Problem-based learning, Worked examples, Interactive lecture, Discussion-based learning, Scenario-based leraning
10. **Teaching methods:** Practical exercises, Problem solving
11. **Evaluation methods:** Projects
12. **Internships:** No
13. **Scheduling:** Self-paced

Program Content

The project work is divided into two student groups. The first group is tasked with creating an educational video on energy exchange in a city between consumers and producers. LEGOS is utilized as a model to represent Smart Cities and serves as an explanatory tool for video recording. The explanations in the video are bilingual, in German and Italian. To produce the videos, German students visit the ACS institute on 31.10.2023 to develop scenarios. Simultaneously, Italian students in the group provide support by translating Italian-language explanations for the subtitles.

The second student group is responsible for crafting bilingual quiz questions for the videos, which are then adapted for educational purposes using the Edpuzzle app. The Edpuzzle is created via Veggian. This group also undertakes the research for a collaborative video conference scheduled for 01.12.2023, featuring Prof. Monti as the energy expert. The two key questions addressed during the conference are:

- Milan: How does energy supply work in the big city?
- What might the future of energy supply look like?

The agenda for the video conference is as follows:

1. General Introduction to the Energy Grid (past and future) by Prof. Monti.
2. Presentation by students showcasing their work with the LEGOS Model.
3. Q&A: Students asking questions to Prof. Monti in both Italian and German, focusing on general inquiries related to the Energy Grid topic.

The video conference is recorded and incorporated into the educational materials. Additionally, all educational materials produced in the project will be accessible on the European eTwinning platform as an EduBreakout.

Main Findings

The activity fostered the collaboration of high school students in the 12th grade from two countries on the topic of energy grids. The students successfully collaborated bilingually to create educational material and deepen their understanding of the changes in the energy grid. The majority of the participants expressed a desire to participate in such an event again. This indicates that the project is addressing the students in the right framework and creates a collaborative environment. In addition, the project created an opportunity for students to build a network with foreign high school students and build a first connection to the university.

The activity aimed to enhance the understanding of energy grids and the digitalization of energy systems among students. The survey results provide valuable insights into the effectiveness of this initiative, with the majority of the respondents agreeing that their understanding has improved, and they desire to learn more about it. However, the activity had a mixed impact on the participants' interest in the topic. The results show that the majority of participants could not imagine themselves working in the energy sector in the future but are interested in learning more about specific professional figures, indicating the need to transfer and explain the needed job profiles of the digital energy sector in high school.

The participants were generally satisfied with the implementation of the SmartMilano project in terms of using the LEGOS demo. Also, the teachers from the school were very happy to have access to a demonstrator focusing on smart grids. Overall, this cooperation between the school and university was very welcomed and further projects like this are wanted. It was noticed by the conductors that the LEGOS demo could has some areas of improvements to address the topic of smart grids. This could include digital functions like showing the real time consumption and production of entities in the grid. Also, the consideration of vertical hierarchic roles of DSO and TSO through the integration of double LED strips in the branches of the model (see current branch in Figure 5).

In conclusion, the Smart Milano activity has been effective in enhancing the participants' understanding of energy networks and the digitalization of energy systems. However, more efforts may be needed to increase their interest in the topic of digital energy and to encourage them to consider careers in the energy sector. The feedback provided by the participants can be used to further improve activities of this type.

Table 7 Summary of SmartMilano

Summary	Main remarks
Success factors	• Enhancement of understanding of the current and future energy grid • Motivation of student to follow STEM topics • Collaboration and networking between German and Italian students • Collaboration between university and high school
Areas of improvements	• Integration of more digital functions into the LEGOS demo • Integration of vertical hierarchic roles (DSO and TSO) into the LEGOS demo
Recommendations	• Expose more secondary level students to the topic of digital energy • Presentation of studies and job opportunities in digital energy

2.2.5. Science Night at RWTH

The Science Night is a yearly event hosted by the RWTH and its Institutes with numerous lectures, experiment stations and exhibit booths to illustrate scientific topics to everyone in a tangible way. It is an open event with a wide target audience including children, parents, students, experts, and academics Also ACS is part of this with a presentation on digital energy and a stand displaying the LEGOS demonstrator.

Program fact sheet

1. **Name of program:** Wissenschaftsnacht (Eng. Science Night)
2. **Program format:** On campus / On-site
3. **Program language:** German
4. **Length of program:** 1 day

5. **Student´s estimated effort in working hours:** 5h
6. **Industrial challenges addressed 1. - Economic and organizational:** Goals/ target-tracking
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Technology integration (compatibility with existing processes/ technologies)
9. **Industrial challenges addressed 4. - Energy system:** Network planning: Digital tools for network planning
10. **Industrial challenges addressed 5. - Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** N/A
13. **ISCED code of program content:**
    - **a. #1:** 0099 Generic programmes and qualifications not elsewhere classified
    - **b. #2:** 0031 Personal skills and development
    - **c. #3:** 0713 Electricity and energy
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (Pre-career stage), Employees (Mid-career stage), Professionals between jobs
18. **EQF level:** 1-8
19. **Lifelong learning and certification:**
    - **a.** Is it possible to combine the program with a job? Yes
    - **b.** Does the program provide credits (ECTS)? No
    - **c.** Is it modularized? No
    - **d.** Does it provide any certification per module? No
20. **Certification:** N/A

<u>**Business and operational model**</u>

1. **Relevance of program:**
    - a. **#1:** Public relations work
    - **b. #2:** visibility of scientific issues
    - **c. #3:** raising public awareness of energy technology and digital issues
    - **d. #4:** pointing out solutions for a sustainable and secure energy supply
2. **Definition of targets:**
    - **a.** Name the skills you target: electricity and energy
    - **b.** Enter their ESCO codes: N/A
    - **c.** Name the occupations you target: N/A
    - **d.** Enter their ESCO codes: N/A
    - **e.** Name the tools and systems that you target: N/A
3. **Financial structures:** N/A
4. **Use of resources:**
    - **a. #1:** Presentation
    - **b. #2:** Energy grid demonstrator (LEGOS)
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
    - **a. #1:** RWTH Aachen webpage
    - **b. #2:** Information flyers and posters in the city of Aachen
    - **c. #3:** Advertisements in local newspapers
7. **Employer feedback:**
    - **a. #1:** Questionnaire on the program presented
    - **b. #2:** Evaluation of the questionnaires
8. **Alumni engagement:** N/A

<u>**Learning and teaching model**</u>

14. **Admission requirements:** No requirements
15. **Training goals:**

  - **a.** Training goal #1: Awareness-raising on the topic of the energy transition and renewable energies
  - **b.** Training goal #2: Introduction to digitalisation of the energy grid
  - **c.** Training goal #3: Introduction to the operation and issues of the energy grid
16. **Program content - Syllabus elements in ICT/ Digital: /**
17. **Program content - Syllabus elements in another STEM than ICT/Digital:**
    - **a.** **#1:** CONTROL – Control system
    - **b.** **#2:** CONTROL – Distributed Control
18. **Program content - Syllabus elements in Energy:**
    - a. **#1:** ELECTRICAL ENGINEERING - configuration of RES Installations
    - b. **#2:** ELECTRICAL ENGINEERING - Electrical Substations
    - c. **#3:** ELECTRICAL ENGINEERING - Electrical design
    - d. **#4:** ELECTRICAL ENGINEERING - Electrical engineering
    - e. **#5:** ELECTRICAL POWER SYSTEM - RES (Solar Energy, wind energy)
    - f. **#6:** ELECTRICAL POWER SYSTEM - power plants, lines and substations
    - g. **#7:** ENERGY MANAGEMENT & GREEN SKILLS - Energy transition
19. **Program content - Syllabus elements in transversal skills:**
    - a. **#1:** Humanities & Ethics - Critical thinking
    - b. **#2:** Transversal Professional Skills - Problem Solving
20. **Re-use of training modules:** Yes – Training modules used from the Gymnasium Workshop
21. **Intellectual Property Rights:** No
22. **Methodologies:** Magistral lecturing, Interactive lecture, Discussion-based learning, Worked examples
23. **Teaching methods:** Magistral lectures, Practical lab sessions
24. **Evaluation methods:** No evaluation necessary
25. **Internships:** No
26. **Scheduling:** Evening attendance

Program Content

The Science Night first includes an introduction to the topic of electricity grids by means of a presentation. The presentation entitled "Active customers for active grids" shows the changes in the distribution grid due to the increasing number of distributed generation plants. The focus will also be on grid stability and the associated role of customers. The audience will learn about the increasingly active role of customers in the electricity market due to decentralized small power plants and solutions such as smart meters. The digitalisation of the energy system serves as a key function for active customers and the concept of the energy community promoted by the European Commission. To this end, the presentation will introduce reference solutions such as the SOGNO software platform developed by RWTH Aachen University, which has received an award. Finally, some examples show first solutions for the active integration of customers through digitalisation measures.

In a second part, the participants will have the chance to visually see the effects of small changes in the power grid using the Lite Emulator of Grid Operations (LEGOS) developed by RWTH. LEGOS is a multi-layered learning platform for demonstrating use cases of smart energy services. It consists of nodes that allow the connection of up to 6 branches and one unit (generator, consumer, storage, ...). Each branch is an active component that enables measurement and control of the energy flow between two units. The LED strips on the branches allow visualization of the magnitude and direction of the current flow through their activation patterns. Each unit can be controlled remotely through haptic interaction or as an IoT device. The activity “Gymnasium Workshop” use the same LEGOS demonstrator.

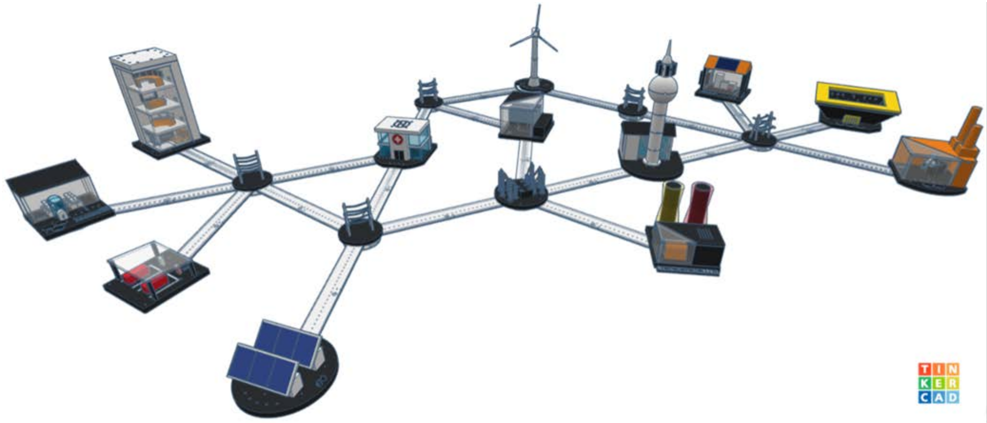


Figure 7 LEGOS Demonstrator developed by RWTH Aachen University

Main Findings

The “Science Night at RWTH” activity aimed to enhance participants’ understanding of electricity grids and the role of customers in maintaining grid stability. The activity utilized a presentation and the Lite Emulator of Grid Operations (LEGOS) developed by RWTH to visually demonstrate the effects of small changes in the power grid.

The survey results from the event indicate that the activity was successful in achieving its objectives. All participants agreed that the model effectively demonstrated the interactions in the grid, and almost all agreed that the visualization of power flow was helpful. The LEGOS demonstrator was particularly effective in teaching about the flow of energy in the grid. The vast majority (32 out of 35 participants) reported that they learned about this topic. The demonstrator also helped 23 participants understand the role of participants in the grid and 20 participants grasp the dynamics in energy consumption. However, fewer participants reported learning about the transmission of measurement information, digital energy transition, and grid stability from the demonstrator.

Participants appreciated the stable structure, interactivity, and vividness of the LEGOS demonstrator. They also liked the diversity of participants represented in the model, particularly in the hospital context. However, some participants pointed out areas for improvement, such as the stability of contacts, the size of the model, and the absence of a dashboard.

In conclusion, the “Science Night at RWTH” activity successfully engaged participants in understanding the complexities of the energy grid and the role of customers in maintaining grid stability. The LEGOS demonstrator proved to be an effective tool for visually illustrating these concepts. However, the survey results suggest that the demonstrator could be improved to better teach about certain topics, such as the transmission of measurement information, digital energy transition, and grid stability. These findings provide valuable insights for the future development of the LEGOS demonstrator and similar educational tools.

Table 8 Summary of Science Night at RWTH

Summary	Main remarks
Success factors	• Reach of broad audience including children of all ages and adults • Enhancement of understanding of volatile integration of wind energy into the grid
Areas of improvements	• Integration of more digital functions into the LEGOS demo
Recommendations	• Consistent involvement in this and similar exsisting programs

2.2.6. Workshop on Data Platforms for the Energy Infrastructure

Together with the Institute for Electro Mobility of the Bochum University of Applied Sciences, ACS will organize a workshop on open source data platform for the energy infrastructure in the IDEASFORUM e.V. of the City of Herne. The workshop will give a general overview of the challenges of data management targeting pupils form industry and municipality as well as citizens. The focus will be the presentation of smart city applications with FIWARE and Message Queue Telemetry Transport (MQTT) and the display of different functions with demonstrators. Part of the workshop will be a general introduction to FIWARE as well as MQTT, practical examples and demonstrations of smart city applications and the presentation of smart energy business models.

Program fact sheet

1. **Name of program:** FIWARE Workshop
2. **Program format:** On campus / On-site
3. **Program language:** English
4. **Length of program:** half day
5. **Student´s estimated effort in working hours:** 4h
6. **Industrial challenges addressed 1. - Economic and organizational:** Business model adaptation, Low top management commitment, Goals/ target-tracking
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Technology integration (compatibility with existing processes/ technologies), Lack of adequate skills from employees
9. **Industrial challenges addressed 4. - Energy system:** Network planning: Digital tools for network planning, Customers: Remote metering
10. **Industrial challenges addressed 5. - Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Programming and development competences, Data management and analysis, Big Data
13. **ISCED code of program content:**
    a. **#1:** 0688 Inter-disciplinary programmes and qualifications involving Information and Communication Technologies (ICTs)
    b. **#2:** 0713 Electricity and energy
14. **Starting point of program design:** Both
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Employees (Mid-career stage), Professionals between jobs
18. **EQF level:** 5/6
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? Yes
    b. Does the program provide credits (ECTS)? No
    c. Is it modularized? Yes
    d. Does it provide any certification per module? No
20. **Certification:** N/A

Business and operational model

1. **Relevance of program:**
    a. **#1:** Increase the citizen involvement in smart city applications
    b. **#2:** Give an introduction in smart city platforms
    c. **#3:** Reach interested people in the area of smart city
2. **Definition of targets:**
    a. Name the skills you target: electricity and energy
    b. Enter their ESCO codes:
    c. Name the occupations you target: Electrical Engineers, Electronics Engineers, Information and Communications Technology Operations and User Support Technicians
    d. Enter their ESCO codes: 2151, 2152, 351
    e. Name the tools and systems that you target: IoT communication protocols
3. **Financial structures:** N/A
4. **Use of resources:**

   a. **#1:** Physical facilities from the City of Herne
   b. **#2:** Demonstrator objects
   c. **#3:** FIWARE Platform
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
   a. **#1:** On the IDEASFORUM e.V. website
   b. **#2:** Distribution among the members of the IDEASFORUM e.V.
7. **Employer feedback:** N/A
8. **Alumni engagement:**
   a. **#1:** Participants can get a member of the IDEASFORUM e.V.
   b. **#2:** Participants can get a member of the FIWARE Foundation

Learning and teaching model

1. **Admission requirements:** No requirements
2. **Training goals:**
   a. Training goal #1: Give an introduction to the FIWARE Platform
   b. Training goal #2: Provide insights into smart city applications with demonstrations
   c. Training goal #3: Provide insights into smart energy business models
3. **Program content - Syllabus elements in ICT/ Digital:**
   a. **#1:** INFORMATION TECHNOLOGY – Networking, communications, and security
   b. **#2:** INFORMATION TECHNOLOGY – New Trends in Information Technology
   c. **#3:** EMBEDDED SYSTEMS – Wireless sensor and Networks
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** CONTROL – Digital Control
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – RES (Solar Energy, wind energy)
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS – Regulation & new business models
   c. **#3:** ENERGY MANAGEMENT & GREEN SKILLS – Flexible demand and Smart home/buildings
   d. **#4:** ENERGY MANAGEMENT & GREEN SKILLS – Assembly management of RES
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS – Problem solving
   b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Computer Technology
7. **Program content - Re-use of training modules:** Not clear yet
8. **Program content - Intellectual Property Rights:** Material is open to public.
9. **Methodologies:** Magistral lecturing, Worked examples, Interactive lecture, Discussion-based learning
10. **Teaching methods:** Magistral lectures, Practical exercises, Problem solving
11. **Evaluation methods:** Other – Interactive surveys, questionnaire
12. **Internships:** No
13. **Scheduling:** Self-paced

Program Content

Energy grids are becoming increasingly complex due to the growing decentralization and volatility of energy generation as well as the necessary flexibility. As a result, digital, efficient and smart technology solutions are needed to enable the long-term transition to an economical and renewable energy system as well as security of supply.

The workshop deals with the important role of open source data platforms and business models for the necessary change of the energy grid in the context of the energy transition. The open source technologies MQTT (Message Queuing Telemetry Transport) and FIWARE will be presented for use in smart energy networks. Physical demonstrators are presented to illustrate the functions and fields of application. The LEGOS demonstrator, supported by visual live graphs, is showcased for the MQTT application. For the FIWARE application, Functional Miniature Models of the climate quarter in Herne are presented (see Figure 8). The development of business models in connection with smart cities are also discussed.

Figure 8 Functional Miniature Models of the climate quarter in Herne developed by Bochum University

The workshop is dedicated to the following questions:

- What challenges in data management does the energy grid have to face in the context of the energy transition?
- What role do open source technologies play in smart energy grids?
- What are concrete examples of the use of open source technologies such as MQTT and FIWARE?
- What role do business models for smart city solutions play in the energy transition?

In short presentations by different speakers, impulses are given, and current concepts are presented. Participants have the opportunity to network with each other and with the speakers. The following table gives an overview of the speakers:

Table 9 Overview of the content at Workshop on Data Platforms for the Energy Infrastructure

Content	Speaker	Institution
Open source data platforms for energy infrastructure	Antonello Monti	ACS, RWTH Aachen University
FIWARE	Haydar Mecit	Institute for Electro Mobility, Bochum University of Applied Sciences
MQTT and LEGOS	Jonathan Klimt	ACS, RWTH Aachen University
Smart city business models	Leonie Wegener	Institute for Electro Mobility, Bochum University of Applied Sciences
Functional Miniature Models of climate quarter Herne	Martin Neuwirth	Institute for Electro Mobility, Bochum University of Applied Sciences

Main Findings

The participants' understanding of various topics was assessed through questionnaires administered before and after the workshop. The results showed a significant increase in knowledge across several areas. In terms of technical understanding, the participants showed an average improvement in their knowledge of electrical energy generation by solar cells from photovoltaic systems, understanding of stationary battery storage, knowledge of electric cars as consumers, and understanding of technical correlations of a solar-battery-consumer system.

The workshop also had a substantial impact on the participants' understanding of smart grids. This is a crucial aspect of the digitalization of energy systems and networks, indicating that the workshop was successful in enhancing the participants' ICT skills in this area. In the context of smart city solutions in the energy transition, the participants' understanding of business concepts improved by 58.33% on average. This suggests that the workshop was effective in providing insights into the practical applications and business models of smart city technologies.

After the deployment of the LEGOS in previous pilot activities the integration of the real time visualisation of the current consumption and production of the entities was in place and well received by the participants. Hence, for a smother demonstration some further adjustments are needed.

Finally, the participants' knowledge of open-source technologies like MQTT and FIWARE had the most significant increase. This demonstrates the effectiveness of the workshop in promoting the use of open-source technologies in the energy sector. In conclusion, the workshop was successful in enhancing the participants' understanding of various aspects of the energy infrastructure, from technical details to business concepts and open-source technologies.

Table 10 Summery of Workshop on Data Platforms for the Energy Infrastructure

Summary	Main remarks
Success factors	• Enhancement of understanding in smart energy topics • Participation of stakeholders from the municipality and industry
Areas of improvements	• Integration of more digital functions into the LEGOS demo
Recommendations	• Dissemination of demo objects to citizens of Herne

2.2.7. Leonardo lecture on energy transition

The Leonardo lecture series “Energy Transition – Potential Tension between Economy, Politics and Science” at RWTH is an interdisciplinary teaching series of lectures open to all students. Lecturers from different scientific backgrounds and industry collectively offer this course to a broad audience by highlighting different parts of the energy transition. Depending on the study regulations and performance, 2 ECTS credits can be acquired through participation and a protocol with a critical analysis. In addition, a Certificate of Participation (0 ECTS, not graded) is possible. The main part of this pilot activity is the lecture “Digital Energy Revolution” by Prof. Monti from the Institute for Automation of Complex Power Systems highlighting the topic digitalisation of the energy system and the lecture “Urban Electrical Energy Systems” by Prof. Ponci from the Teaching and Research Area Monitoring and Distributed Control for Power Systems.

