TRANSIT

Transition to Sustainable Future Through Training and Education

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DELIVERABLE 3.1

Knowledge Gaps and Best Practices Report

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Deliverable Description	**D3.1 Knowledge Gaps and Best Practices** Report provides a description and outputs of **Task 3.2 Cataloguing available platforms and tools for sustainability and educational aspects of RE** which aims to analyse (i) teaching and training curricula associated with renewable technologies for a range of stakeholders and (ii) current practices for the delivery of teaching and training curricula associated with renewable technologies. D3.1 reports on specific areas for re-training of personnel across different geographical regions and stakeholder types and levels in Europe, to facilitate the adoption of renewable and low carbon technologies, as well as circularity principles, among different communities.
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Partner Responsible	UNIMAN
Person Responsible	Eduardo A. Martínez Ceseña
Author(s)	E. A. Martínez Ceseña[1], Ali Ehsan[1], Jovica Milanovic[1], Tomislav Baskarad[2], J.M. Riquelme-Domínguez [4], P. Rodríguez-Pajarón [4], S. Sastre [4], I. de Pablo [4], C. Nuñez, [4] A. Hernandez[4], Stella Hadjistassou[3], Mathaios Panteli[3], Brian Azzopardi[6], Martin Calasan[8], Aleksandra Krkoleva Mateska[7], Stefan Borozan[7]
Participating Beneficiaries	[1]UNIMAN, [2]UNIZG, [3]UCY, [4]UPM, [5]UNI-FEE, [6]FiR, [7]UKIM, [8]UOM, [9]APPA,
Reviewed by	Brian Azzopardi[6], Vesna Borozan[7], Igor Kuzle[2], Lidija M. Korunović[5], Austeja Mockeviciute – Azzopardi[6], Vojkan Kostić, Mihailo Micev[8], Petar Krstevski[7], Irma Villar[9]
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Abbreviations

AWEA	American Wind Energy Association
CPD	Continuous professional development
DSM	Demand Side Management
EIT	European Institute of Innovation and Technology
EHB	European Hydrogen Backbone
HEI	Higher Education Institutions
LCT	Low Carbon Technology
MOOC	Massive Open Online Courses
NEED	National Energy Education Development
NREL	National Renewable Energy Laboratory
RE	Renewable Energy
SEIA	Solar Energy Industries Association
UNEP	United Nations Environment Programme
VET	Vocational and Educational Training

TRANSIT

Contents

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Executive summary

TRANSIT aims to facilitate training, educational and reskilling programmes for the current and future workforce that is developing, and will continue to develop, a sustainable energy future. The project focuses on multidisciplinary approaches to deliver teaching and training on renewable energies and fuel technologies more effectively. TRANSIT also identifies and tackles global and local challenges to train the work force to deliver the European sustainability ambitions, and cater for the needs of different stakeholders.

TRANSIT dedicates its resources and educational materials to target groups of policymakers, regulators, innovators, industry, trade associations, universities and local communities, covering the various sectorial strategies under the European Green Deal. Therefore, the TRANSIT framework establishes (i) success stories and practices that are catalogued, retained and promoted in terms of circularity and sustainable aspects, (ii) develop a hands-on training approach to revamp industry-academic curricula, and (iii) establish a web enabled platform for the innovative and interactive multidisciplinary programme from educational campaigns to hands-on courses.

To meet the above ambitious by actively engaging with key stakeholders and capture the challenges they face, their ambitious and needs, the activities in Work Package (WP) 3 “Community Engagement, challenges, knowledge gaps” were designed to:

(I) Establish and engage with a large stakeholder community in Europe to raise knowledge and awareness about renewable technologies sustainable and circularity principles.
(II) Address challenges related to understanding & adoption of renewable technologies, energy efficiency, and circularity principles across different regions and stakeholders.
(III) Address critical areas in gender-related knowledge and skills gap.
(IV) Provide basis for implementing an EU level framework for multi-layer education & training that generate systemic & structural impact on skills development, ensure the delivery of high-quality skills, knowledge, and training responding to Industry 4.0

Within WP3, Task 3.2 “**Cataloguing available platforms and tools for sustainability and educational aspects of RE**” (M1 – M9) involves two distinctive aims.

Firstly, the task aims to analyse current training and curricula associated with renewable technologies for a wide range of stakeholders, especially in the industry and energy sector. To be more specific, the level of knowledge and awareness about the technologies that enables the energy transition (RES, storage, DSM, electric vehicles, carbon capture) is investigated. For this purpose, questionnaires were developed, and surveys performed in partner countries. These activities helped to collect information on curricula and modes of delivery used in pre-university and university level education, continuous professional development, industry re-training, and community awareness-raising approaches.

Secondly, current practices in the delivery of teaching and training in renewable technologies were reviewed. For this purpose, the teaching approaches & tools used in standard, online and blended learning, have been assessed, especially those associated with sustainability and adoption of low carbon technologies, to identify gaps in teaching practices and coverage of the relevant areas. The available teaching tools that facilitate the study process of renewable and other innovative technologies have been explored.

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The information from T3.2 are collected and summarized in T3.3 "**Mapping relevant externalities, circularity & sustainability aspects in knowledge gaps in Renewable Energy**" (M7 – M12), to report on specific areas for re-training of personnel involved in sustainable development, e.g., installation of renewable technologies and Low Carbon Technologies (LCTs). This information will shed light on training needs in different geographical regions and eventually produce a roadmap for enhanced adoption in sustainability and circularity principles of RE.

This report (M9) presents the outcomes of the activities in Task 3.3 which facilitate identifying knowledge gaps and best practices in teaching and training associated with sustainable development. To be more specific, this report provides:

1. Dedicated surveys developed to identify teaching and training gaps associated with sustainable development from the perspectives of:
    - University stakeholders
    - Pre-university stakeholders
    - Industry stakeholders
    - Wider community stakeholders
2. An overview of teaching and training methods relevant to sustainable development:
    - Standard and online teaching and training practices
    - Common practices in general and the EU context
    - Best practices
3. Analysis of the information collected from the literature survey and questionnaires to identify key teaching and training gaps such as:
    - From the literature survey
        i. Gaps in teaching and training
        ii. Consideration of EU policy
        iii. Challenges faced during the COVID pandemic
    - From the questionnaires:
        i. Gaps and areas of improvement identified by different stakeholders
        ii. Key considerations in different countries

The presented data serves as a basis for identifying knowledge gaps in general and across different regions and for further development of educational programs and curricula on these topics.

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1. TRANSIT questionnaires and surveys

This section provides an overview of the purpose and focus of the four surveys conducted to identify knowledge gaps and improve educational programs in Renewable Energy (RE) and sustainability. The surveys target four main groups of stakeholders in (i) university education, (ii) pre-university education, (iii) industry, and (iv) wider community across different regions of the European Union (EU), including TRANSIT partner countries. By addressing key questions related to the curricula, teaching approaches, industry adoption of EU policies, and areas for further development, these surveys provide valuable information to enhance existing educational initiatives in the field of energy sustainability.

The primary objective of the surveys is to identify knowledge gaps in energy sustainability curricula and the methods of delivery. By gathering data from various stakeholders, including educators, students, industry professionals, and policymakers, these surveys aim to gain insights into the existing educational landscape and identify areas for improvement. The focus is on assessing the inclusion of relevant technologies, such as energy storage and energy efficiency measures, within the curricula.

Furthermore, the surveys aim to evaluate the teaching approaches employed in energy sustainability programs. They seek to determine whether the instruction primarily follows a theoretical and pen-and-paper approach or adopts an interactive and hands-on methodology. Understanding the teaching methods used helps to assess the effectiveness of current approaches and identify opportunities to enhance student engagement and practical learning experiences.

The surveys also aim to evaluate the extent to which EU policies and recommendations regarding RE and sustainability are understood and adopted in the industry. By examining industry perspectives and practices, the surveys seek to provide insights into the alignment between educational programs and real-world applications. This assessment contributes to bridging the gap between academia and industry and foster the integration of sustainable practices in various sectors.

Lastly, the surveys aim to identify areas and skills that require further development through additional training and education in different industries. By understanding the specific needs and demands of various sectors, educational programs can be tailored to equip individuals with the necessary knowledge and skills to address emerging challenges and contribute to the sustainable energy transition.

1.1. Questionnaire – University Stakeholders

The questionnaire discussed in this section is provided in Appendix A: Questionnaire – University Stakeholders.

The purpose of this questionnaire is to gather valuable information about the status and scope of sustainable energy education in universities worldwide. By reaching out to educators across different universities, the survey aims to gain insight into the availability of undergraduate and postgraduate programs related to sustainable energy. It also seeks to understand enrolment trends, the topics covered within these programs, the teaching approaches used, and additional aspects related to sustainable energy education.

The questionnaire begins by collecting basic demographic information, such as the name of the university and the country where the respondent teaches. This provides a broader understanding of the global distribution of sustainable energy education and allows for regional comparisons.

Next, the survey explores the affiliation of the respondents with specific schools or departments, allowing for classification into relevant academic disciplines. This helps identify the diversity of fields involved in sustainable energy education, ranging from electrical and electronic engineering to natural sciences, social sciences, and more.

The questionnaire then delves into the offerings of undergraduate and postgraduate programs in sustainable energy-related topics. It assesses the presence of programs focusing on sustainable electric power systems engineering, energy efficiency, renewable and sustainable energy, and environmental sciences. By examining the availability of these programs, the survey provides an overview of the educational opportunities for students interested in sustainable energy and identifies potential gaps in the curriculum.

The enrolment aspect is another key focus of the questionnaire. It seeks to determine the percentage of students who choose to enrol in sustainable energy programs each year and how that enrolment trend has changed over the past decades. This information helps evaluate the level of interest and demand among students for sustainable energy education and provides insights into the attractiveness of these programs. In addition, it allows for the identification of any shifts in student preferences and interests, providing valuable information for universities and policymakers in adapting their programs to meet evolving needs and demands in the field of sustainable energy.

The questionnaire also inquiries about the specific topics covered in the sustainable energy courses offered by the respondents' schools or departments. It aims to uncover the breadth of knowledge being imparted to students in relation to sustainable energy, including areas such as energy efficiency, renewable and sustainable energy, environmental sciences, energy storage technologies, multi-energy systems, and more. This information helps assess the comprehensiveness of the curriculum and the alignment with current industry needs.

Additionally, the survey explores the timing of sustainable energy course enrolment, investigating whether students typically enrol in these courses during the early or later years of their undergraduate programs or during their postgraduate studies. Understanding when students engage with sustainable energy education provides insights into the progression and integration of sustainable energy topics throughout their academic journey.

The questionnaire investigates the teaching approaches used for delivering course material in sustainable energy topics. It aims to uncover whether the instruction is mostly theoretical and pen-and-paper-based or interactive and hands-on. This aspect provides insights into the instructional methods employed, such as traditional classroom approaches, inverted classroom models, problem-based learning, or active learning strategies. Understanding the teaching approaches helps identify effective methods for engaging students and enhancing their learning experience in the field of sustainable energy.

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In one of the last questions, the questionnaire aims to gather insights into the availability of renewable/sustainable energy source demonstration sites or laboratories within the university/school/department premises. Participants are requested to specify the types of facilities they possess, including solar, wind, storage technologies, and electrical vehicle technologies. This line of inquiry evaluates the practical resources and hands-on learning opportunities offered to students, emphasizing the institution's commitment to providing experiential education. Additionally, the survey examines the extent of engagement in outreach activities related to renewable and sustainable energy. Respondents are asked to indicate the frequency of organizing or participating in outreach initiatives targeting pre-university pupils, industry and policymakers, and the wider community. This question sheds light on the institution's dedication to promoting awareness and knowledge about sustainable energy beyond the confines of academia, showcasing its involvement in fostering sustainable practices and collaborations with external stakeholders.

Finally, the questionnaire inquiries about the respondents' interest in getting involved in specific activities related to the TRANSIT project. Options include surveys/questionnaires and participation in focus groups with consortium partners. The survey also assesses the interest of respondents in receiving trainings/lectures delivered by the TRANSIT consortium partners. The training material is designed for master's/PhD students and covers various topics such as the integration of sustainable technologies in power systems, modelling of different RE sources, power system planning and operation under energy transition, power system dynamics, stability, control, and power quality, as well as offline and real-time simulation tools for power system analysis. Overall, this explores the willingness of educators to contribute to research and collaborative initiatives in the field of renewable and sustainable energy and allows educators to express their preferences for professional development opportunities in specific areas of expertise.

By gathering responses to these questions, the survey aims to create a comprehensive and detailed picture of the state of sustainable energy education. The information obtained is valuable for researchers, policymakers, and educational institutions, as it can guide decision-making processes, curriculum development, and resource allocation to enhance and expand sustainable energy education globally. It will also contribute to fostering collaboration and knowledge exchange among universities and stakeholders involved in sustainable energy education.

1.2. Questionnaire – Pre-university Stakeholders

The questionnaire discussed in this section is provided in Appendix B: Questionnaire – Pre-university Stakeholders.

This survey was designed for pre-university stakeholders and aims to gather valuable information about sustainable energy education and practices. Each question serves a specific purpose to achieve a comprehensive understanding of the current state and potential improvements in the field.

The initial questions focus on basic demographic information such as the school, country, and job description of the respondent. This provides context and helps identify the diversity of participants, including their institutional affiliations and roles within the education system.

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The survey then explores the respondent's main field of teaching, allowing for a deeper understanding of the disciplinary perspectives involved in sustainable energy education. This information helps identify the range of expertise and subject areas through which sustainable energy topics are integrated into the curriculum.

Participants are asked to select the topics covered by compulsory or elective subjects in their school. This question assesses the inclusion of key areas such as energy efficiency, renewable and sustainable energy, environmental sciences, energy storage technologies, multi-energy systems, and more. It helps estimate the breadth of sustainable energy topics incorporated into the curriculum, reflecting the interdisciplinary nature of sustainable energy education.

Field trips play a vital role in enhancing students' practical understanding of RE. The survey inquiries about the frequency of organizing field trips to RE power plants, sustainable technology companies, and university laboratories. This question highlights the hands-on learning experiences provided to students outside the classroom, fostering a deeper connection between theoretical knowledge and real-world applications.

The survey also addresses the frequency of hands-on workshops and guest lectures related to renewable and sustainable energy. This question evaluates the level of engagement in practical activities and the exposure to industry professionals, providing insights into the enriching experiences offered to students. It emphasizes the importance of experiential learning and the integration of industry perspectives to bridge the gap between academia and the practical aspects of sustainable energy.

To understand the teaching approaches employed, respondents are asked to select from a range of methods used to deliver subject material in the fields of renewable and sustainable energy, energy efficiency, and climate science. This question assesses the instructional strategies employed, including traditional classroom approaches, problem-based learning, active learning, videos, simulations, and more. It recognizes the diverse pedagogical approaches used to engage students and enhance their understanding of complex sustainability concepts.

The availability of renewable/sustainable energy source demonstration sites or laboratories within the school premises is explored by asking participants to indicate the types of facilities they have, such as solar, wind, storage technologies, and electrical vehicle technologies. This question evaluates the practical resources and hands-on learning opportunities provided to students. It underscores the importance of tangible resources for students to explore and experiment with sustainable energy technologies, fostering a deeper understanding of their functionality and potential applications.

The survey also addresses the challenges encountered in delivering units or courses on renewable and sustainable energy, energy efficiency, or climate science. This question aims to identify common obstacles and areas where support may be required, such as student engagement, availability of resources, assessment difficulties, and more. By understanding the challenges faced by educators, appropriate measures can be taken to overcome these obstacles and provide better support for effective teaching and learning.

Participants are asked to rate their own knowledge in various topics and assess the representation of these topics in the existing school curricula. This provides insights into self-perceived expertise and the alignment between personal knowledge and curriculum content. It helps identify areas where educators may require additional professional development or resources to enhance their own understanding of sustainable energy concepts and ensure comprehensive coverage in the curriculum.

Lastly, respondents are given the opportunity to express their interest in getting involved in various activities as part of the TRANSIT project, such as surveys/questionnaires, focus groups, teacher trainings/lectures/workshops, and activities for students. This question allows participants to indicate their willingness to contribute and engage in collaborative efforts to advance sustainable energy education.

Overall, the survey aims to gather comprehensive data to identify strengths, areas for improvement, and potential opportunities for enhancing sustainable energy education at the pre-university level. The information collected informs future initiatives, curriculum development, and resource allocation, ultimately fostering a more sustainable and energy-conscious society.

1.3. Questionnaire – Industry Stakeholders

The questionnaire discussed in this section is provided in Appendix C: Questionnaire – Industry Stakeholders.

The survey for industry stakeholders plays a crucial role in capturing valuable insights and information pertaining to sustainable energy practices and professional development within organizations. Its primary objective is to gain a comprehensive understanding of the perspectives of industry professionals and their companies regarding various aspects of sustainability, collaboration with academia, employee training, and engagement with the TRANSIT project. This global perspective allows for the identification of regional differences and best practices that can be shared across borders.

The survey begins by requesting basic information, such as the respondent's company name and country of operation. This introductory section sets the stage for understanding the broader context in which sustainable energy practices are being implemented. It also helps identify potential variations and trends based on geographical location.

Following the introductory section, the survey delves into exploring the job positions within the companies. This information provides valuable insights into the range of roles and responsibilities that exist in the industry. Categorizing job positions into categories such as engineers, project managers, higher management, and others enables a better understanding of the perspectives and priorities of different professionals.

