D2.1

Stakeholder map and good practices

skillbill

SKILL TO BOOST INNOVATION & PROFESSIONAL FULFILLMENT IN A SUSTAINABLE ECONOMY

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ABBREVIATIONS

AI	Artificial Intelligence
BIPVs	Building Integrated Photovoltaics
CECs	Citizen Energy Communities
CHP	Combined Heat and Power
CSDs	Civil Society Organizations
CSR	Corporate Social Responsibility
DC	Direct current
EDP	Electronic Data Processing
GAGDs	Gass-Assisted Gravity Drainage Process
GPPs	Geothermal Power Plants
HJT	Heterojunction Technology
ICT	Information and communication technology
IRENA	International Renewable Energy Agency
IT	Information Technology
NGOs	Non-governmental Organizations
ORC	Organic Ranking Cycle
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
RECs	Renewable Energy Communities
RES	Renewable Energy Source / Sector
RESCoops	Renewable Energy Cooperatives
SCs	Solar Cells
SMEs	Small-medium Enterprises

SNMR	Surface Nuclear Magnetic Resonance
STEM	Science, Technology, Engineering and Mathematics

Executive summary

The purpose of this deliverable is to present the findings of a stakeholder community mapping and the findings from our exploratory research study conducted as part of the Horizon Europe SKILLBILL Project. The report aims to **provide insights and knowledge that will inform the design of key objectives within the project, including, but not limited to**:

- **The *Stakeholder Joint Initiative* (WP2):** SKILLBILL establishes multidisciplinary working groups to discuss technical and non-technical hurdles on renewable energy deployment, involving stakeholders across quadruple helix (industry, academia, government and civil society);
- **The *EU Master* (WP3):** SKILLBILL drives the development and establishment of an educational program for the upskilling of technicians, designers and researchers with an added focus on circular economy, implemented by several universities together with industry.
- **The *Vocational Education and Training Program* (WP5):** SKILLBILL establishes new training courses online (and/or using virtual reality) for people looking for new or upgraded competences on RES.

To this end the deliverable deploys a mixed-methods approach comprising **desk research** and **semi-structured interviews**. As part of the secondary research, an **inventory of the stakeholder community** relevant to the SKILLBILL project in the fields of renewable energy and renewable fuel technologies was conducted and the **key stakeholders of the quadruple helix planning to be involved in the joint stakeholder initiative were identified**. The semi-structured interviews consisted of **32 interviews with experts in the field, with the purpose of gaining a deeper understanding of the skill needs associated with cutting-edge as well as established RES technologies and analyzing current best practices in renewable energy education and training that incorporate principles of circularity and sustainability.**

The results reveal a number of **cutting-edge technological advances** in the renewable energy sector. At the same time, education and skills are urgently required also for deploying established and mature RES technologies, such as roof-top PV and wind farm development. Stakeholder interviews and extensive research have **identified innovative solutions** in solar, wind, bioenergy, hydrogen, and hydro/ocean power. However, the proliferation of renewable energy initiatives is **hindered by a complex array of barriers**, including financial, environmental, social, and regulatory challenges. **To overcome these challenges**, professionals must possess cross-disciplinary knowledge, technical abilities, soft skills, and an understanding of socio-economic and environmental impacts. Effective communication and collaboration with diverse groups are also essential for promoting the widespread adoption of renewable energy technologies.

The **gender skills gap** at RES and **barriers to sustainable and circular practises in renewable energy** development were also discussed. The core elements to close the gap are: Promoting STEM education, targeted training and showing the examples of successful women in STEM/RES/energy sector. Identified barriers to achieving sustainable RE practices are also explored. The **main barriers** are: lack of collaboration, financial constraints and political will. **Best practises** are proposed, based on both desk research and the experiences of stakeholders involved in the interviews. The good practises show, among other things, that cooperation between different stakeholders is possible, that there are some political steps towards RES education and that there are free, accessible and flexible study programmes for all. The key findings of this report can be summarised as such: continuous learning, collaboration and political/policy support are essential to promote sustainable practises and the transition to a more sustainable future.

1. Introduction

The report was prepared as part of SKILLBILL Task 2.1 "Stakeholder community mapping and user research to better appreciate current training needs and skilling practices". Its aim is to **examine current novel and conventional renewable energy technologies and respective needs for education and training as well as to provide a review of established RE skilling and educational practices**. Stakeholder engagement is an essential part of the objective mentioned above. Indeed, stakeholders play an important role both as educators/trainers and as recipients of educational programmes. In order to achieve this objective, a group of thirty (30) stakeholders were selected based on certain criteria and interviewed to gather their views on the latest technological advances and skill requirements in the field of renewable energy education.

The structure of the current report is as follows:

- **Chapter 2** presents the overall approach and the methodological steps applied;
- **Chapter 3** provides the stakeholder mapping based on the quadruple helix;
- **Chapter 4** presents desk research insights on novel renewable energy technologies and respective needs for education and training;
- **Chapter 5** presents a review of established RE skilling practices, based on findings from literature review;
- **Chapter 6** includes an analysis of the findings from the semi-structured interviews with relevant stakeholders;
- **Chapter 7** summarizes the findings of the report;
- **Annexes** include the template to map the stakeholders and interviews' questionnaire

The main goal of the SKILLBILL project is to **pave the way to different forms of training and education in order to meet new skills requirements in RES field, along with bridging the gender gap in the sector**. SKILLBILL aims to identify current educational and training needs in renewable energy systems to meet labour market demands, increase involvement in RES, and promote economic stability and equity. Thus, **D2.1 results are crucial for project's success** as they provide important insights into the needs of stakeholders in the renewable energy sector.