<u>**Program fact sheet**</u>

1. **Name of program:** Energiewende (engl. Energy Transition)
2. **Program format:** On campus / On-site
3. **Program language:** german/english
4. **Length of program:** 6 months
5. **Student´s estimated effort in working hours:** 60
6. **Industrial challenges addressed 1. – Economic and organizational:** Goals/ target-tracking
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. – Technical and regulatory:** Data management, Technology integration (compatibility with existing processes/ technologies)
9. **Industrial challenges addressed 4. - Energy system:** Customers: Dedicated information about their energy profile, Digital tools for network planning
10. **Industrial challenges addressed 5. - Extreme situations:** No
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Programming and development competences, Data management and analysis
13. **ISCED code of program content:**
    a. **#1:** 0520 Environment not further defined
    b. **#2:** 0713 Electricity and energy
    c. **#3:** 0488 Inter-disciplinary programmes and qualifications involving business, administration and law
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A

17. **Target groups:** Students (Pre-career stage)
18. **EQF level:** 6-7
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? No
    b. Does the program provide credits (ECTS)? Yes
    c. Is it modularized? No
    d. Does it provide any certification per module? No
20. **Certification:** Certificate of Accomplishment

Business and operational model

1. **Relevance of program:**
    a. **#1:** Convey the challenges, possibilities and concepts related to the digitalisation and transformation of the energy sector.
    b. **#2:** Highlight current discourses and challenges in the context of energy (policy).
    c. **#3:** Reaching a wide range of interdisciplinary students and creating a discussion forum about the energy transition.
    d. **#4:** Connect students, research and industry stakeholders with each other to discuss the energy transition.
    e. **#5:** Promoting the empowerment of students to use their subject-specific knowledge in a broader context to tackle global and societal challenges and thus to solve problems with responsibility.
2. **Definition of targets:**
    a. Name the skills you target: electricity and energy
    b. Enter their ESCO codes: N/A
    c. Name the occupations you target: N/A
    d. Enter their ESCO codes:N/A
    e. Name the tools and systems that you target: understanding the challenges and opportunities of the energy transition
3. **Financial structures:**
    a. **#1:** Payment of RWTH external lectures from a dedicated RWTH Leonardo fund
4. **Use of resources:**
    a. **#1:** Physical facility on the campus of RWTH
    b. **#2:** Online Moodle course room with educational materials and additional information
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
    a. **#1:** Distributing the course program among all students of the RWTH in the beginning of the semester by Mail from Human Technology Center
    b. **#2:** Leonardo lecture website with information
7. **Employer feedback:** N/A
8. **Alumni engagement:**
    a. **#1:** Students of the summer school will become part of the alumni network of the RWTH International Academy with exclusive updates and a alumni newsletter.
    b. **#2:** Possibility to continue to participate in career events and benefit from the job postings.
    c. **#3:** Students have the possibility to stay connected with other graduates at Alumni events and expand their professional network.
    d. **#4:** Former students of the summer school can become a business partner in the job portal and search the talent database or the Career Center events for promising candidates.

Learning and teaching model

1. **Admission requirements:** High school diploma
2. **Training goals:**
    a. **Training goal #1:** The students know the technical possibilities as well as the hurdles on the way to a CO2-neutral power generation and future-oriented power distribution.
    b. **Training goal #2:** The students understand the different requirements for distribution and transmission grids and can thus comprehend the debate on grid expansion or grid restructuring.

   c. **Training goal #3:** The students learn to evaluate the tensions arising from the complete realignment of the energy sector and the social and economic requirements.
   d. **Training goal #4:** The students are able to look at issues regarding the energy transition from different angles.
   e. **Training goal #5:** The students are able to carry out reflections on the future energy supply.
3. **Program content - Syllabus elements in ICT/ Digital:**
   a. **#1:** INFORMATION TECHNOLOGY – New Trends in Information Technology
   b. **#2:** CONTROL – Digital control
   c. **#3:** CONTROL – Remote Control and Automation
   d. **#4:** ENGINEERING PROJECTS & REPORTS – Papers, reports
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** ENGINEERING PROJECTS & REPORTS – Papers, reports
   b. **#2:** HEAT & COOLING ENGINEERING – Heat & Cooling installations
   c. **#3:** CONTROL – Control systems
   d. **#4:** ELECTRICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
   e. **#5:** MECHANICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS – Flexible demand and Smart home/building
   c. **#3:** ELECTRICAL POWER SYSTEMS – Grid Development in the area of Smart Grids
   d. **#4:** ELECTRICAL POWER SYSTEMS – Optimal Power Flow, systems operation & control
   e. **#5:** ELECTRICAL POWER SYSTEMS – RES (Solar Energy, wind energy)
   f. **#6:** ELECTRICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
   g. **#7:** MECHANICAL ENGINEERING – Power Plant (conventional and RES) Operation and Maintenance
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** FOREIGN LANGUAGES – English (mandatory)
   b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Verbal & written communication
   c. **#3:** HUMANITIES & ETHICS – Critical thinking
   d. **#4:** MANAGEMENT & BUSINESS - Economy of Energy, Markets and Regulation
7. **Program content - Re-use of training modules:** Yes, other similar lecture (t.b.d.)
8. **Program content - Intellectual Property Rights:** All contents are protected by copyright. They may only be used within the limited circle of participants of the Moodle learning room and for private purposes. Sharing the content beyond the limited group of participants in the Moodle learning room thus constitutes publication subject to permission.
9. **Methodologies:** Magistral lecturing, Interactive lecture, Discussion-based learning
10. **Teaching methods:** Magistral lectures, Personal study
11. **Evaluation methods:** Other - Report
12. **Internships:** No
13. **Scheduling:** Full-Time

Program Content

In the context of the lecture series "Energy Transition – Potential Tension between Economy, Politics and Science", current discourses and challenges in the context of energy (policy) are highlighted and discussed. Different forms of energy as well as their production and supply mechanisms are also considered. The political and economic interests are considered and compared with the technical feasibility. Different fields of action and approaches to solutions are discussed from an interdisciplinary point of view. An overview of actors in the energy industry, regional energy production in Aachen and current research issues will be provided. The final discussion is prepared by questions of the students in the course of the module. For this, students collect points in the first two months, which will be discussed in the last event.

The general program is organized by RWTH Human Technology Center, whereas the content outline is organized by Prof. De Doncker from E.ON Energy Research Center, RWTH Aachen. In the following table is the list of lectures and lecturers:

Table 11 List of lectures in the Leonardo lecture series "Energy Transition – Potential Tension between Economy, Politics and Science"

	Content	Speaker	Institution
1	Introduction and Information	Prof. Rik De Doncker	E.ON Energy Research Center, RWTH Aachen
2	Flexible electrical Grids for the Energy Transition – *English session*	Prof. Rik De Doncker	E.ON Energy Research Center, RWTH Aachen
3	Charting the Energy Future – an introduction to trends, scenario thinking and innovation strategies – *English session*	Bert Stuij, Vice President Innovation	Energy Delta Institute (NL)
4	Hydrogen Economy – considerations of efficiency, application areas and challenges	Prof. Dirk Uwe Sauer	Chair for Electrochemical Energy Conversion and Storage Systems, RWTH Aachen
5	Energy-efficient building	Prof. Dirk Müller	Institute for Energy Efficient Buildings and Indoor Climate, RWTH Aachen
6	Selected Economic Aspects and Issues of a Sustainable Energy Transition – English session	Prof. Reinhard Madlener	Institute of Future Energy Consumer Needs and Behavior, RWTH Aachen
7	**Digitalisation of the energy system – English Session**	**Prof. Antonello Monti**	**Institute for Automation of Complex Power Systems, RWTH Aachen**
8	Circular Economy 4.0: Digitization as a fire accelerator or opportunity driver for more climate protection and resource efficiency in industrial transformation?	Dr. Stephan Ramesohl	Co-Head of Research Unit Digital Transformation Division Circular Economy, Wuppertal Institute
9	**Urban Electrical Energy Systems – English Session**	**Prof. Ferdinanda Ponci**	**Teaching and Research Area Monitoring and Distributed Control for Power Systems, RWTH Aachen**
10	How secure is our energy supply?	Prof. Aaron Praktiknjo	Energy Resource and Innovation Economics, RWTH Aachen
11	Energy Transition: Goals, ways and challenges	Dr. Frank-Detlef Drake	E.ON SE

The focus in this piloting activity is more on the lectures "Digital Energy Revolution" and "Urban Electrical Energy Systems". Content of the lecture "Digital Energy Revolution" is:

- Digitalisation is completely transforming the energy sector
- New options and possibilities are open at every level
- Digitalisation means also new concepts for operation that completely transform the way the grid is operated
- Open standards are key enablers for this process

Subject matter of the lecture “Urban Electrical Energy Systems” is:

- Impact and complexity of urban energy systems
- Energy communities – Types, objectives, relations and characteristics
- Performance and characteristics of Smart grids
- Different forms of local energy systems

Main Findings

The lecture “Digital Energy Revolution” focused on how digitalization is transforming the energy sector, opening new options and possibilities at every level. It emphasized the importance of open standards as key enablers for this process. The lecture “Urban Electrical Energy Systems” discussed the impact and complexity of urban energy systems, the concept of energy communities, the performance and characteristics of smart grids, and different forms of local energy systems. A quiz conducted immediately after the “Digital Energy Revolution” lecture evaluated the knowledge gained by the students. The quiz consisted of four questions, with 70% of the students answering three out of the four questions correctly. This suggests that the lecture was effective in conveying complex concepts related to the digitalization of the energy sector. However, one question related to a key ingredient for a data economy in the energy sector was answered correctly by only 29% of the students. This indicates a potential area for further emphasis or clarification in future iterations of the lecture.

In conclusion, the “Leonardo Lecture on Energy Transition” activity successfully engaged students in understanding the complexities of the energy transition and the role of digitalization in this process. The quiz results provide quantitative evidence of the effectiveness of the lecture in imparting knowledge on these topics. However, the results also highlight areas for further improvement, particularly in conveying the importance of context in a data economy in the energy sector. These findings provide valuable insights for the future development of the lecture series and similar educational initiatives.

Table 12 Summary of Leonardo Lecture on Energy Transition

Summary	Main remarks
Success factors	• Enhancement in understanding the complexities of the energy transition and the role of digitalization in this process
Areas of improvements	• Focus more on a data economy in the energy sector in future events
Recommendations	• Consistent involvement in this and similar established programs

2.2.8. Future energy systems lecture on energy digitalisation

The pilot activity “Future energy systems lecture on energy digitalisation” is a Master level course with 4 ECTS points and a highly interdisciplinary lecture series presented by different chairs. The lecture gives a comprehensive overview of the essential elements of the future energy system as well as important topics of sector coupling. In this lecture series, the Institute for Automation of Complex Power Systems has one lecture on the topic “Digitalization of the Energy System” by Prof. Monti.

Program fact sheet

1. **Name of program:** Future energy systems lecture on energy digitalisation
2. **Program format:** On campus / On-site and Online
3. **Program language:** English
4. **Length of program:** 6 months
5. **Student´s estimated effort in working hours:** 120 h
6. **Industrial challenges addressed 1. - Economic and organizational:** N/A
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Technology integration

9. **Industrial challenges addressed 4. - Energy system:**
    a. **#1:** Future energy systems
    b. **#2:** digitalization of the energy system
10. **Industrial challenges addressed 5. - Extreme situations:** N/A
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Understanding of future energy systems and their digitalization
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
    b. **#2:** 0714 Electronics and automation
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (Pre-career stage)
18. **EQF level:** 7
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? - No
    b. Does the program provide credits (ECTS)? – Yes
    c. Can you study parts of the program? - No
    d. Does it provide any certification per module? - No
20. **Certification:** N/A

<u>Business and operational model</u>

1. **Relevance of program:**
    a. **#1:** Providing comprehensive knowledge about the future energy systems and the digitalization of the energy system.
    b. **#2:** Preparing students for the challenges and opportunities in the energy sector.
2. **Definition of targets:**
    a. Name the skills you target: Understanding of future energy systems, digitalization of the energy system, power flow under high load, load-frequency control, voltage control, microgrids, etc.
    b. Enter their ESCO codes:
    c. Name the occupations you target: Energy system engineers, power system analysts, etc.
    d. Enter their ESCO codes: 2151.1
    e. Name the tools and systems that you target: Power system simulation tools, smart grid technologies, etc.
3. **Financial structures:** University Course - financed by the state North Rhine-Westphalia
4. **Use of resources:**
    a. **#1:** Classroom
    b. **#2:** Matlab / Simulink
    c. **#3:** Moodle
    d. **#4:** Jupyter
5. **Licenses for digital tools: Yes**
6. **Marketing and student recruiting procedures:**
    a. **#1:** ACS Webpage
    b. **#2:** Student event at the institute
    c. **#3:** Lecture overview
7. **Employer feedback:** N/A
8. **Alumni engagement:**
    a. **#1:** Engagement as working student possible

<u>Learning and teaching model</u>

1. **Admission requirements:**
2. **Training goals:**
    a. Training goal #1: Understand the power flow under high load, especially in strong-wind scenarios
    b. Training goal #2: Understand the challenges of a generation-driven system with more distributed generation

   c. Training goal #3: Understand the principles of primary, secondary, and tertiary load-frequency control
   d. Training goal #4: Understand the requirements for future distribution grids and the concept of microgrids
3. **Program content - Syllabus elements in ICT/ Digital:**
   a. **#1**: Digitalization of the energy system, use of smart meters, state estimation, etc.
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** Power flow under high load
   b. **#2:** Digitalization of the energy system
   c. **#3:** Hierarchical voltage control
   d. **#4:** Requirements for future distribution grids
   e. **#5:** Microgrids
5. **Program content - Syllabus elements in another STEM than ICT/Digital**:
   a. **#1:** Power flow under high load
   b. **#2:** Load-frequency control
6. **Program content - Syllabus elements in Energy:**
   a. **#1:** Future energy systems
   b. **#2:** Digitalization of the energy system
   c. **#3:** Hierarchical voltage control
   d. **#4:** Requirements for future distribution grids
   e. **#5:** Microgrids
   f. **#6:** Future of distribution grid control
7. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** Critical thinking
   b. **#2:** Problem-solving
   c. **#3:** Teamwork
   d. **#4:** Communication skills
8. **Program content - Re-use of training modules:** No
9. **Program content - Intellectual Property Rights:** All contents are protected by copyright. They may only be used within the limited circle of participants of the Moodle learning room and for private purposes. Sharing the content beyond the limited group of participants in the Moodle learning room thus constitutes publication subject to permission.
10. **Methodologies:** Practical learning, problem-based learning, Project-based learning, Worked examples, Interactive lecture, Discussion-based learning
11. **Teaching methods:** Personal study, Problem solving, Search for and select bibliographical material, data or statistics
12. **Evaluation methods:** Written examination
13. **Internships:** No
14. **Scheduling:** Part-Time

Program Content

The main teaching object is the comprehensive lecture series on “Future energy systems lecture on energy digitalisation”, with a specific focus on the lecture “Digitalization of the Energy System” by Prof. Monti. The lecture provides a deep dive into the essential elements of the future energy system and important topics of sector coupling. The lecture includes a variety of topics such as power flow under high load–strong-wind-scenario, the electrical grid of tomorrow with more distributed generation, primary, secondary and tertiary load-frequency control, hierarchical voltage control in transmission level, requirements for future distribution grids, and the concept of microgrids. The lecture also discusses the future of distribution grid control, optimized coordination for the active participation of consumers with load management, robust operation against physical attacks and cyber-attacks, and real-time monitoring of the grid state through the use of various measuring units like Smart Meter, PMU, and state estimation. The lecture is designed to be interactive, with discussions and problem-solving exercises to enhance understanding. It provides students with a comprehensive understanding of the challenges and opportunities in the energy sector, preparing them for future roles in this field.

Table 13 List of lectures for the course "Future energy systems – Part 2"

	Lectute	Speaker
1	Flexibilities and Sector Coupling in Future Energy System	Prof. Dirk Uwe Sauer
2	Fundamentals, Technologies, and Markets of Solar Thermal Power Plants	Prof. Robert Pitz-Paal
3	Fundamentals, Technologies, and Markets of Geothermal Energy for Heat and Power	Prof. Wagner & PD Dr. Frank Strozyk
4	Integrated Energy Infrastructures	Prof. Andreas Ulbig
5	Natural and Synthetic Gas Systems	Prof. Albert Moser
6	Hydrogen Economy and Fuel Cells	Prof. Egbert Figgemeier
7	Digitalisation of the Energy System	Prof. Antonello Monti
8	Distributed Intelligent Systems	Prof. Ferdinanda Ponci
9	Energy Demand and Supply Concepts in Industrial Processes and Industrial Parks	Dr.-Ing. Dominik Bongartz & Prof. Alexander Mitsos
10	Life Cycle Assessment	Prof. Aaron Praktiknjo
11	Mobility	Prof. Dirk Uwe Sauer
12	Demand, Generation, Storage, and Distribution of Heat in the Building Sector	Prof. Dirk Müller
13	Power-to-fuel technologies	Prof. Stefan Pischinger
14	New Energy Services, Business Models and Energy Policy Challenges in a 4D World	Prof. Reinhard Madlener

Main Findings

The lecture series, which includes a specific focus on the lecture "Digitalization of the Energy System" by Prof. Monti, aims to delve into the challenges and opportunities in the energy sector regarding the digitalization. The survey results from the event indicate that the activity was successful in achieving its objectives.

All participants agreed or strongly agreed that the activity raised their awareness about the digitalization of energy. Furthermore, most participants expressed interest in participating in a similar future activity, suggesting that the lecture was engaging and informative. However, the survey results also revealed mixed responses regarding the motivational aspect of the activity for further research, with 42.9% strongly agreeing, 42.9% remaining neutral, and 14.3% strongly disagreeing. This suggests that while the lecture was effective in conveying complex concepts related to the digitalization of the energy sector, it may need to incorporate additional elements to motivate students for further research. When asked about the helpfulness of the activity in providing insights and ideas for their future professional path, the responses were varied with 14.3% strongly agreeing, 28.6% agreeing, and 57.1% remaining neutral. This indicates a potential area for further emphasis or clarification in future iterations of the lecture. In terms of areas of interest for future activities, data management and analysis emerged as the top choice, followed by big data, and cybersecurity and programming.

In conclusion, the "Future Energy Systems Lecture on Energy Digitalisation" activity successfully engaged students in understanding the complexities of the energy transition and the role of digitalization in this process. However, the survey results suggest that the lecture could be improved to better motivate students for further research and provide clearer insights into future professional paths in the field of digitalization of the energy system. These findings provide valuable insights for the future development of the lecture series and similar educational initiatives.

Table 14 Summary of Future Energy Systems Lecture on Energy Digitalisation

Summary	Main remarks

Success factors	• Enhancement of understanding in smart energy topics • Motivation of students to participate in lectures related to future energy systems
Areas of improvements	• Presentation of job profiles in the field of the digitalisation of the energy systems
Recommendations	• Consistent engagement in this and similar lecture series

2.2.9. ACS lecture on automation of complex systems

The Automation of Complex Power Systems Institute at the E.ON ERC of RWTH University offers the lecture ‘‘Automation of Complex Power Systems’’. It provides an introductory course on current research topics in modern power systems. Through this course, students will gain a basic understanding of the technologies used to monitor, control and communicate complex power systems. The course can be taken from 16 different study plans within the faculties Mathematics, Computer Science and Natural Sciences, and Electrical Engineering, Information Technology, and Computer Engineering. Depending on a study plan, it can be either bachelor or master course, and ECTS can vary from 4-6 credits.