One key area of focus in the survey is the continuous professional development (CPD) courses offered by companies. By identifying the specific topics covered in these courses, such as sustainable electric power systems engineering, energy efficiency, renewable and sustainable energy, and environmental sciences, the survey assesses the extent to which companies invest in upgrading their employees' skills and knowledge in sustainable energy practices. This information is essential for determining the gaps in training and identifying areas where companies can further enhance their CPD offerings. Additionally, the survey specifically evaluates the level of importance

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that companies place on continuous professional development (CPD) in the field of renewable and sustainable energy.

Collaboration between industry and academia is a vital aspect of advancing sustainable energy practices. The survey seeks to understand the willingness of companies to collaborate with academia in organizing training and continuous education programs. By evaluating interest levels and preferences for collaboration, the survey helps identify opportunities for academia-industry partnerships. These collaborations can lead to the development of customized training programs that address specific industry needs and bridge knowledge gaps.

To gain a deeper understanding of knowledge gaps within companies, the survey explores topics that employees may lack a strong understanding of. By identifying areas such as energy efficiency, renewable and sustainable energy, environmental sciences, energy storage technologies, multi-energy systems, district heating, and demand-side management, the survey highlights specific areas for improvement. This information guides the design of educational programs that target these knowledge gaps and equips employees with the necessary expertise. Additionally, industry perceptions of recent university graduates' skills and preparedness for the job market is also evaluated. By exploring factors such as technical skills, practical application of theoretical knowledge, adaptability to business culture, and the transition from academia to industry, the survey sheds light on the alignment between educational curricula and industry needs. This information is invaluable for both universities and companies in enhancing their strategies and bridging the gap between academic knowledge and industry requirements.

The survey delves into two key areas related to employee training and development. Firstly, it assesses the time dedicated to different training processes, including upskilling, reskilling, learning internal tools, and relearning external tools. By analysing this data, the survey offers valuable insights into the level of investment companies make in enhancing their employees' skills and knowledge. Additionally, the survey explores the various approaches used by companies to deliver subject material in employee training. It examines a wide range of methods such as the standard classroom approach, inverted classroom approach, problem-based learning, active learning, real laboratories, remote laboratories and laboratories and others. This comprehensive examination of training methodologies aims to identify effective and innovative approaches that can be shared across organizations, enhancing the overall learning experience and outcomes.

Another critical area covered by the survey is the presence of internal policies on sustainability and circularity within companies. By understanding whether companies have established policies in these areas, the survey assesses the level of commitment towards sustainable practices. This information helps identify companies that have already taken proactive steps in promoting sustainability and circularity.

The survey also explores the implementation of sustainable practices in daily business operations. By assessing practices such as RE for self-consumption, smart heating, smart lighting, etc., the survey provides a holistic view of the extent to which companies are incorporating sustainable measures. This data aids in understanding the current landscape of sustainable practices and identifying areas where further improvements can be made.

To evaluate the level of engagement with external stakeholders and educational outreach, the survey examines the frequency of organizing/participating in outreach activities. This includes workshops, school visits, and student visits to the company. By understanding the level of

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involvement in these activities, the survey assesses the commitment of companies to promoting sustainability awareness among pre-university students, university students, and external stakeholders. This information helps identify companies that actively contribute to educational initiatives and engage with the wider community.

Lastly, the survey also aims to capture industry interest in participating in TRANSIT project activities, including follow-up surveys/questionnaires, focus groups, and internships for PhD students. This valuable feedback from industry stakeholders helps shape future initiatives within the project and ensures active engagement and collaboration with industry partners. Furthermore, the survey assesses the interest of industry stakeholders in receiving trainings and lectures from TRANSIT consortium partners. Topics of interest include integration of sustainable technology in power systems, power system planning and operation under energy transition, power system dynamics, stability, control and others. This information allows the consortium to tailor their training programs to industry needs, facilitating relevant and valuable knowledge transfer.

In conclusion, the survey for industry stakeholders aims to capture valuable insights regarding sustainable energy practices, professional development, collaboration with academia, and engagement with the TRANSIT project. By exploring a wide range of topics and gathering diverse perspectives, the survey provides a comprehensive understanding of industry needs, knowledge gaps, and opportunities for improvement. The data collected helps to shape the development of educational programs, foster academia-industry collaboration, and contribute to the overall advancement of sustainable energy practices within the industry.

1.4. Questionnaire – Wider Community Stakeholders

The questionnaire discussed in this section is provided in Appendix D: Questionnaire – Wider Community Stakeholders.

The survey for the wider community serves as a valuable tool to gather essential information from individuals residing in different countries. This data provides insights into the perspectives, behaviours, and attitudes of the broader population towards RE, sustainability, and the environment. By capturing a diverse range of participants, the survey aims to create a comprehensive understanding of the wider community's engagement with sustainable practices.

The initial questions focus on the basic information such as the country of residence, level of education and involvement in the fields of RE, sustainability, or environment. Understanding the geographical distribution of respondents allows for regional analysis and the identification of variations in sustainable practices and awareness across different areas. By capturing data on the highest level of education obtained, researchers can gain insights into the educational background of the respondents.

The survey also investigates participants' personal adoption of RE for self-consumption. By asking respondents to indicate which RE sources they utilize in their day-to-day lives, such as solar, wind, hydro, or geothermal, researchers gain insights into the extent of individual engagement with sustainable energy technologies. This data helps identify prevalent RE and potential barriers to wider adoption, informing strategies to promote and support the implementation of RE systems in residential settings.

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The survey assesses participants' implementation of home energy efficiency practices, such as smart heating, reducing/reusing/recycling habits, smart lighting, and energy-efficient facades and windows. This provides insights into the integration of energy-efficient practices into daily routines. Additionally, the survey examines the motivating factors for implementing sustainable practices. This data helps understand the underlying motivations driving individuals' adoption of sustainable behaviours, informing effective messaging, campaigns, and policy frameworks.

To gain deeper insights into the barriers preventing the implementation of sustainable practices, the survey provides a list of common obstacles that participants can select from. These barriers include factors such as cost, complexity, lack of actionable information, lack of interest, or other specific challenges. Understanding the challenges faced by individuals helps in tailoring interventions, developing educational materials, and implementing targeted support mechanisms to address these barriers effectively.

The survey also explores participants' awareness of various energy-related topics. By providing a list of topics such as energy efficiency, renewable and sustainable energy, environmental sciences, energy storage technologies, and others, researchers gain insights into the level of familiarity and understanding within the wider community. This knowledge assessment enables the identification of knowledge gaps and areas where awareness-building efforts can be focused to improve understanding and promote informed decision-making.

The survey also aims to gauge individuals' willingness to engage in community activities to learn about sustainable practices in everyday life. By asking participants to indicate their level of interest, the survey captures the potential for community involvement and collective learning. This information helps identify the level of community engagement and interest in participating in activities aimed at promoting sustainable practices.

To assess the level of trust in different information sources related to RE, the survey presents a list of common sources such as books, social media, news, TV, etc., and asks participants to rate their trust on a scale from 1 to 5. This understanding can guide efforts to improve the dissemination of accurate and trustworthy information to the wider community.

Lastly, the survey aims to gauge participants' interest in engaging in specific activities related to the TRANSIT project, including follow-up surveys/questionnaires and focus groups. These activities provide opportunities for individuals to contribute with their opinions and experiences, shaping future project initiatives and ensuring active engagement and collaboration with the wider community. Furthermore, participants have the chance to select topics of interest for receiving information or guidance, such as understanding the benefits of active energy consumption and the design of small power plants like solar PV. This allows the TRANSIT consortium to tailor their information-sharing and guidance efforts to the specific needs and interests of the participants, ensuring the provided knowledge is relevant and valuable.

In summary, the survey for the wider community plays a vital role in gathering data and insights related to energy, sustainability, and the environment. This valuable information guides the development of targeted interventions, education campaigns, and policy frameworks aimed at promoting sustainable practices, addressing barriers, and enhancing knowledge transfer. By actively engaging with the wider community, the TRANSIT project can foster a collaborative

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approach towards achieving a sustainable energy future, where individuals are empowered to make informed decisions and actively contribute to environmental sustainability.

1.5. Reach of the surveys

The outputs of the TRANSIT questionnaires are used as a foundation for enhancing energy sustainability curricula and delivery methods. By obtaining insights from a diverse range of stakeholders, these surveys aim to inform and guide future educational initiatives in the field of energy sustainability, ultimately promoting a more sustainable and resilient energy future for the European Union and beyond. That said, as presented in Figure 1, even though there were over 489 participants (by June 2023) from 29 different countries who completed the surveys, the vast majority of the responses come from TRANSIT partner countries.

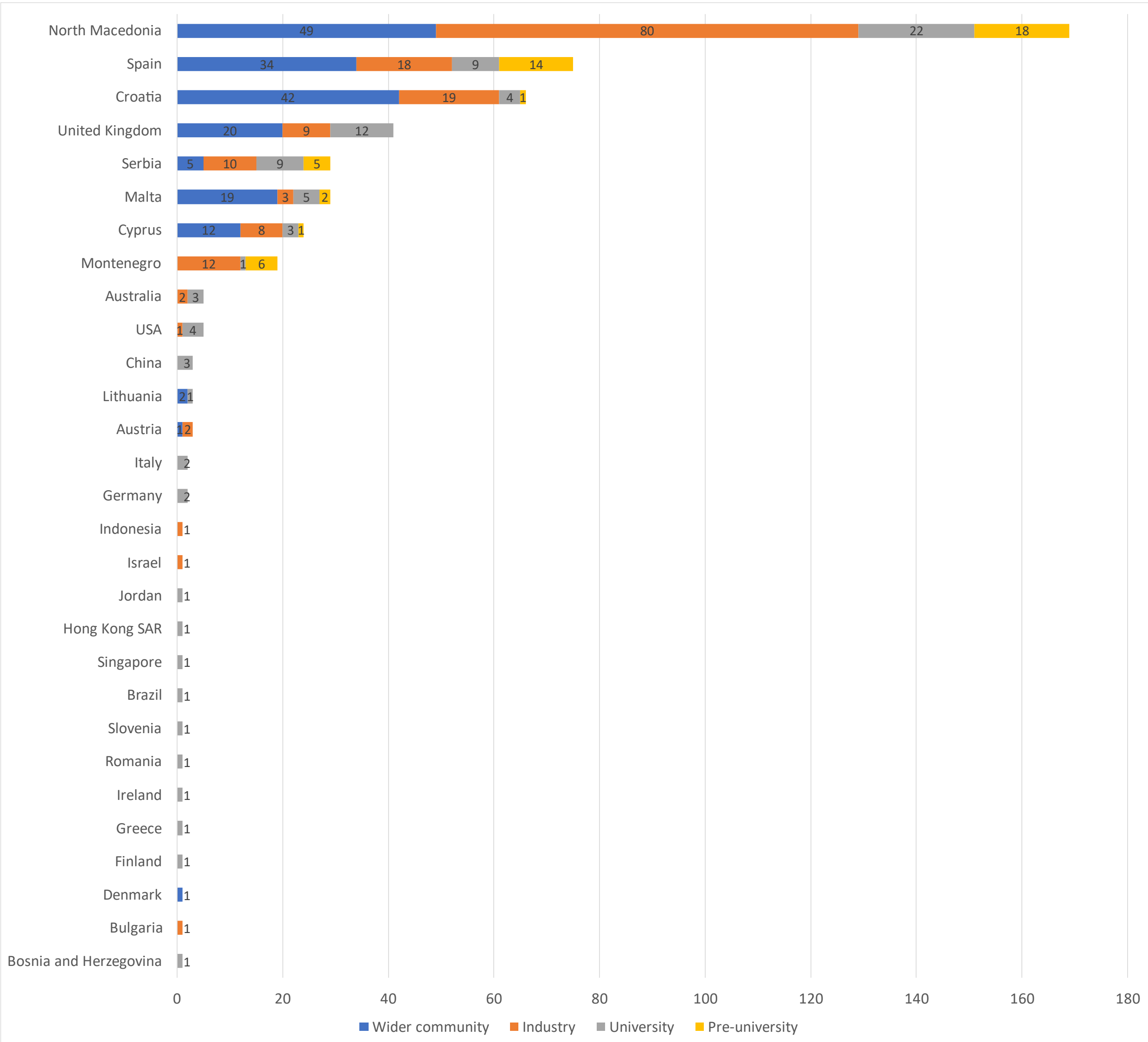

Figure 1. Survey Responses by Country.

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As the replies from non-TRANSIT partner countries are relatively low (1-3 replies), it is challenging, at this stage, to produce results with statistical significance for such countries. Accordingly:

- The analysis presented in this report (Section 3.2.) will focus on TRANSIT partner countries: North Macedonia, Spain, Croatia, UK, Serbia, Malta, Cyprus and Montenegro.
- The questionnaires will remain available, and the TRANSIT consortium will target non-TRANSIT partner countries to collect information with more statistical significance.
- An additional document or an addendum to this report will be produced with updated results from the questionnaires.

2. Teaching and training methods

This section provides a literature review on capacity building associated with sustainable development, e.g., training and teaching on RE, LCT and circularity. The survey firstly focuses on key teaching and training practices and aims to highlight the common practices. A catalogue of training activities is presented in Appendix E. Afterwards, the teaching and training practices are discussed in the context of the EU, emphasizing best practices.

2.1. Teaching and training to support sustainable development

RE, LCT and circularity education can neither be confined to traditional teaching methods of knowledge transmission nor to the integration of a handful of courses related to RE. Traditionally, engineering education was designed on principles of a common curriculum in college focusing on mathematics and engineering sciences coupled with liberal arts subjects (see [1]). The curricula were moulded by lecture-based instruction and behaviourism-embedded teaching techniques, where rote memorization and knowledge recitation were used, rather than creative thinking, innovation, creativity and autonomy. In the post-World War II era, the dynamics, skills, and industry demands imposed new demands on college education, driven by the need for new methods of teaching, novel technologies, machines, and a better equipped labour force based on industry's needs [2]. As the socioeconomic and political conditions also changed, with college education becoming more accessible and particular emphasis was placed on ethnicity, gender, equity, and diversity, reforms in the higher education system were imperative. At the same time, industrial innovations, global and state requirements, industry demands, and labour market needs, as well as technological innovations compelled higher education to move beyond the trajectories of conventional engineering instruction. The aim was to focus on RE education and pursue new pathways to enrich the curricula through teaching methods, content, technical and technological knowledge, task-based and meaningful learning, and industry and research innovations.

As [3] indicates, "modern RE education includes a study of the technology, resources, system design, economics, circularity, industry structure and policies in an integrated package" (p. 435). Enriched curricula include a wide constellation of courses not limited to fundamental principles in engineering, but also in renewable energies, RE generation, energy security, RE policy, circular economy and RE technologies. Hands-on training, technical knowledge and understanding of complex energy systems, problem-solving and interdisciplinary skills and knowledge are promoted by higher education systems striving to equip students with the skills and competences to respond to the labour market needs.

More recently, in the post-pandemic era and with shifts to online education, teaching methods in RE leverage multiple technologies, including augmented reality (AR) and virtual reality (VR) to promote a learner-centred approach where future engineers acquire knowledge in interactive, engaging, and participatory ways. Hybrid models are also increasingly gaining popularity across academic institutions around the globe. The work from Vergara, Fernández-Arias, Extremera, Dávila, and Rubio [4] describes a model in which virtual laboratories are used where Virtual-embedded Virtual Laboratories "are widely accepted and demanded by students, who likewise consider real laboratories (RLs) necessary in face-to-face teaching. In the current post-COVID-19 educational scenario, VLs and RLs will coexist within the new hybrid models that combine face-to-face and online teaching and learning" (p. 155). In this post-pandemic era characterised by an exponential increase of the need for well-equipped human capital in RE, the basis for instructions can be formed by a combination of novel skill- and knowledge-based curricula, embedded in novel teaching methods, mediated by both traditional and virtual instruction, novel technologies, and renewable industry and technological needs. Furthermore, the artificial Intelligence is gradually gaining momentum and contributing to this educational endeavour.

The most recent event on the global scene, which made significant impact on the energy sector, is the conflict between Russia and Ukraine. This event provoked European Commission to adopt REPowerEU Communication in March and a REPowerEU Plan in May (year 2022). The replacement for fossil fuels form Russia is found in massive and accelerated deployment of renewables. The main actions suggested by the Commission comprise[1]:

- Calling the stakeholders in the energy sector to invest in the development of the skills required by the energy transition, as well as to strengthen their reskilling and upskilling programmes by investing more in education and training programmes and actions to match job offer and demand;
- Calling public authorities at Member States and local level to take urgent action for putting forward the targeted training and education programmes and for providing the right financial support for these programmes and to make the best possible use of existing EU financing instruments;
- Considering the upskilling of civil servants, coupled with a simultaneous modernisation process of the public sector, of most urgent importance to speed up the permitting procedures for renewable energy installations.

Along with the facts pointing towards the need for training and upskilling employees for renewables, it is also very important to maintain the sufficient number of employees for conventional electrical energy sources-oil and gas. Many skilled professionals in conventional energy sources industry have moved toward either renewables or other spheres, such as tech. Overall, the calculations show that the energy industry will need hundreds of thousands of talents, properly trained and skilled. The only way to maintain adequate supply of conventional energy and to increase the capacity in renewable energy is to retain and hire large number of talents in energy industry[2].