By conducting a stakeholder community mapping and exploratory research study, **the report identifies key obstacles and opportunities for promoting the adoption of renewable energy technologies**. The report informs the development of several key objectives within the project, including the Stakeholder Joint Initiative, EU Master, and Vocational Education and Training Program.

Overall, D2.1 highlights the importance of cross-disciplinary knowledge, technical abilities, soft skills, and an understanding of socio-economic and environmental impacts for professionals in the renewable energy sector.

2. Methodological Approach

The first step of T2.1 research activities was to conduct a stakeholder mapping exercise that identified the key stakeholders in the quadruple helix (science and academia, government and public sector, industry and private sector, and civil society). This approach ensured that a broad range of perspectives and expertise could be included in the further activities besides Task 2.1. Moving on to collecting information from participants about renewable energy training (RES), the semi-structured interview is the most effective method. Thus, consortium conducted a pre-selection to identify potential interview candidates from the stakeholder map. A targeted questionnaire (Annex 2) was developed focusing on cutting-edge technological innovations, skills need identification, sustainable and circular renewable energy development, and training and education practises. This approach allows flexibility in exploring participants' experiences while ensuring that the same essential information is obtained from each participant. Furthermore, this includes assessing the quality of the data, e.g. checking for bias, ambiguity and missed opportunities to go deeper.[1] Each of these activities is discussed in more detail below:

Stakeholder Community Mapping: In this activity, the SKILLBILL project team carried out a stakeholder mapping exercise to identify key stakeholders in the quadruple helix of science and academia, government and public sector, industry and private sector, and civil society. The aim was to identify and profile stakeholders according to their skilling requirements and needs, and to map stakeholders within the quadruple helix.

In-Depth Literature Review: an in-depth literature review was conducted to identify technological advances; skill needs and best practices in renewable energy training and education. This literature review helped the team to identify gaps in existing research, as well as to determine the most promising areas for further investigation.

Qualitative Research: SKILLBILL consortium implemented 32 semi-structured interviews, using a questionnaire developed by White Research (WR) based on the findings from the literature review. The team selected participants with the aim of being well-balanced across the quadruple helix as well as gender. These interviews aimed to explore participants' experiences and perspectives on cutting-edge technological innovations, skill needs identification, sustainable and circular renewable energy development, and training and education practices. This approach allowed flexibility in exploring participants' experiences while ensuring that the same essential information was obtained.

All exploratory activities described took place from October 2022 to April 2023, spanning a period of seven months in total. During the overall period of research activities, WR remained at the full disposal as well as was in close contact with all contributing partners in order to provide support needed (such as proper instructions, activities coordination, identification of potential risks and problems, as well as the effective mitigation within the scheduled timeline.

[1] Kvale, S. (1996). Interviews: An introduction to qualitative research interviewing. Sage Publications.

3. Stakeholders' mapping

3.1 Quadruple helix analysis

Science and Academia

Renewable energy has been a major topic of discussion, research and investments in the EU scientific community. Basic science and academia stakeholder groups, such as Universities, Research Centres & R&D Institutes, are active links or connectors between higher education and vocational training programmes. Therefore, these groups can be considered as key actors related to RE skilling, upskilling and reskilling processes. Scientific community is highly interested in understanding and developing novel technologies and new services on RES.

Furthermore, academia is a key-source from which fundamental knowledge and training skills about RES derives. Thus, academia along with research and development institutes consult and assist decision makers while often practically supporting their work. These actors provide novel solutions to particular challenges and assist in achieving the best possible outcome through research on novel materials and technologies. They may have amassed technological, human, and physical capability over time through utilizing public and private resources. Strategic partnerships bring together industry and universities in an integrated research, innovation and education set-up aiming to accelerate technology, knowledge and dissemination in RES sector. International cooperation plays an important role, characterized by openness of the higher education systems, recognition and to some degree also the consistency between educational systems. The Academia stakeholder group indicatively includes subgroups such as:

- **Educational staff** (e.g. professors, lecturers, instructors)
- **Administrative staff** (e.g. deans, directors, chairs or heads of departments)
- **Researchers and scientists**

Major disciplines, highly linked to the SKILLBILL objectives can include, but are definitely not limited to fields such as : **material scientists; engineers; geotechnical and natural scientists; chemists; physicists; economists; business developers; social scientists; RES designers; green architecture researchers.**

Private sector (Industry & SMEs)

Novel as well as established and mature RES technologies are widely recognised as a **critical means in tackling climate change** and attaining energy policy objectives. Thus, RES industry is seen as a key driver for the **development and diffusion of renewable energy sources**. Moreover, **research and development** processes carried out internally in many companies lead to RES technologies upgrade and the development of new applications.

Professions that are actively involved in RES manufacturing and implementation process include:

- **Planners**, as a cross sectoral profession in energy sector covering environmental, architectural and logistics affairs (e.g. project managers).
- **Renewable energy systems engineers** for, indicatively:

  - designing large-scale renewable systems implementations,
  - recommending engineering and manufacturing changes,
  - developing specification and integration requirements,
  - designing electrical diagrams for power systems,
  - running computer simulations and providing respective analyses,
  - providing technical direction or support,
  - performance monitoring.