Program fact sheet

1. **Name of program:** Automation of Complex Power Systems (ACS) lecture
2. **Program format:** On campus / On-site and Online
3. **Program language:** English
4. **Length of program:** 6 months
5. **Student´s estimated effort in working hours:** 120 h
6. **Industrial challenges addressed 1. - Economic and organizational:** N/A
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Technology integration
9. **Industrial challenges addressed 4. - Energy system:**
   a. **#1**: Network operation: Automation and fault clearance
   b. **#2**: Network operation: Load Profiles
10. **Industrial challenges addressed 5. - Extreme situations:** N/A
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Programming and development competences
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
    b. **#2:** 0714 Electronics and automation
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (Pre-career stage)
18. **EQF level:** 7
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? - No
    b. Does the program provide credits (ECTS)? – Yes
    c. Can you study parts of the program? - No
    d. Does it provide any certification per module? - No
20. **Certification:** N/A

Business and operational model

1. **Relevance of program:**
   a. **#1:** Provides an overview of the necessary competence for designing the energy system of the future
   b. **#2:** Introduction into a modern power system

2. **Definition of targets:**
    a. Name the skills you target: K-knowledge - engineering, manufacturing and construction - engineering and engineering trades - electronic and automation / electricity and energy
    b. Enter their ESCO codes:
    c. Name the occupations you target: Electrical engineers - electrical engineer
    d. Enter their ESCO codes: 2151.1
    e. Name the tools and systems that you target:
3. **Financial structures:** University Course - financed by the state North Rhine-Westphalia
4. **Use of resources:**
    a. **#1:** Classroom
    b. **#2:** Matlab / Simulink
    c. **#3:** Moodle
    d. **#4:** Pingo Questions
    e. **#5:** Jupyter Hub
5. **Licenses for digital tools: Yes**
6. **Marketing and student recruiting procedures:**
    a. **#1:** ACS Webpage
    b. **#2:** Student event at the institute
    c. **#3:** Lecture overview
7. **Employer feedback:** N/A
8. **Alumni engagement:**
    a. **#1:** Engagement as working student possible

<u>Learning and teaching model</u>

1. **Admission requirements:**
2. **Training goals:**
    a. Training goal #1: Basics of automation of power systems as it is today
    b. Training goal #2: Tools to realize the transformation to a modern grid
    c. Training goal #3: Control techniques required in a modern grid
    d. Training goal #4: Interdisciplinary approach to the automation of power systems
3. **Program content - Syllabus elements in ICT/ Digital:**
    a. **#1:** PROGRAMMING LANGUAGES – C, C++, Matlab, Phthon
    b. **#2:** COMMHNICATIONS; NETWORKS & BUSES – Remote control Systems, SCADA Systems
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
    a. **#1:** CONTROL – Distributed Control
    b. **#2:** CONTROL – Control systems
    c. **#3:** CONTROL – Remote Control and Automation
    d. **#4:** MODELLING, SIMULATION & OPTIMISATION – Simulation tools (Matlab, Labview, R)
    e. **#5:** MODELLING, SIMULATION & OPTIMISATION – Modelling, simulation & optimization
5. **Program content - Syllabus elements in Energy:**
    a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
    b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS – RES (Solar Energy, wind energy)
    c. **#3:** ELECTRICAL POWER SYSTEMS – Grid Development in the area of Smart Grids
    d. **#4:** ELECTRICAL POWER SYSTEMS – Planning & Operation of future distribution networks
    e. **#5:** ELECTRICAL POWER SYSTEMS – RES (Solar Energy, wind energy)
    f. **#6:** ELECTRICAL ENGINEERING – Electrical instrumentation
    g. **#7:** ELECTRICAL ENGINEERING – Electrical engineering
    h. **#8:** POWER ELECTRONICS – Power electronics
    i. **#9:** POWER ELECTRONICS – Applications: electric drives & controllers
    j. **#10:** MODELLING, SIMULATION & OPTIMISATION – Simulation tools (Matlab, LAbview, R)
6. **Program content - Syllabus elements in transversal skills:**
    a. **#1:** HUMANITIES & ETHICS – Critical thinking
    b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Teamwork
    c. **#3:** TRANSVERSAL PROFESSIONAL SKILLS – Problem solving
7. **Program content - Re-use of training modules:** Yes - Lecture Future Energy Systems II

8. **Program content - Intellectual Property Rights:** All contents are protected by copyright. They may only be used within the limited circle of participants of the Moodle learning room and for private purposes. Sharing the content beyond the limited group of participants in the Moodle learning room thus constitutes publication subject to permission.
9. **Methodologies:** Practical learning, problem-based learning, Project-based learning, Worked examples, Interactive lecture, Discussion-based learning
10. **Teaching methods:** Project, Personal study, Problem solving, Search for and select bibliographical material, data or statistics
11. **Evaluation methods:** Written examination and Project
12. **Internships:** No
13. **Scheduling:** Part-Time

Program Content

The course Automation of Complex Power System (ACS) teaches skills for designing a modern energy system. This includes the areas of control and automation of the energy system. The course has 12 lecture and 6 exercise sessions. An overview of the lectures is listed in Table 15.

Table 15 List of lectures for the course "Automation of Complex Power System"

	Lecture	Speaker
1	Introduction and Basic Principles	Prof. Antonello Monti
2	Review of Basic Principles	Prof. Antonello Monti
3	Renewable Energy Sources Interface	Prof. Antonello Monti
4	Converter Control	Prof. Antonello Monti
5	Microgrids	Prof. Antonello Monti
6	Grid Forming Control	Prof. Antonello Monti
7	Integration of Distribution Generation and grid codes	Prof. Antonello Monti
8	DC Grids	Prof. Antonello Monti
9	Voltage control	Prof. Antonello Monti
10	Distribution Management System	Prof. Antonello Monti
11	Demand Response, IEE std 2030.11-2021 and USEF	Prof. Antonello Monti
12	Communication Standards in Power Systems	Prof. Antonello Monti

The focus of the course is in particular on frequency and voltage control as well as potential power quality problems and their solutions. Since modern energy systems are based on renewable energies, initial knowledge of renewable energy sources and alternative grid concepts, such as micro grids, is taught. This includes the power electronic interface as well as control structures for distributed energy sources and for the converters themselves. A large number of renewable energy sources work either with direct current (PV) or use a DC link (wind). Therefore, the concept of DC distribution grids is presented and possible control strategies and protection concepts are elaborated. The increasing share of volatile distributed energy sources requires not only a suitable measurement infrastructure for monitoring the system and appropriate communication standards, but also load management concepts for demand side management. The use of interactive Jupyter notebooks allows students hands-on experience in programming techniques and simulations.

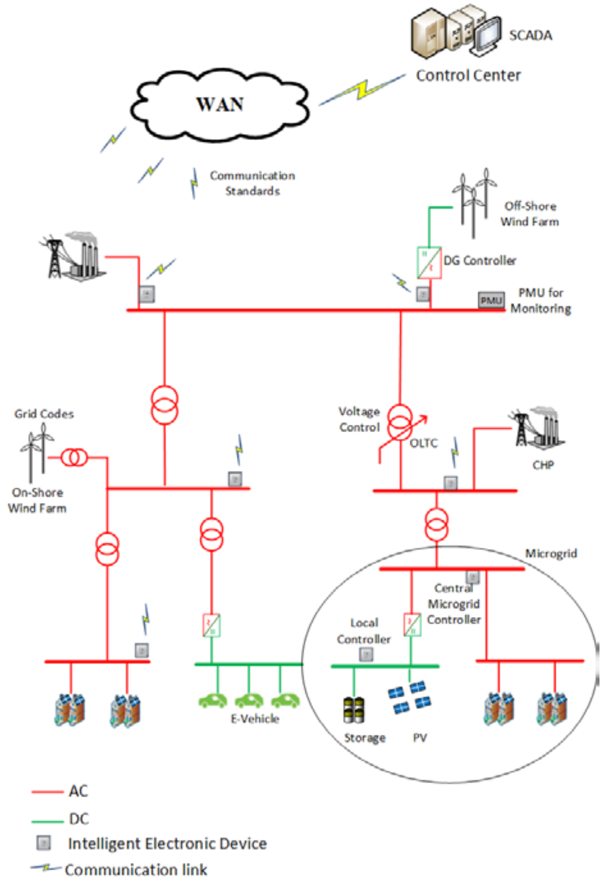


Figure 9 Content of the ACS lecture

Main Findings

The implementation of interactive learning methods, specifically the use of Pingo interactive questions during exercise sessions, has shown a positive impact on student performance and knowledge retention in the "Automation of Complex Power Systems" course. The comparison of student performance on Pingo questions and their corresponding exam questions revealed an improvement in scores from the Pingo activities to the traditional exam scenarios. This was particularly evident for the demand-side management (DSM) concepts, where the exam questions closely mirrored the topics and formats covered by the interactive Pingo activities.

However, students performed comparatively worse on the Common Information Model (CIM) questions than on the DSM questions. This could be attributed to the divergence in the nature of the questions asked in the Pingo exercises and the exam. The Pingo questions focused narrowly on deducing relationships between CIM classes, while the exam tested broader knowledge of CIM applications and standards mapping. This highlights the importance of aligning interactive learning checks with desired exam outcomes. A comparison of student exam performance between the SS22 and SS23 iterations of the course, before and after implementing the new interactive learning methods, showed an improvement in the average exam grade. Notably, even with an increased passing threshold of 50% versus 44% previously, the average exam grade improved from 2.68 in SS22 to 2.55 in SS23.

In addition to the interactive learning methods, the course also introduced new lecture scripting. Detailed lecture scripts covering all course topics were created over the course of the semester and provided to students for review and retention. The scripts provided a structured and detailed overview of the course content, allowing students to review and reinforce their understanding outside of lecture hours. This additional resource likely contributed to the improved performance observed in the course, as it allowed students to engage with the material at their own pace and revisit complex concepts as needed.

These results provide quantitative evidence that the blended interactive and active learning methods piloted in SS23 improved student exam performance and knowledge retention compared to the previous traditional lecture format. The significant increases in average scores and question part accuracy highlight the benefits of interleaving targeted knowledge checks and discussions during instruction. Keeping students actively engaged appears to have strengthened conceptual mastery and equipped them with better retention and recall on relevant exam topics.

Overall, integration of different learning methods in the lecture increased the preforms of students in the final exam. This suggest that similar practice could be performed in other courses. However, this pilot activity showed that there is still need for connecting the learned methods and tools with higher level topics.

Table 16 Summary of ACS lecture on automation of complex systems

Summary	Main remarks
Success factors	• Development of new educational materials • Improvement of exam results compared to previous years
Areas of improvements	• Integration of more opportunities to apply learned methods and tools • Motivation of students to attend lectures and exercises in person
Recommendations	• Integration of multiple teaching methods to other lectures

3. Field test Cologne

EWI has crafted three programs designed to address the needs of the energy sector. These initiatives are crafted to address the growing demand for enhanced knowledge, skill development, and competency in various aspects of energy economics and digital transformation.

The target groups, EQF levels and contents vary across the different programs. The EWI Academy provides modular training for companies, blending online and in-person formats with lectures, workshops, and discussions for various professional levels. The Certificate in Future Energy Business bridges academia and practical demands, offering theoretical and real-world project-based learning for students and professionals. The Smart Energy Certificate Programme, aimed at experienced professionals, delves into digitalization and energy economics over five months, with modules and a capstone project on topics like smart mobility. Collectively, these programs demonstrate EWI's dedication to advancing the energy sector, equipping a range of professionals with the skills and knowledge to navigate future challenges and opportunities in the field.

3.1. Overview of activities

Table 17 Overview of pilot activities in Cologne

Piloting Activity	Target group	EQF Level	Duration	Main stakeholders	Part/s of Blueprint Strategy tested	Results delivered to EC	Energy sector	Contents
EWI Academy	Companies interested in trainings for own employees	4-5	Events are taking place at various dates; length of the workshops are customized to the companies needs	EWI, Companies in the energy sector and companies affected by the energy transition and markets	levers to reduce skills gaps, general templates, best practices	Bridged knowledge gaps in the broad area of energy markets, depending on the specific workshop for new employees and those interested in the specific topics.	all-round view on the energy value chain	modularized lectures on different contents of the energy value chain; booked by companies as trainings for employees who are new to the energy domain or interested in trainings on specific topics: - electricity value chain (basics) - hydrogen economy (basics) - e-mobility (basics) - scenario generation (advanced) -energy system modelling (advanced)
Smart Energy Certificate Programme	Professionals with min. 3 years postgraduate work experience	7	Various lectures on specific dates	Prof. Marc-Oliver Bettzüge, EWI Cologne Business School	levers to reduce skills gaps, TBD		energy economics, business administration digitalization	Certificate programme for on different aspects of the energy sector's digitization. Several modules (Energy Business, Smart Home, Smart city) and a capstone project
Certificate in Future Energy Business	University students	6	One year programme with various on site and online lectures usually every Friday, additionally one week project-based workshop	Prof. Marc-Oliver Bettzüge, EWI EWI e.V:11 companies out of the energy field	levers to reduce skills gaps, preparation to meet job profiles, general templates, best practices		energy economics, business administration digitalization	two-semester programme for students interested in energy; blend of theoretical contents on energy economics and relevant research methods combined with two practical projects in collaboration with energy companies

3.2. Presentation of activities

3.2.1. EWI Academy

The EWI Academy is a training program designed for companies that want to train their employees in the field of energy. The program consists of several modules on different contents of interest related to the digitization-driven transition of the energy sector. The addressees of the EWI Academy are companies, both on the supply- and demand-side, that are willing to offer training to their employees on different carrier stages. The programs' modules are offered online and in-person, combining input sessions with active parts, such as discussions. Besides lectures, the courses can be accompanied by interactive workshop sessions. The modularized structure allows adjusting each training program content- and process-wise to the needs of the companies (e.g., the training can be held on a single day or in multiple day sessions). The training's language is German or English. Participants receive a proof of certification.

So far, four workshops have taken place, which covered the fields of electricity markets and value chains, the hydrogen economy and e-fuels more broadly, e-mobility, and scenario generation for energy modelling. The duration of the various workshops varied. The workshop designed to be an interactive mix between an onsite and online program.

Program fact sheet

1. **Name of program:** EWI Academy
2. **Program format:** On site or online
3. **Program language:** German/English
4. **Length of program:** Each module lasts between 1 day- 4 days
5. **Student´s estimated effort in working hours:** 8-32 hours.
6. **Industrial challenges addressed 1. - Economic and organizational:** Business model adaptation, high economic costs
7. **Industrial challenges addressed 2. – Social:** acceptance of new technologies, lack of citizen engagement
8. **Industrial challenges addressed 3. - Technical and regulatory:** lack of adequate skills from employees, data management
9. **Industrial challenges addressed 4. - Energy system:** network planning: load profiles
10. **Industrial challenges addressed 5. - Extreme situations:** Yes, Extreme weather
11. **Industrial challenges addressed 6. – Other: N/A**
12. **Skill gap area:** Programming and development competences, Data management and analysis
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
    b. **#2:** 0613 -Software and applications development and analysis
    c. **#3:** 0712- Environmental protection technology
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** No
16. **Funding 2. - Types of funding:** Corporate funding
17. **Target groups:** Employees (Mid-career stage)
18. **EQF level:** 4-5
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? Yes
    b. Does the program provide credits (ECTS)? No
    c. Is it modularized? Yes
    d. Does it provide any certification per module? Yes
20. **Certification:** Certificate of Accomplishment

Business and operational model

1. **Relevance of program:**
    a. **#1:** Understand the concepts and challenges related to the energy transition
    b. **#2:** Understand the role of digitization in the energy transition.

   c. **#3:** Develop new business opportunities in the energy sector
   d. **#4:** Promote energy modelling.
   e. **#5:** Help companies to develop a skilled labor force that understand the energy sector.
2. **Definition of targets:**
   a. Name the skills you target: electricity and energy, database and network design and administration
   b. Enter their ESCO codes: 0713, 0612
   c. Name the occupations you target: Electrotechnology engineer, Management and organisation analysts, Policy administration professionals
   d. Enter their ESCO codes: 215, 2421, 2422
   e. Name the tools and systems that you target:
3. **Financial structures: /**
4. **Use of resources:**
   a. **#1:** Laptop and projector
   b. **#2:** EWI classroom or virtual room (Ms teams)
   c. **#3:** 2 EWI employees per course.
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
   a. **#1:** Advertising to EWI customers
   b. **#2:** EWI Academy homepage
   c. **#3:** Advertising via energy email list server (Strommarktverteiler)
7. **Employer feedback:** N/A
8. **Alumni engagement:**
   a. **#1:** Use Alumni as testimonials on the website.
   b. **#2:** Advertise follow-up modules to alumni
   c. **#3:** receive feedback for the course.

<u>Learning and teaching model</u>

1. **Admission requirements:** Working experience
2. **Training goals:**
   a. **Training goal #1:** Understand the regulatory framework of energy markets.
   b. **Training goal #2:** Understand electricity, gas and heating grid infrastructure.
   c. **Training goal #3:** Understand new business opportunities in the energy markets.
   d. **Training goal #4:** Understand the importance of scenarios and know how to interpret them.
   e. **Training goal #5:** Understand the next steps of the energy transition towards carbon neutrality.
3. **Program content - Syllabus elements in ICT/ Digital:**
   a. **#1:** INFORMATION TECHNOLOGY: Blockchain
   b. **#2:** MODELLING; SIMULATION,OPTIMISATION: MODELLING; SIMULATION,OPTIMISATION
   c. **#3:** MODELLING; SIMULATION,OPTIMISATION: – Simulation tools
4. **Program content - Syllabus elements in another STEM than ICT/Digital:#5:**
5. **Program content - Syllabus elements in Energy:**
   a. **:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS: Sustainable Transportation, E-mobility
   c. **#3:** ELECTRICAL POWER SYSTEMS – Grid Development in the area of Smart Grids
   d. **#4:** ENERGY MANAGEMENT & GREEN SKILLS: Regulation & New Business Models
   e. **#5:** ELECTRICAL POWER SYSTEMS – RES (Solar Energy, wind energy)
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** MANAGEMENT & BUSINESS: Economy of Energy, Markets and Regulation
   b. **#2:** HUMANITIES & ETHICS: critical thinking
7. **Program content - Re-use of training modules:** not decided yet
8. **Program content - Intellectual Property Rights:**
9. **Methodologies:** Magistral lecturing, Interactive lecture, Discussion-based learning
10. **Teaching methods:** Magistral lectures,
11. **Evaluation methods:** other: attendance.
12. **Internships:** No
13. **Scheduling: N/A**

Program Content

The different courses in the EWI Academy, students of the program are asked to understand the energy system and critically assess current development and challenges. Hereby, regulatory challenges of energy policies are highlighted, and future business cases and development discussed. Different forms of energy, such as electricity, gas, H2 etc. and their properties are discussed. Special attention will be paid to the topics of decentralization and digitization. Besides the supply side, some course focus on the demand, by e.g., focusing on electric vehicles.

The program is organized and hosted by EWI. Sessions were led by an EWI manager and one EWI research associate. The program of the EWI academy consists of the following courses, which can be taken individually, or subsequently, depending on the educational needs of the customers.

In coordination with the companies the workshops were tailored to the specific needs of the companies but were based on the following modules: Energy Management Compact, Crash Course Energy Scenarios, Compact Course Energy Scenarios, and Energy System Modelling, Crash Course Hydrogen Economy, Crash Course E-Mobility.

Table 18 List of course in EWI academy

	Lecture	Speaker	Institution
1	Energy Economics Compact	Dr. Johanna Bocklet; Nicole Niesler/Jakob Junkermann	EWI
2	Crash Course Energy Scenarios	Philipp Kienscherf, Arne Lilienkamp	EWI
3	Compact Course Energy Scenarios and Energy System Modelling,	Dr. Johanna Bocklet/ Philipp Kienscherf, TBD	EWI
4	Crash Course Hydrogen Economy	David Schlund, TBD	EWI
5	Crash Course E-Mobility	Philipp Kienscherf, Philip Theile/Arne Lilienkamp	EWI

Main Findings

The EWI Academy workshops were highly successful, garnering positive feedback for their comprehensive and adaptive approach to energy sector training. Participants particularly valued the blend of theoretical knowledge with practical insights, enhanced by interactive elements like workshops and discussions. These sessions effectively bridged the gap between current industry practices and emerging trends, appealing to professionals across various career stages. One key observation was the varying levels of knowledge among participants, which highlighted the need for a flexible and inclusive educational approach. From this experience, we learned the importance of catering to diverse learning needs and the value of integrating different expertise levels into the training process. For future workshops, we recommend continuing to balance theory with practice, while also customizing content to accommodate the varied knowledge backgrounds of participants. This approach will ensure that the workshops remain relevant, engaging, and beneficial for all professionals, fostering a collaborative and enriching learning environment in the dynamic field of energy economics.

In conclusion, the EWI Academy workshops achieved success by combining theoretical knowledge with practical insights, incorporating interactive elements and accommodating diverse knowledge levels, underscoring the importance of a flexible and inclusive educational approach for professionals in the dynamic field of energy economics.