The working personnel in gas and oil energy sectors are proven to have medium and high skills transferability in percentage of 90%, according to the study conducted by Robert Gordon University. This fact puts them in pole position for upskilling to be available to contribute in sectors like solar, wind, hydrogen fuel and carbon capture technologies. The need for maintaining, and even increase the available workforce lies in the following analysis: The UK offshore sector is planning to invest £174 billion by 2030, while such investment will require about 200,000 skilled workers for various projects. Precisely, about 45% of the skilled workers are going to be engaged for wind energy production[3].

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[1] https://commission.europa.eu/system/files/2022-06/ceif_joint_statement_on_skills.pdf
[2] https://www.ogv.energy/news-item/training-and-skills-will-play-key-roles-in-the-future-of-energy
[3] https://energyresourcing.com/blog/transferable-skills-energy-jobs

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2.2. Common practices

The delivery of teaching and training in renewable technologies and sustainability exhibits significant global variations, showcasing the diverse approaches and priorities adopted by various countries and educational institutions. For example, high level descriptions of different capacity building activities in different countries are presented in Appendix E: Catalogue of . That said, several common practices can be observed, highlighting seven key aspects of the current teaching practices:

1. **Academic programs and degrees**: Many universities and educational institutions offer dedicated academic programs and degrees focused on renewable technologies. These programs typically include courses on RE integration, energy conversion, power network operation, and environmental management. Imperial College London, for example, offers a master's program titled Sustainable Energy Futures [5]. These courses primarily employ traditional classroom teaching methods to deliver the curriculum. Students engage in interactive lectures and group discussions, enabling them to grasp theoretical concepts and develop technical skills in renewable technologies.

2. **Interdisciplinary programs and courses**: Recognising the complex nature of sustainability challenges, many universities adopt an interdisciplinary approach to teaching and training in renewable technologies and sustainability. For instance, The University of Oxford provides a master's program called "Environmental Change and Management" [6]. These programs and courses integrate elements of environmental science, economics, and policy, enabling students to cultivate a holistic understanding of the interplay between environmental, social, and economic dimensions of sustainability.

   A topic of particular interest that goes beyond RE technologies and LCTs is circular economy. That is, it is not enough to deploy REs and LCTs at a large scale to meet current sustainable development goals. It is also critical to step away from designing technologies that produce large volumes of waste. The adoption of circular economies that facilitate reusing, repairing and recycling or upcycling resource will reduce different forms of waste, including energy currently used to collect and process waste [7].

3. **Practical and experiential learning**: Practical and experiential learning plays a vital role in providing hands-on experience and real-world applications. This may include laboratory work, field visits to RE installations, participation in sustainability-focused projects, and internships with industry partners. These experiences enable students to apply theoretical knowledge, develop practical skills, and gain a deeper understanding of the practical challenges associated with renewable technologies and sustainability. For instance, students at the Massachusetts Institute of Technology participate in the Solar Spring Break program, where they travel to underserved communities and install solar panels, gaining practical experience in RE implementation [8].

4. **Online learning platforms and learning management systems**: There is a growing emphasis on incorporating modern technologies and interactive learning experiences into teaching and training in renewable technologies and sustainability. Online learning platforms provide multimedia resources, such as video lectures, simulations, and virtual laboratories, allowing students to access course materials and engage in learning activities remotely.

Learning management systems, for example Blackboard Learn [9], are extensively used to facilitate discussions and assess student progress. Such systems not only provide opportunities for asynchronous learning but also enable communication and collaboration among students and lecturers.

5. **Blended learning**: Given greater flexibility and accessibility, the blended learning approach has demonstrated valuable in-teaching and training in renewable technologies and sustainability, particularly after the COVID pandemic. It combines online instructions with in-person experiences, providing an adaptable framework that accommodates changing circumstances, ensuring an uninterrupted education and the convenience of self-paced learning.

6. **Collaboration and partnerships**: Collaboration and partnerships between educational institutions, industry, government, and civil society organisations are critical in delivering effective teaching and training in renewable technologies and sustainability. Collaborative initiatives may include joint research projects, industry placements, guest lectures by experts, and advisory boards comprising stakeholders from diverse sectors. The RE and Energy Efficiency Partnership (REEEP), for example, is a global network that promotes collaboration between universities, research institutions, and governments [10]. Such collaborations facilitate knowledge exchange, industry placements, guest lectures, and joint research projects, enhancing the practical relevance of teaching and training.

7. **Research and innovation**: Research and innovation have played a crucial role in advancing renewable technologies and sustainability practices. Relevant research projects usually focus on areas including RE development, energy efficiency, sustainable materials, climate change mitigation, and policy planning. Educational institutions often engage in research projects and collaborate with industry, government agencies, and international organisations to address sustainability challenges. Students and faculty contribute to cutting-edge research, helping drive innovation in the field of sustainability.

In addition to the aforementioned common practices, the following two aspects are also essential for enhancing education in the field, yet they are not widely adopted. These aspects serve as valuable complements to existing practices.

1. **Continuous professional development**: Continuous professional development plays a vital role in keeping professionals updated with the latest developments in renewable technologies. Some universities offer specialised training programs, workshops, and seminars for professionals working in the RE sector, helping individuals enhance their knowledge and skills and stay abreast of industry advancements. For instance, the Energy Institute at the University of Texas at Austin offers a Continuing and Professional Education program in Clean Energy Technology to help professionals stay current in the field [11]. To cater to a wider audience and promote accessibility, online platforms are also employed to deliver such courses. Besides the universities, the other organizations, such as local CIGRE committee and Engineering Chamber can organize and support training programs, seminars, or even smaller conferences dedicated to professional development in area of RES and sustainable technologies.

2. **Capacity-building programs**: In many developing countries, capacity-building programs are implemented to enhance the skills and knowledge of local communities and professionals

in renewable technologies. These programs aim to support the adoption and implementation of RE solutions in areas with limited access to electricity or in regions vulnerable to climate change impacts. For example, the "Project Navigator" provided by The International Renewable Energy Agency (IRENA) offers guidance and training to help countries develop RE projects [12].

2.3. The EU context

Currently Europe is confronted with critical labour market shortages, with over three-quarters of enterprises reporting challenges in recruiting a skilled labour force [13]. Shortages are not confined to a single area but rather include multiple critical areas, including ICT and engineering. Precisely, "the occupations which dominated the list of widespread shortages were related to software, healthcare and construction and engineering craft occupations" [14].

In RE, about 12.7 million were employed in 2022 [15], but the numbers are anticipated to expand exponentially, reaching "38 million by 2030" [16]. However, the number of students pursuing a degree in engineering is not sufficient to meet the constantly expanding labour market needs. As indicated by the Organization for Economic Cooperation and Development [17] only 16% pursued a degree either in engineering or in a related field, including manufacturing and construction. As demonstrated by the OECD (2022) "10% of tertiary-educated individuals studied engineering, manufacturing and construction in Iceland, Ireland, Luxembourg and the United States, while the share is 25% or more in Austria and Germany" (p.40) [17].

The relatively limited number of engineering graduates and technicians contributes to the labour market shortage. At the same time, the existing Higher Education, lifelong learning programs and Vocational and Educational Training (VET) systems are not fully aligned with the energy industry needs. The current curricula and training do not adequately equip graduates and the existing labour force with the skills and competences to compete and advance in the labour market. Engineers need a heterogeneous constellation of skills, including:

- sector specific skills and competences,
- technical skills,
- digital and data science skills,
- renewable technology skills,
- transferable skills,
- transversal skills,
- renewable policies and regulations (see [18]–[20]).

The model promoted by Higher Education which exposes students to traditional engineering concepts remains vital, but not sufficient for their preparation to meet the labour market needs. Higher Education curricula include several courses on renewable energies and sustainability; however, their content does not provide an in-depth examination and understanding of the field [3]. Curricula and training programs need to be enriched further through RE technologies and sustainability practices and initiatives. In addition, the flow of knowledge and synergies among the education and training systems and the energy industry often requires extensive planning and organization to adapt the curricula and training to help engineers build the required skills and competences. HE institutions need to expand beyond the traditional trajectories of learning to

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collaborate with the energy industry and offer students hands-on training and exposure to technology developments. At the same time, both the local and global contexts and needs should be considered in curricula development and training activities to equip engineers with the knowledge and skills to navigate through energy industry.

The EC has already launched the REPowerEU plan where all key actors involved in RE and related authorities are invited to develop results-driven skills partnerships by drawing on the "Pact of Skills," Erasmus+, and other-related initiatives. Targeted investments are not limited to infrastructure, electricity grid, and the European Hydrogen Backbone (EHB), but also extends to include investments in human capital through skill augmentation. HE curricula and VET providers have not established potent partnerships where the flow of knowledge among Higher Education Institutions (HEIs), VET providers, and the energy industry can help redesign the curricula to help engineers build the required skills and competences in RE, such as in RE technology and technical skills. Further, targeted investments and initiatives need to be undertaken at the EC, HEI/VET industry, and community level to achieve this ambitious goal.

2.4. Best practices

In today's world, where the urgent need to combat climate change is paramount, effective teaching and training practices are crucial for equipping individuals with the knowledge and skills required to navigate the realm of low carbon technologies (LCTs) [21]. By adopting best practices in education and training, we can empower students and professionals to become catalysts for sustainable change.

There are several key best practices for teaching and training in the field of low carbon technologies, highlighted here.

1. **Interdisciplinary approach**: Incorporate elements from various disciplines such as engineering, environmental science, economics, and policy to provide a holistic understanding of LCTs; as well as foster collaboration and integration of knowledge across different fields to address the multidimensional challenges of climate change [22], [23], [24].

2. **Hands-on experiences**: Provide practical opportunities for students to engage with LCTs through laboratory work, field studies, and real-world projects, and enable students to apply theoretical concepts to practical situations, enhancing their problem-solving skills and critical thinking abilities [21].

3. **Collaboration with industry experts and research institutions**: Establish partnerships with industry experts, research institutions, and relevant organizations to expose students to real-world applications and emerging trends [25], [26], [24]. Collaboration with institutions from different countries is highly desirable because students would have the opportunities to see different sustainability approaches and sources of renewable energy, which they might not be able to see in their own country.

4. **Integration of sustainability principles**: Infuse sustainability principles throughout the curriculum to develop a mindset that prioritizes environmental responsibility and long-term

sustainability. Emphasize the importance of life cycle assessments, carbon footprints, and the triple bottom line (economic, environmental, and social) in evaluating LCTs [22], [25], [23].

5. **Experiential and project-based learning**: Incorporate experiential learning methods, such as case studies and simulations, to enhance students' understanding of complex concepts and scenarios. Encourage project-based learning where students work in teams to design and implement innovative solutions for real-world sustainability challenges [21], [23].

6. **Continuous professional development for educators**: Provide ongoing training and professional development opportunities for educators to stay updated with the latest advancements in LCTs. Equip educators with the necessary skills and knowledge to effectively deliver quality education and training, including pedagogical techniques specific to the field [23].

7. **Networking and community engagement**: Facilitate networking opportunities and community engagement activities to connect students and professionals in the field of LCTs. Encourage participation in conferences, workshops, and sustainability initiatives to foster a sense of community and collaboration among learners [21], [23].

By adopting these best practices, we can enhance the effectiveness of teaching and training in the field of low carbon technologies. Equipping individuals with interdisciplinary knowledge, providing hands-on experiences, fostering collaboration with industry experts, integrating sustainability principles, promoting experiential learning, facilitating continuous professional development, and encouraging networking and community engagement will empower learners to drive the transition to a sustainable and low-carbon future. It is through these collective efforts that climate change can be addressed and a more resilient and environmentally responsible society can be created.

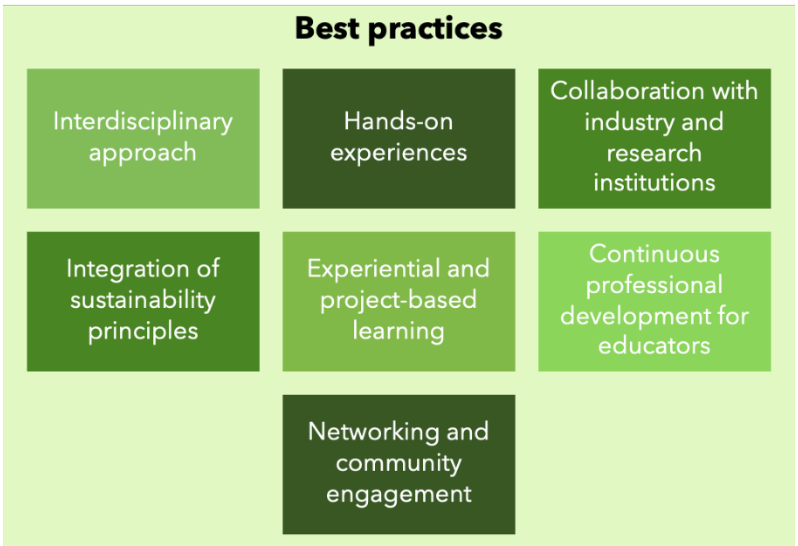

Figure 2 Best practices in education and training

3. Analysis of the collected data

This section builds on the information collected with the questionnaires (Section 1.) and literature survey (Section 2.) to flag key teaching and learning gaps associated with sustainable development.

3.1. Gaps in teaching and learning

3.1.1 General gaps

As discussed in the previous section, there has been significant progress in the delivery of teaching and training associated with sustainable development, such as renewable technologies, Low Carbon Technologies (LCTs), sustainability and so on [27]. However, based on the review literature there are still some gaps to address.

1. **Inadequate professional development for educators** [28]. Continuous learning and professional development are crucial in fast-paced industries like renewable technologies and sustainability. However, there can be a gap in providing opportunities for professionals to update their knowledge and skills in industries. Some educators might require further training to educate about these technologies, which can impact the intensity and accuracy of the coverage provided to students [23]. Accordingly, employers and industry organizations should support and encourage ongoing professional development of educators through workshops, conferences, certifications, and other means. Educators remain key actors in facilitating learners' transition to sustainable ways of life, in an age where information is available everywhere and their role is undergoing great change. Also, educators in all educational settings can help learners understand the complex choices that sustainable development requires and motivate them to transform themselves and society. In order to guide and empower learners, educators themselves need to be empowered and equipped with the knowledge, skills, values and behaviours that are required for this transition. However, lecturers in the universities and higher institutions may not always receive adequate training and professional development opportunities to effectively teach renewable technologies and sustainability concepts. This can result in knowledge gaps and a lack of confidence among educators, ultimately impacting the quality of instruction.

   Professional development programs that centre around RE education are instrumental in keeping educators abreast of the latest advancements, teaching methodologies, and resources. Tailored workshops, seminars, and online courses can significantly enhance their understanding and instructional abilities in this domain. A noteworthy initiative in this regard is the National Energy Education Development (NEED) Project [29]. They provide a range of professional development resources designed specifically for educators interested in teaching RE topics. These resources include comprehensive lesson plans, engaging hands-on activities, and curated curriculum materials. The NEED Project equips teachers with the knowledge and tools necessary to deliver impactful instruction, aligning with the significance highlighted in the referenced source [30].

   LCTs are fast-evolving technologies, and it can be demanding for educational institutions to keeping up the pace with the most recent developments. some educators might require further training to educate about these technologies, which can impact the intensity and accuracy of the coverage provided to students [23].

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2. **Inadequate access to up-to-date information**: The field of renewable technologies is continuously evolving, with new technologies and innovations emerging regularly. Accordingly, the rapid pace of technological advancements in the RE sector necessitates the continuous updating of course content to reflect the latest developments. This can present a challenge for educators who need to stay informed and incorporate cutting-edge information into their teaching. To address this gap, it is crucial to ensure educators have access to reliable and current information, resources, and case studies. For example, establishing partnerships with research institutions (e.g., IEEE Xplore, ScienceDirect, and Google Scholar), industry organizations and RE companies (e.g., the International RE Agency, the American Wind Energy Association, and the Solar Energy Industries Association) can provide educators with direct access to the latest findings, innovations, and best practices in the field. Other valuable resources include industry conferences, webinars, and online platforms like RE World, Clean Energy Council, and GreenBiz. These resources offer valuable insights and information on emerging technologies. Additionally, collaboration with research institutions and industry experts can provide access to cutting-edge research and expertise in the field. By actively seeking and utilizing up-to-date content and incorporating emerging technologies into their teaching practices, educators can effectively prepare students for the evolving RE sector.

3. **Lack of practical hands-on experience**: Teaching renewable technologies and sustainability often requires practical skills and hands-on experience [31]. That is, students may benefit from further exposure to real-world LCTs applications, such as case studies of successful implementation, corporate partnerships, or internship opportunities [32]. With this experience, students may recognize the relevance and potential influence of these technologies in addressing real-world environmental concerns. However, resource constraints, limited access to equipment, or inadequate laboratory facilities (e.g., due to lack of financial resources) can hinder students' opportunities for practical learning. There is hence a need to ensure that practical training and hands-on experiences are adequately integrated into the curriculum, allowing students to gain real-world skills and experience.