- **Technicians**, such as, indicatively: installers, solar-thermosolar technicians, hydraulic technicians, electricians, craftsmen etc.
- **Technology providers**, such as, indicatively: R&D specialists, developers, engineers, A.I. specialists, Energy Management System solution providers, Security software providers, integrated smart technology providers[2].

  For renewable energy system technology providers is essential to possess a high level of training in order to effectively develop and customize technology to meet the needs and requirements of local experts and customers. In addition, the successful diffusion of a technology often requires the involvement of enterprises capable of producing the technology itself and interested in hiring skilled workers for its implementation. Therefore, it is crucial to establish networks comprising skilled technology suppliers, local experts, and informed customers, as well as facilitate communication and exchange between demand and supply stakeholders in order to achieve a satisfactory balance between functionality and user-friendliness[3].
- **Energy industry standardization internal / external auditors[4]** for, among else, quality management systems (ISO 9001), environmental management systems (ISO 14001), international management systems (ISO 50001), occupational health and safety (ISO 45001), information security management systems (ISO 27001), international carbon neutrality (PAS 2060) and anti-bribery management systems (ISO 37001).
- **Manufacturers and installers** of: RES components (such as rooftop PV, wind farms, hear pumps), Solid State Transformers, converters, DC protection systems and electrical/electronic safety in general, monitoring and control systems.

As the world's renewable energy ambitions expand, the availability of skilled employees is crucial for RES projects deployment. It is critical for the workforce to have the necessary education and skills in order to use or implement a certain technology, since lack of skilled workers might be a hindrance[5]. Certain technologies are difficult to use, installers are challenged to identify particular solutions and combinations of components, resulting in installers repeating the same technologies over and over without considering innovative technologies[6].

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[2] Stefan Wiesner, et. Al, "The development of technicians as a key factor for a sustainable development of renewable energies using an adapted education method based on the successful german Dual Education (Duale Ausbildung)", 2014, doi: 10.1016/j.egypro.2014.10.069
[3] Aura Caramizaru, JRC science for policy report, Energy communities: an overview of energy and social innovation 2020, 2021
[4] https://www.nqa.com/en-us/certification/sectors/energy
[5] Article 14 of the RES Directive (2009/28/EC) requires EU Member States to provide, by 31st December 2012, certification or equivalent qualification schemes for installers of building-integrated biomass stoves and boilers, shallow geothermal energy systems, heat pumps, photovoltaic and solar thermal systems so that they can be mutually recognisable.
[6] Aura Caramizaru, Andreas Uihlein, JRC science for policy report, Energy communities: an overview of energy and social innovation 2020, 2021

Government, Energy Authorities & Policy Makers

Governments play a crucial role in the clean energy transition, being responsible for **designing and enforcing legislation** which can, in turn, drive and safeguard the implementation of measures for such transition to take place. At the same time, governments are responsible **for aligning taxes** and **subsidies** to promote growth and employment in ways that favour a circular economy approach. The above-mentioned governmental roles underscore the significance of their involvement both in the RE project development as well as in RE/green skilling processes. In fact, governments launch open-source initiatives **to facilitate and disseminate energy education** in the traditional educational systems, career development tools and continuing education and training, not least in the energy efficiency area. Finally, governments are in many cases the basic funder of research institutes, academic institutions and private R&D firms.[7]

In the public sector another key player is the **local municipalities**, being significantly important as far as political decision-making is concerned; **mayors, relevant agencies and authorities in the energy sector as well as the local environmental department(s)** can provide key solutions in the era of the clean energy transition. For example, local climate plans, administration of property, increasing the value of property, and securing of stable and long-term energy supplies through longstanding concepts and strategies are some of the main tasks aligned to the local municipalities.[8] To that end, the role of local authorities in terms of education in the RES is twofold: on the one hand they have to be well- informed/trained in order to facilitate the clean – energy transition, and on the other hand to ensure that the citizens in the area of their jurisdiction are also well – informed/educated.

Given the administrative nature of the public sector, both governmental and regional, some of the subgroups needed skilling, reskilling or upskilling or who can be providers of such training material are as follows:

- **Experts on International Climate, Environment and Energy Affairs, Experts on Energy Legal Affairs**, who are important stakeholders because most of the energy policies are EU and internationally derived, e.g. the Green Deal, Paris Agreement;
- **Information and Communication Technology, Digitalization and Organizational Development officers**, who are important in the era of the twin transition;
- **Experts on Green Finance and Sustainable Economy, Energy Efficiency and Heat Funding Instruments**, because circular economy is one of the most promising aspects of the clean energy transition and funding is a key driver to achieve the above-mentioned goal;
- **Education and Training officers as facilitators, trainers, educators** of the trainings either on a national or a regional level;
- **Equality and Diversity experts**, being particularly important to implement the social aspect of the sustainability principle;
- **Crisis Managers and Energy officers**, given the ongoing crises in Europe (e.g. the geopolitical crises in the Ukraine) as well as in the world (e.g. the COVID-19 pandemic);

[7] International Energy Agency (IEA). (2020). Energy Policies of IEA Countries: Greece 2020 Review; European Commission. (2019). A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1560341420425&uri=CELEX:52018DC0773.