3.2.2. Certificate in Future Energy Business

Companies need qualified applicants to fill relevant open positions to cope with the transformation of energy systems. Addressing this by targeting to close the gap between academia and practice, the Future Energy Certificate is an extra curriculum education offer that focuses on specific preconditions for working in the energy sector. It seeks to reduce the mismatch between the needed qualifications in the energy sector and the ones applicants offer after graduating from university.

The program consists of several courses that EWI and participating companies offer. This approach ensures the practical relevance of the curriculum. Companies have the incentive to engage in teaching to position themselves as potential employers for the participants. By this approach, addressees of the program are students and companies from the energy sector. EWI is responsible for theoretical lectures on energy economics, for the administration, the communication between participants and companies, and the quality of this educational program.

In general, there are two curriculum segments: lectures and projects. Lecture-wise, the program offers courses on energy economics, future energy perspective, and methods and skills (39 hours). Additionally, it consists of two projects organized by participating companies (60 hours).

To address the challenge of effectively advertising the program, it was transitioned into a more modular design. This adaptation enabled students to select classes individually, aligning with their specific interests and requirements, rather than enrolling in a fixed course lineup. As of the latest update, the program has successfully conducted 18 classes, each averaging 7 students, with attendance fluctuating between 3 to 13 participants per class. Additional classes are scheduled to commence in early 2024, continuing this flexible and responsive approach to education.

Program fact sheet

1. **Name of program:** Certificate in Future Energy Business
2. **Program format:** On site
3. **Program language:** German
4. **Length of program:** 1 year
5. **Student´s estimated effort in working hours:** 99 hours
6. **Industrial challenges addressed 1. - Economic and organizational:** Goals/target tracking
7. **Industrial challenges addressed 2. – Social:** acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** lack of adequate skills from employees
9. **Industrial challenges addressed 4. - Energy system:** Customers: Remote metering, Network planning: Digital tools for network planning, Network planning: Load profiles; Network operation: Short-term load forecasting
10. **Industrial challenges addressed 5. - Extreme situations:** Yes, Extreme weather
11. **Industrial challenges addressed 6. –** Other: energy transition due to war in Ukraine/
12. **Skill gap area:** Big data**,** Programming and development competencies, Data management and analysis
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
    b. **#2:** 0588 -interdisciplinary programs and qualifications involving natural science, mathematics and statistics
    c. **#3:** 0712- Environmental protection technology

14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** No
16. **Funding 2. - Types of funding:** individual
17. **Target groups:** Students (pre-career stage)
18. **EQF level:** 6
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? Yes
    b. Does the program provide credits (ECTS)? No
    c. Can you study parts of the program? Yes
    d. Does it provide any certification per module? Yes
20. **Certification:** Certificate of Accomplishment

Business and operational model

1. **Relevance of program:**
    a. **#1:** Understand the concepts and challenges related to the energy transition
    b. **#2:** Work on real world problems and connect with industry experts

c. **#3:** Develop new business opportunities in the energy sector
d. **#4:** Combine theoretical knowledge with practical experience.
e. **#5:** Help companies to develop a skilled labor force that understand the energy sector.

2. **Definition of targets:**
   a. Name the skills you target: electricity and energy, database and network design and administration
   b. Enter their ESCO codes: 0713, 0612
   c. Name the occupations you target: Electrotechnology engineer, Management and organisation analyst, Policy administration professionals
   d. Enter their ESCO codes: 215, 2421, 2422
   e. Name the tools and systems that you target:
3. **Financial structures:**
   a. **#1:** participating companies pay between 4500-6000€ a year to be part of the program.
   b. **#2:** Students pay 100€ for one year (in order to reduce the drop-out rate)
   c. **#3**: Further expensive are sponsored by the EWI sponsoring associating.
4. **Use of resources:**
   a. **#1:** Laptop and projector
   b. **#2:** EWI classroom or on site a participating companies
   c. **#3:** 2 EWI employees per course or 2 company representatives.
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
   a. **#1:** Advertise at university lectures at University of Cologne and surrounding universities.
   b. **#2:** Homepage, and online flyers.
   c. **#3:** Blackboard at the University
   d. **#4:** EWI website
7. **Alumni engagement:**
   a. **#1:** Use Alumni as testimonials on the website.
   b. **#2:** Create alumni network
   c. **#3:** receive feedback for the course
   d. **#4:** create email list server for job announcement and follow up courses

Learning and teaching model

1. **Admission requirements:** Bachelor's degree
2. **Training goals:**
   a. **Training goal #1:** Understand the regulatory framework of energy markets.
   b. **Training goal #2:** Understand electricity, gas, and heating grid infrastructure.
   c. **Training goal #3:** Understand new business opportunities in the energy markets.
   d. **Training goal #4:** Understand the challenges of businesses in the energy field..
   e. **Training goal #5:** Develop a new mindset on design thinking and change management.
3. **Program content - Syllabus elements in ICT/ Digital:**
   a. **#1:** PROGRAMMING LANGUAGES: Programming Principles, basics & fundamentals
   b. **#2:** INFORMATION TECHNOLOGY: New trends in Information technology
   c. **#3:** MODELLING; SIMULATION, OPTIMISATION: – Simulation tools
   d. **#4:** MODELLING; SIMULATION,OPTIMISATION: MODELLING; SIMULATION,OPTIMISATION
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** BASIC MECHANICS: Thermodynamics
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS: Sustainable Transportation, E-mobility
   c. **#3:** ELECTRICAL POWER SYSTEMS – Grid Development in the area of Smart Grids
   d. **#4:** ENERGY MANAGEMENT & GREEN SKILLS: Regulation & New Business Models
   e. **#5:** ELECTRICAL POWER SYSTEMS – RES (Solar Energy, wind energy)
   f. **#6:** ENERGY MANAGEMENT & GREEN SKILLS: Sustainable Development
   g. **#7:** ENERGY MANAGEMENT & GREEN SKILLS: Flexible demand and smart home/building
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** ENGINEERING, PROJECTS & REPORTS: Field Management Project
   b. **#2:** MANAGEMENT & BUSINESS: Economy of Energy, Markets and Regulation

c. **#3:** TRANSVERSAL PROFESSION SKILLS: Problem Solving
d. **#4:** TRANSVERSAL PROFESSION SKILLS: Leadership & Change Management
e. **#5:** HUMANITIES & ETHICS: critical thinking

7. **Program content - Re-use of training modules:** Theoretical lectures from EWI will be partially reused in the EWI academy program.
8. **Program content - Intellectual Property Rights:**
9. **Methodologies:** Practical learning Project-based learning, Magistral lecturing, Interactive lecture, Discussion-based learning, Collaborative learning
10. **Teaching methods:** Magistral lectures, Projects, Personal study, Problem solving.
11. **Evaluation methods:** Projects.
12. **Internships:** No
13. **Scheduling:** weekend attendance

Program Content

The certificate in the future energy business is a two-semester course designed to bridge the gap between theoretical knowledge in energy economics and practical challenges from companies in the energy business. Students have to take 39 credits and do two field projects (60 credits in total). 1 credit is equivalent to 1 hour of work. Students can select from a wide range of courses, which will be taught by lectures from EWI and/or practitioners from the energy field. In order to accommodate for the low number of applications we also allowed more modular approaches, with students being able to select only the courses they were interested in. So far, the course program consists of the following courses. If not noted otherwise, the courses took place already.

Table 19 List of courses for the certificate in future energy

Name	Date	Companies involved
Introduction to Electricity Markets	26.05.2023	EWI
Current Issues in Energy Market Regulation with a Special Focus on Climate Protection in Public Transport	02.06.2023	Agency
Introduction to Gas Markets	09.06.2023	Consultant Company 1
Introduction to the Regulation of Energy Markets	16.06.2023	Energy Provider 1
Future of the Building Sector	23.06.2023	Municipal Utility Company 1
Introduction to Electricity Grids - Technology and Regulation	26.06.2023	EWI
Digitalization in Network Operation	03.07.2023	EWI
Introduction to Hydrogen	07.07.2023	Energy Provider 2
Energy and Climate Scenarios	14.07.2023	Consultant Company 1
Future of the Energy Sector	21.07.2023	Cancelled
Electromobility - Integral Part of the Mobility and Energy Transition	29.09.2023	EWI
History & Structure of the Energy Industry	05.10.2023	Company in the energy sector
Digital Business Models in the Energy Sector	06.10.2023	Cancelled
Marketing of Renewable Energies	13.10.2023	Energy Provider 3
Energy Trading & Trading Strategies	16.10.2023	Consultant Company 2
Change Management	19.10.2023	Municipal Utility Company 2
Design Thinking and Entrepreneurship	09.11.2023	Energy Provider 4

Crisis Management	13.11.2023	Consultant Company 2
Introduction to Energy Market Modelling	17.11.2023	Energy Provider 5
Conflict Management	24.11.2023	EWI
TBD	15.01.2023	EWI
TBD	19.01.2023	Energy Provider 6

Main Findings

The Student Certificate Program has yielded significant insights into effective energy sector education. Key findings include the importance of integrating theoretical knowledge with practical industry applications, a method that greatly enhances student learning and employability. The collaboration with industry partners has been pivotal in aligning the curriculum with real-world demands, ensuring that graduates are well-prepared to meet the challenges of the energy sector. Furthermore, the flexibility in course selection allows students to tailor their learning to specific interests and career goals. These findings underscore the value of such programs in bridging the gap between academic training and industry needs, highlighting the potential for similar models in other sectors.

Initially envisioned as a two-semester commitment with a set number of hours, the Certificate in Future Energy Business program had to adapt due to lower-than-expected sign-ups. In response, the program was restructured into a more modular format, allowing students the flexibility to enrol in individual classes. This change offered the possibility of earning the full certificate upon completion of a sufficient number of classes, catering to varying schedules and commitments of students.

Despite this adaptation, the program faced challenges in advertising and securing consistent commitment. While initial interest was high, with over 20 sign-ups per class on average, actual participation was notably lower, averaging only 6 students per class. This gap between sign-ups and participation highlights the need for more effective marketing strategies and engagement techniques to ensure better commitment and attendance rates.

The program, however, received positive feedback from both students and companies, particularly for its effectiveness in bridging the gap between academic content and practical industry needs, as well as in facilitating networking opportunities. The integration of theoretical knowledge with practical industry applications and the collaboration with industry partners were key strengths. These aspects made the curriculum both relevant and dynamic, effectively preparing students for the challenges of the energy sector and creating valuable connections between future professionals and established companies.

In conclusion, while the program's flexible, modular approach was well-received, the findings point to a need for improved strategies in marketing and student engagement to enhance commitment and participation. Despite these challenges, the program's potential as a model for bridging academic and industry gaps is evident, highlighting its role in equipping students with essential skills and fostering industry connections.

3.2.3. Smart Energy Certificate Programme

The fast transition of the energy sector, combined with digitization, puts pressure on existing business models. However, at the same time, it brings new opportunities. Companies need new knowledge in management positions to leverage untapped business potentials. The Certificate targets employees with at least 3 years of working experience who want to deepen their knowledge on digitalization and energy economics.

Because of a low number of signups, we combined the curriculum and classes with that of the Future Energy Business Certificate (3.2.1.), also allowing for the same modular approach as discussed in the previous chapter. However, we had no signups for this program till the day of writing.

Program fact sheet

1. **Name of program:** Smart Energy Certificate Programme
2. **Program format:** online
3. **Program language:** English
4. **Length of program:** 5 months (now modular setup)

5. **Student´s estimated effort in working hours:** 40 hours
6. **Industrial challenges addressed 1. - Economic and organizational:** Business Model Adaptation
7. **Industrial challenges addressed 2. – Social:** acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** lack of adequate skills from employees
9. **Industrial challenges addressed 4. - Energy system:** Customers: Remote metering, Network planning: Digital tools for network planning, Network planning: Load profiles; Network operation: Short-term load forecasting
10. **Industrial challenges addressed 5. - Extreme situations:** no.
11. **Industrial challenges addressed 6. –** Other: /
12. **Skill gap area:** Big data**,** Programming and development competences, Data management and analysis
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
    b. **#2:** 0610Information and communications technologies not further specified
    c. **#3:** 0712- Environmental protection technology
14. **Starting point of program design:** both
15. **Funding 1. - Available for free:** No
16. **Funding 2. - Types of funding:** individual
17. **Target groups:** Employees (mid-career stage)
18. **EQF level:** 7
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? Yes
    b. Does the program provide credits (ECTS)? No
    c. Can you study parts of the program? Yes
    d. Does it provide any certification per module? Yes
20. **Certification:** Professions Certification (through the cologne business school)

Business and operational model

1. **Relevance of program:**
    a. **#1:** Understand the concepts and challenges related to the energy transition
    b. **#2:** Comprehend the role of digitalization for the energy transition.
    c. **#3:** Develop new business opportunities in the energy sector
    d. **#4:** Combine theoretical knowledge with practical experience.
    e. **#5:** Help companies to develop a skilled labor force that understand smart technologies and the energy sector.
2. **Definition of targets:**
    a. Name the skills you target: electricity and energy, database and network design and administration
    b. Enter their ESCO codes: 0713, 0612
    c. Name the occupations you target: Electrotechnology engineer, Management and organisation analysts, Policy administration professionals
    d. Enter their ESCO codes: 215, 2421, 2422
    e. Name the tools and systems that you target:
3. **Financial structures:**
    a. **#1:** Students need to pay to participate in the programme.
    b. **#2:** Sponsorships can be applied to via the Cologne Graduate School
4. **Use of resources:**
    a. **#1:** E-Learning plattform
    b. **#2:**virtual classroom (MS Teams)
5. **Licenses for digital tools:** No
6. **Marketing and student recruiting procedures:**
    a. **#1:** Advertising through the Cologne Graduate School
    b. **#2:** Reach out to EWI customers and advertise educational programm.
    c. **#3:** EWI Website
    d. **#4:** Email list server (Strommarktverteiler)
7. **Employer feedback:**
8. **Alumni engagement:**
    a. **#1:** Use Alumni as testimonials on the website.

   b. **#2:** Advertise follow-up modules to alumni
   c. **#3:** receive feedback for the course

Learning and teaching model

1. **Admission requirements:** Graduate, Working Experience
2. **Training goals:**
   a. **Training goal #1:** Understand the regulatory framework of energy markets.
   b. **Training goal #2:** Understand the role of digitization and smart technologies for the energy transition.
   c. **Training goal #3:** Understand new business opportunities in the energy markets.
   d. **Training goal #4:** Develop a new mindset on design thinking and change management.
3. **Program content - Syllabus elements in ICT/ Digital:**
   a. **#1** INFORMATION TECHNOLOGY: New trends in Information technology
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Energy Transition
   b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS: Sustainable Transportation, E-mobility
   c. **#3:** ELECTRICAL POWER SYSTEMS – Grid Development in the area of Smart Grids
   d. **#4:** ENERGY MANAGEMENT & GREEN SKILLS: Regulation & New Business Models
   e. **#5:** ELECTRICAL POWER SYSTEMS – RES (Solar Energy, wind energy)
   f. **#6:** ENERGY MANAGEMENT & GREEN SKILLS: Sustainable Development
   g. **#7:** ENERGY MANAGEMENT & GREEN SKILLS: Flexible demand and smart home/building
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:**FOREIGN LANGUAGES: English (mandatory)
   b. **#2:** MANAGEMENT & BUSINESS: Economy of Energy, Markets and Regulation
   c. **#3:** MANAGEMENT & BUSINESS: Project Economics – CAPEX, Cash Flow, Rate of Return
   d. **#4:** TRANSVERSAL PROFESSION SKILLS: Leadership & Change Management
   e. **#5:** HUMANITIES & ETHICS: critical thinking
7. **Program content - Re-use of training modules:** no.
8. **Program content - Intellectual Property Rights:**
9. **Methodologies:** Magistral lecturing, Interactive lecture, Discussion-based learning, case-based learning
10. **Teaching methods:** Magistral lectures, Personal study, Problem solving
11. **Evaluation methods:** Written Examination
12. **Internships:** No
13. **Scheduling:** self-pace

Program Content

The Smart Energy Certificate Program was initially conceptualized as a specialized educational pathway catering to professionals with at least three years of postgraduate work experience. The program's structure comprised four distinct modules and a capstone project, with content delivered in both English and German. These modules, designed to be self-paced and spread over ten days within a five-month period, covered various critical topics including Transforming the Energy Business, Smart Mobility, Smart Customer and Home, Smart City and Infrastructure, and a Smart Energy Capstone Project.

However, the program faced significant challenges in attracting enrollments, with an extremely low number of sign-ups. This situation necessitated a strategic shift. Consequently, the Smart Energy Certificate Programme was merged with the Certificate in Future Energy Business program. This amalgamation was aimed at enhancing the program's appeal by broadening its scope and providing a more diverse range of topics and learning opportunities.

The combined program intended to foster an exchange of ideas and knowledge between participants of both cohorts, enriching the learning experience. Despite these efforts, the merged program encountered challenges similar to those faced by the Certificate in Future Energy Business, particularly in the realms of marketing and participant engagement.

Main Findings

While the original vision of the Smart Energy Certificate Programme was ambitious and well-aligned with industry needs, the lack of initial interest highlighted the necessity for more effective marketing and engagement strategies. The program's integration with the Certificate in Future Energy Business represents a flexible and adaptive approach to educational offerings in the energy sector, emphasizing the importance of continuous innovation and responsiveness to market demands.

4. Field test Athens

Stemming from the development of the Blueprint strategy of the EDDIE project and its different elements, the piloting activities are being designed to test the applicability and relevance of the results. The activities are chosen in order to test a wide range of BSDE parts and reach a variety of target groups. Specific parts of the BSDE, utilized in the activities design and development stages, include levers to reduce skills gaps, recommendations and overall action set (obtained from D5.4), general templates structure and best practices identification and analysis.

In this direction, the set of lectures is being developed based on general templates designed in EDDIE project. The identified best practices are a valuable guideline for the content development of the lectures, which are designed aiming to mitigate parts of the skill gaps identified through the project. The whole design process follows the recommendations and overall action set of the BSDE strategy. These lectures will be presented to MSc students in the context of NTUA MSc program “Energy production and management”. The program aims to cover a wide range of scientific areas, from conventional & RES production, thermal production and electrical installations to energy economics, energy savings, sustainable environmental management, energy markets and digitalization of energy systems. The lectures will be part of the course “Digitalization of energy systems”. An initial presentation of these lectures was conducted during the spring semester 2022 of the MSc program, aiming to receive feedback from the attendants and adjust the content till the final delivery of the lectures in spring semester 2023.

The activities are complemented by a set of introductory lectures/presentations in the MOOC and Summer School developed in the context of ERIGRid 2.0 project (H2020 project). The main goal of ERIGrid 2.0 is to support the research, technology development, and innovation of smart grid and smart energy systems approaches, concepts, and solutions in Europe taking a holistic and cyber-physical systems-based approach into account. In this direction, a MOOC will be designed and developed focusing on advanced validation methods for smart grids, targeting students, researchers and professionals. EDDIE will participate with an introductory lecture, presenting the targets of the project, focusing on the Blueprint strategy and the identified skill gaps, addressing appropriate levers to reduce these gaps between skill demand from the industry and status in education. Accordingly, a Summer School will take place during summer ’23, aiming to reach wider audience, with general focus on modern power systems and smart grids. EDDIE will participate in the Summer School with a presentation addressing similar topics with the ones presented in the MOOC.

4.1. Overview of activities

Table 20 Overview of pilot activities in Athens

Piloting Activity	Target group	EQF Level	Duration	Main stakeholders	Part/s of Blueprint Strategy tested	Results delivered to EC	Energy sector	Contents
Lectures on Local energy markets, energy communities and blockchain applications	Master's students	7	June '23	NTUA, MSc on Energy production and management, EDDIE	Levers to reduce skills gaps, Design of recommendations and overall action set, general templates, best practices	Digital platforms, Blockchain, computing tools and platforms, mathematical optimization, data analysis	Power	Two 45-minute lectures on local energy markets and blockchain applications
Lectures on AI applications on energy systems: Dynamic security and forecasting	Master's students	7	June '23	NTUA, MSc on Energy production and management, EDDIE	Levers to reduce skills gaps, Design of recommendations and overall action set, general templates, best practices	Artificial Intelligence, mathematical optimization, forecasting, data analysis, machine learning	Power	Two 45-minute lectures

MOOC (cooperation with ERIGrid 2.0 project)	Bachelor and master students, professionals	6, 7	December '23	NTUA, EDDIE, ERIGrid 2.0	Design of recommendations and overall action set		Power	MOOC
Summer school (cooperation with ERIGrid 2.0 project)	TBD	TBD	Summer '24	NTUA, EDDIE, ERIGrid 2.0	TBD	TBD	Power	Presentations, educational material, workshops

4.2. Presentation of activities

4.2.1. Lecture on Local energy markets, energy communities and blockchain applications

The lectures focus on Local Energy Markets (LEM) and the role of blockchain technology in securing the decentralized coordination of distribution grids. The content of the lectures has been developed with the aim to mitigate part of the skill gaps identified through the EDDIE project on the skill gaps that these lectures are targeting, which are digital platforms, blockchain, computing tools & platforms, mathematical optimization and data analysis. This pilot activity will be divided in two 45-minute lectures to MSc students.