   To address this, educators can utilize various resources and strategies. Virtual labs and simulations, such as the virtual hybrid renewable-nuclear plant developed by National RE Laboratory (NREL) [33], provide students with remote access to practical experiments, but require fibre-optic cabling to provide high-speed, low-latency, and low-jitter data connections between laboratories. Other options include hands-on workshops, training sessions, and apprenticeship programs can be organized. Industry associations like the American Wind Energy Association (AWEA) and the Solar Energy Industries Association (SEIA) often offer training programs that include practical training modules. Additionally, partnerships with RE companies and project developers can provide opportunities for on-the-job training and real-world application of skills. Collaborating with industry partners offers internships, apprenticeships, and site visits also allows students to gain hands-on experience in real-world RE projects.

4. **Inequality in access to education** [28]: There may be disparities in access to quality education and training opportunities, particularly in developing regions or marginalised communities. This can further exacerbate the gaps in knowledge and skills related to renewable technologies and sustainability. Efforts should be made to improve the accessibility and affordability of renewable technology education, especially for individuals from underrepresented communities. Strategies such as providing scholarships and grants,

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implementing community outreach programs, leveraging online learning platforms, fostering partnerships with non-profit organizations, and advocating for government initiatives and policies can help mitigate the inequality. For example, The University of Manchester partners with The Cowrie Scholarship Foundation to provide scholarships for underrepresented Black African and Caribbean heritage applicants from socio-economically disadvantaged backgrounds [34]. The courses with respect to renewables energy and sustainability in the University of Cambridge provide opportunities for refugees, who are charged the same tuition fees as domestic students, for example [35].

5. **Barriers for women**: A significant increase in an educated workforce will be required to meet current sustainable development targets. However, there are currently several barriers for women, which roughly correspond to 50% of the global population, to get actively involved in sustainable development [36], for example women only account for about 30% of STEM researchers [37]. There are several factors that can discourage women from getting involved in careers associated with sustainable development, that said, some or the most prominent ones are the expectation of unequal payment, followed by gender stereotypes [38], [39].

   Addressing the aforementioned factors and encouraging more women to get more involved in sustainable development is not a simple task. That said, there are emerging efforts to tackle this issue such as de emergence of sustainable development goal 5 "setting the achieving gender equality" [40], dedicated support [41], and the STEM women limited organization [42]. Existing literature suggest that stronger efforts are needed to address salary expectations, attitudes towards diversity and inclusion, imposter syndrome, and representation, amongst others.

6. **Lack of standardized programs and certifications**: The lack of standardized programs and certifications in renewable technologies and sustainability poses a challenge in assessing and comparing skills and knowledge globally. Without globally recognized standards, it becomes difficult for employers to identify qualified professionals and for individuals to showcase their expertise. Standardization and comprehensive coverage across institutions are crucial for ensuring a well-rounded education in renewable technologies. For instance, the implementation of more extensive and structured practical training programs can bridge the gap between theory and real-world applications. An example of an institution addressing this need is Imperial College London, which offers a course in Future Power Networks providing an IET certificate, demonstrating the commitment to delivering recognized qualifications in the field [43]. Also, MSc educational programme Smart Electrical Networks and Systems at KTH Royal Institute of technology has the label of EIT (European Institute of Innovation and Technology), which makes it widely recognised and standardized.

7. **Inadequate industry-academia collaboration**: The pace of innovation and emerging technologies in the RE sector often outpaces the development of educational programs. Furthermore, many industries related to renewable technologies and sustainability, such as solar, wind, or energy efficiency, require specialized skills and knowledge. However, there is often a lack of industry-specific training programs tailored to the needs of these sectors. Generic training programs may not adequately prepare individuals for the specific challenges and demands of working in RE or sustainability industries.

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This creates a gap between the skills taught in educational institutions and the skills required by industries. As a result, collaboration between educational institutions and industries is crucial to aligning educational programs with the needs of the job market. However, there is often limited interaction between academia and industry, resulting in a mismatch between the skills taught and those demanded by the RE and sustainability sectors. There can also be a gap in communication between these sectors.

To address these issue, stronger partnerships and collaborations (e.g., industry partnerships, internships, etc.) need to be fostered. Industry advisory boards can provide guidance in curriculum development, internship and work placement programs can offer practical experience, guest lectures and industry speakers can provide insights into industry practices, and curriculum co-development can ensure alignment with industry standards.

8. **Lack of emphasis on interdisciplinary approaches**: Sustainability goes beyond RE technologies and encompasses broader environmental, social, and economic aspects [44]. For example, LCTs incorporate technology solutions as well as social and behavioural change [45]. However, many educational organizations have compartmentalized curricula that do not adequately combine these fields, leading to crumbled coverage of LCTs [22]. Accordingly, there can be a gap in understanding how to integrate sustainability principles into industry practices and decision-making. Unfortunately, many educational programs tend to focus primarily on the technical aspects of renewable technologies while neglecting the broader socio-economic and policy contexts (e.g., human behaviour, societal acceptance, and cultural components).

   Training programs should emphasize the importance of considering the full life cycle of projects, social equity, and environmental stewardship to provide a more complete understanding of the problems and opportunities associated with sustainable development. To incorporate interdisciplinary perspectives into the curriculum, online platforms like Coursera, edX, and FutureLearn offer online courses and Massive Open Online Courses (MOOCs) that cover interdisciplinary aspects of sustainability and renewable technologies.

9. **Inadequate policy and regulation coverage**: LCTs and renewable technologies are part of a larger policy and regulatory framework. Many educational programmes, however, may limit coverage of policy and regulatory aspects of LCTs. Understanding the legislative context, as well as the motivations and challenges to adopting LCTs, is critical for students who wish to make a difference in the field [46].

10. **Soft skills development**: While technical skills are vital, soft skills such as communication, teamwork, problem-solving, and project management are equally important for professionals working in renewable technologies and sustainability. However, these skills are often overlooked in training programs, resulting in a gap between technical competence and the ability to effectively collaborate and communicate within teams or with stakeholders. Inadequate emphasis on soft skills: Effective collaboration with industry partners can provide insights into the specific soft skills required for success in the RE workforce. Universities and higher education institutions can enhance their courses by allocating more time for group projects and oral presentations.

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11. **Limited integration of sustainability in educational curricula**: Many educational institutions still lack comprehensive and standardized sustainability curricula, where renewable technologies and sustainability concepts are often taught as standalone courses or electives rather than being seamlessly integrated across different disciplines and subjects. To support the integration of sustainability into educational curricula, organizations like the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Programme (UNEP) provide guides and resources for curriculum development that emphasize sustainability across subjects.

12. **Addressing global context and local challenges**: Teaching and training in renewable technologies and sustainability should consider the global context while also addressing local challenges and specific regional needs. This requires tailoring education to the specific circumstances and socio-economic factors of each region. Different regions and countries have unique environmental challenges, policy frameworks, and cultural perspectives that should be taken into account when designing educational programs.

Addressing the aforementioned deficiencies necessitates a comprehensive approach that includes curriculum innovation, faculty development, investment in infrastructure and laboratory facilities, collaboration with industry partners, and policy engagement. By filling these gaps, educational institutions can better educate students to contribute to the development and deployment of LCTs in the real world.

3.1.2 How curricula addresses EU policy

Low-carbon technologies curricula are crucial in addressing EU policy objectives related to climate change and sustainability. The European Union has set ambitious targets to reduce greenhouse gas emissions, transition to a low-carbon economy, and promote clean energy technologies. Curricula focusing on LCTs can contribute to these policy goals in the following ways [47]:

- **Developing a skilled workforce**: Curricula based on LCTs can provide students with the knowledge and skills required to operate in industries related to RE, energy efficiency, and sustainable practices [48]. These curricula contribute to the development of a competent workforce that can support the EU's transition to a low-carbon economy by providing specialised training [24]–[26].

- **Promoting research and innovation**: Research and innovation in the clean energy sectors are facilitated by curricula that incorporate low-carbon technologies [49]. These curricula can aid in the creation and application of cutting-edge technologies like solar power, wind power, energy storage, smart grids or renewable H2 by encouraging a culture of scientific inquiry and problem-solving, [24].

- **Supporting policy implementation**: LCTs curricula can give students a thorough understanding of the laws and rules that influence the EU's energy and climate policies [50]. Future professionals can successfully contribute to the implementation of EU policies relating to RE objectives, carbon pricing, energy efficiency standards, and emissions reduction initiatives by navigating the complicated regulatory framework with the help of this knowledge [46].

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- **Understanding EU funding processes**: In order to effectively address the pressing issue of climate change and promote the transition to a low-carbon future, it is crucial for curricula in low carbon technologies to include notions on the EU funding process. By incorporating an understanding of the EU funding process into the curricula, students can gain valuable knowledge on how to access and secure funding for their innovative ideas and projects in the field of low carbon technologies. This knowledge will enable them to navigate the complex funding landscape, understand the eligibility criteria, and effectively develop proposals that align with the EU's sustainability goals. Equipping students with this knowledge will not only empower them to contribute to the transition to a greener economy but also enhance their entrepreneurial skills and increase their chances of success in securing the necessary resources to bring their sustainable ideas to fruition.

- **Encouraging multidisciplinary approaches**: LCTs curricula use a multidisciplinary approach, incorporating knowledge from subjects like as engineering, environmental science, economics, and policy [51]. This multidisciplinary approach is consistent with the EU's emphasis on integrated policy solutions and encourages collaboration across sectors, encouraging holistic thinking and problem-solving [22], [23].

- **Raising awareness and fostering behaviour change**: LCT curricula can help enhance student knowledge of climate change and sustainability issues. These curricula promote behavioural change and urge individuals to embrace more sustainable lifestyles in their personal and professional lives by giving knowledge on the environmental impact of energy systems, carbon footprints, and sustainable practices [23], [52].

In conclusion, LCTs directly fulfil EU policy objectives by generating a competent workforce, stimulating research and innovation, assisting with policy implementation, encouraging interdisciplinary approaches, and increasing student awareness. These curricula provide persons with the information and skills needed to help the EU transition to a low-carbon, sustainable future. In order to effectively incorporate EU policies on low carbon technologies (LCTs) into curricula, continuous improvement and adaptation are essential. As EU policies evolve to align with societal and environmental needs, it becomes imperative for curricula-makers to remain up to date and adapt their educational programs accordingly. This ongoing process of adaptation ensures that students are equipped with the most relevant and current knowledge in LCTs, enabling them to effectively address the challenges and opportunities presented by EU policies in this field.

3.1.3 Teaching practices used during COVID-19

The COVID-19 pandemic disrupted traditional educational practices, leading to the rapid adoption of alternative educational models, being online learning the most common one [53]. This section

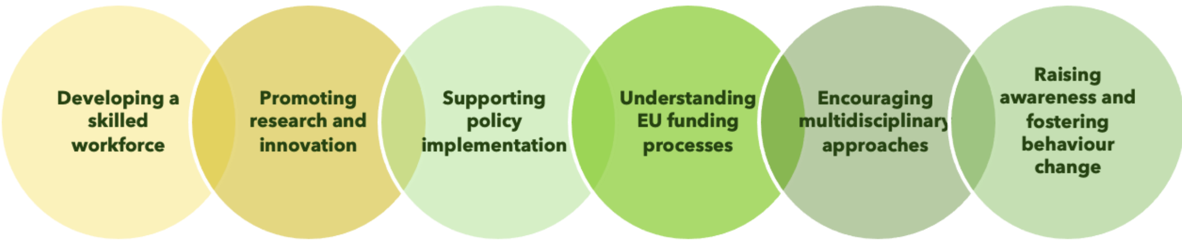

Figure 3: EU Policy Goals fostered by curricula.

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provides an overview of the teaching and training tools as well as practices used during the pandemic to overcome this crisis and its clear impact on education.

In this scenario, synchronous learning involved real-time teaching and learning, where students and teachers interacted simultaneously mainly via video conferencing tools [54]. Asynchronous learning allowed students to access pre-recorded lectures, videos, and materials at their own pace. While a combination of both approaches ensured flexibility and accommodated diverse learning styles and time zones.

For online synchronous teaching, video conferencing platforms such as Zoom, Microsoft Teams, Google Meet or Cisco Webex played a crucial role in facilitating virtual classrooms. They allowed teachers to deliver live lectures, engage with students, and conduct interactive discussions [55]. These platforms helped maintain real-time communication and fostered a sense of connection between teachers and students. However, as Henriksen et al. (2020) posed [54], the abrupt replication of existing face-to-face synchronous teaching pedagogies to synchronous videoconferencing did not take into account the importance of the medium, and many challenges appeared, such as digital divide, students' low participation, and the inability to receive feedback from them due to lack of eye or personal contact [56], [57].

As a useful complement to any of these online tools for synchronous teaching, collaborative tools like Google Drive, Microsoft OneDrive or Dropbox fostered group work and enabled students and teachers to collaborate on projects, share files, and provide feedback [58] (Jacques et al., 2021). These tools facilitated seamless collaboration and promoted active engagement among learners. Similarly, virtual whiteboards, such as Jamboard, Microsoft Whiteboard or Explain Everything, allowed teachers to conduct interactive lessons by writing, drawing, and annotating on shared platforms [56] (Gupta, 2021). This way, students could actively participate, collaborate, and contribute to their learning process.

Additionally, Learning Management Systems (LMS), also used before the pandemic, emerged in this moment as central platforms for remote education. LMS, such as Moodle or Blackboard, facilitated the organization of course materials, sharing resources, and managing assignments. These systems provided a centralized hub for communication, content delivery, and assessment [59]. The University of Montenegro (UoM) have developed their system called Distance Learning (DL) system, which is very similar to classic Moodle system. In other words, it is very suitable for delivering the materials for course, publishing notifications, results and various materials. However, this system contains integrated video conference and virtual whiteboard platform, called BigBlueButton (BBB), which was very widely used for online classes instead of Zoom. The developed DL system is also very suitable for making tests and exams in electronic form, so it is often applied even in real classrooms, when the classic exams done on paper are replaced with exams in electronic form. The DL system allows developing base of questions, and randomly chosen questions from the base appear on the test. By this way, the diversity of tests among all students is ensured. Furthermore, communication platforms like Slack, Microsoft Teams, or Google Classroom facilitated ongoing communication between students and teachers [53]. These platforms provided channels for discussions, announcements, and private messaging, promoting collaboration and engagement.

These platforms could be used as a complement for the synchronous lessons, but also as a necessary tool for asynchronous lessons, where teachers needed a digital space to share and communicate with their students. Moreover, asynchronous teaching often required the recording of lectures, tutorials and demonstrations. For this, tools like Screencast-O-Matic, Loom, or

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QuickTime Player were available. These were particularly useful for asynchronous learning, but also for reference or revision. However, the faculty´s digital divide and lack of technological resources at home often prevented the recording of such videos [57].

Furthermore, some institutions explored the use of Virtual Reality (VR) and Augmented Reality (AR) technologies to create immersive learning experiences [60]. Students could virtually visit historical sites, conduct virtual experiments, or explore 3D models and simulations, enhancing their understanding and engagement.

Another relevant issue during the COVID pandemic was the assessment. The educational system needed to guarantee that the students had achieved the required competences, abilities and knowledge. In this sense, online assessment tools or internal systems administered by the own educational institution, enabled teachers to create and administer quizzes, tests, and exams remotely. But still some challenges were posed by several authors, who highlighted teachers' lack of technological knowledge and students´ lack of stable internet connectivity, possible cheating and plagiarism problems and the difficulty to follow students' progress and interact effectively with them [61], [62]. Therefore, online assessment needs to be completely redesigned and not only replicated in online settings, to ensure students learning and achievement [57].

Finally, professional development for teachers was a crucial part for the success of any remote teaching activity during the pandemic. Furthermore, the ability to adapt to this crisis and use all the available digital tools to redesign their teaching, was intimately linked to the teachers' training before and during the pandemic [63], [64]. Teachers engaged in webinars, online courses, virtual workshops or even self-guided training through video-tutorials to enhance their digital teaching skills and learn new pedagogical approaches [57]. Platforms like Coursera, edX or Udemy, as well as educational institutions' own professional development programs, offered a wide range of training opportunities.

In conclusion, the COVID-19 pandemic prompted a rapid transformation in teaching and training practices, with a shift towards remote learning, where the use of digital tools became a central part of the learning-teaching process. Video conferencing platforms, learning management systems, collaborative tools, and online assessments played a vital role in ensuring the continuity of education. In this sense, teachers' professional development opportunities and the overcome of barriers both for students and faculty, was a central part of the more or less successful implementation of remote learning models [64]. Future research should focus on evaluating the effectiveness and long-term impact of these tools and practices on students' learning outcomes.

3.2. Findings from the questionnaires

As discussed in Section 1.5. over 489 stakeholders answer the TRANSIT questionnaires (by June 2023). However, most answers (i.e., 449) were provided from North Macedonia, UK, Spain, Serbia, Malta, Croatia, Cyprus and Montenegro, which are TRANSIT partner countries. That is, there is only enough information to produce conclusions with statistical significance for the TRANSIT partner countries. Accordingly, the information presented in this section focuses on these countries, and additional information from other countries will be collected and presented in an additional document or an addendum to this deliverable.

A brief summary of survey results from TRANSIT consortium partner countries is presented here. 480 individuals (belonging to 185 institutions) responded to the survey. 449 individuals (166 institutions) belonged to partner countries, while 31 (19 institutions) respondents belong to Rest of the World. A breakdown (by sector and country) of respondent individuals and institutions from partner countries is shown in Table 1.