[8] progRESsHEAT Report: Barriers and Drivers, Using Renewable Energy for Heating and Cooling: Barriers and Drivers at Local Level, 2017, p. 29.

- **Energy Market and Statistics analysts**, who are significant drives because they follow the market needs and prices;
- **Public Relations, Protocol and Event Management officers**, being important for disseminate the energy related information, events, legislation (e.g. a well- tailored education program on new technological advances in RES, has to be disseminated properly in order to reach the relevant group).
- **Administrative staff**, mostly at local and regional level, who is competent and qualified to accelerate and simplify permit granting procedures

Civil society

Citizens' initiatives, civil society organizations (CSOs) and non-governmental organizations (NGOs) can be the key drivers in the clean energy transition, as they are able to apply pressure on both to the private as well as public sector**. Renewable Energy Communities (RECs), Citizen Energy Communities (CECs) or Renewable Energy Cooperatives (RESCoops)**[9] further aim to involve **citizens**, **cooperatives**, **national associations, local municipalities and small and medium-sized enterprises (SMEs) in the energy transition**. **RECs** and **CECs** can contribute to improving local acceptance of renewable energy projects and increasing the share of renewables in the energy mix while improving energy savings for households and SMEs. In the longer term, **energy communities** can lead to more sustainable consumption behaviours, lower supply tariffs, as well as changes in supply and demand patterns for the benefit of citizens. However, most of the times these entities lack expertise and information,[10] financial capacity or a very narrow view of nature or personal environment and related legal responsibilities[11].

Overall, some of the subgroups in the civil society that need skilling, reskilling or upskilling or can be providers of such training material are as follows:

- **Advocacy officers, campaigns and policy managers/makers** play a key role in the enforcement and the shaping of law, monitoring policies and encouraging political participation at the community level;
- **Programme/project officers/managers**, **planning and performance analysts, reporting analysts,** given the project/programme nature of most civil society entities;
- **Financial, Development and IT managers/officers,** who are important drivers for the implementation and continuation of the work carried out in civil society-based entities;
- **NGOs' Administrative staff, such as the Director, Board Members, Secretariats,** who are the main actors for the functionality of civil society organizations;
- **Communication managers/officers,** with their role being very important, given the power of media with a focus on social media;
- **General public,** being mostly the recipients of such training/educational material, as they luck expertise/information, even though they are influenced by the clean energy transition

[9] Through the Clean energy for all Europeans package, adopted in 2019, the EU introduced the concept of energy communities in its legislation, notably as citizen energy communities and renewable energy communities. See also the Directive on common rules for the internal electricity market ((EU) 2019/944) and the revised Renewable energy directive (2018/2001/EU).
[10] Giuliana Folco , Report on Stakeholders' Mapping and Identification, TIGON, 2021, p. 30.
[11] Otto-Banaszak, Ilona; Matczak, Piotr; Wesseler, Justus; Wechsung, Frank, Different perceptions of adaptation to climate change: a mental model approach applied to the evidence from expert interviews. Reg Environ Change 11 (2): 217–228, 2011.

the most. Citizens themselves need to be skilled, reskilled or upskilled in order to start or enhance their own projects/initiatives.[12]

3.2 Identification of key stakeholders' groups

Stakeholder classification

An important step in stakeholder community mapping is to identify the key-stakeholders with whom SKIILLBILL consortium will communicate and collaborate. The process of stakeholders' identification is twofold. Understanding which results the project will deliver (skilling, upskilling, reskilling) and how stakeholders can get involved in those results.

The mapping of stakeholder communities was conducted using two main criteria: firstly, the profiling of stakeholders based on their potential skill requirements and needs; and secondly, the mapping of stakeholders across the quadruple helix, which includes industry, academia, government, and civil society. Thus, following the desk-research for mapping stakeholder groups and subgroups, a template for stakeholder mapping has been circulated to the consortium (Annex I). Each partner has been asked to identify key-player stakeholders across quadruple helix and categorize them based on the following criteria:

- **group / subgroup they belong to**
    - *Stakeholder groups*: Scientific Community, Policy Makers, Energy authorities and associations, Industry / Technology providers, SMEs, Potential Investors, General public, Climate and energy NGOs
    - *Stakeholder subgroups*: Educational institutions, Researchers, Professors, Students, Research organisations, R&D units in private companies, Experts and individual researchers, National public authorities, Policy making institution, International policy makers and public authorities, EU decision-makers, Bioenergy associations, RES industry support organization, Solar Power Industry, Wind Energy Industry, Geothermal Energy Industry, Biomass Energy Industry, Research Companies, Nanotechnology Industry, Engineers, Workers, RES designers, Green financing, Business Angels
- **expertise** (e.g. decarbonization of fossil gas sector, EU policy-making, advocacy on energy and climate policies, networking, marine biomass, RES integration, monitoring, operation, maintenance, science field etc.)

Stakeholder identification process is horizontal throughout the project in order to be ensured that no groups or individuals have been missed and to develop a large and comprehensive SKILLBILL network.

SKILLBILL consortium partners identified **108 stakeholders from all target groups across Europe**, out of which 30 interview candidates were selected (see Chapter 6).