Program fact sheet

1. **Name of program:** Lectures on Local energy markets, energy communities and blockchain applications, contained in MSc program "Energy Production and Management" and specifically during the course "Digitalization of energy systems"
2. **Program format:** Blended
3. **Program language:** Greek
4. **Length of program:** Two lectures, 45 minutes each
5. **Student´s estimated effort in working hours:** 2 hours per week for one semester (referring to the course "Digitalization of energy systems")
6. **Industrial challenges addressed 1. - Economic and organizational:** Business model adaptation
7. **Industrial challenges addressed 2. – Social:** privacy concerns, acceptance of new technologies, lack of citizen engagement
8. **Industrial challenges addressed 3. - Technical and regulatory: N/A**
9. **Industrial challenges addressed 4. – Energy system:** remote services to customers, short-term load forecasting, maintenance and asset management
10. **Industrial challenges addressed 5. – Extreme situations: N/A**
11. **Industrial challenges addressed 6. – Other: N/A**
12. **Skill gap area:** Data management and analysis, Big Data, Cybersecurity, Digital platforms, Blockchain, Computing tools & platforms, Mathematical optimization
13. **ISCED code of program content:**
    a. **#1:** 0713 Electricity and energy
14. **Starting point of program design:** Energy program with an ICT add-on & ICT program with an Energy add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (MSc)
18. **EQF level:** 7
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job: Yes
    b. Does the program provide credits (ECTS): Yes
    c. Is it modularized: Partly (referring to the whole MSc program)
    d. Does it provide any certification per module: No

    The course is part of the MSc program, and the adequate understanding of its content is certified through written exams at the end of the semester. The successful completion of the whole MSc program provides students with 60 credits (ECTS)

20. **Certification:** University degree (Master of Science)

Business and operational model

1. **Relevance of program:** Deepening of engineers in techniques and methods of a more integrated interdisciplinary approach, research and treatment of the individual topics of the energy subject. Training new engineers in the concept of developing new acknowledge through research in this continuously developing field (referring to the whole MSc program)
2. **Definition of targets:**
    a. **#1:** Name the skills you target: Algorithms, Blockchain, Operations research, logistics, Game Theory, Regulation & new Business Models, Flexible demand and Smart home/buildings, Energy Transition, Economy of Energy, Markets and Regulation, Modelling, simulation & optimisation
    b. **#2:** Enter their ESCO codes:
    c. **#3:** Name the occupations you target: Data analysts (Energy Analyst), Senior Sustainability Consultant, Blockchain engineer (Distributed Ledger Technology), Energy Modeler, Renewable Energy Consultant, Optimization Engineers, Engineer in Mathematical Optimization
    d. **#4:** Enter their ESCO codes: 2511.3, 3112.5, 3112.7, 2433.3, 2512.4.1
    e. **#5:** Name the tools and systems that you target: peer to peer exchange tools, use of simulation tools
3. **Financial structures:** N/A
4. **Use of resources:** the resources needed for the program are just lecture classes
5. **Licenses for digital tools:**
6. **Marketing and student recruiting procedures:**
7. **#1:** informative conferences
8. **#2:** promoting website of the program. Via the website the achievements of graduates of the program, career opportunities and the many fields of energy section studied could be the highlights of a promoting procedure
9. **Employer feedback:** N/A
10. **Alumni engagement:** N/A

Learning and teaching model

1. **Admission requirements:** Bachelor’s degree, Master degree - Degree from Greek Polytechnic schools which award 5 year integrated Bachelor and Master's
2. **Training goals:**
    a. Training goal #1: Overview of Local Energy Market stakeholders and components
    b. Training goal #2: Familiarize with the Local Energy Markets formulation examples and with optimization, game theoretic and auction-based models for the Local Energy Markets formation
    c. Training goal #3: Practical understanding of the basic optimization functions for the everyday operation of a Local Energy Market
    d. Training goal #4: Familiarize with the blockchain technology and with Bitcoin and Ethereum structures.
    e. Training goal #5: Analysis of the smart contracts structure and the use of blockchain technology for the facilitation of Local Energy Markets operation
3. **Program content - Syllabus elements in ICT/Digital:**
    a. **#1:** MODELLING, SIMULATION & OPTIMISATION - Modelling, simulation & optimization
    b. **#2:** DATA MODELING - Operations research, logistics, Game Theory
    c. **#3:** INFORMATION TECHNOLOGY – Blockchain
    d. **#4:** PRIVACY: Identification and authentication
    e. **#5:** INFORMATION TECHNOLOGY - New Trends in Information Technology
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
    a. **#1:** MODELLING, SIMULATION & OPTIMISATION - Modelling, simulation & optimization
    b. **#2:** DATA MODELING - Operations research, logistics, Game Theory
5. **Program content - Syllabus elements in Energy:**
    a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS - Flexible demand and Smart home/buildings
    b. **#2:** ENERGY MANAGEMENT & GREEN SKILLS - Energy Transition

   c. **#3:** DATA MODELING - Operations research, logistics, Game Theory
6. **Program content - Syllabus elements in transversal skills:**
   a. **#1:** MANAGEMENT & BUSINESS - Economy of Energy, Markets and Regulation, Regulation & new Business Models
   b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Computer Technology
7. **Program content – Re-use of training modules:** Yes, in the lectures of the course for the upcoming years of the MSc program
8. **Program contents – Intellectual Property Rights:** All contents are protected by copyright, They may only be used within the limited circle of participants of the Moodle learning room and for private purposes. Sharing the content beyond the limited group of participants in the Moodle learning room thus constitutes publication subject to permission
9. **Methodologies:** Problem-based learning, Scenario-based learning, Case-based learning
10. **Teaching methods:** Lectures
11. **Evaluation methods:** written examination
12. **Internships:** Yes. The program provides the students in the last year with career opportunities, providing information for job vacancies in several energy entities.
13. **Scheduling:** evening attendance (off-business hours, targeting also professionals)

Program Content

The lectures on Local energy markets, energy communities and blockchain applications consist of two lectures, one on “local energy markets in the context of smart grids” and one on “Securing the Decentralized Coordination of Active Distribution Grids with Blockchain”.

The first lecture initially contains an overview on smart grids structure, Demand Side Management components and benefits and flexibility concept map, followed by the basic structure of the Greek energy market and the relevant stakeholders. Energy Communities as a key-role part of the future energy markets are being presented. Greece is one of the first countries among European Union to adopt the EU directive for energy communities in its regulatory framework. Therefore, a short analysis of the relevant law is presented, focusing on the key targets, activities and benefits, as well as the potential beneficiaries and the trading methods of energy communities. The overview is followed by a more detailed analysis on the trading methods inside LEMs and peer-to-peer trading. An indicative map of LEM formulation examples, separated according to their main purposes in optimization, game theoretic and auction-based models. Each model is briefly described focusing on its main target.

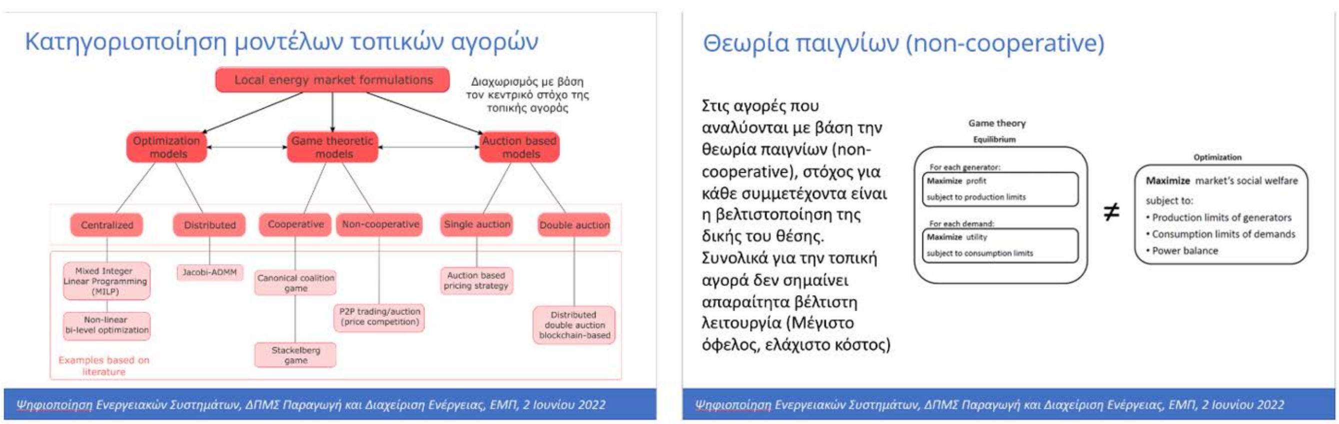


Figure 10 Local Energy Markets formulation examples

The first lecture ends with a simple example of a LEM and a case study, in order to familiarize the students with the problem of optimization. The case study includes an approach of the operation of a LEM. The basic variables and functions of the optimization problem are presented and explained, including flexibility equations and the standard values of the simulations. Then, the results of the simulation are shown, aiming to prove the benefits of all the relevant stakeholders participating in the LEM, compared to acting alone.

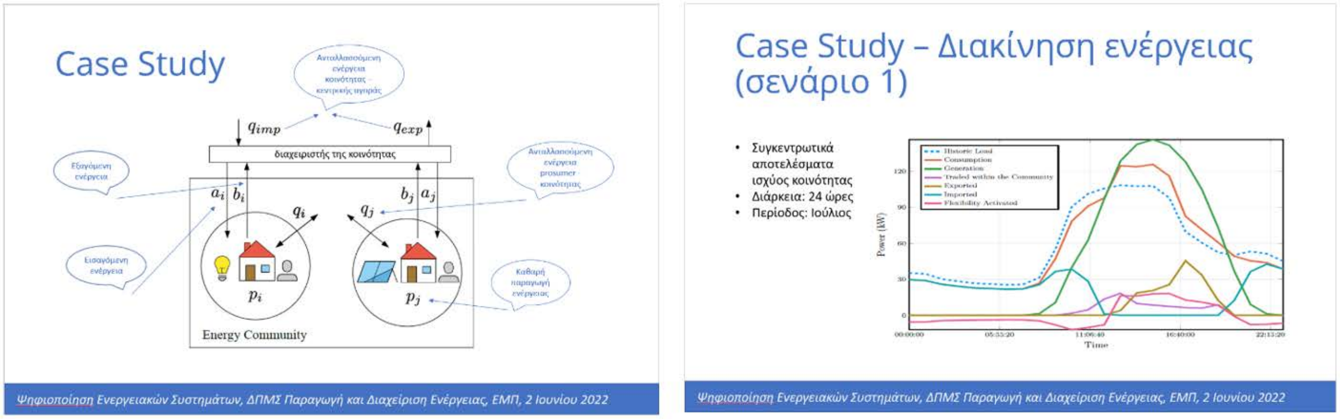


Figure 11 Case study and energy exchanges

The second lecture initially contains an overview of distributed computer network protocols and blockchain technologies. The example of Bitcoin is presented and analysed to familiarize the students with the procedures of introducing new blocks of data, changing state and the relevant consensus mechanisms. Subsequently, aiming to explain the smart contracts' structure, Ethereum is presented, as a global decentralized computing infrastructure. Special focus is given to contract account activation, nodes function and the computation costs. In order to connect smart contracts with energy markets, the terms of transactive energy & decentralized energy markets are analysed, connected to the advantages provided for transactions in Energy markets. To further enlighten the role of blockchain technology, two examples are developed. The first refers to a practical decentralized application, where the operator of a LEM is replaced by a protocol. The main security assumptions and the basic modelling of the protocol with the use of smart contracts are described, followed by an overview of the simulation results and conclusions.

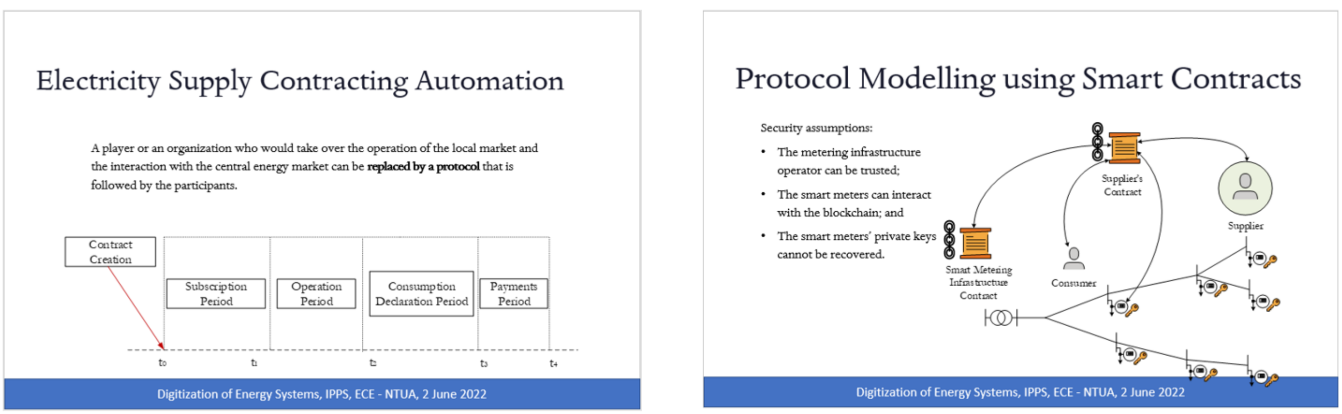


Figure 12 A practical decentralized application enabling smart contracts

The second example involves an Ethereum-based application for the facilitation of an LEM of an energy community. The main target is the optimal match of local consumption with production. The model used for the simulation is a double auction negotiation. The lecture ends with the presentation of the simulation's indicative results and conclusions.

Main Findings

The lectures on Local Energy Markets and Blockchain applications primarily focus on the various stakeholders of LEMs, fundamental principles, and optimization strategies, for forming a LEM and the integration of blockchain technologies for the secure operation of LEMs. The lectures were designed to address digital platforms, blockchain, computing tools & platforms, mathematical optimization and data analysis, as relevant identified skill gaps.

The assessment that leads to the main findings after the deployment of the lectures, includes input from the survey to students, feedback from the presenters, as well as findings that occurred during the design and deployment stages of the field activities. The assessment procedure, that aims to measure the impact of the activities and provide feedback to the Strategy is described in detail in deliverable D6.7 “Analysis of skill gap mitigation”.

The questionnaire to students serves a dual purpose. Firstly, it seeks to offer constructive feedback to the designers of the pilot activities, evaluating their impact, acceptance, and the satisfaction level of the participants. Secondly, it aims to gauge how effectively the activities address perceived skill gaps among participants, accompanied by suggestions for further enhancements.

The topic of Local Energy Markets presented strong interest by the students and created interaction during the lectures’ deployment, as a trending topic not yet included in the national education programs. The energy markets formation, optimization and operation that is highly dependent on data management and analysis, raised a lot of questions, highlighting the importance of digital skills in the future energy systems, a fact identified both by the activity participants and the presenters. In the development stage of the lectures, the intention of explaining and analyzing a Local Energy Market in a simple but comprehensive way was considered as a challenge, as the relevant literature is mainly aimed to researchers and already skilled professionals with in-depth knowledge of the matter. In this direction the presentation of the topic in a more abstract level raised the interest of most of the attendees. In spite of the fact that all the participants have a scientific background (bachelor's degree), digital platforms and data analysis are highlighted as topics that need to be further developed and analyzed. This fact indicates the continuously evolving and increasing demand that appears for digital skills overall. To achieve the higher possible coverage of these specific topic, demo simulations should be included in the lectures, ensuring the engagement of the students in a problem-solving environment.

The second part of the lectures was related to Securing the Decentralized Coordination of Active Distribution Grids with Blockchain. Designing a lecture about Blockchain was a challenging procedure, as this technology’s utilization emerged during the last decade with far-reaching applications. As a consequence, the presenter should consider that there is no previous knowledge of this technology and develop content that introduces the topic and still achieve to analyze how it can facilitate the coordination of active distribution grids. Given the circumstances, the participants' grasp of this topic was the lowest among all covered in the survey conducted after the lectures. This insight is really valuable as it showcases the lack of previous educational knowledge or experience and the continuous effort that should be conducted to provide with sufficient expertise regarding this specific topic.

Taking the aforementioned into account, the presenters considered that the time offered for the lectures is not sufficient for a holistic coverage of the topics. This indication was validated by the survey results, that highlighted time limitation as a bargaining factor for in-depth analysis of the proposed topics. As the lectures have been introduced for the first time and covered novel topics in the context of the master program, this limitation serves as a catalyst for potentially expanding these topics in future semesters. Surveys highlighted a clear guideline for improvement: integrate more practical examples, hands-on applications and real-time simulations. These additions are anticipated to enhance engagement and deepen understanding among students. These key findings were then discussed with the presenters leading to the proposal of splitting the topics’ content across multiple lectures, that would give them the opportunity for adequate theoretical analysis combined with more interactive examples.

In general, the feedback from the survey can be considered as positive, affirming the success in meeting the lectures' objectives. Most of the questionnaires indicated an adequate coverage of the proposed topics. A notably positive observation is the significant motivational role of the lectures for further research in the specific field, as well as the alignment of the content with the current needs of the industry.

4.2.2. Lectures on AI applications on energy systems: Dynamic security and forecasting

The lectures focus on AI applications on energy systems and specifically on dynamic security and forecasting. The content of the lectures has been developed based on artificial Intelligence, mathematical optimization, forecasting, data analysis, machine learning as identified skill gaps. This pilot activity will be divided in two 45-minute lectures to MSc students.