It is worth noting that, while analysing the survey responses of individuals from each institution, it became apparent that there was some diversity in the individual responses. However, despite this diversity, it was possible to determine an aggregated institutional response by identifying the majority individual responses. Subsequently, the aggregated country response was determined by identifying the majority institutional responses. For instance, 2 out of 3 individual respondents from The University of Manchester agreed with the statement, "Students enrolling in university education lack prior knowledge in renewable energy sources and energy sustainability"; therefore, the aggregated response from The University of Manchester was determined as "Agree." Subsequently, the aggregated response of all 5 UK universities was determined as "Agree"; therefore, the aggregated response form the UK university sector was determined as "Agree."

The survey was aimed at four main groups of stakeholders in: university education, pre-university education (elementary and middle school), industry (continuous professional development (CPD), upskilling and re-skilling) and wider community. To avoid biasing the results, in cases where multiple partners from the same institutions answered the surveys, the answers were consolidated as a single reply. That is, the results presented are based on the number of institutions captured in the surveys (not the number of individuals). The results are then aggregated to produce statistics per correspondent country[4]. The key findings for each stakeholder are presented in the subsections below:

Table 1: Breakdown of respondent individuals (institutions).

	NM	UK	Spain	Serbia	Malta	Croatia	Cyprus	Montenegro	Sector Total
University	22 (6)	10 (5)	9 (8)	9 (4)	5 (1)	4 (2)	3 (2)	1 (1)	63
Pre-University	17 (13)	0	14 (9)	5 (2)	2 (2)	1 (1)	1 (1)	6 (4)	46
Industry	80 (48)	9 (8)	18 (15)	10 (5)	3 (3)	19 (15)	8 (7)	12 (4)	159
Community	49	20	34	5	19	42	12	0	181
Country Total	0	39	75	29	29	66	24	19	Grand total= 449

[4] There is diversity in responses from each country; therefore, final response from each country is considered to be the majority response based on institutions; e.g., when 4 out of 5 respondent universities from the UK agreed to a given statement in the survey, the aggregated response from the UK university sector was considered to be Agree

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3.2.1 University

- 100% of respondent countries stated that their university offer undergraduate and postgraduate programmes in the following topics: (Sustainable) electric power systems engineering, Energy efficiency, and Renewable and sustainable energy, while 75% stated the same for Environmental sciences
- 75% of respondent countries stated that there has been a steady decrease (or no change) in the number of students who enrol in programmes that deal with sustainable energy over the last 10 years
- 63% of respondent countries stated that 10-30% of all students in their school enrol in Undergraduate and postgraduate programmes that deal with sustainable energy each year
- 88% of respondent countries stated that students enrol for the first time in a course that deals with sustainable energy in later years of undergraduate programme
- 100% of respondent countries agreed that students enrolling in university education lack prior knowledge in renewable energy sources and energy sustainability
- 100% of respondent countries stated that they have solar energy demonstration site/lab on the university premises; while 88% stated the same for Wind, Storage technologies and Electrical vehicle technologies
- 100% of respondent countries stated that they use standard classroom approach, Inverted classroom approach, Problem-based learning and Active learning for the delivery of the course material in sustainable energy topics
- 13% of respondent countries (only Spain) stated that they use remote labs for the delivery of the course material in sustainable energy topics; while 50% stated the same for interactive notebooks
- 50% of respondent countries stated that they organize/participate 1 time per year in outreach activities on renewable and sustainable energy for pre-university students; while 70% stated the same for Industry/policymakers and Wider community
- 100% of respondent countries stated that they would you like to get involved with Surveys/Questionnaires in the future; while 88% of respondent countries stated the same for Focus groups
- 100% of respondent countries stated that they would be interested in receiving trainings/lectures delivered by the TRANSIT consortium partners on any of the following topics: Integration of sustainable technology in power systems, Power system planning and operation under energy transition, Power system dynamics, stability, control and power quality in the presence of renewable energy sources, and Offline and real-time simulation tools for power system analysis
- 100% of respondent countries stated that the topics covered by the undergraduate/postgraduate courses offered by their department include: Renewable and sustainable energy and Energy storage technologies; while 88% (except Montenegro) stated the same for Energy efficiency, EV Technology, Environmental sciences and Circularity; and 75% stated the same for Multi-energy systems and district heating, and Demand-side management.

3.2.2 Industry

- 100% of respondent countries stated that their company find the continuous professional education on renewable and sustainable energy of its employees important

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- 100% of respondent countries stated that their company will be interested in collaborating with academia to organize training/continuous education in sustainable energy technologies for its employees
- 100% of respondent countries stated that the following topics are relevant to the company operation, but the employees do not have a strong understanding of: Energy efficiency, Renewable and sustainable energy, Environmental sciences, Energy storage technologies, Multi-energy systems and district heating, Demand-side management, Circularity
- 75% of respondent countries stated that their company have internal policies on sustainability and circularity
- 75% of respondent countries stated that their company implements renewable energy for self-consumption in its day-to-day business; while 88% (except Montenegro) stated the same for Reducing/Reusing/Recycling and 63% stated the same for Smart lighting
- 13% of respondent countries (only North Macedonia) stated that their company implement smart heating in its day-to-day business while 38% stated the same for Energy efficient facades and windows
- 50% of respondent countries stated that they use remote labs for the delivery of the course material in sustainable energy topics; while 63% stated the same for interactive notebooks
- 100% of respondent countries stated that they would you like to get involved with Surveys/Questionnaires, Focus groups and internships in the future
- 88% of respondent countries (except Serbia) disagreed that Graduate students have all the technical skills I am looking for right after they graduate
- 100% of respondent countries disagreed that Graduate students have sufficient knowledge in sustainability/circularity that would benefit the organization
- 100% of respondent countries disagreed that Graduate students have sufficient hands-on/practical skills right after they graduate
- 50% of respondent countries disagreed that Graduate students can apply theoretical knowledge to actual day-to-day practice with ease
- 75% of respondent countries disagreed that Graduate students transition well from academia to industry and immediately begin to contribute to the organization

3.2.3 Pre-University

- 85% of respondent countries stated that the Topics covered by one or more subjects in their school include Energy efficiency, Renewable and sustainable energy, Environmental sciences, Energy storage technologies; while 57% stated the same for Multi-energy systems and district heating, 14% (only Spain) stated the same for Demand-side management and 28% (Spain and Montenegro) stated the same for Circularity
- 64% of respondent countries stated that they don't organize any field trips to renewable energy power plants; companies in the renewable sector; and university laboratories or research institutions in the field of renewable
- 43% of respondent countries stated that they don't organize any Hands-on workshop for students in the field of renewable and sustainable energy; while 57% stated the same for Guest lecturers from the field of renewable and sustainable energy
- 100% of respondent countries stated that they use standard classroom approach, Inverted classroom approach, Problem-based learning and Active learning for the delivery of the course material in sustainable energy topics
- 28% (North Macedonia and Montenegro) of respondent countries stated that they use remote labs for the delivery of the course material in sustainable energy topics; while 0% stated the same for interactive notebooks

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- 64% of respondent countries stated that they have renewable/sustainable energy source demonstration site/laboratory (solar, EV technologies, wind) on the school premises
- 100% of respondent countries stated that the biggest challenge that they have encountered in the delivery of the courses on renewable and sustainable energy, energy efficiency or climate science was Lack of supplementary hardware and software; while 71% stated the same for Lack of appropriate literature for students and Insufficient engagement from students; and 42% stated the same for Difficulties with assessment
- 57% of respondent countries rated that their knowledge below 3 on a scale from 1 (I know very little) to 5 (I am very knowledgeable in this topic) in the following topics: Multi-energy systems and district heating; Demand-side management; Circularity
- 65% of respondent countries rated the representation of the following topics in the existing school curricula below 3 on a scale from 1 (I know very little) to 5 (I am very knowledgeable in this topic): Energy storage technologies, Multi-energy systems and district heating; Demand-side management; Circularity
- 65% of respondent countries rated the expected representation of the following topics in the school curricula at 3 or above on a scale from 1 (not represented at all) to 5 (very well represented): Environmental sciences; Energy storage technologies (e.g., batteries, and pumped-hydro); Multi-energy systems and district heating; Demand-side management; Electric vehicles technologies; Circularity

3.2.4 Wider community

- 32% of respondent countries stated that they work in the field relating to energy, sustainability or environment
- 66% of respondent countries stated that they do not use renewable energy for self-consumption in their day-to-day life; while 23% stated the same for solar energy
- 76% of respondent countries stated that they implement home energy efficiency in their day-to-day life through Reducing/Reusing/Recycling; while 38% stated the same for Energy efficient facades and windows, 29% for smart heating and 22% for smart lighting
- 65% of respondent countries stated that the barriers that are preventing them from implementing sustainable practices include high costs; while 30% stated the same for Lack of actionable information and 20% stated the same for complexity
- 45% of respondent countries ranked the Reduction in energy bill as the most motivating factor for implementing sustainable practices in their day-to-day life; while 23% stated the same for Personal satisfaction knowing I contribute to environmental sustainability; 25% for I want to leave a better world for future generations and 8% for More independency from the utility companies
- 80% of respondent countries stated that they are aware of or have heard about Energy efficiency, Renewable and sustainable energy,
- Environmental sciences and Energy storage technologies; while 30% stated the same for Multi-energy systems and district heating, Demand-side management and Circularity
- 60% of respondent countries stated that they would engage in community activities to learn about sustainable practices in everyday life
- 75% of respondent countries indicated that they trusted the information provided by Books and Formal education systems on the topic of renewable energy sources; while 27% indicated the same for News and TV, Friends and family, and Local community groups; and only 14% indicated the same for Social media

- 63% of respondent countries indicated that they would they like to get involved with TRANSIT Surveys/Questionnaires in the future; while 35% indicated the same for Focus groups
- 54% of respondent countries indicated that they would be interested to receive information or guidance on the following topics: Understanding the benefits of becoming an active energy consumer and Design of small power plants such as solar PV

4. Conclusion

This deliverable, D3.1, reports on areas of improvement for training for (and from) pre-university, university, industry and wider community stakeholders in different geographical regions, especially in Europe. This information is meant to facilitate sustainable development, e.g., through the adoption of RE, LCT and circularity principles. For this purpose, specialised surveys were developed for the four stakeholder groups and extensive literature surveys were conducted to collect relevant information from different countries.

The literature survey highlighted that the key best practices for training associated with sustainable development include:

1. Interdisciplinary approach
2. Hands-on experiences
3. Collaboration with industry experts and research institutions
4. Integration of sustainability principles
5. Experiential and project-based learning
6. Continuous professional development for educators
7. Networking and community engagement

The questionnaires were answered by over 449 individuals (by June 2023). However, most answers were from TRANSIT partner countries (i.e., North Macedonia, UK, Spain, Serbia, Malta, Croatia, Cyprus and Montenegro). This to provide findings of statistical significance, the findings presented in this report focus on the TRANSIT partner countries (information from additional countries will be collected and release as an additional document or addendum). The outcomes of the questionnaires highlighted the following:

- **Universities:**
    - All respondents currently offer programmes associated with sustainable development; although, not all technologies are covered (e.g., Montenegro did not mention energy efficiency and other technologies).
    - Most countries (75%) have experienced a steady decrease (or no change) in the number of students who enrol in these programmes
    - About 10-30% of students deal with sustainable energy each year; however, most students only enrol in course that deals with sustainable energy in later years of their undergraduate programmes
    - All respondent agreed that students lack prior knowledge in renewable energy sources and energy sustainability
    - All respondents have solar energy demonstrators, whereas 88% have demonstrators for Wind, Storage technologies and Electrical vehicle technologies
    - Universities use a wide range of teaching tools, including standard teaching, Inverted classroom, problem-based learning and Active learning. That said, only Spain mentioned using remote labs
    - Only about 50% and 70% of the respondents respectively engage in outreach activities, and with Industry/policymakers and the Wider community
- **Industry**
    - Industry finds the continuous professional education on renewable and sustainable energy of its employees important
    - All respondents expressed interest in collaborating with academia
    - Most respondents (75%) confirmed having internal policies on sustainability and circularity

- Some (38%) of respondents confirmed having energy efficiency measures, whereas only North Macedonia confirmed implementing smart heating
- Half of the respondent use remote labs; 63% use interactive notebooks
- Only Serbia agreed that Graduate students have all the technical skills they need. That said, all respondents concluded that Graduate students lack knowledge in sustainability/circularity

- **Pre-University**
  - Most (85%) respondents cover topics associated with sustainable development
  - Most (64%) respondent countries stated not organising relevant field trips, whereas 43% do not organize hands-on workshop
  - All respondents use standard classroom approach, Inverted classroom approach, Problem-based learning and Active learning
  - North Macedonia and Montenegro stated using remote labs (none use interactive notebooks)
  - 64% of respondent countries have demonstrators
  - All respondents flagged issues accessing required supplementary hardware and software, whereas 71% lack appropriate literature
- **Wider community**
  - 32% of the respondent work in a field relating to sustainable development
  - Most (66%) respondent do not use renewable energy for self-consumption
  - Most (76%) respondents implement home energy efficiency
  - Most (65%) respondent see the high costs as the main barrier for adopting RE or LCTs; whereas 30% and 20% see the lack of information and high complexity as the main challenges, respectively
  - The main factors that motivate respondents to adopt REs and LCTs include lower energy bills (45%), personal satisfaction (23), improving the world (25%) and becoming energy independent (8%)
  - 60% of respondent countries stated that they would engage in community activities to learn about sustainable practices in everyday life

The information presented in this report will be further elaborated (e.g., collecting data from more countries) to serve as a basis to identify knowledge gaps in general and across different regions and for further development of educational programs and curricula on RE, LCTs and circularity.

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Appendix A: Questionnaire – University Stakeholders

Questionnaire – University Stakeholders

1. What university do you teach at?
2. What country do you teach in?
3. What school/department do you belong to?
    a) Electrical/electronic engineering and computer science
    b) Mechanical engineering
    c) Natural sciences
    d) Chemical engineering
    e) Social sciences (Humanities)
    f) Environmental studies
    g) Other
4. Does your university/school offer undergraduate programmes (bachelor's) in any of the following topics?
    a) Sustainable) electric power systems engineering
    b) Energy efficiency
    c) Renewable and sustainable energy
    d) Environmental sciences (climate science, environmental protection, ecology)
    e) Other
5. Does your university/school offer postgraduate programmes (master's) in any of the following topics
    a) (Sustainable) electric power systems engineering
    b) Energy efficiency
    c) Renewable and sustainable energy
    d) Environmental sciences (climate science, environmental protection, ecology)
    e) Other
6. On average, what percentage of all students in your school/department enrols in these programmes (listed in the previous question) each year?

	<10%	10%-30%	30%-50%	50%-70%	>70%
Undergraduate programmes					
Postgraduate programmes					

7. How has the number of students who enrol in these programmes changed over the last 10 years

	Sharp decrease	Steady decrease	No change	Steady increase	Sharp increase
Undergraduate programmes					
Postgraduate programmes					

8. Please select the topics that are covered by the undergraduate/postgraduate courses/units offered by your school/department
    a) Energy efficiency
    b) Renewable and sustainable energy

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c) Environmental sciences (climate science, environmental protection, ecology)
d) Energy storage technologies (e.g., batteries, pumped-hydro, etc.)
e) Multi-energy systems and district heating
f) Demand-side management
g) Electrical vehicles technologies
h) Circularity
i) None of above
j) Other

9. In which period of their studies do the students enrol for the first time in a course/unit that deals with sustainable energy
    a) Early years of undergraduate programme (years 1-2)
    b) Later years of undergraduate programme (years 3-4)
    c) Postgraduate programme
10. To what extent do you agree that students enrolling in university education lack prior knowledge in renewable energy sources and energy sustainability
    a) Strongly agree
    b) Agree
    c) Neutral
    d) Disagree
    e) Strongly disagree
11. What approaches are you using for the delivery of the course material in sustainable energy topics?
    a) Standard classroom approach (explaining the content using blackboard and/or slideshows: instructor has an active role, while students have a passive role)
    b) Inverted classroom approach (The students are introduced to the course material at home and practice working through it at school)
    c) Problem-based learning (Learning through the experience of solving an open-ended problem)
    d) Active learning (Actively engaging the students with course material through discussions, polls, quizzes, case studies, problem solving, etc.)
    e) Experiential learning (Learning by doing: a hands-on interaction is conducted and then reflected upon)
    f) Videos
    g) Animations
    h) Real laboratories (hands-on experience with actual hardware)
    i) Remote laboratories (access to remote hardware)
    j) Virtual laboratories (completely software-based)
    k) Computer simulation tools
    l) Interactive notebooks
    m) Technical visits to industrial facilities (e.g., renewable energy plants)
    n) Guest lecturers from industry
    o) Other
12. What type of renewable/sustainable energy source demonstration site/laboratory do you have on the university/school/department premises?
    a) Solar
    b) Wind
    c) Storage technologies
    d) Electrical vehicle technologies
    e) None of above

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f) Other

13. How many times per year do you organize/participate in outreach activities on renewable and sustainable energy for the following groups?