Stakeholder mapping results (Groups, subgroups and number of stakeholders identified in each case) are presented in the following table:

[12] Client Earth, Enforcing the rights of energy communities - Overview of judicial and non-judicial mechanisms at EU and national levels, October 2022. Available at: https://www.clientearth.org/media/hgbimxld/clientearth_legal-actions-for-energy-communities_17_10_22.pdf. Last accessed: 29/11/2022.

Table 1. Stakeholder mapping results

Group	Subgroup
Industry / Technology providers: 18	International policy makers and public authorities: 1
	RES designers: 2
	Solar Power Industry: 3
	R&D units in private companies: 4
	Geothermal Energy Industry: 1
	Wind Energy Industry: 2
	Engineers: 1
	RES industry support organisation: 2
	Biomass Energy Industry: 1
	Nanotechnology Industry: 1
Scientific Community: 26	Researchers: 4
	Professors: 14
	Research organisations: 6
	Educational institutions: 1
	Experts and individual researchers: 1
SMEs: 10	Workers: 3
	Engineers: 3
	Experts and individual researchers: 1
	Non-Governmental Organisations (NGOs): 1
	Citizens' initiatives: 1
	RES designers: 1
Energy authorities and associations: 18	Solar Power Industry: 2
	Wind Energy Industry: 2
	International policy makers and public authorities: 1
	Non-Governmental Organisations (NGOs): 2
	Bioenergy associations: 2
	Research organisations: 2
	Users (regulatory authorities, industry associations, energy companies, energy consumers): 3
	EU decision-makers: 1
	National public authorities: 3
Climate and energy NGOs: 13	Non-Governmental Organisations (NGOs) : 6
	Bioenergy associations: 1
	Experts and individual researchers: 2
	Biomass Energy Industry: 1
	RES industry support organisation: 2
	Sellers: 1
Policy Makers: 19	EU decision-makers: 4
	Bioenergy associations: 1
	National public authorities: 1
	Policy making institution: 10
	International policy makers and public authorities: 1
	Regional/Local Authorities: 2
General public: 3	Non-Governmental Organisations (NGOs): 1
	Citizens' initiatives: 2

4. Novel RE technologies and respective education/training needs

4.1 Cutting-edge and established technological advances

Attaining a carbon-neutral European Union is a highly complex endeavour that requires the implementation of numerous interconnected measures and strategies simultaneously. The growth of existing renewable energy sources (RES) technologies, as well as research and development of new alternative techniques and tools, may all contribute considerably to this overall effort. Many technologies, e.g. solar panels, wind turbines, bioenergy etc., already seem to be promising solutions for electricity production on large scale through the exploitation of solar energy, wind and biomass energy[13]. Based on the Blue Map Scenario and the Sustainable Development Scenario from the International Energy Agency (IEA)[14], a set of new as well as older technologies (e.g. power generation by nuclear, coal, gas hydro, wind, solar, biomass and wastes, geothermal, ocean etc.) are needed to significantly reduce emissions associated with energy production.

The development of renewable energy technologies in the context of Industry 4.0 highlights the **need to adapt the skills of individuals in the sector to keep up with the pace of current and ever evolving changes**. The increasing use of technologies such as smart sensors and artificial intelligence (AI) in the renewable energy industry confirms the great need to familiarize those working in the sector with these tools. Across all areas of the renewable energy sector, including solar, wind, bioenergy, geothermal, hydrogen, ocean, and hydropower, **technological innovations, as well as the roll-out of established and mature RES technologies, are creating a need for specialized, multidisciplinary knowledge and the acquisition of specific skills to ensure the successful and safe completion of sustainable and circular by design renewable energy projects**.

Implementing much more additional RES is likely to increase the demand for both low and medium-skilled (such as supervisors, technicians, and skilled as well as non-skilled craftsmen and women) and high-skilled (professional and managerial) professionals. Moreover, there will be a need for individuals with knowledge and expertise in social initiatives and new business models, including entrepreneurship, business and customer awareness, finance, economics, legal literacy, self-management, problem-solving, and team-working.

This section briefly presents the main domains where RE technological advances took place over the past decades.

Solar energy

The sun is regarded as the most abundant and pure source of renewable energy. Along with third generation solar cells (e.g. printed photovoltaics) and their various applications (building-photovoltaics, agrivoltaics etc.), many more technologies have emerged that concern either new methods of installing photovoltaics or enhancing their efficiency. Thus, technologies related to the construction of photovoltaics (e.g. use of nanostructures, smart materials, lens in PV panel structure

[13] Akhtar Hussain et al., “Emerging renewable and sustainable energy technologies: State of the art”, 2017, doi: 10.1016/j.rser.2016.12.033
[14] https://www.iea.org/

etc) or integration (e.g. floating solar farms, retrofit solar cells) are also important to solar RES sector development in the upcoming years.[15]

Wind energy

Wind energy is used to generate power by turning the kinetic energy of moving air into electricity. Contemporary wind turbines use rotor blades, flying blades or even wings to convert kinetic energy into electricity. Technological advances on wind energy field are presented not only in the structure of wind turbines but also in the safety (e.g. air edges to reduce weather impact), maintenance (e.g. cable protection systems, break cooling systems, remote control and maintenance applications etc.) and even alternative methods of using wind turbines (water desalination using wind turbines).[16]