<u>**Program fact sheet**</u>

1. **Name of program:** Lectures on AI applications on energy systems: Dynamic security and forecasting, contained in MSc program “Energy Production and Management”
2. **Program format:** Blended
3. **Program language:** Greek

4. **Length of program:** Two lectures, 45 minutes each
5. **Student´s estimated effort in working hours:** 2 hours per week for one semester (referring to the course "Digitalization of energy systems")
6. **Industrial challenges addressed 1. - Economic and organizational: Goals/target-tracking**
7. **Industrial challenges addressed 2. – Social:** acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Reliability and stability need for machine-to-machine communication, data management, Technology integration
9. **Industrial challenges addressed 4. - Energy system:** Network operation: Data for longer term load forecasting, Short term load forecasting, Predictive maintenance
10. **Industrial challenges addressed 5. – Extreme situations:** N/A
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Data management and analysis, Big Data, Programming and development competences, Artificial Intelligence, Mathematical optimization, Forecasting, Machine learning
13. **ISCED code of program content:** 713 Electricity and energy
14. **Starting point of program design:** Energy program with an ICT add-on & ICT program with an Energy add-on
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** Students (MSc)
18. **EQF level: 7**
19. **Lifelong learning and certification:**
    a. **Is it possible to combine the program with a job:** Yes
    b. **Does the program provide credits (ECTS):** Yes
    c. **Is it modularized:** Partly (referring to the whole MSc program)
    d. **Does it provide any certification per module:** No
    The course is part of the MSc program, and the adequate understanding of its content is certified through written exams at the end of the semester. The successful completion of the whole MSc program provides students with 60 credits (ECTS)
20. **Certification:** University degree (Master of Science)

Business and operational model

1. **Relevance of program:** Deepening of engineers in techniques and methods of a more integrated interdisciplinary approach, research and treatment of the individual topics of the energy subject. Training new engineers in the concept of developing new acknowledge through research in this continuously developing field (referring to the whole MSc program)
2. **Definition of targets:**
    a. **Name the skills you target:** Dynamic systems, Control systems, Modelling, simulation & optimization, Mathematics for engineering & technology, Assembly Management of RES, Machine Learning for Engineers
    b. **Enter their ESCO codes:** N/A
    c. **Name the occupations you target:** systems integration engineer, simulation engineer, AI and ML engineer, machine learning engineer, optimization engineer
    d. **Enter their ESCO codes:** 2511.17, 2511.11
    e. **Name the tools and systems that you target:** distribution management tools, intelligent maintenance systems, use of simulation tools
3. **Financial structures:** N/A
4. **Use of resources:** The resources needed for the program is just lecture classes.
5. **Licenses for digital tools:** N/A
6. **Marketing and student recruiting procedures:**
    a. **#1:** informative conferences
    b. **#2:** promoting website of the program. Via the website the achievements of graduates of the program, career opportunities and the many fields of energy section studied could be the highlights of a promoting procedure
7. **Employer feedback:** N/A
8. **Alumni engagement:** N/A

Learning and teaching model

1. **Admission requirements:** Bachelor's degree, Master degree - Degree from Greek Polytechnic schools which award 5 year integrated Bachelor and Master's
2. **Training goals:**
    a. Training goal #1: Familiarize with machine learning and dynamic control of power systems principles, as well as with the crucial role that machine learning can play in dynamic control of future power systems.
    b. Training goal #2: Analysis of machine learning logic, regarding training sets, classifiers, decision trees and the evaluation procedure.
    c. Training goal #3: Familiarize with wind & solar power predictions and its mathematical formulation
    d. Training goal #4: Understanding of artificial neural networks starting from basic approach to deep learning.
    e. Training goal #5: Focus on evaluation process for the efficiency of the training sets and the basic evaluation metrics.
3. **Program content - Syllabus elements in ICT/Digital:**
    a. **#1:** MODELLING, SIMULATION & OPTIMISATION - Modelling, simulation & optimization
    b. **#2:** MODELLING, SIMULATION & OPTIMISATION – Statistics
    c. **#3:** MACHINE LEARNING - machine learning for engineers
    d. **#4:** CONTROL - Control systems
    e. **#5:** CONTROL - Digital control
    f. **#5:** CONTROL - Remote control & Automation
    g. **#6:** PROGRAMMING LANGUAGES - Algorithms
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
    a. **#1:** MODELLING, SIMULATION & OPTIMISATION - Modelling, simulation & optimization
    b. **#2:** MODELLING, SIMULATION & OPTIMISATION – Statistics
    c. **#3:** CONTROL - Control systems
    d. **#4:** CONTROL - Digital control
    e. **#5:** CONTROL - Remote control & Automation
    f. **#2:** DATA MODELING - Operations research, logistics, Game Theory
    g. **#3:** Basic Maths - Mathematics for engineering & technology
5. **Program content - Syllabus elements in Energy:**
    a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS RES (Solar Energy, Wind Energy)
6. **Program content - Syllabus elements in transversal skills:**
    a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS – Computer Technology
7. **Program content – Re-use of training modules:** Yes, in the lectures of the course for the upcoming years of the MSc program
8. **Program contents – Intellectual Property Rights:** All contents are protected by copyright, They may only be used within the limited circle of participants of the Moodle learning room and for private purposes. Sharing the content beyond the limited group of participants in the Moodle learning room thus constitutes publication subject to permission
9. **Methodologies:** Problem-based learning, Scenario-based learning, Case-based learning
10. **Teaching methods:** Lectures
11. **Evaluation methods:** written examination
12. **Internships:** Yes. The program provides the students in the last year with career opportunities, providing information for job vacancies in several energy entities.
13. **Scheduling:** evening attendance (off-business hours, targeting also professionals)

Program Content

The lectures on AI applications on energy systems: dynamic security and forecasting consists of two lectures, one on "Application of supervised machine learning for dynamic safety assessment in electrical power systems" and one on "Introduction to RES production forecasting".

The first lecture starts with basic information about machine learning regarding its principal characteristics, the reasons that machine learning is used in power systems and the relevant challenges, as well as basic information about dynamic safety of electrical power systems regarding safety assessment, load flow analysis, dynamic simulations and the challenges of dynamic safety assessment addressed through an adequate example. After this information it is made clear which are the benefits that machine learning will provide in the dynamic safety assessment of power systems. Therefore, the concepts of creating training sets, the selection of the method, the training and evaluation of the classifiers for the application in the assessment of the system's safety are presented. In this procedure, the training sets are crucial and therefore they will further be analysed, focusing on classifiers performance and the techniques for estimating the most suitable training sets.

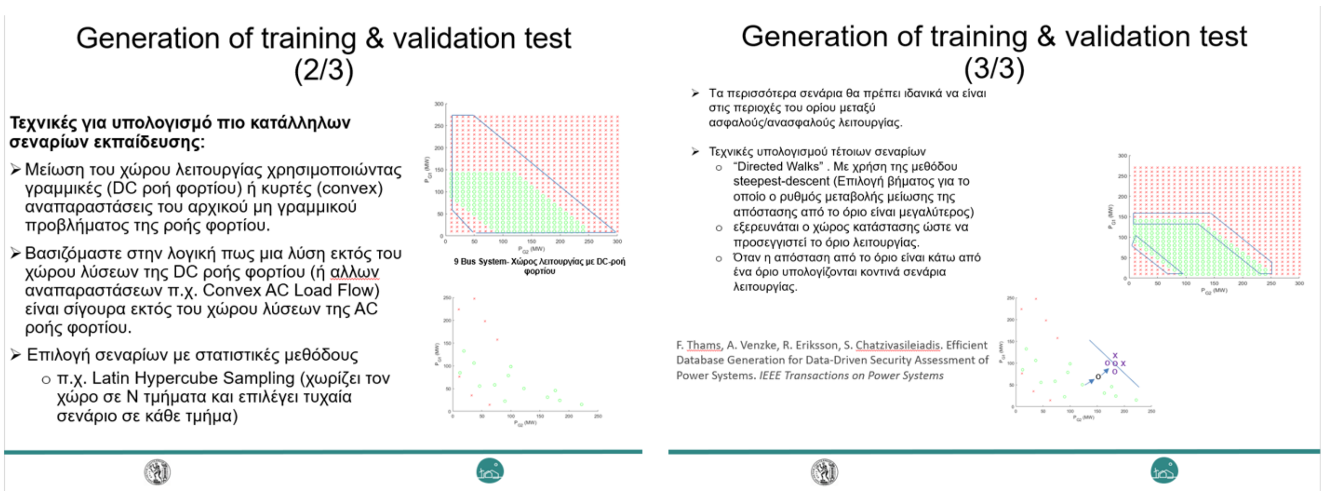


Figure 13 Generation of training & validation test

The following slides include the analysis of supervised learning algorithms, presenting various classification methods, such as decision trees, artificial neural networks and the support vendor machines, with further details concerning decision trees and optimal classification trees.

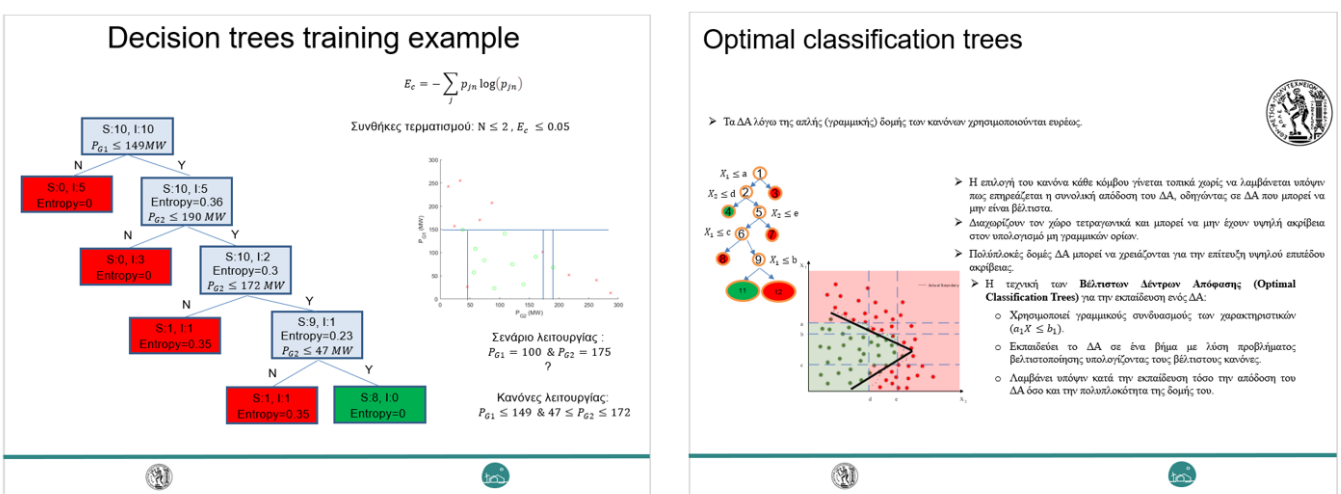
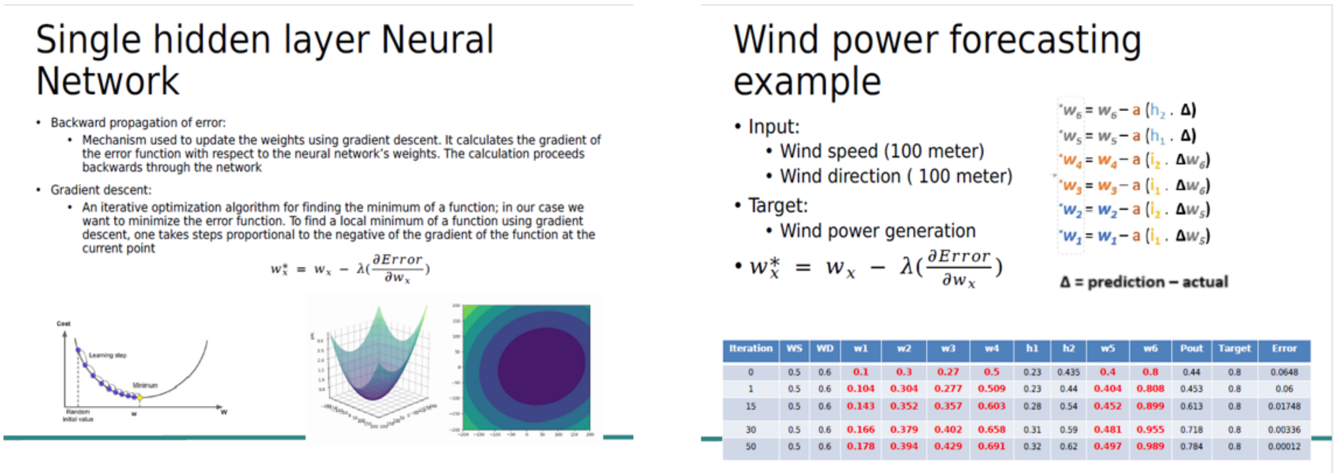


Figure 14 Examples of decision trees training and optimal classification trees

The lecture summarizes the content with a practical example of classifiers application and comparison in the power system of a non-interconnected Greek island. The basic parameters of the system are described in order to generate the training set and then the training time and the accuracy of the different classifiers are shown and compared, resulting to the evaluation of the machine learning techniques in dynamic security of power systems and a short reference to the advanced evaluation techniques.

The second lecture starts with an introduction to power predictions, stating the meaning, necessity, relevant stakeholders and basic function mechanism of wind and solar power predictions, followed by the challenges connected to power prediction. The introduction is supplemented by the mathematical formulation of forecasting basic principles, considering the power conversion functions. Artificial neural networks are a crucial part of the forecast procedure, and therefore the training process of the artificial neural network, combined with the inputs and error functions is presented. For further understanding of this process, an example of a single hidden layer neural network is analysed, introducing forward pass, calculating error and gradient descent. The lecture then combines the aforementioned information into an actual power forecasting example with the use of artificial neural networks. The basic approach of single layer is then expanded to deep learning, presenting the full advantages of neural networks in wind & solar power forecasting.



Iteration	WS	WD	w1	w2	w3	w4	h1	h2	w5	w6	Pout	Target	Error
0	0.5	0.6	0.1	0.3	0.27	0.5	0.23	0.435	0.4	0.8	0.44	0.8	0.0648
1	0.5	0.6	0.104	0.304	0.277	0.509	0.23	0.44	0.404	0.808	0.453	0.8	0.06
15	0.5	0.6	0.143	0.352	0.357	0.603	0.28	0.54	0.452	0.899	0.613	0.8	0.01748
30	0.5	0.6	0.166	0.379	0.402	0.658	0.31	0.59	0.481	0.955	0.718	0.8	0.00336
50	0.5	0.6	0.178	0.394	0.429	0.691	0.32	0.62	0.497	0.989	0.784	0.8	0.00012

Figure 15 Single hidden layer Neural Network and forecasting example

The training process of the model is followed by the evaluation of the developed model, presenting the need of evaluation and the basic evaluation metrics (bias, mean absolute error, mean square error, root mean square error). These metrics are further analysed, presenting the equations and outcomes of the evaluation for each metric. The lecture ends with an application of the various metrics into the evaluation of a power prediction example.

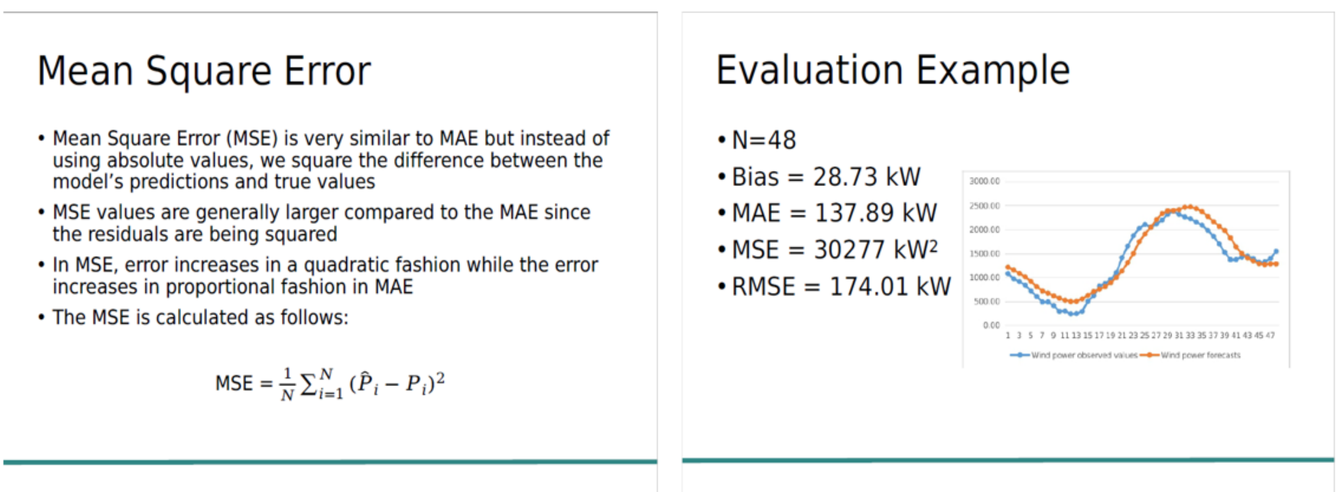


Figure 16 Evaluation metrics example and simulation results

Main Findings

The lectures primarily concentrate on the assessment of the dynamic security and the power production forecasting mechanisms in power systems. The emphasis is put towards artificial Intelligence, mathematical optimization, forecasting, data analysis, and machine learning, stemming from the skill gaps identified in WP2 analysis.

The main findings, following the lecture deployment, encompass inputs from student surveys, feedback gathered from presenters, and discoveries made during the design and implementation phases of the field activities, following the assessment procedure as described in the previous activity.

This set of lectures focuses mainly on machine learning and artificial neural networks. The principal purpose of the presenters was to utilize these identified skill gaps, introducing their basic principles and linking them to real-life applications in modern power systems. A critical challenge in the development of the lectures was to present the complex systems of machine learning in dynamic security and artificial intelligence in forecasting algorithms in a conceivable and comprehensive manner. The feedback received from the students, aligned with the estimation that the presenters received during the lectures, indicate that the topics were sufficiently covered. While deemed sufficient, improvements in participant engagement through more practical examples and simulations were suggested. Taking into account the fact that the lectures introduced topics linked to the identified skill gaps to students already equipped with BSc in relevant studies, it indicates the high potential for future adjustments.

A key finding occurred from the presenters' opinion, where they highlighted the fact that they found it substantially difficult to keep the students' interest, while going deeper into the connection between machine learning or artificial intelligence with power systems. The single presentation of some simulation examples' results was thought to be insufficient for serving its purpose on engagement. The same result obtained from the survey. As a potential mitigation action for the next semester is to focus not on the results of the simulations that prove the concepts, but to how the simulations are built, motivating the students to take action and try to build similar simulation concepts.

An outcome obtained by the surveys in both activities (the two-lecture series) is the crucial role of digitalisation in the evolution of the energy sector. Considering that the activities have been deployed in the context of the MSc course "Digitalisation of Energy Systems", the recognition of digitalisation's importance holds significant value, as it comes from students aware of the topic and the basic needs & trends of the sector. This significance was further emphasized by the presenters, positioning digitalization at the forefront of educational programs associated with power production and management (the general topic of the MSc program). They specifically highlighted that the content of this course (that contains also the two-lecture series) is linked to most of the content of the rest of the courses, facilitating the transition of all power systems.

4.2.3. Introductory lecture into MOOC on advanced validation methods for smart grids

The MOOC will be organized by the H2020 project ERIGrid 2.0 and will focus on the topic of advanced validation methods for smart grids. EDDIE will participate in the MOOC with a lecture raising awareness in the educational challenges that occur due to the digitalization of the energy systems. The lecture will be available to BSc and MSc students, as well as to young professionals and researchers.

Program fact sheet

1. **Name of program:** Advanced validation methods for smart grids
2. **Program format:** Online
3. **Program language:** English
4. **Length of program:** One 45-minutes lecture
5. **Student´s estimated effort in working hours:** 45 minutes
6. **Industrial challenges addressed 1. - Economic and organizational:** Business model adaptation
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Lack of adequate skills from employees
9. **Industrial challenges addressed 4. - Energy system:** N/A
10. **Industrial challenges addressed 5. - Extreme situations:** N/A
11. **Industrial challenges addressed 6. – Other:**
12. **Skill gap area:** Data management and analysis, Big Data, Cybersecurity, Programming and development competencies
13. **ISCED code of program content:** N/A
14. **Starting point of program design:** N/A
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** students, employees, professionals between jobs
18. **EQF level: 6-7**
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job: Yes
    b. Does the program provide credits (ECTS): No

   c. Is it modularized: Yes
   d. Does it provide any certification per module: No
20. **Certification:** Certification of attendance

Business and operational model

1. **Relevance of program:** N/A
2. **Definition of targets:**
   a. Name the skills you target: N/A
   b. Enter their ESCO codes: N/A
   c. Name the occupations you target: N/A
   d. Enter their ESCO codes: N/A
   e. Name the tools and systems that you target: N/A
3. **Financial structures:** N/A
4. **Use of resources:** N/A
5. **Licenses for digital tools:** N/A
6. **Marketing and student recruiting procedures:** N/A
7. **Employer feedback:** N/A
8. **Alumni engagement:** N/A

Learning and teaching model

1. **Admission requirements: N/A**
2. **Training goals:**
   a. Training goal #1: raising awareness in the educational challenges that occur due the digitalization of the energy systems
   b. Training goal #2: Inform the participants about the identified skill gaps and the basic guidelines of the Blueprint strategy
3. **Program content - Syllabus elements in ICT/Digital:**
   a. **#1:** INFORMATION TECHNOLOGY - New Trends in Information Technology
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. **#1:** ELECTRICAL ENGINEERING – Electrical Engineering
5. **Program content - Syllabus elements in Energy:**
   a. **#1:** ELECTRICAL ENGINEERING – Electrical Engineering
6. **Program content - Syllabus elements in transversal skills:** N/A
7. **Program content – Re-use of training modules:** N/A
8. **Program contents – Intellectual Property Rights**: All contents are protected by copyright, They may only be used within the limited circle of participants of the Moodle learning room and for private purposes. Sharing the content beyond the limited group of participants in the Moodle learning room thus constitutes publication subject to permission**.**
9. **Methodologies:** N/A
10. **Teaching methods:** N/A
11. **Evaluation methods:** N/A
12. **Internships:** N/A
13. **Scheduling:** N/A

Program Content

The introductory presentation, during the MOOC, will spotlight the emerging needs in the educational sector, as an outcome of the ongoing digitalization procedure of the energy systems. Its primary objective is to share the outcomes and tools developed within the project, specifically highlighting the Blueprint Strategy of the EDDIE project, that targets to meet and anticipate the skills demands of the energy sector.

Additionally, the presentation's second segment will focus to the current challenges in the energy sector, as well as the identifies skills gaps in the energy industry and the methodologies used to pinpoint them, utilizing the work conducted within the framework of WP2.

Main Findings

The presentation for the MOOC is under development, intended to be available when the MOOC goes live by the end of the year. Consequently, there are no main findings at this stage. Nevertheless, it underscores the interest of other European programs in power and energy topics regarding the skill gaps and the related process of identification and revision undertaken during the EDDIE project.

4.2.4. Participation in ERIGrid 2.0 Summer School

The Summer School organized under ERIGrid 2.0 (H2020 project), will take place during summer 2023 and will focus on smart grid applications. EDDIE will participate by organizing a presentation targeting to disseminate the projects' goals and outcomes, facilitated by the training materials developed during the project.