	None	1	2	3 or more
Pre-university pupils (e.g., workshops, visiting schools or organizing pupils visits to the university				
Industry and policymakers (e.g., roundtable discussions, workshops)				
Wider community (e.g., roundtable discussions, workshops)				

14. Which TRANSIT project activities would you like to get involved with in the future?
    - Surveys/Questionnaires (up to five follow-up surveys, throughout the course of the project)
    - Focus groups (online or face-to-face interviews or meetings with consortium partners)
15. Would you be interested in receiving trainings/lectures delivered by the TRANSIT consortium partners on any of the following topics? The training/lecture material is aimed at master's/PhD students and above
    a) Integration of sustainable technology in power systems (e.g., energy storage, electric vehicles, renewable energy sources, design of solar PV power plants, power plant grid compliance)
    b) Power system planning and operation under energy transition (e.g., modelling, optimization, dynamic security assessment, risk management)
    c) Power system dynamics, stability, control and power quality in the presence of renewable energy sources (e.g., voltage and frequency dynamics, dynamic modelling of major power system components, control of power electronics)
    d) Offline and real-time simulation tools for power system analysis (e.g., Typhoon HIL,MATLAB/Simulink, PSS/E, Power Factory, NEPLAN)

Appendix B: Questionnaire – Pre-university Stakeholders

Questionnaire – Pre-university Stakeholders

1. What school do you teach at?
2. In which country do you teach?
3. What is your current job description? (Please mark all that apply)
    a) Teacher
    b) Principal/Headmaster
    c) Other
4. What is your main field of teaching?
5. What is the preuniversity education level you teach at?
    a) Children aged < 11
    b) Children aged 11-15
    c) Children aged 15-19
6. Please select the topics that are covered by one or more compulsory subjects in your school
    a) Energy efficiency
    b) Renewable and sustainable energy
    c) Environmental sciences (climate science, environmental protection, ecology)
    d) Energy storage technologies (e.g., batteries, pumped-hydro, etc.)
    e) Multi-energy systems and district heating
    f) Demand-side management
    g) Electrical vehicles technologies
    h) Circularity
    i) None of above
    j) Other
7. Please select the topics that are covered by one or more optional subjects in your school
    a) Energy efficiency
    b) Renewable and sustainable energy
    c) Environmental sciences (climate science, environmental protection, ecology)
    d) Energy storage technologies (e.g., batteries, pumped-hydro, etc.)
    e) Multi-energy systems and district heating
    f) Demand-side management
    g) Electrical vehicles technologies
    h) Circularity
    i) None of above
    j) Other

8. How many times per year do you organize field trips?

	None	1	2	3 or more
To renewable energy power plants or low carbon power plants (e.g., wind, PV, nuclear, and biomass)				
To companies working in the renewable and sustainable technology sector				
To universities laboratories or research institutions in the field of renewable and sustainable energy				

9. How many times per year do you organize/participate in the following activities?

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	None	1	2	3 or more
Hands-on workshops for students in the field of renewable and sustainable energy				
Guest lecturers from the field of renewable and sustainable energy				

10. Which approaches do you use for the delivery of subject material in the fields of renewable and sustainable energy, energy efficiency or climate science? *(Please mark all that apply)*
    a) Standard classroom approach (explaining the content using blackboard and/or slideshows: instructor has an active role, while students have a passive role)
    b) Inverted classroom approach (The students are introduced to the course material at home and practice working through it at school)
    c) Problem-based learning (Learning through the experience of solving an open-ended problem)
    d) Active learning (Actively engaging the students with course material through discussions, polls, quizzes, case studies, problem solving, etc.)
    e) Experiential learning (Learning by doing: a hands-on interaction is conducted and then reflected upon)
    f) Videos
    g) Animations
    h) Real laboratories (hands-on experience with actual hardware)
    i) Remote laboratories (access to remote hardware)
    j) Virtual laboratories (completely software-based)
    k) Computer simulation tools
    l) Interactive notebooks
    m) Technical visits to industrial facilities (e.g., renewable energy plants)
    n) Guest lecturers from industry
    o) Other
11. What type of renewable/sustainable energy source demonstration site/laboratory do you have on the school premises? *(Please mark all that apply)*
    a) Solar
    b) Wind
    c) Storage technologies
    d) Electrical vehicle technologies
    e) None of above
    f) Other
12. What did you consider to be the biggest challenge that you have encountered in the delivery of the units/courses on renewable and sustainable energy, energy efficiency or climate science? *(Please mark all that apply)*
    a) Insufficient engagement from the students
    b) Lack of supplementary hardware (e.g., computers, laboratory equipment, etc.)
    c) Lack of supplementary software (e.g., not enough student licences for the given software)
    d) Lack of appropriate literature for students
    e) Difficulties with assessment
    f) No challenges
    g) None of the above

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13. How would you rate your own knowledge in the following topics on a scale from 1 (I know very little) to 5 (I am very knowledgeable in this topic)?

	1	2	3	4	5	Non applicable
Energy efficiency						
Renewable and sustainable energy						
Environmental science (climate science, environmental protection ecology)						
Energy storage technologies (e.g., batteries, and pumped-hydro)						
Multi-energy systems and district heating						
Demand-side management						
Electric vehicles technologies						
Circularity						

14. How would you rate the representation of the following topics in the existing school curricula on a scale from 1 (not represented at all) to 5 (very well represented)?

	1	2	3	4	5
Energy efficiency					
Renewable and sustainable energy					
Environmental science (climate science, environmental protection ecology)					
Energy storage technologies (e.g., batteries, and pumped-hydro)					
Multi-energy systems and district heating					
Demand-side management					
Electric vehicles technologies					
Circularity					

15. On a scale from 1 (not represented at all) to 5 (very well represented), how well represented do you think the following topics should be in the school curricula?

	1	2	3	4	5
Energy efficiency					
Renewable and sustainable energy					
Environmental science (climate science, environmental protection ecology)					
Energy storage technologies (e.g., batteries, and pumped-hydro)					
Multi-energy systems and district heating					
Demand-side management					
Electric vehicles technologies					
Circularity					

16. Which TRANSIT project activities would you like to get involved with in the future?

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a) Surveys/Questionnaires (up to five follow-up surveys, throughout the course of the project)
b) Focus groups (online or face-to-face interviews or meetings with consortium partners)
c) Trainings/Lectures/Workshops for teachers (in renewable energy and sustainability)
d) Activities for students (workshops at universities, field trips to laboratories or industrial facilities relating to renewable energy and sustainability)

Appendix C: Questionnaire – Industry Stakeholders

Questionnaire – Industry Stakeholders

1. What company do you work for?
2. What country do you work in?
3. What is the description of your job position at the company?
   a) Engineer
   b) Project manager
   c) Higher management (CEO, CTO, etc.)
   d) Other
4. Does your company organize continuous professional development (CPD) courses for the employees in any of the following topics? (Please mark all that apply)
   a) (Sustainable) Electric power systems engineering
   b) Energy efficiency
   c) Renewable and sustainable energy
   d) Environmental sciences (climate science, environmental protection, ecology)
   e) None of the above
5. How important does your company find the continuous professional education on renewable and sustainable energy of its employees?
   a) Not at all important
   b) Slightly important
   c) Neutral
   d) Important
   e) Very important
6. Would your company be interested in collaborating with academia to organize training/continuous education in sustainable energy technologies for its employees?
   a) Strongly opposed
   b) Not interested
   c) Neutral
   d) Interested
   e) Very interested
7. Please select all topics that are relevant to the company operation, but you feel the employees do not have a strong understanding of.
   a) Energy efficiency
   b) Renewable and sustainable energy
   c) Environmental sciences (climate science, environmental protection, ecology)
   d) Energy storage technologies (e.g., batteries, pumped-hydro, etc.)
   e) Multi-energy systems and district heating
   f) Demand-side management
   g) Circularity
8. When training employees, how much of their time and effort do different training processes take up?

	None	1-2 days per year	1 week per year	2 weeks per year	More than 2 weeks per year

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Upskilling (Teaching employees new advanced skills, continuous education, etc.)					
Reskilling (Training employees to build new skills to adapt to a new position within the company)					
Learning internal processes and tools which they could not have learned elsewhere (e.g., specific software or data protection processes)					
Re-learning tools which they could have learned elsewhere (e.g., university, independently)					

9. Considering your recent experience with university graduates from any institution, please select the most appropriate responses to the following statements.

	Strongly disagree	Mostly disagree	Neutral	Mostly agree	Strongly agree
Graduate students have all the technical skills I am looking for right after they graduate					
Graduate students can apply theoretical knowledge to actual day-to-day practice with ease					
Graduate students settle in very quickly to the specific business culture and form an integral part of the team					
Graduate students transition well from academia to industry and immediately begin					

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to contribute to the organization					
Graduate students have wide theoretical knowledge of different topics					
Graduate students have deep theoretical knowledge of a single topic					
Graduate students have limited knowledge in sustainability/circularity that would benefit the organization					
Graduate students have sufficient hands-on/practical skills right after they graduate					

10. Does your company have internal policies on sustainability and circularity?
    a) Yes
    b) No
11. Does your company implement any of the sustainable practices listed below in its day-to-day business?

	Yes	No
Renewable energy for self-consumption		
Smart heating		
Reducing/Reusing/Recycling		
Smart lighting		
Energy efficient facades and windows		

12. How many times per year does your company organize/participate in outreach activities (e.g., workshops, school visits or organization of student visits to the company)?

	None	1	2	3 or more
To pre-university students				
To university students				
To external stakeholders and customers				

13. Which approaches does your company implement for the delivery of subject material in the training of employees? (Please mark all that apply)
    a) Standard classroom approach (explaining the content using blackboard and/or slideshows: instructor has an active role, while students have passive role)
    b) Inverted classroom approach (students are introduced to the course material at home and practice working through it at school)

c) Problem-based learning (learning through the experience of solving an open-ended problem)
d) Active learning (actively engaging the students with course material through discussions, polls, quizzes, case studies, problem solving, etc.)
e) Experiential learning (learning by doing: a hands-on interaction is conducted and then reflected upon)
f) Videos
g) Animations
h) Real laboratories (hands-on experience with actual hardware)
i) Remote laboratories (access to remote hardware)
j) Virtual laboratories (completely software-based)
k) Computer simulation tools
l) Interactive notebooks
m) Technical visits to industrial facilities (e.g., renewable energy plants)
n) Other

14. Which TRANSIT project activities would you like to get involved with in the future?
    a) Surveys/Questionnaires (up to five follow-up surveys, throughout the course of the project)
    b) Focus groups (online or face-to-face interviews or meetings with consortium partners)
    c) Internships (Short-term hosting of PhD students from TRANSIT consortium academic partners to acquire hands-on industrial experience in order to improve academic curricula)
15. Would you be interested in receiving trainings/lectures delivered by the TRANSIT consortium partners to your team, on any of the following topics?
    a) Role of flexibility assets in the transition towards clean energy in power systems (e.g., flexibility from generation/demand/energy storage, business models, electricity market design and integration)
    b) Integration of sustainable technology in power systems (e.g., energy storage, electric vehicles, renewable energy sources, design of solar PV power plants, power plant grid compliance)
    c) Power system planning and operation under energy transition (e.g., modelling, optimization, dynamic security assessment, risk management)
    d) Power system dynamics, stability, control and power quality in the presence of renewable energy sources (e.g., voltage and frequency dynamics, dynamic modelling of major power system components, control of power electronics)
    e) Offline and real-time simulation tools for power system analysis (e.g., Typhoon HIL, MATLAB/Simulink, PSS/E, Power Factory, NEPLAN)

Appendix D: Questionnaire – Wider Community Stakeholders

Questionnaire – Wider Community Stakeholders

1. What country do you live in?
2. What is your highest level of education obtained?
    a) Primary school
    b) Secondary school
    c) Bachelor's degree
    d) Master's degree
    e) PhD
3. Do you work in the field relating to energy, sustainability or environment?
    a) Yes
    b) No
4. Do you use renewable energy for self-consumption in your day-to-day life? (Please mark all that apply)
    a) Solar
    b) Wind
    c) Hydro
    d) Geothermal
    e) None of above
    f) Other
5. Do you implement home energy efficiency in your day-to-day life? (Please mark all that apply)
    a) Smart heating (control it remotely)
    b) Reducing/Reusing/Recycling
    c) Smart lighting (sensor/timer operated)
    d) Energy efficient facades and windows
    e) None of above
    f) Other
6. Please select all barriers that are preventing you from implementing sustainable practices listed in the previous question.
    a) Too expensive
    b) Too complex
    c) I don't believe it will make a global difference
    d) Lack of actionable information (i.e., I know about the practices, but don't know a straightforward way to implement them in real life)
    e) I am not interested in implementing them
    f) Other
7. Select all topics you are aware of or have heard about.
    a) Energy efficiency
    b) Renewable and sustainable energy
    c) Environmental sciences (climate science, environmental protection, ecology)
    d) Energy storage technologies (e.g., batteries, pumped-hydro, etc.)
    e) Multi-energy systems and district heating
    f) Demand-side management
    g) Circularity
    h) None of above

8. Please rank the motivating factors for implementing sustainable practices in your day-to-day life from the most important (1) to the least important (4).
    a) Reduction in energy bill
    b) Personal satisfaction knowing I contribute to environmental sustainability
    c) More independency from the utility companies
    d) I want to leave a better world for future generations
9. Would you engage in community activities to learn about sustainable practices in everyday life?
    a) Not at all
    b) Probably no
    c) Neither yes or no
    d) Probably yes
    e) Absolutely
10. When it comes to the topic of renewable energy sources, please indicate the extent to which you trust the information provided by each of the following information sources (1 - I don't trust at all, 5 - I trust completely).

	1	2	3	4	5
Books					
Social media					
News and TV					
Friends and family					
Formal education systems (e.g., public schools)					
Local community groups (e.g., neighbours activity groups, etc.)					

11. Which TRANSIT project activities would you like to get involved with in the future?
    a) Surveys/Questionnaires (up to five follow-up surveys, throughout the course of the project)
    b) Focus groups (online or face-to-face interviews or meetings with consortium partners)
12. Please select the topics in which you would be interested to receive information or guidance to understand.
    a) Understanding the benefits of becoming an active energy consumer
    b) Design of small power plants such as solar PV (requirements, installation, grid compliance)

Appendix E: Catalogue of training associated with sustainable development

Table 2: Example of standard teaching courses associated with sustainable development.

Course	Learning outcomes	Structure
MPhil in Energy Technologies (University of Cambridge)	Fundamental sciences behind technologies; to develop graduates with an overall view of energy engineering, while offering specialisation in a selected area through a research project; to prepare students (if they so wish) for potential future PhD research.	Taught courses; Elective courses; and Research projects
MPhil in Engineering for Sustainable Development (University of Cambridge)	Produce engineers; Connected Electronic and Photonic Systems	Taught courses; Elective courses; and Research projects
MRes in Connected Electronic and Photonic Systems (University of Cambridge)	Begin to equip students for engineering leadership positions, developing a high level of understanding and skills in photonic and electronic systems, in particular, the fundamentals of the field together with technology, systems and applications knowledge, and some research experience.	Taught courses; Elective courses; and Research projects
MSc in Sustainability, Enterprise and the Environment (University of Oxford)	Develop a critical understanding of the nature, drivers and trajectories of climate change and economic development. Examine the role of enterprise and its relationship to environmental and development challenges across a range of risks, technological innovations, investment opportunities and policy responses. Enable students to integrate and apply their interdisciplinary knowledge, advanced methodological skills and science-policy-enterprise network to foster innovation and scalable progress toward net zero and sustainable development.	The course objectives are addressed through a 'foundations module', eight core modules, two electives and a dissertation.