Bioenergy

Bioenergy is a form of renewable energy derived from biomass, or organic matter that has recently been living as organisms or plants. It can be used to generate transportation fuels, heat, power, and other products. There are several methods for converting biomass into energy, including biomass power plants, waste-to-energy plants, biomass co-generation (CHP) plants, distributed cogeneration units such as Organic Rankine Cycle (ORC) or Stirling Engines, large-scale gasification, and anaerobic digestion. These technologies are at various stages of development and can be used in a variety of configurations, including dedicated plants, co-fired plants, and repowered coal plants. Bioenergy is a promising source of renewable energy that can help meet our energy needs.[17]

Geothermal energy

While solar and wind energy are currently the dominant forms of renewable energy, geothermal energy is a widely available and underutilized source that is particularly well suited for building air conditioning applications. Heat pumps are the most common technology for directly harnessing geothermal energy, but other promising technologies have emerged in recent years, including surface nuclear magnetic resonance and closed-loop exchangers that use ground water and ground heat exchange, respectively. These technologies offer significant potential for increasing the use of geothermal energy in a variety of applications.[18]

Hydrogen

Hydrogen is an important renewable energy technology (not an energy source) due to its versatility as an energy carrier. It can be produced using renewable electricity through the process of water electrolysis, and it has numerous potential applications in a variety of sectors. Hydrogen can be used as a feedstock in the chemical industry, as part of a mix of gases in steel production, and for heat and power generation. It also has the potential to be used as a fuel for transportation. Additionally, the development of innovative technologies such as water electrolyzers, thermochemical and photocatalytic water splitters, photoelectrolysis devices, and hydrocarbon reformers has further increased the potential of hydrogen as a renewable energy source. Overall, hydrogen's versatility and the presence of cutting-edge technologies make it a promising renewable energy technology with significant potential for the future.

Ocean and hydropower

Ocean and hydropower are important renewable energy technologies that harness the power of the oceans and bodies of water to generate electricity. Hydropower, which includes technologies such as hydropower and wave power, is well-established and has a long history of more than 150 years

[15] Ntalane S. Seroka et al., " Solar Energy Materials-Evolution and Niche Applications: A Literature Review" , 2022, doi: 10.3390/ma15155338
[16] A. G. Olabi et al., " Selection Guidelines for Wind Energy Technologies", 2021, doi: 10.3390/en14113044
[17] ERP Technology Review 2021: Bio-energy Technologies)
[18] Adriana Greco et al., " A Review on Geothermal Renewable Energy Systems for Eco-Friendly Air-Conditioning", 2022, doi: 10.3390/en15155519

of use. Ocean power, which includes technologies such as tidal power and ocean thermal energy conversion, is a newer field of study, but it has significant potential as a renewable energy source. Both ocean and hydropower offer a reliable, constant source of energy, and the development of new technologies in these areas is helping to increase their efficiency and potential for widespread adoption. Innovation in this domain is now mainly focused on boosting hydropower plant flexibility through changes in turbine design and operational patterns, as well as through digitisation[19].

A series of tables is introduced below, thoroughly showcasing **novel cutting-edge technological advances per examined RE sector**, while also linking to corresponding training and education needs that have respectively emerged.

Table 2. Technological advances and knowledge need in Solar Energy

Technological advance	Technology short description	Knowledge and skill needs
Agrivoltaics	"Use of agricultural land by installing solar panels over crops can enable farms to become self-sustaining, and the shading from solar panels can increase crop yields and decrease water consumption by reducing evaporation."	○ PV System design ○ Fundamentals on PVs ○ Monitoring and operation ○ Energy storage and usage ○ Trouble Shooting ○ Safety measures on manufacturing, operation, maintenance ○ Quality Inspection ○ Asset Integrity Inspection & Management ○ Chemistry, Material Science, Physics, Electronics ○ Alternative PV Integration (building integrated, wearables, automobile etc.) ○ Alternative Methods of Solar Energy Utilisation ○ Nanotechnology & Nanoscience ○ Printing & Coating techniques (lab-scale towards production scale) ○ Solar market ○ Market analysis and strategy ○ New product development ○ Investing in new technologies ○ Building new business sectors
"Insolight" panel coating	"Swiss start-up Insolight has developed a technology that uses hexagonal lenses in the PV's protective glass that coats solar panels to concentrate scattered light and produce more energy. "	
Heterojunction technologies	"Heterojunction technology (HJT) applies layers of thin-film silicon on both sides of a silicon solar cell. The layers increase the light conversion and can bring the efficiency of the silicon cell up to 25%."	
Floating Solar Farms	"Floating PV installations will play a key role in enabling countries with limited available land mass to meet their net-zero pledges. Installing solar energy systems on the water can leave land free for agricultural activity"	
Building-integrated PVs	"Building-integrated photovoltaics (BIPVs) extend beyond rooftop-mounted solar panels to incorporate photovoltaic properties into the building materials themselves. This means roof tiles, window glass, facades, and shades all generate electricity to supply the building. BIPVs actually become part of the architecture, seamlessly blending into the building design and eliminating the need for a separate mounted solar panel system."	
Perovskite SCs	"A type of solar cell that includes a perovskite-structured compound, most commonly a hybrid organic–inorganic lead or tin halide-based material as the light-harvesting active layer"	
Organic photovoltaics	"This type of photovoltaic cells uses organic electronics, a branch of electronics that deals with conductive organic polymers or small organic molecules,] for light absorption and charge transport to produce electricity from sunlight"	