Program fact sheet

1. **Name of program:** Summer school on smart grid applications
2. **Program format:** Online
3. **Program language:** English
4. **Length of program:** One 45-minutes lecture
5. **Student´s estimated effort in working hours:**
6. **Industrial challenges addressed 1. - Economic and organizational:** Business model adaptation
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies
8. **Industrial challenges addressed 3. - Technical and regulatory:** Lack of adequate skills from employees
9. **Industrial challenges addressed 4. - Energy system:**
10. **Industrial challenges addressed 5. - Extreme situations:**
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Data management and analysis, Big Data, Cybersecurity, Programming and development competencies
13. **ISCED code of program content:** N/A
14. **Starting point of program design:** N/A
15. **Funding 1. - Available for free:** Yes
16. **Funding 2. - Types of funding:** N/A
17. **Target groups:** students, employees, professionals between jobs
18. **EQF level:** TBD
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job: Yes
    b. Does the program provide credits (ECTS): No
    c. Is it modularized: Yes
    d. Does it provide any certification per module: No
20. **Certification:** Certification of attendance

Business and operational model

1. **Relevance of program:** N/A
2. **Definition of targets:**
    a. Name the skills you target: N/A
    b. Enter their ESCO codes: N/A
    c. Name the occupations you target: N/A
    d. Enter their ESCO codes: N/A
    e. Name the tools and systems that you target: N/A
3. **Financial structures:** N/A
4. **Use of resources:** N/A
5. **Licenses for digital tools:** N/A
6. **Marketing and student recruiting procedures:** N/A
7. **Employer feedback:** N/A

8. **Alumni engagement:** N/A

Learning and teaching model

1. **Admission requirements:** N/A
2. **Training goals:** N/A
    a. Training goal #1: Dissemination of the projects' goals and outcomes
    b. Training goal #2: Familiarize the participants with the training material of the project
3. **Program content - Syllabus elements in ICT/Digital:**
    a. **#1:** INFORMATION TECHNOLOGY - New trends in information technology
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
    a. **#1**: ELECTRICAL ENGINEERING - electrical engineering
5. **Program content - Syllabus elements in Energy:**
    a. **#1:** ELECTRICAL ENGINEERING - electrical engineering
6. **Program content - Syllabus elements in transversal skills**: N/A
7. **Program content – Re-use of training modules:** N/A
8. **Program contents – Intellectual Property Rights:** All contents are protected by copyright.
9. **Methodologies:** N/A
10. **Teaching methods:** N/A
11. **Evaluation methods:** N/A
12. **Internships:** N/A
13. **Scheduling:** N/A

Main Findings

The content for the Summer School is presently in development as the Summer School of ERIGrid 2.0 project is expected to take place during Spring 2024. Therefore, there are no main findings available at this stage.

5. Field test Milano

This pilot action focuses on the design, development, delivery, and monitoring of massive open online courses (MOOC). The course, titled "Energy management for real estates - Fundamentals, methods and digital tools" delves into the figure of the energy manager and is targeted at all those professionals who revolve around energy management in the real estate field. The course was delivered online, through POK - Polimi Open Knowledge platform and Coursera; it has been provided for free and open to all. In addition, the materials were distributed under a Creative Commons License (CC-BY 4.0), to ensure the opportunity of reuse and remix.

5.1. Overview of activities

Table 21 Overview of pilot activity in Milan

Piloting Activity	Target group	EQF Level	Duration	Main stakeholders	Part/s of Blueprint Strategy tested	Results delivered to EC	Energy sector	Contents
Design, production and implementation of a MOOC	Professionals	7	August '22	Politecnico di Milano Departments Italian Federation for the Rational Use of Energy	Training program marketplace. (MOOC: reduction of skill gaps, drafting of best practices, development of general templates)	Job profile addressed: Energy Manager Skills covered: · Define the energy profile of buildings · Analyze energy consumption · Identify energy needs · Conduct energy audit · Advise on heating systems energy efficiency · Promote environmental awareness	Digital Energy management for real estates	Video Lectures, quizzes, case studies, online exploration, peer discussion

5.2. Presentation of activities

5.2.1. MOOC on Energy management for real estates

Since the launch of the MOOC, three editions have been proposed to the public and target group among the two platforms.

Table 22 MOOC editions

Platform	1st edition	2nd edition
POK	3rd April – 15th October 2023	15th October 2023 – 7th April 2024
COURSERA	8th May 2023	

Part of the content has been designed in collaboration with Daniele Forni, Chief Technology Officer of FIRE - Italian Federation for the Rational Use of Energy. He hold an online event titled "Practical Introduction to energy audit" was organised for participants but open to anyone interested that took place on May 3, 2023.

Program fact sheet

1. **Name of program:** Energy management for real estates - Fundamentals, methods and digital tools
2. **Program format:** MOOC (Massive Open Online Course)
3. **Program language:** English
4. **Length of program:** 4 Weeks
5. **Student´s estimated effort in working hours:**12 hours
6. **Industrial challenges addressed 1. – Economic and organizational:** None
7. **Industrial challenges addressed 2. – Social:** None
8. **Industrial challenges addressed 3. – Technical and regulatory:** Lack of adequate skills from employees; Technology integration (compatibility with existing processes/ technologies)
9. **Industrial challenges addressed 4. – Energy system:** Customers: Dedicated information about their energy profile
10. **Industrial challenges addressed 5. – Extreme situations:** None
11. **Industrial challenges addressed 6. – Other:** N/A
12. **Skill gap area:** Data management and analysis; Big Data; Cybersecurity; Programming and development competences
13. **ISCED code of program content:** 07 Engineering, manufacturing and construction
14. **Starting point of program design:** Energy program with an ICT add-on
15. **Funding 1. - Available for free:** yes
16. **Funding 2. - Types of funding**
17. **Target groups:** Professionals
18. **EQF level:**7
19. **Lifelong learning and certification:**
    a. **Is it possible to combine the program with a job?** Yes. It is specifically dedicated to Energy manager
    b. **Does the program provide credits (ECTS)?** No
    c. **Is it modularized?** No
    d. **Does it provide any certification per module?** No
20. **Certification:** Certificate of accomplishment

Business and operational model

1. **Relevance of program:**
    a. Promoting the empowerment of students to use their subject-specific knowledge in a broader context to tackle global and societal challenges and thus to solve problems with responsibility.
    b. Offering a learning path that addresses specific educative gaps in energy sector
    c. Promoting and disseminating knowledge coming from public universities to a larger public
2. **Definition of targets:**
    a. **Name the skills you target:** N/A
    b. **Enter their ESCO codes:** N/A
    c. **Name the occupations you target:** Energy manager
    d. **Enter their ESCO codes:** 1349.12
    e. **Name the tools and systems that you target:**
3. **Financial structures:** The programme is included in university didactical activities
4. **Use of resources:**
    a. **#1:** staff days to maintain the programme
    b. **#2:** Permanent and free accessibility of the programme in the future
5. **Licences for digital tools:** No
6. **Marketing and student recruiting procedures:**
    a. **#1:** University social network
    b. **#2:** Teacher's connection
    c. **#3:** POLI TAM TAM
7. **Employer feedback:** N/A
8. **Alumni engagement:**
    a. **#1:** Politecnico di Milano Career office newsletter

b. **#2:** METID social networks

Learning and teaching model

1. **Admission requirements:** no requirements
2. **Training goals:**
   a. **Training goal #1:** Understand and critically assess Energy Efficiency policies and the process and tools for estimating the energy savings potential of a building and implementing and verifying savings.
   b. **Training goal #2:** Categorize Energy consumption in a building, determine a strategy to evaluate Energy performance, and define and explain the multiple benefits of Energy Efficiency
   c. **Training goal #3:** Explain the barriers to investment in cost-effective Energy Efficiency and define and evaluate the tools that can overcome these barriers, with specific focus on digital based strategies.
   d. **Training goal #4:** To identify elements of digital transformation in the energy for building sector, challenges and solutions, and impact
   e. **Training goal #5:** Collect, manage and analyse data
3. **Program content - Syllabus elements in ICT/digital:**
   a. #1: CONTROL - Remote Control and Automation
   b. #2: CONTROL - Applications: electric drives & controllers
   c. #3: CONTROL - Advanced Control Techniques
   d. #4: CONTROL - Industrial automation, Industrial control (PLC, PID, etc.)
   e. #6: MODELLING, SIMULATION & OPTIMISATION - Modelling, simulation & optimisation
4. **Program content - Syllabus elements in another STEM than ICT/Digital:**
   a. #1: HEAT & COOLING ENGINEERING - Heat & cooling installations
   b. #2: BASIC MECHANICS - Thermal engines (heating and cooling)
   c. #3: BASIC MECHANICS - Heat transfer
   d. #4: ENERGY MANAGEMENT & GREEN SKILLS - Sustainable development
   e. #5: HEAT & COOLING ENGINEERING - Heat & cooling installations
5. **Program content - Syllabus elements in Energy**
   a. #1: MODELLING, SIMULATION & OPTIMISATION - Modelling, simulation & optimisation
   b. #2: CONSTRUCTION/INFRASTRUCTURE - Structures & construction
   c. #3: ENERGY MANAGEMENT & GREEN SKILLS - Energy Transition
   d. #4: ENERGY MANAGEMENT & GREEN SKILLS - Flexible demand and Smart home/buildings
6. **Program content - Syllabus elements in transversal skills**
   a. #1: MANAGEMENT & BUSINESS - Economic Analysis of electrical systems
   b. #2: MANAGEMENT & BUSINESS - Economy of Energy, Markets and Regulation
7. **Program content -** Re-use of training modules: Yes, by others Politecnico di Milano courses
8. **Program content -** Intellectual Property Rights: the course will be released under a Creative Commons licence. The experts are evaluating which one.
9. **Methodologies:** Worked examples - Magistral lecturing
10. **Teaching methods:** Magistral lectures - Personal study - Practical exercises
11. **Evaluation methods:** Other (please specify): quizzes
12. **Internships:** No
13. **Scheduling:** self-paced

Program Content

The program content for this pilot action was designed, with a team of Politecnico di Milano faculty, from the needs and skill gaps identified in the EDDIE project WP2. In particular, the program will focus on the figure of the Energy Manager in the real estate sector and will provide the necessary information to:

- verify consumption, through ad hoc audits or, if available, through digital models or reports produced by remote management;
- optimize consumption through the correct regulation of systems and their appropriate use from an energy point of view;
- promote energy-aware behavior by employees and/or occupants of the facility;

- propose improvement investments, possibly improving production processes or the performance of related services.

The course design, as well as the subsequent phases of this pilot activity, takes into account the drivers and objectives of the Blueprint Strategy: it therefore covers part of the "green skills" or "sustainability skills" that are becoming increasingly in demand in the energy management sector. It also provides "integrated" knowledge and train experts to understand issues that are traditionally outside their area of expertise. The MOOC targets real estate professionals but will be open to anyone interested in the field. During the design phase, the skill gaps to be covered were identified, and starting from these, POLIMI faculty defined the intended learning outcomes of the course. Then the structure of the course was set, and the contents were outlined as follows:

Table 23 Structure of MOOC on Energy management for real estates

MOOC TABLE OF CONTENT	
WEEK 0	About the course About you
WEEK 1 (INTRODUCTION)	MOOC presentation (trailer) The energy manager profile and main skills/activities
WEEK 2	Structure of the energy sector at national and international level Energy Commodity Supply and Markets Heat transfer and energy balance of a building Sun, light and glazing Building technical systems Weekly Quiz
WEEK 3	Energy audit Energy efficiency of the building envelope Practical Introduction to energy audit (WEBINAR) Energy efficiency of the technical systems Renewable energy sources Weekly Quiz
WEEK 4	Energy digital models and simulations Retrofit of existing buildings Weekly Quiz

All videos produced will be uploaded, along with the quizzes and textual content, in the 2 platforms, POK - Polimi Open Knowledge and Coursera.

Main Findings

POLIMI monitors enrolments and participation in both courses and in the webinar. Here below a summary of data updated at the 30th November 2023.

Table 24 Main data about MOOC participation

MAIN DATA ABOUT MOOC PARTICIPATION	POK	COURSERA
Participants enrolled	121	918
Certificates earned	25	217
Rating	3.4 (up to 4)	4.3 (up to 5)

In both courses an initial and final customer care questionnaire has been proposed to participants as part of the standard MOOC creation procedure in POLIMI. Moreover, a specific survey, developed by EDDIE partnership, has been included in the final week of the course aiming to measure the impact of the activities on participants awareness and competences on the project's topics. The replies collected through POLIMI questionnaires are 40 to the initial one and 11 to the final.

Here below are showed some demographic data about participants who attended the MOOC in Coursera. Respect POK users, that came from Italy, mostly, the majority of enrolled users in Coursera are from Asia (India in particular). Gender and age among the platforms are aligned with the majority of them concentrated between 25-35 years old.

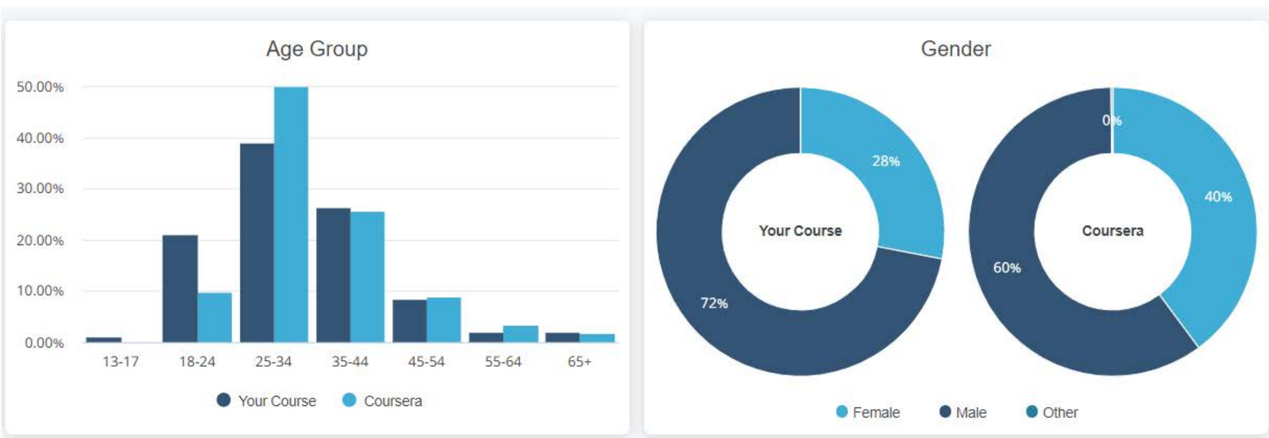


Figure 17 Age and gender of MOOC participants in Coursera

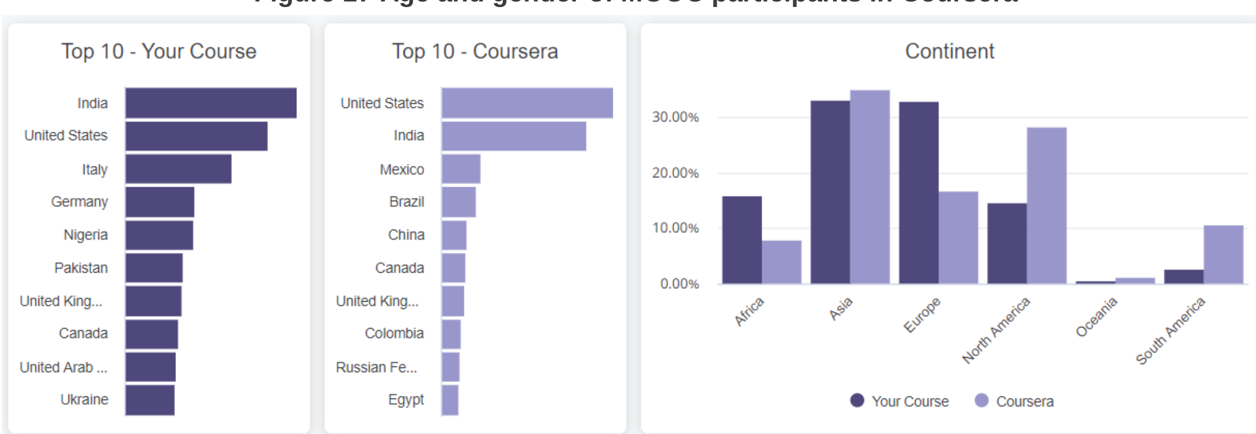


Figure 18 Provenience of MOOC participants in Coursera

The majority of respondents to initial questionnaire in POK (80%) declared to have a master (in line with Coursera users) or PhD. Almost 70% are working while a 24% is studying while Coursera data indicated a quite important percentage (20%) of users who are looking for a job. In general participants declared they joined the course for both professional than personal interest and they'd like to complete the whole course.

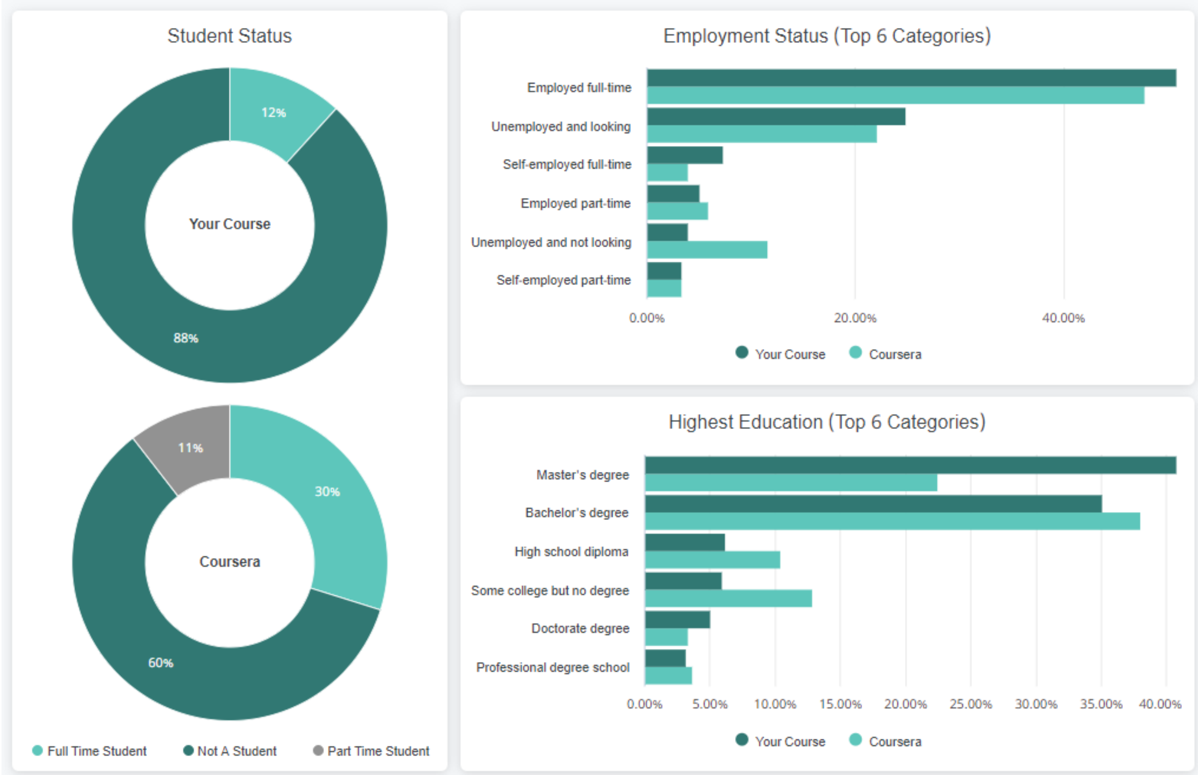


Figure 19 Educational level of MOOC participants in Coursera

In general, participants declared that they improved the sense of what energy management for real estate is (4 on 5 point max). Joining such activity was helpful for gaining skills, knowledge, experience useful for your future professional and motivational for further research in such field. They are less aware about the concrete opportunities to apply what learnt in work or any practice situation (3 on 5 points max).

After this experience, they say they would you be interested in participating in similar future activity with a special interest in data management and analysis and programming and development competences. They would recommend this course to colleagues. They indicated, as appreciate the communication style of lessons.

The overall learning experience has been rated positively.