MSc in Global Energy Technologies and Systems (University of Birmingham)	Provide both the understanding of how energy systems are changing, and what technologies will be important in the future	Taught courses; Elective courses; and Research projects
MSc in Electrical Power Systems (University of Birmingham)	Provide the skills and knowledge you need to significantly enhance your career prospects in the electrical power industry, developing your power engineering skills through expert teaching and extensive research work undertaken in collaboration with power industry partners.	Taught courses and Research projects
MSc in Sustainable Energy Systems (University of Edinburgh)	While there is particular focus on the deployment of renewable energies in grid-connected systems, there are also opportunities to explore off-grid systems on some of the optional courses and as part of dissertation projects	Taught courses; Elective courses; and Research projects
MScR in Energy Systems (University of Edinburgh)	Covers all aspects of the low carbon energy chain: resource modelling, impact of climate change, wind, wave, tidal & solar energy, electrical power conversion, energy storage, carbon capture, biofuels and delivery into the electrical network.	Research projects
MRes in Sustainable Futures (University of Bath)	Develop in-depth knowledge and skills of research methods. Prepare yourself for an academic or professional career with a focus on policy and the environment.	Taught courses; Elective courses; and Research projects
MSc in Sustainable Engineering: Renewable Energy Systems & the Environment (University of Strathclyde)	Comprises compulsory technical modules, a choice of broader generic modules, which are recommended by accrediting professional bodies, group projects with industry input, and individual projects	Taught courses; Elective courses; and Research projects

MSc in Sustainable Energy Futures (Imperial College London)	The main aim of the programme is to develop the next generation of leaders for the energy transition.	Three terms
MSc in Future Power Networks (Imperial College London)	Learn about the challenges posed by the rapidly changing power generation mix with increasing fractions of clean energy sources such as wind and solar. Study the enabling technologies and the system-level solutions to facilitate deep decarbonisation of the electric power sector in a secure and cost-effective way.	Taught modules, optional modules, and Research Project
MSc in Sustainability (University of Southampton)	This MSc Sustainability programme is designed as a research-led, applied interdisciplinary programme that considers sustainability in both developed and developing societies, and addresses critical global challenges.	Taught and Research
MSc in Energy Technologies for Sustainable Development (Polytechnic University of Valencia)	The objective of the programme is to provide its graduates with all the necessary knowledge to undertake professional activity or research work in the energy sector, in accordance with the needs of sustainable development, that is to say: improving efficiency and savings, as well as limiting the environmental impact of energy generation, transport and use processes.	Taught courses; Elective courses; and Research projects
BSc in Renewable Energies and Energy Efficiency Engineering (University of Barcelona)	The programme covers current RE sources, such as hydrolic, eolic, photovoltaic, geothermal, solar thermal, concentrated solar power (CSP) and biomass. Students will be oriented towards the search of new clean energy sources and to optimise the process with ways to economise and efficiently use energy.	Taught courses; Elective courses
MSc in Renewable Energies and Energy Efficiency (University of Zaragoza)	The aim of this programme is to develop researchers in renewable energies and energy efficiency, which can then pursue a PhD or a position in a research centre, also supporting innovation in industry.	Taught courses; Elective courses; and Research projects
MSc in Sustainable Energy Engineering (Aalborg University)	This programme aims to equip students with knowledge to develop sustainable energy systems of the future. Students analyse, design and model of systems such as	Taught courses; Elective

	PtX, CCUS, offshore wind turbines, offshore robotics and energy islands.	courses; and Research projects. The programme offers a job guarantee
MSc in Sustainable Energy (Technical University of Denmark)	This MSc programme educates candidates in the deep technical aspects of RE technologies as well as energy conversion and storage technologies. Moreover, it educates candidates in energy system aspects and assessment of sustainability – thus offering a unique opportunity for a cross-cutting and international MSc programme within sustainable energy.	Taught courses; Elective courses; and Research projects
MSc in Mechanical Engineering and Sustainable Technology (The Malta College of Arts, Science and Technology)	This course offers high critically problems and use professional skills and knowledge in the systematic development of complex engineering systems. The students will acquire a broad range of skills in major engineering disciplines, preparing them for senior technical or project management roles within the industry.	Taught and research
MSc in Electrical Engineering (The University of Malta)	Students will carry out an in-depth dissertation on an area of choice. Use the appropriate research methodology skills for independent and academic research. Discuss and write effectively using the appropriate jargon related to the area. Contribute students' knowledge on electrical engineering at the workplace and in discursive atmospheres. Be able to use practical mind set to solve engineering-related issues.	Research-based postgraduate course
MSc in Electrical Engineering and Information Technology (University of Zagreb)	This course offers students a comprehensive understanding of various aspects of the field, covering topics such as power systems control, energy efficiency, environmental protection, and more. Students will gain knowledge in areas like optimization methods, reliability theory, power system protection, and transmission and distribution networks.	Taught and Research

MSc in Electrical Engineering (University of Cyprus)	This program offers research and study opportunities in diverse fields such as Power and Renewables, Telecommunication Systems and Networks, Biomedical Engineering, Signal and Image Processing, Intelligent Systems and Control, and Electronic Devices, and Nanotechnology. Students can explore sustainable energy, advanced communication systems, biomedical innovations, digital signal analysis, electromagnetic principles, artificial intelligence, and nanoscale engineering.	Taught and Research
MSc in Energy Technologies and Sustainable Desing (University of Cyprus)	The program provides a specialization in Energy Technologies with a focus on Sustainable Design. It offers an interdisciplinary approach, allowing students to engage with various scientific fields and collaborate with peers from different disciplines. This fosters synergies and complementary efforts towards shared goals. As a result, graduates gain a comprehensive and multidisciplinary training in the diverse field of Energy.	Taught and Research project, restricted elective
Bachelor of Science in Electrical Engineering and Information Technology (University of Zagreb)	This programme develops competencies to analyse and solve engineering problems of various complexities, to operate as an efficient member of a team, and to contribute to design of systems and processes in electrical engineering and information technology.	Taught and Project based learning
Advanced Diploma in Environmental Sustainability (The Malta College of Arts, Science and Technology)	This programme of studies includes topics related to environmental monitoring, even within manufacturing industries, that are fundamental to the development of environmental awareness, and provides the necessary practical skills and techniques.	Taught and Research
Bachelor of Science (Honours) in Environmental Science and Sustainable Technologies (The Malta College of Arts, Science and Technology)	This program covers the fundamentals of environmental engineering across industries. Students will learn to conduct water, energy, and environmental audits, as well as basic environmental impact assessments. They will also gain knowledge of environmental legislation and regulations necessary for developing environmental policies. Additionally, students will acquire skills in monitoring, logging, data management, and	Taught and Research

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	interpretation of environmental parameters to arrive at scientific conclusions for specific issues.	
MSc in Applied Environmental Science (The Malta College of Arts, Science and Technology)	This program provides knowledge and skills for seizing opportunities in environmental fields including global cycles, sustainable technologies, pollution assessment, and natural hazards. Students explore system analysis and ecosystem theory for managing human-environmental systems.	Taught and Research
MSc in Environmental Resource Management (The Malta College of Arts, Science and Technology)	The programme is characterised by several modules that will allow students to develop technical solutions needed to solve, attenuate or control environmental issues.	Taught and Research
MSc in Urban Environmental Science Management (The Malta College of Arts, Science and Technology)	The course introduces students to the necessary knowledge and skills to seize opportunities presented by new developments in areas such as global cycles, biogeochemistry, sustainable technologies, environmental pollution assessment and remediation, and natural hazard.	Taught and Research
Master's in electrical engineering (Cyprus University of Technology)	The Program is designed to meet the modern needs of industry and the market at a global level and to provide the student with all the resources for original research and contribution in the field of Electrical Engineering. Specifically, students will enrich their knowledge in advanced topics such as: Telecommunications Systems, Signal and Image Processing, Decision, Control and Automation Systems, Electromagnetism, Antennas and Optics, Electric Power Systems, Renewable Energy Systems and Biomedical Engineering.	Taught and Research
Master's in electrical engineering (Frederick University)	The main objectives of the Program are to equip students with postgraduate level knowledge, tools and methodologies on Advanced Electrical Engineering Topics pertinent to three areas of study: generation transmission and distribution of Electric Power via conventional or renewable energy sources, Telecommunication Systems and Automation and Control Systems	Taught and Research

BSc in Electrical and Electronic Engineering (European University Cyprus)	This program enables students to specialize with either an energy focus (production, distribution and renewable energy) or a telecommunication focus. The program emphasizes the knowledge and skills required in a fast-changing industry, so that students are able to appropriately design, develop, evaluate, maintain and upgrade electrical and electronic systems.	Taught and Research
Master's in electrical engineering (University of Nicosia)	The content of the program is focused on four very hot thematic areas, namely, (a) Signal Processing & Communications, (b) Electromagnetics, Antennas & Microwave Engineering, and (c) Renewable Energy Sources and Power Systems, and (d) VLSI & Embedded Systems and allows the students to choose those courses that will meet their future career goals.	Taught and Research
Master in Renewable Energies and Environment (Polytechnic University of Madrid)	The Master ERMA academic programme is updated annually and consider all forms of renewable energy, energy efficiency and environmental impact assessment methodologies, using the tools, techniques and software from top companies in the renewable energy sector.	Taught and Research
Master in Renewable Energies in Electrical Systems (Universidad Carlos III de Madrid)	This programme aims to train professionals with collaboration from industry experts to work in the electrical and renewable energies sector, working on the development and technological innovation of emerging technologies such as technology of renewable energies; management and evaluation of the profitability of renewable energy projects and companies; specific education focused on intelligent networks.	Taught and Research
Master in Renewable and Sustainable Energy (Universidad de Barcelona)	This master's degree addresses the concept of sustainability from every angle and with the necessary academic rigour. It prepares students to work in companies and institutions that contribute sustainable solutions or actively integrate a concern for sustainability into their business strategies. As several studies have shown, this is a major growth sector that offers a significant number of positions for individuals with	Taught and Research

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	training in renewable energy sources and energy efficiency.	
Master in Renewable Energies (University of La Laguna)	The general objectives of this qualification focus, on the one hand, on offering official university training in the field of Renewable Energies, with well-defined professional profiles:	Taught and Research
Master's in electrical engineering (University of Belgrade)	The basic objective of the Academic Master studies program of Electrical Engineering and Computer Science is to additionally educate engineers who are competent for analysis, maintenance, development and design of the parts of the system, as well as complex systems, and also dealing with scientific work.	Taught and Research
Master's in electrical engineering (School of Electrical and Computer Engineering of Applied Studies in Belgrade)	The goals of the study program Electrical Engineering are to train professionals in the fields of electronics, telecommunications, automation and energy for the needs of production enterprises, in development, production and maintenance; institutions of economic and extracurricular activities, in the affairs of selection in the procurement and maintenance of equipment; public enterprises in operations in exploitation and maintenance of equipment, systems and plants; project organizations.	Taught and Research
Master in Energy Technologies (University of Novi Sad)	Faculty of Technical Sciences provides courses and programs related to energy and environmental engineering. Students can study topics like Energy Efficiency, Renewable Energy Technologies, and Sustainable Energy Systems.	Taught and Research
Master's in electrical engineering and computing (University of Kragujevac)	the expected learning outcomes are mastering methods and tools for analysis, synthesis and design of electronic and computer systems as well as other specialized computer tools and programs, mastery of specific knowledge and skills acquired through study research work, work on project tasks and professional practice, acquiring the ability to plan and implement scientific and / or applied research, which means taking into account economic, environmental, organizational and social relations.	Taught and Research

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MSc in Environment and Energy Transition (Comillas Pontifical University)	Multidisciplinary approach at this study programme includes various disciplines like RES and their integration, energy efficiency in buildings, air and water pollution, sustainable economy, corporate responsibility and ethics, smart grids, numerical modelling in energy systems, etc.	Taught and research
Renewable Energy Sources (Cyprus Energy Agency)	This training delivered by CEA includes various presentation and lectures about photovoltaic systems, solar thermal systems, wind turbines, geothermal heat pumps, biomass, biogas, wave energy and liquid biofuels.	Taught and research
BSc in Energetics and Automation (University of Montenegro)	After completing this study programme, students will be available to: Understand and interpret the features and characteristics of the electricity production; Define and understand the role, characteristics and models of the constituent elements of the power system, subsystems of production, transmission, distribution and consumption, as well as methods for calculation of normal working regimes of power systems; implement the knowledge gained from the design of electrical installations of low voltage; implement the knowledge referring to role, structure, principles of operation and characteristics of electrical machines; Understand and interprets the basic principles of signal processing and automatic control; Understand and analyse the components and power electronics devices; Independently use appropriate software tools for simulation and analysis of work.	Taught and research
MSc in Power Systems (University of Montenegro)	Learning outcomes of this MSc study programme are: Define and understand the impact of energy on the environment; Know the role and type of relay protection and understands the principles of protective relay settings; Understand the role and structure of the control of the electric power system; Understand and define the parameters of the power distribution and transmission networks (switching status, voltage, load profile, stability, security, voltage and frequency control); Understand the role and structure of the electricity market; Understand	Taught and research

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	and calculate the parameters of the grounding system and network elements; Understand the role of generating units and methods of optimal engagement; Know the nature and methods of modelling transient overvoltages; Understand and analyse the working principles, characteristics and models of different distributed sources of electricity; Calculate the effects of the integration of distributed sources of electricity on the operating modes of the power networks in terms of current and voltage, stability, power quality; Apply methods of optimization of power and distribution systems; Define and analyse advanced (smart) power networks and systems.	
BSc in Electrical Engineering and Computing, module Electrical Power Engineering (University of Niš, Faculty of Electronic Engineering)	By finishing this Study Programme and module, students gain competencies in terms of designing, fabricating, testing and maintaining electrical circuits, devices and systems, as well as the necessary software logistics in the field of electrical power engineering - electrical power networks, electrical power plants, renewable energy sources, electrical machines and drives,	Taught courses; Elective courses
MSc in Electrical Power Engineering (University of Niš, Faculty of Electronic Engineering)	Special goals of this Study Programme cover additional education in the fields of electric power network operation and planning, electric power market, distributive network control, power plants, electric power convertors and drives control, regulated electric motor drives, measurement and information systems in industry, electromagnetic compatibility, as well as the most actual chapters in mathematics covering this fields.	Taught courses; Elective courses; and Research projects
BSc in Renewable Energy Engineering (Kaunas University of Technology)	The programme aims to provide knowledge and develop the skills required to competently address the design and application of renewable energy sources and their control systems, to evaluate scientific achievements in the field of renewable energy and the main factors of the business environment.	Taught, offering elective courses
BSc in Electrical Engineering and Information Technologies, in	The study programme provides graduated electrical engineer with high-level educated research skills and	Taught courses; Elective courses;

Power Engineering, Automation and Renewable Energy (Ss. Cyril and Methodius in Skopje, North Macedonia)	competencies for design, professional development and put into operation the power plants and devices, in entire power system (production, transmission and distribution) utilizing the principles of electro-thermicall and electro-mechanical energy conversion. Graduated engineers from this profile are empowered with skills to work in power sector (power plants utilities, energy transmission and distribution) in industry, small and medium enterprises, engineering and consulting companies as well as in research and development centres and educational institutions	Research Projects
BSc in Electrical Engineering and Information Technologies, in Power Systems, (Ss. Cyril and Methodius in Skopje, North Macedonia)	The study programme in Power Systems enables students to acquire know-how and skills in three out of four main activities of Power Industry: electricity transmission, distribution and supply. The teaching process includes use of state-of-the-art software tools for simulation and analyses of Power Systems operation, as well as, for in-deep study of Power Systems planning and control, Electricity Markets, High Voltage Engineering, Low Voltage Installations, Lighting and Quality of Supply. The Lab exercises in Faculty's Laboratories provide additional opportunities for students to gain practical knowledge in the area of power engineering. .	Taught courses; Elective courses; Research Projects
MSc in Electrical Engineering and Information Technologies in the field of Energy Efficiency, Environment and Sustainable Development, (Ss. Cyril and Methodius in Skopje, North Macedonia)	The purpose of the study program is to enable leading highly competent engineering staff for research, development, design and implementation of complex interdisciplinary projects in the areas of energy efficiency, the impact of electricity on the environment and sustainable development. Accordingly, candidates of this study program will be able to solve problems related to the promotion of energy efficiency and sustainable future.	Taught courses; Elective courses; Research Projects

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MSc in Sustainable Energy (University of Malta)	This programme is offered for graduates with a background in an area related to Sustainable Energy. Research projects normally investigate the area of renewable energy and energy efficiency, covering topics ranging from new technology to policy, economic and environmental issues. Research topics in other areas related to Sustainable Energy may also be considered if an academic supervisor with the necessary expertise is available.	Taught courses; Elective courses; Research Projects
MSc in Electrical Engineering and Information Technologies in the field of Power Systems, (Ss. Cyril and Methodius in Skopje, North Macedonia)	The aim of the study program is to educate professionals following the needs of the modern economy and the quality criteria for teaching at a university level. The proposed study program includes the most important aspects of power systems, whereby students will acquire knowledge in the field of transmission and distribution systems, their exploitation, management and planning, integration of distributed energy sources in power system, electricity markets, power quality and smart grids.	Taught courses; Elective courses; Research Projects

Table 3: Example of online and blended courses associated with sustainable development.

Course	Learning outcomes	Study mode	Duration
Climate Change for Decision-Makers: Challenges, Transformations, Strategies (University of Cambridge)	Confidence to find new innovative pathways to address climate change, and understand its broader collective political and legal implications.	Tutor guided	6 weeks
Climate Change for Decision-Makers: Challenges, Transformations, Strategies (University of Cambridge)	Confidence to find new innovative pathways to address climate change, and understand its broader collective political and legal implications.	Tutor guided	6 weeks

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Sustainable Finance (University of Cambridge)	Learn about the pressures and trends affecting the current financial system. Discover how sustainable finance can open up new opportunities and drive long-term business returns.	Online, tutor-assisted	8 weeks
Sustainable Electrical Power Systems Engineering (The University of Manchester)	Develop an understanding of how electrical networks will be designed and operated in the future.	Online, tutor-assisted	12-30 months
Sustainability Leadership (Imperial College London)	Articulate how sustainability fits into a competitive business strategy. Use the 6P model to evaluate your organisation's sustainable development	Online, tutor-assisted	13 weeks
Climate Innovation: Accelerating to Net Zero Emissions (Imperial College London)	Investigate the impact of climate change on society, the global economy, and business. Illustrate the role of innovation in addressing climate change challenges. Explore innovation strategies to contextualise the impact of climate change in your sector, industry, and organisation.	Online	6 weeks
Sustainable Finance and Investing: Unlock Global Investment Strategies (Imperial College London)	Identify the latest developments and trends in sustainable finance, with a special focus on environmental, social, and impact-aligned investment. Distinguish between different types of sustainable finance products in the capital markets and relevant eligibility criteria. Explore the regulatory and policy environment currently driving the sustainable finance agenda. Apply various sustainability scoring and assessment approaches to real-life case studies Understand how sustainable finance is evolving in emerging markets	Online	6 weeks
Executing Sustainability Strategies (Imperial College London)	Develop a future-proof sustainability strategy expertly geared to your organisation’s objectives.	Online, On-campus	11 weeks

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	Navigate the cultural and political challenges that can derail change initiatives. Lead the execution of your sustainability strategy and support your organisation in the transition phase towards more sustainable business.		
Renewables academy online (renac, Berlin)	Variety of online trainings in specific RE and energy efficiency technologies (e.g., batteries, heat pumps, wind, power to X, etc.) and associated topics (e.g., digitalisation, protections, finance, etc.).	Asynchronous training materials and virtual classrooms	12h - One month

Table 4: Example of training courses for pre-university students, the wider community and industry.