[19] https://www.iea.org/reports/hydroelectricity

Technological advance	Technology short description	Knowledge and skill needs
		○ Web marketing ○ Technical sales ○ Legislation ○ Environmental protection

Table 3. Technological advances and knowledge need in Wind Energy

Technological advance	Technology short description	Knowledge and skill needs
Airborne Wind Energy Systems (AWES)	Wind energy technology that is based on flying blades or wings attached to the ground by a tether.	○ Wind turbines technology essentials ○ Maintenance ○ Trouble Shooting ○ Safety measures on manufacturing / operation / maintenance / energy storage ○ Quality Inspection ○ Engineering ○ Wind turbines operation ○ Remote operation and maintenance ○ Wind turbines installation ○ Material engineering ○ Electrical engineering ○ Electronics ○ New technologies apply (e.g. drones, thermal cameras etc.) ○ Asset Integrity Inspection & Management ○ Legislation ○ Environmental protection
Freshwater Mill-wind turbine	Wind-driven water desalination using high conversion efficiency hydraulic wind turbines	
Air edge	Technology reducing the impact of extreme weather conditions on wind turbines	
Balmoral FiberFlex™	Patented offshore wind cable protection system	
EnergyPod	A compact wind and solar-driven electrical generator. Transportable and autonomous energy container	
Marinecrete Mattresses (Marinematts)	Carbon negative subsea protection for cables, pipelines and monopiles	
Ogab Sustainable Braking System	Active cooling for wind turbine brake systems, prevents critical wind turbines failures due to fires	
Operation and maintenance (O&M) techniques	Use of drones equipped with high-resolution cameras and thermal cameras. Allow users to capture images and videos in order to detect technical faults in places with difficult access. Analyze the thermal images for internal damage to the devices.	
Improved Turbines	"These redesigned systems can replace the less efficient ones already in use, as well as non-powered dams. This process would save money, as it modifies existing systems instead of building new ones."	
Modular Hydropower	"This technology uses river currents to generate energy without impeding the flow of the river or otherwise disrupting the habitat. Because of their smaller size, companies can even install modular systems in city waterways like sewers. This convenience would allow even landlocked cities to benefit from hydroelectricity."	

Table 4. Technological advances and knowledge needs in Bioenergy

<table>
<tr><th>Technological advance</th><th colspan="2">Technology short description</th><th>Knowledge and skill needs</th></tr>
<tr><td rowspan="2">Biomass direct-combustion processes[20]</td><td>HydroFlame Process</td><td>Direct contact combustion and heat transfer based on enclosing a high-intensity flame in the vortex core of a rotating body of water.</td><td rowspan="5">○ Engineering
○ Mass and Heat Transfer
○ Chemical and Analytical aspects for biorefineries
○ Biorefinery Technologies
○ Energy system design, integration & operation
○ Maintenance
○ Safety measures on manufacturing / operation / maintenance / energy storage
○ Bioresources
○ Biorefinery Energy Systems
○ Chemistry and physics principles
○ Modelling & Simulation
○ Bioeconomy & Sustainability Principles
○ Socio-economics
○ Agriculture basics
○ Legislation
○ Environmental protection
○ Biorefinery Economics</td></tr>
<tr><td>Gas-Assisted Gravity Drainage Process (GAGD)</td><td>GAGD deviates from the current industry practice of horizontal displacement of gas-oil mixture in the reservoir to a vertical one.</td></tr>
<tr><td rowspan="3">Biomass co-combustion process (pulverized combustion, fluidized combustion. Packed-bed combustion, cyclone combustion)[21]</td><td>Direct co-firing</td><td>“The biomass and the coal are burned in the same furnace. The mills for the grinding of the fuel and the burners may be the same as or be separate from the coal feeding. This depends on the biomass used and its fuel properties.”</td></tr>
<tr><td>Indirect co-firing</td><td>“A gasifier converts the solid biomass into a fuel gas that is then burned with coal in the same boiler.”</td></tr>
<tr><td>Parallel co-firing</td><td>“A separate boiler is used for biomass, and its steam generation is then mixed with steam from conventional boilers.”</td></tr>
</table>

[20] https://directcombustiontech.com/products-technical-solutions/gas-assisted-gravity-drainage-gagd-process/
[21] IEA-ETSAP and IRENA© Technology Brief E21, “Bio-mass co-firing, technology brief””, Jan.2013

Technological advance	Technology short description		Knowledge and skill needs
Thermochemical conversion of bio-mass	Torrefaction	"Torrefaction is a safe and promising thermochemical process that is often used as a thermal pre-treatment of biomass resources"	
	Pyrolysis	"The organic substance in the biomass undergoes an irreversible transformation generate biofuels"	
	Liquefaction	"A thermochemical technique for biomass conversion into bio-crude oil . Hydrogenation and high-pressure disintegrate bio-mass and transforms solid waste in bio-crude oil"	
	Gasification	"A thermochemical reaction with the potential to convert any carbonaceous substance into syngas. Gasification uses various fuels to produce gaseous products (e.g. H_2, CO, CO_2 and CH_4)	
	Transesterification	Transesterification is the reaction of non-edible oils with alcohols (methanol). And ethanol) to produce biodiesel. These alcohols are commonly utilized because	