Table 25 Summary of MOOC on Energy management for real estate

Summary	Main issues
Success factors	• Differentiate the environments through which the course is delivered • Openness of didactical contents • Course materials always available and usable at participants own pace
Areas of improvements	• The course lack of concrete examples told by instructors
Reccomendations	• Enrich the didactical materials with examples/case studies

6. Field Test Madrid

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

Vocational training in Spain and around the world is undergoing rapid change. Our students must be up to date with all the digital tools that are being developed to improve their work and for the benefit of the users for whom they will develop their work. In relation to technical professionals, there is a great need for training in digital skills. That is why, from the ESCUELAS PROFESIONALES PADRE PIQUER in Madrid, we have decided to implement a pilot course of 30 hours for our students of electrical and telecommunications installations (EQF levels 4 and 5) only focused on the management of digital tools to improve the energy efficiency of a house.

6.1. Overview of activities

Table 26 Overview of pilot activities in Marid

Piloting Activity	Target group	EQF Level	Duration	Main stakeholders	Part/s of Blueprint Strategy tested	Results delivered to EC	Energy sector	Contents
Home Energy efficiency and electrical installations course	Students, employee and /or professionals	4 and 5	30 hours	Escuelas Profesionales Padre Piquer (Madrid)	Best practices, levers to reduce skills gaps, general templates	Teaching/learning material on electrical installations for smart homes.	Power, IT.	1. Electrical Installations in dwelling/ regulations 2. Home energy consumption 3. Domotic systems aimed at improving energy consumption. 4. Regulations 5. Adaptations of the electrical installation 6. Phantom consumptions 7. Digitalization of consumption

6.2. Presentation of activities

6.2.1. Home Energy Efficiency and Electrical Installations

This training develops a complementary training module to the VET offer of electrical technicians, addressing the restructuring of the electrical installation of a home, the application of energy efficiency measures, and the adoption of energy management. The training aims to fill in the current gap in the official training of general electrical installers, as tend to be mainly based on domotic systems for reducing energy consumption in air conditioning and lighting equipment, leaving aside the possible adaptation of the installation of the dwelling to improve energy consumption, the use of smart devices for continuous monitoring and control, and the training in the use of applications to allow such smart operation by both the installer and the user.

<u>**Program fact sheet**</u>

1. **Name of program:** Home Energy Efficiency and Electrical Installations Course.
2. **Program format:** On campus / On-site

3. **Program language:** Spanish
4. **Length of program:** 1 week
5. **Student´s estimated effort in working hours:** 30 h.
6. **Industrial challenges addressed 1. – Economic and organizational:** N/A
7. **Industrial challenges addressed 2. – Social:** Acceptance of new technologies and Lack of citizen engagement
8. **Industrial challenges addressed 3. – Technical and regulatory:** Reliability and stability need for machine-to-machine communication/ Lack of adequate skills from employees
9. **Industrial challenges addressed 4. – Energy system:**
   Customer: Remote services to customers.
   Customers: Remote metering.
10. **Industrial challenges addressed 5. – Extreme situations:** NO
11. **Industrial challenges addressed 6. – Other:** Home automation
12. **Skill gap area:** Data management and analysis/ Programming and development competences
13. **ISCED code of program content:** 0714, 0619 and 0713
14. **Starting point of program design:** Both
15. **Funding 1. - Available for free:** NO
16. **Funding 2. - Types of funding:** Public funding
17. **Target groups:** students/employees and professionals
18. **EQF level:** 4
19. **Lifelong learning and certification:**
    a. Is it possible to combine the program with a job? YES
    b. Does the program provide credits (ECTS)? NO
    c. Is it modularized? YES
    d. Does it provide any certification per module? YES
20. **Certification:** Diploma

Business and operational model

1. **Relevance of program:**
   a. **#1:** Specific and short training for electrical installers.
   b. **#2:** Training aimed at improving the energy efficiency of households.
   c. **#3:** Telecommunications and computer applications for consumption management.
   d. **#4:** Introduction of home automation as a digital tool to reduce energy consumption.
2. **Definition of targets:**
   a. Name the skills you target: Electronics and automation
   b. Enter their ESCO codes: N/A
   c. Name the occupations you target: Domestic electrician
   d. Enter their ESCO codes: 7411.1.1.1Name the tools and systems that you target: Smart devices and appliances for demand response
3. **Financial structures:**
   a. **#1:** Public funds for the teaching activity.
   b. **#2:** School´s own funds for the equipment.
4. **Use of resources:**
   a. **#1:** Classroom / lab.
   b. **#2:** Computers.
   c. **#3:** Multimedia projector.
   d. **#4:** Air conditioning equipment.
   e. **#5:** Electrical and home automation equipment.
5. **Licenses for digital tools:** YES but will be free access

6. **Marketing and student recruiting procedures:**
    a. **#1:** Students that are already finishing their studies at our School.
    b. **#2:** Short-term course before going into an internship to finish their studies.
7. **Employer feedback:** N/A
8. **Alumni engagement:**
    a. **#1:** A survey will be conducted after the internship to find out if the contents of the course have been used.
    b. **#2:** After 2 years there will be a follow-up on how the employability of the students who have taken the course has improved.

Learning and teaching model

1. **Admission requirements:** High school diploma
2. **Training goals:**
    a. Training goal #1: Extend the training of the participants.
    b. Training goal #2: Specific training in Energy-Efficient Homes.
    c. Training goal #3: Specific training in "phantom energy use" generated by devices in standby.
3. **Program content - Syllabus elements in ICT/ Digital:**
    a. **#1:** COMMUNICATIONS, NETWORKS & BUSES – Remote monitoring
    b. **#2:** INFORMATION TECHNOLOGY – Intelligent Systems
    c. **#3:** INFORMATION TECHNOLOGY – Internet of Things
    d. **#4:** INFORMATION TECHNOLOGY – Technical communications
    e. **#5:** CONTROL – Remote control and Automation
    f. **#6:** MOBILE APP DEVELOPMENT – Usability & User Interface
    g. **#7:** MOBILE APP DEVELOPMENT – IOS and Android Operating Systems.
4. **Program content - Syllabus elements in another STEM than ICT/Digital:/**
5. **Program content - Syllabus elements in Energy:**
    a. **#1:** ENERGY MANAGEMENT & GREEN SKILLS – Flexible demand and Smart home / buildings
6. **Program content - Syllabus elements in transversal skills:**
    a. **#1:** TRANSVERSAL PROFESSIONAL SKILLS – Problems solving
    b. **#2:** TRANSVERSAL PROFESSIONAL SKILLS – Teamwork
7. **Program content - Re-use of training modules:** Yes, future envisioned.
8. **Program content - Intellectual Property Rights:** Property of Piquer**.**
9. **Methodologies:** Practical learning, Problem-based learning, Interactive lecture, Scenario based learning
10. **Teaching methods:** Practical lab lessons, practical exercises, problem solving
11. **Evaluation methods:** Written examination, Projects
12. **Internships:** No
13. **Scheduling:** Full time

Program Content

The pilot activity developed by the ESCUELAS PROFESIONALES PADRE PIQUER (Madrid) has as its strong point on the emphasis on the practical training of the proposed course. The course consists of 30 theoretical-practical hours in which students will simulate the electrical installation of a house in the most efficient way using the necessary technologies. This learning based on real simulation will use modern applications and materials (such as solar panels, Specific systems for reducing the standby consumption, etc.) that will bring the student closer to a real scenario.

The program consists of seven modules starting with the basics of the electrical installations in a house and the regulations, addressing the phantom or idle consumption, the applicable tariffs, the domotic systems, the generation technologies in buildings, the adaptation of the electrical installations, and the consumption management. Special attention is given to the domotic systems, the adaptations of the electrical installations, and the telecommunication and computer applications for energy management.

Module 1: Electrical installations in dwellings / Regulations (1.5h)

- Setting the bases and requisites necessary for the main objective of the course.

Module 2: Energy consumption of a dwelling (1.5h)

a) Study of the average consumption of a home, as well as the individual consumptions of typical equipment / devices.
b) Phantom or idle consumption.
c) Costs and tariffs applicable to the user of a dwelling.

Module 3: Domotic systems aimed at reducing energy consumption (4.5h)

- Basic competences in existing domotic systems needed to address the main objective of the course.

Module 4: Power generation systems in houses, and applicable regulations (3h).

Module 5: Adaptations of the electrical installations (4.5h)

- Possible adaptations and modifications to the electrical installation of a building with the aim of facilitating the monitoring and control by the installer and subsequently by the user, to improve energy efficiency and manage consumption.

Module 6: Phantom consumption (3h)

- Specific systems for reducing the standby consumption of devices normally connected in a house.

Module 7: Digitalisation of consumption (12h)

- Telecommunications and computer applications for consumption management.

<u>Main Findings</u>

Once the pilot activity was completed, an assessment completed by the participants has yielded several key findings:

- The coverage of the topics was found to be adequate. That was achieved by utilizing various of the tools of the Blueprint strategy, aiming to design and implement up-to-date and motivational activities.
- The methodology was found very adequate to cover the aim of the course.
- The digitalization of the energy was covered by this course with the Smart home and domotics.
- Computing tools and platforms along with digital platforms are identified as the least mitigated skill gaps. As a demand of some students, they expect more practical work and hands-on involvement.
- The most preferred area for future education/training activities is Cybersecurity, followed by Data management and analysis.
- The learning of this kind of contents are highly preferred to be develop in-person
- Instructors underlined the high involvement and motivation of participants.

7. Conclusion

EDDIE project aims to develop a Blueprint Strategy for the Digitalisation of Energy value chain (BSDE). This Blueprint will be industry-driven, considering the various technological, social and economic challenges created due to the digital transformation of the Energy Sector. New skills demand appears that needs to be covered in order to ensure the sustainability of the energy sector. Vital for reducing the new skills gaps are updated, modern training programs, that will enhance knowledge and expertise exchange among all involved stakeholders in a common way throughout European Union. Thus, the Blueprint Strategy focuses on the aforementioned issues, planning to establish a solid and sustainable framework to facilitate the continuous update of training programs offered in Europe, considering the current industry demand each time. Soft and green skills, social sciences, and humanities economics, as well as gender dimension will be taken under consideration in multidisciplinary approach, aiming to adjust to the rapidly evolving sector.

Tools and mechanisms of the Blueprint need to be tested and updated, ensuring the sustainability of the strategy, not only during the project, but mainly after its completion. Therefore, one central pilot in Germany (Aachen) and four smaller-scale pilots in Germany (Cologne), Greece (Athens), Italy (Milano) and Spain (Madrid) are developed. Activities for various EQF levels, are conducted, including most of the parts of the Blueprint strategy.

In this deliverable the content of each activity is described in-depth. In the attempt to reach greater participation, the planned actions cover different EQF levels and include interactions with local communities and young citizens, courses in universities, MOOCs, participation in summer schools and lectures in academies, as well as between lectures & simulations & project-based programs. Some of the actions take place in the context of synergies, expanding the dissemination of the project goals. The main findings of the five pilot sites are described in the subchapters following.

7.1. Field Test Aachen

In the field test conducted in Aachen, various educational initiatives were conducted to enhance understanding in the areas of renewable energy and the digitalization of the energy sector. These initiatives encompassed diverse formats, including workshops, lectures, and hands-on activities. A common thread across these efforts was the intentional focus on interactive and experiential methodologies, aiming to actively engage participants in the learning process. The incorporation of participant feedback through surveys emerged as a key strategy, allowing for continuous improvement of the educational experiences. Additionally, there was a shared commitment to addressing knowledge gaps, ensuring that participants received comprehensive insights into the complexities of renewable energy and digitalization in the energy sector. This holistic approach aimed to foster a deeper understanding among participants and promote active involvement in the ongoing energy transition.

Several common points can be identified across the various educational activities and initiatives described:

1. **Interactive and Hands-On Learning:** Many of the activities, including the "Archimedischer Sandkasten", "Gymnasium Workshop," "Girls' Day," and "Science Night at RWTH," emphasized the importance of interactive and hands-on learning methods. The use of demos, models, and interactive tools proved effective in engaging participants and enhancing their understanding of complex concepts related to renewable energy, energy grids, and digitalization.
2. **Focus on Renewable Energy and Digitalization:** All activities shared a common focus on renewable energy, energy transition, and the role of digitalization in the energy sector. The content aimed to convey the complexities of these topics, and the positive responses indicated successful engagement and understanding among participants.
3. **Emphasis on Digitalization:** Digitalization emerged as a key theme across activities, with a focus on its role in energy transition, smart grids, data management, and open-source technologies. The survey results often highlighted participants' awareness of the importance of digitalization in the energy sector, while also indicating areas for further education in this domain.
4. **Interest in Career Exploration:** The activities, particularly the "Gymnasium Workshop" and "Girls' Day," highlighted the interest of participants in understanding potential career paths in the field of energy technology and the energy transition. Participants expressed curiosity about job descriptions, indicating a need for career exploration in addition to knowledge dissemination.
5. **Focus on Students and Youth:** Many activities targeted students and youth, aiming to spark interest and understanding early on. The "Girls' Day" and "Archimedischer Sandkasten" activities, in particular,

emphasized introducing topics like energy grids and electrical engineering at an early stage, underlining the importance of early education in these areas.

6. **Quantitative Assessment of Learning:** Several activities such as “Workshop on Data Platforms for the Energy Infrastructure” and “ACS lecture on automation of complex power systems” incorporated quantitative assessments of participant learning, such as quizzes and comparisons of exam performance before and after the introduction of new teaching methods. This emphasis on measurable outcomes provides valuable data on the effectiveness of educational initiatives.
7. **Survey Feedback for Improvement:** Each activity utilized surveys to gather feedback from participants, whether they were children, parents, interested adults, students, or event attendees. The survey results played a crucial role in assessing the effectiveness of the activities, identifying areas for improvement, and shaping future iterations. The emphasis on continuous improvement based on participant feedback is a common thread.
8. **Awareness of Knowledge Gaps:** The activities demonstrated an awareness of knowledge gaps among participants. For example, the development of a new demo for the "Archimedischer Sandkasten" and the adaptation of the "Girls’ Day" demo aimed at addressing specific skill gaps, such as Energy Management Systems.

In summary, the various educational initiatives discussed underscore the significance of interactive, hands-on learning methods, a commitment to continuous improvement guided by participant feedback, a thematic focus on renewable energy and digitalization, encouragement of career exploration, recognition of knowledge gaps, an emphasis on digitalization within the energy sector, a dedicated focus on students and youth engagement, and a commitment to the quantitative assessment of learning outcomes. These shared principles highlight a holistic and dynamic approach to energy education, aiming to foster understanding, interest, and measurable impact across diverse participant groups.

7.2. Field Test Cologne

The field test carried out in cologne featured a diverse array of educational programs, including the EWI Academy workshops, the Future Energy Business Program, and the Smart Energy Certificate Program. These have collectively offered valuable insights into the current landscape of energy sector education and training.

EWI Academy: These workshops were celebrated for their dynamic and adaptive approach, effectively marrying theoretical knowledge with practical insights. The feedback highlighted the importance of interactivity and the need to address varying levels of knowledge among participants. **This underlined a key learning: the necessity of a flexible educational approach that integrates various expertise levels, ensuring relevance and engagement for a diverse professional audience**.

Certificate in Future Energy Business: This program initially envisioned as a structured two-semester course, had to be reimagined into a more modular format due to lower-than-expected enrollment. This flexibility allowed students to choose individual classes, aligning with their schedules and interests. Despite the positive feedback on content and the program's ability to bridge academic and practical realms, the challenge of securing consistent commitment remained. **The discrepancy between high sign-up rates and lower actual attendance underscored the need for enhanced marketing and engagement strategies.**

Smart Energy Certificate: The initial lack of interest in this program, designed for experienced professionals, led to its integration with the Certificate in Future Energy Business. This amalgamation aimed to broaden the program's appeal and scope. However, like Future Energy Business, it faced challenges in marketing and participant engagement, emphasizing the need for more effective strategies to attract and retain participants.

In conclusion, while each program had its unique strengths and focus areas, common themes emerged across all initiatives. The need for flexible, adaptive program structures that cater to diverse learning needs and professional backgrounds was evident. Additionally, the importance of effective marketing and engagement strategies to ensure participant commitment and attendance was a consistent learning. These insights not only highlight the potential of such educational models in bridging gaps between academia and the industry but also underscore the necessity for continuous innovation and responsiveness to the evolving demands of the energy sector.

7.3. Field Test Athens

In the field Test Athens various activities have been designed and developed, targeting mainly to participants of high EQF levels (6-7) that aim to delve into various of the topics that are related to the digitalisation of the energy. The main part of the already deployed activities was conducted in the format of lectures to MSc students and focused on utilizing the work of skills gaps identification, aiming to provide educational content and real-world examples in an effort to mitigate these skill gaps.

Various of the activities' topics focus on emerging skills gaps in the energy industry, such as Artificial Intelligence, Machine Learning, Blockchain, Forecasting, Mathematical optimization, to support the development of professionals, capable of adequately covering the increasing needs of businesses, organizations, and institutions in the energy sector. This approach also aims to raise the interest of the participants to diverse topics related to energy sector, broadening their scope and opportunities during their career paths exploration or adjustment.

The activities were followed by a tailormade structured survey in order to receive feedback from the participants, creating a mechanism of continuous enhancement and adjustment of the content. Additionally, the opinion of the presenters for the development and deployment stage of the activities has been obtained. The core of the field test consists of the lectures, that are planned to have a periodical deployment (once per year). This initiative, along with the feedback mechanism will secure the fulfillment of the self-sustainability of the Strategy and achieve to be up to date in the continuously evolving environment of the digitalisation of the energy sector.

Efforts to integrate practical examples into sessions aimed to boost engagement and comprehensive learning. The survey results indicated that the activities are in the right direction, aligned with their needs, although adoption of hands-on applications are needed, such as, real-time simulations with the participation of the students. These suggestions are aligned with the presenters' feedback, aiming to increase participants engagement.

Digital skills are at the forefront of the activities, gathering substantial interest among students, such as data analysis. While these competences are being addressed through the activities, a lot of effort is required to meet the demands from industry.

In summary, the design, development and deployment of the lectures have proven successful, measuring their acceptance from the attendees and the opinion and comments from the presenters. The activities primarily aimed to mitigating skill gaps, while also introducing a feedback mechanism for content update. In the spotlight is the professional development and career exploration of the activities' attendees. In this context, field test Athens remains committed to empowering future energy specialists, fostering ongoing learning, and providing valuable career insights, cementing its role in shaping and supporting capable professionals for the digitalized energy landscape.

7.4. Field Test Milano

The pilot in Milan aims at offering to professionals and workers in the frame or real estates, a ready-to-use and free opportunity to update and align competences and knowledge on the field. The learning experience was appreciated by participants; it worked at raising awareness about digitalization of energy and its management and participants indicated that it has been useful to gain skills and knowledge useful for future professional path demonstrating the program's efficacy in bridging skill gaps.

The possibility to launch the MOOC on two different educational platforms had a great added value. In fact, thanks to the peculiar characteristics of each virtual environment, we had the opportunity to achieve a wild variety of targets with different backgrounds, experiences and provenience that can provide feedback and inputs for evaluating future improvements

The business model, including free accessibility, aligns with the program's goal of disseminating knowledge from public universities, promoting lifelong learning for professionals. The learning and teaching model, incorporating various elements such as magistral lectures and quizzes, fosters an engaging and comprehensive educational experience. The modular structure, covering diverse aspects from energy systems to transversal skills, enhances the program's adaptability and effectiveness.

The main findings indicate a substantial enrollment, high certificate attainment, and positive ratings on both platforms. Participant feedback reflects an improvement in understanding energy management, Overall, the MOOC stands as a successful initiative, contributing significantly to the education and professional development of participants in the realm of energy digitalization.

7.5. Field Test Madrid

This pilot activity has been organized in the context of "Digitalisation of energy systems" to cover the existing gap between the traditional contents and the real needs nowadays concerning the energy sector, specifically its efficiency. The aim of this training is to establish a complementary training module to the educational offer in Vocational Education Training (VET) (EQF level 4 and 5) at **ESCUELAS PROFESIONALES PADRE PIQUER**, which explicitly includes the possible restructuring of the electrical installation of a home, and the use of automation to improve energy efficiency and manage the energy consumption. By the assessment of the participants, one of the conclusions is that the pilot activity has achieved this goal.

The program has been divided in seven modules starting with the basis of the electrical installations in a house and the regulations, addressing the phantom or idle consumption, the tariffs applicable, the automation systems, the generation technologies in buildings, the adaptation of the electrical installations, and the consumption management. Special attention has been given to the home automation systems, the adaptations of the electrical installations, and the telecommunication and computer applications for energy management. The participants have found the contents of the pilot activity met their expectations.

The participants agreed that this course provides new skills for electrical installers and emphasises the digitalisation of the systems and the skills of both installers and consumers to improve energy efficiency.

The knowledge acquired can be applied throughout the national territory as it is based on the state regulations for the electrification of housing, and the training, as well as the model, can be exported to any member country of the European Union.