Course	Description	Structure
Renewable Energy from A to Z (Nordic Folkecenter for Renewable Energy)	Training programme for high school students which covers RE cooperatives, solar thermal and district heating, installations, green mobility and hydrogen, SDGs, wind energy and PV.	Two weeks taught courses; practical exercises
Promotion of Renewable Energy Sources and Energy Efficiency (Deutsche Gesellschaft für Internationale Zusammenarbeit)	Training on solar energy courses for high school teachers and solar panel installers in Serbia, Germany, etc.	Two days taught courses
STEM ambassadors (STEM learning Ltd.)	Volunteering position for academia and industrial partners ranging from SMEs to large STEM employers. STEM ambassadors conduct outreach activities to schools, colleges and the wider community to disseminate STEM topics such as renewable energies.	Bespoke outreach activities
Youth Employment Network for Energy Sustainability in Islands (CEA)	Training on green jobs for touristic islands such as energy efficiency, renewable energy sources, sustainable tourism and sustainable mobility for	e-courses (taught), success stories

	young people (25-29 year old) that are currently not in education, employment or training.	
Energy Academy (CEA)	Trainings on climate change, energy efficiency, just transition, sustainable mobility, energy communities, renewable energy sources, sustainable tourism, circular economy and financing.	Training seminars and examinations for special professional qualifications
Summer school in Montenegro: "Green energy is the future-we are learning about it, it belongs to us!"	Presentations about the general energy situation in Montenegro, solar energy, wind energy, and energy storage systems.	One day of presentations, two days of visiting two hydropower plants and one solar power plant.
Energy Advice (Lithuania)	Training on Digital Twin biomass boiler efficient operations, refrigeration systems efficiency increase, digital transformation for district heating companies' effectiveness, digital transformation for industry	Training and webinars for companies and individuals

References

[1] K. Moore, C. Jones, and R. S. Frazier, 'Engineering Education For Generation Z', *American Journal of Engineering Education (AJEE)*, vol. 8, no. 2, 2017, doi: 10.19030/ajee.v8i2.10067.

[2] I. Gratchev and H. G. Espinosa, *Advancing Engineering Education Beyond COVID*. 2022. Accessed: Jun. 15, 2023. [Online]. Available: 10.1201/9781003263180

[3] P. Jennings, 'New directions in renewable energy education Keywords', *Renew Energy*, vol. 34, 2008, Accessed: Jun. 15, 2023. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0960148108002115

[4] D. Vergara, P. Fernández-Arias, J. Extremera, L. P. Dávila, and M. P. Rubio, 'Educational trends post COVID-19 in engineering: Virtual laboratories', in *Materials Today: Proceedings*, 2022. doi: 10.1016/j.matpr.2021.07.494.

[5] 'Sustainable Energy Futures MSc', *Imperial College London*, 2023. https://www.imperial.ac.uk/study/courses/postgraduate-taught/sustainable-energy-futures/ (accessed Jun. 13, 2023).

[6] 'MSC in Environmental Change and Management', *University of Oxford*, 2023. https://www.ox.ac.uk/admissions/graduate/courses/msc-environmental-change-and-management (accessed Jun. 13, 2023).

[7] M. de Wit, S. Ramkumar, J. Hoogzaad, H. Friedl, and A. Douma, 'The Circularity Gap Report.', *Circle Economy*, 2018, Accessed: Jun. 20, 2023. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.cea.org.cy/wp-content/uploads/2021/03/circularity-gap-report-2021.pdf

[8] 'Solar spring break: Inspiring energy students to give back to the community', *MIT*, 2023. https://energy.mit.edu/news/solar-spring-break-inspiring-energy-students-to-give-back-to-the-community/#:~:text=The%20program%2C%20called%20Solar%20Spring,providing%20ubiquitous%20sustainable%20energy%20access (accessed Jun. 13, 2023).

[9] 'Blackboard Learn', *Blackboard*, 2023. https://www.blackboard.com/en-mea/teaching-learning/learning-management/blackboard-learn (accessed Jun. 13, 2023).

[10] 'Renewable Energy and Energy Efficiency Partnership', *REEEP*, 2023. https://www.reeep.org/ (accessed Jun. 13, 2023).

Funded by the European Union
Funded by UK Research and Innovation

[11] 'Clean Energy Technology', *The University of Texas at Austin*, 2023. https://www.me.utexas.edu/research/research-areas/clean-energy-technology (accessed Jun. 13, 2023).

[12] 'IRENA Project Navigator', *IRENA*, 2023. https://navigatorbeta.irena.org/ (accessed Jun. 14, 2023).

[13] 'Towards 2023: The European Year of Skills', *European Comission*, 2023. https://data.europa.eu/en/publications/datastories/towards-2023-european-year-skills#:~:text=In%20October%2C%20the%20President%20of,to%20focus%20on%20digital%20skills%3F (accessed Jun. 15, 2023).

[14] EURES, 'Report on labour shortages and surpluses 2022', 2022. Accessed: Jun. 15, 2023. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ela.europa.eu/sites/default/files/2023-03/eures-labour-shortages-report-2022.pdf

[15] IRENA, 'Renewable energy and jobs: Annual Review 2022', 2022. Accessed: Jun. 15, 2023. [Online]. Available: https://www.mendeley.com/search/?page=1&query=renewable%20energy%20and%20jobs%3A%20Annual%20Review%202022&sortBy=relevance

[16] International Renewable Energy Agency (IRENA), *World energy transitions outlook* . 2022. Accessed: Jun. 15, 2023. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jun/IRENA_World_Energy_Transitions_Outlook_2021.pdf?rev=71105a4b8682418297cd220c007da1b9

[17] OECD, 'Education at a Glance 2022: OECD Indicators', 2022. Accessed: Jun. 15, 2023. [Online]. Available: https://www.oecd-ilibrary.org/sites/a8525f6b-en/index.html?itemId=/content/component/a8525f6b-en

[18] H. Lucas, S. Pinnington, and S. Pinnington, 'Education and training gaps in the renewable energy sector', *Solar Energy*, vol. 173, 2018, doi: 10.1016/j.solener.2018.07.061.

[19] C. Malamatenios, 'Renewable energy sources: Jobs created, skills required (and identified gaps), education and training', *Renewable Energy and Environmental Sustainability*, vol. 1, 2016, doi: 10.1051/rees/2016038.

[20] H. Lucas, 'IRELP Portal to Facilitate Education and Training in Renewable Energy', *Renewable Energy World*, 2012.

Funded by the European Union
Funded by UK Research and Innovation

https://www.renewableenergyworld.com/baseload/irelp-portal-to-facilitate-education-and-training-in-renewable-energy/#gref (accessed Jun. 15, 2023).

[21] S. Alonso-García, I. Aznar-Díaz, M. P. Cáceres-Reche, J. M. Trujillo-Torres, and J. M. Romero-Rodríguez, 'Systematic Review of Good Teaching Practices with ICT in Spanish Higher Education Trends and Challenges for Sustainability', *Sustainability (Switzerland)*, 2019, doi: 10.3390/su11247150.

[22] M. Obrecht, Z. Feodorova, and M. Rosi, 'Assessment of environmental sustainability integration into higher education for future experts and leaders', *J Environ Manage*, 2022, doi: 10.1016/j.jenvman.2022.115223.

[23] Department for education, 'Sustainability and climate change: a strategy for the education and children's services systems', *GOV.UK*, 2022. https://www.gov.uk/government/publications/sustainability-and-climate-change-strategy/sustainability-and-climate-change-a-strategy-for-the-education-and-childrens-services-systems#contents

[24] A. Georgakaki, U. von Estorff, and S. D. Peteves, *Strategic Energy Technology (SET) Plan Roadmap on Education and Training*. 2014.

[25] Interreg Europe, 'Renewable Energy Communities, A Policy Brief from the Policy Learning Platform on Low-carbon economy. EU.', *Elsevier*, 2018.

[26] ILO/EU, 'Anticipating skill needs for the low carbon economy? Difficult, but not impossible', *Res Brief*, 2011.

[27] H. Lucas, S. Pinnington, and L. F. Cabeza, 'Education and training gaps in the renewable energy sector', *Solar Energy*, 2018, doi: 10.1016/j.solener.2018.07.061.

[28] S. Giannini, 'Education for Sustainable Development: A roadmap', 2020. Accessed: Jun. 18, 2023. [Online]. Available: https://unesdoc.unesco.org/ark:/48223/pf0000374802/PDF/374802eng.pdf.multi

[29] info@need.org, 'National Energy Education Development (NEED)', *NEED project*, 2023. https://www.need.org/ (accessed Jun. 18, 2023).

[30] E. Redman, A. Wiek, and A. Wiek, 'Continuing Professional Development in Sustainability Education for K-12 Teachers: Principles, Programme, Applications, Outlook', *J Educ Sustain Dev*, vol. 12, no. 1, 2018, doi: 10.1177/2455133318777182.

[31] S. Sharma and N. Sengar, 'Review of solar PV training manuals and development of survey based solar PV system training formats for beginners', *Solar Energy*. 2022. doi: 10.1016/j.solener.2022.05.055.

Funded by the European Union

Funded by UK Research and Innovation

[32] A. Verma and K. Baltaci, ‘Interdisciplinary Collaboration to Engage Engineering Students’ Interest in Renewable Energy Concepts’, in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2022.

[33] C. O’Neil, ‘Combined “SuperLab” Demonstrates Unique Hybrid Power Plant’, *NREL*, 2023. https://www.nrel.gov/news/features/2023/combined-superlab-demonstrates-unique-hybrid-power-plant.html (accessed Jun. 18, 2023).

[34] UoM, ‘The Cowrie Foundation Scholarships for Black British students’, *The University of Manchester*, 2023. https://www.manchester.ac.uk/study/undergraduate/student-finance/2023/university-scholarships/cowrie-foundation-scholarships/#:~:text=The%20Cowrie%20Scholarship%20Foundation%20will,at%20The%20University%20of%20Manchester (accessed Jun. 18, 2023).

[35] UoC, ‘MPhil in Engineering for Sustainable Development’, *University of Cambridge*, 2023. https://www.postgraduate.study.cam.ac.uk/courses/directory/egegmpesd (accessed Jun. 18, 2023).

[36] L. L. de P. Gewehr, E. Parenti, M. de Oliveira Veras, and J. B. S. O. de Andrade Guerra, ‘The Importance of Women’s and Girl’s Education for the Achievement of Sustainable Development: A Literature-Based Review’, in *Climate Change Management*, 2020. doi: 10.1007/978-3-030-57235-8_19.

[37] J. Huang, A. J. Gates, R. Sinatra, and A. L. Barabási, ‘Historical comparison of gender inequality in scientific careers across countries and disciplines’, *Proc Natl Acad Sci U S A*, 2020, doi: 10.1073/pnas.1914221117.

[38] APM, ‘Unequal pay is main barrier for women in project management, new study reveals’, *APM*, 2022. https://www.apm.org.uk/news/unequal-pay-is-main-barrier-for-women-in-project-management-new-study-reveals/

[39] A. Boddison, ‘Salary and Market Trends Survey 2023’, 2023.

[40] United Nations, ‘Achieve gender equality and empower all women and girls’, *United Nations*, 2022. https://sdgs.un.org/goals/goal5 (accessed Jun. 18, 2023).

[41] ‘Scholarships for Women’, *The Scholarship Hub*, 2023. https://www.thescholarshiphub.org.uk/scholarships-women/ (accessed Jun. 18, 2023).

[42] ‘STEM Women’, *STEM women limited*, 2020. https://www.stemwomen.com/ (accessed Jun. 18, 2023).

Funded by the European Union

Funded by UK Research and Innovation

[43] ICL, 'MSc in Future Power Networks', *Imperial College London*, 2023. https://www.imperial.ac.uk/study/courses/postgraduate-taught/future-power-networks/ (accessed Jun. 18, 2023).

[44] R. Z. Seitz and D. G. Krutka, 'Can the Green New Deal Save Us? An Interdisciplinary Inquiry', *The Social Studies*, 2020, doi: 10.1080/00377996.2019.1677547.

[45] S. Alam, M. E. Moule, and R. Lahdelma, 'Social Acceptability of Using Low Carbon Building: A Survey Exploration', *International Journal of Sustainable Energy*, pp. 951–963, 2020.

[46] 'Skills for a low-carbon Europe The role of VET in a sustainable energy scenario', *Skills for a low-carbon Europe The role of VET in a sustainable energy scenario,* 2012. https://www.cedefop.europa.eu/en/events/skills-low-carbon-europe-role-vet-sustainable-energy-scenario

[47] I. IPCC Report, 'Climate change 2022: Impacts, Adaptation and Vulnerability. Summary for policymakers. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change', *United Nations Environment Programme UNEP*, 2022.

[48] M. Storksdieck, 'Climate Change Education : Preparing Future and Current Business Leaders : A Workshop Summary', *the National Academies*, 2014.

[49] B. K. Sovacool, M. Martiskainen, A. Hook, and L. Baker, 'Beyond cost and carbon: The multidimensional co-benefits of low carbon transitions in Europe', *Ecological Economics*, 2020, doi: 10.1016/j.ecolecon.2019.106529.

[50] U. Singh and S. Singh, 'Future research directions to facilitate climate action and energy transitions', *Energy and Climate Change*, 2023, doi: 10.1016/j.egycc.2022.100092.

[51] P. C. Del Granado *et al.*, 'Energy transition pathways to a low-carbon Europe in 2050: The degree of cooperation and the level of decentralization', *Economics of Energy and Environmental Policy*, 2020, doi: 10.5547/2160-5890.9.1.PCRE.

[52] M. Fay, S. Hallegatte, A. Vogt-Schilb, J. Rozenberg, and U. Narloch, 'Decarbonizing development: Three steps to a zero-carbon future', *Renewable Resources Journal*, 2015, doi: 10.1596/978-1-4648-0479-3.

[53] S. Pokhrel and R. Chhetri, 'A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning', *Higher Education for the Future*, 2021, doi: 10.1177/2347631120983481.

Funded by the European Union

Funded by UK Research and Innovation

[54] D. Henriksen, E. Creely, and M. Henderson, 'Folk Pedagogies for Teacher Educator Transitions: Approaches to Synchronous Online Learning in the Wake of COVID-19', 2020.

[55] C. Nadire and S. A. Daniel, 'A comparison of online video conference platforms: Their contributions to education during COVID-19 pandemic', *World Journal on Educational Technology: Current Issues*, 2021, doi: 10.18844/wjet.v13i4.6329.

[56] M. Gupta, 'Impact of Coronavirus Disease (COVID-19) pandemic on classroom teaching: Challenges of online classes and solutions', *Journal of Education and Health Promotion*. 2021. doi: 10.4103/jehp.jehp_1104_20.

[57] S. Sastre-Merino, M. C. Nunez-Del-Rio, A. Caravantes, and J. L. Bravo-Ramos, 'Perceptions of Engineering Faculty Members of Online Teaching Due to COVID-19', *INTERNATIONAL JOURNAL OF ENGINEERING EDUCATION*, 2021.

[58] S. Jacques, A. Ouahabi, and T. Lequeu, 'Synchronous E-learning in higher education during the COVID-19 pandemic', in *IEEE Global Engineering Education Conference, EDUCON*, 2021. doi: 10.1109/EDUCON46332.2021.9453887.

[59] U. Alturki and A. Aldraiweesh, 'Application of learning management system (Lms) during the covid-19 pandemic: A sustainable acceptance model of the expansion technology approach', *Sustainability (Switzerland)*, 2021, doi: 10.3390/su131910991.

[60] M. Raja and G. G. Lakshmi Priya, 'Using Virtual Reality and Augmented Reality with ICT Tools for Enhancing Quality in the Changing Academic Environment in COVID-19 Pandemic: An Empirical Study', *Studies in Computational Intelligence*, 2022, doi: 10.1007/978-3-030-93921-2_26.

[61] M. Montenegro-rueda, A. Luque-de la Rosa, J. L. S. Sánchez-serrano, and J. Fernández-cerero, 'Assessment in higher education during the covid-19 pandemic: A systematic review', *Sustainability (Switzerland)*. 2021. doi: 10.3390/su131910509.

[62] M. S. Diarsini, L. P. Artini, N. N. Padmadewi, N. M. Ratminingsih, I. G. A. L. P. Utami, and N. P. E. Marsakawati, 'Challenges and Opportunities of Online Assessment Implementation During Covid-19 Pandemic in Indonesia Based on Recent Studies', *European Journal of Education and Pedagogy*, 2022, doi: 10.24018/ejedu.2022.3.6.421.

[63] C. Brown, P. Correll, and K. J. Stormer, 'The "new" normal: Re-imagining professional development amidst the COVID-19 pandemic', *Middle School Journal*, 2021, doi: 10.1080/00940771.2021.1978787.

Funded by the European Union

Funded by UK Research and Innovation

[64] J. M. C. Chin *et al.*, 'Perspectives on the Barriers to and Needs of Teachers' Professional Development in the Philippines during COVID-19', *Sustainability (Switzerland)*, 2022, doi: 10.3390/su14010470.