Technological advance	Technology short description		Knowledge and skill needs
		they are cheap and easy to find”	

Table 5. Technological advances and knowledge need in Geothermal Energy

Technological advance	Technology short description		Knowledge and skill needs
Direct use of ground water	Surface Nuclear Magnetic Resonance (SNMR)	“Technology that uses nuclear magnetic resonance effect to detect ground water”	○ Geothermal Power Plants (GPPs) Basics ○ GPPs maintenance & operation ○ GPPs trouble shooting ○ Safety measures on manufacturing / operation / maintenance / energy storage ○ Geology Principles (e.g. earths heat, volcano regions, geothermal reservoirs etc) ○ Engineering, chemistry and physics principles ○ Renewability and Sustainability Principles ○ Modelling & Simulation ○ Uses of geothermal water ○ Resources conservation & Exploitation ○ Environmental Protection ○ Legislation
Closed-loop ground heat exchangers	Dual-speed or variable-speed dual-source heat pumps	“This technology can draw heat from either the air or the ground, depending on which is most efficient at the time, making it much more effective than traditional heat pump models”[22]	

Table 6. Technological advances and knowledge needs in Hydrogen sector

Technological advance	Technology short description	Knowledge and skill needs
Water electrolysis	○ *Alkaline Electrolysers*: are typically composed of electrodes, a microporous separator and an aqueous alkaline electrolyte ○ *Proton Exchange Membrane Electrolyser*: separates hydrogen from oxygen, allowing	○ Hydrogen production and conversion technologies basics

[22] https://www.resource-innovations.com/resources/so-hot-right-now-innovations-heat-pump-technology

Technological advance	Technology short description	Knowledge and skill needs
	either product to be exploited as needed. This technology has been used variously to generate hydrogen fuel and oxygen for life-support systems in vessels ○ *Solid Oxide Electrolyser:* splits water into hydrogen by transferring oxygen through a solid ionic conductive membrane that after form oxygen molecules.	○ Technology design, implementation & operation ○ Safety measures on manufacturing / operation / energy storage ○ Engineering, chemistry and physics principles ○ Carbon capture ○ Fuel cells basics ○ Recycle and co-design principles ○ Hydrogen fuel applications ○ Environmental Sustainability principles ○ Modelling & Simulation ○ Hydrogen economy and market ○ Legislation
Thermolysis & Thermochemical Water Splitting	○ *Thermolysis*: water is directly split using thermal energy or it can be split indirectly using some other chemical materials ○ *Thermochemical Water Splitting*: uses high temperatures—from concentrated solar power or from the waste heat of nuclear power reactions—and chemical reactions to produce hydrogen and oxygen from water.	
Photonic process	○ Photocatalytic Water Splitting: an artificial photosynthesis process using photocatalysis for the dissociation of water into hydrogen and oxygen ○ Photoelectrolysis: a semiconductor device that absorbs solar energy and generates the necessary voltage to split water molecules.	
Biomass treatment	○ Biomass Gasification Technology: uses a controlled process involving heat, steam, and oxygen to convert biomass to hydrogen and other products, without combustion. ○ Biological Hydrogen Production Technology: catalysing hydrogen production by microorganisms through light energy or fermentation	
Hydrocarbons Reforming Technology	○ Steam reforming: technology that uses methane from natural gas is heated, with steam, usually with a catalyst, to produce a mixture of carbon monoxide and hydrogen ○ Auto-thermal: technology that uses both oxygen (and sometimes carbon dioxide) and steam in a reaction with hydrocarbon to form syngas (hydrogen and carbon monoxide) ○ Partial oxidation: technology which converts feedstock into a gas, 'syngas', that is made up of large quantities of hydrogen and carbon monoxide.	

Table 7. Technological advances and knowledge needs in Hydro & Ocean power sector

Technological advance	Technology short description	Knowledge and skill needs
Marine and Hydrokinetic (MHK) technology	"These devices capture energy from the natural motion of ocean water, such as waves or tides. MHK power sources have the potential to generate more than 538 terawatt-hours of electricity a year, enough to power millions of homes."	○ Operational & maintenance ○ Small-scale hydropower plants ○ Potential and location analyses ○ Basic hydraulic principles ○ Mechanical engineering materials ○ Safety measures on manufacturing / operation / maintenance ○ Machine dynamics ○ Design ○ Pumped-storage plants ○ Surge tank concept ○ Dam structures, sealing systems ○ Hydraulic steel structures ○ Basics of electrical machines ○ Energy transport, circuit types ○ Construction permit planning ○ Construction management ○ Control technology for hydraulic machines ○ Legislation
Improved Turbines	"These redesigned systems can replace the less efficient ones already in use, as well as non-powered dams. This process would save money, as it modifies existing systems instead of building new ones."	
Modular Hydropower	"This technology uses river currents to generate energy without impeding the flow of the river or otherwise disrupting the habitat. Because of their smaller size, companies can even install modular systems in city waterways like sewers. This convenience would allow even landlocked cities to benefit from hydroelectricity."	

4.2 Common Needs and Soft Skills

While each renewable energy sector has its unique characteristics, there are some common needs that they share. For instance, all renewable energy sectors require access to capital to finance projects, whether it's for research and development or actual implementation. They also need a supportive policy environment that incentivizes the development of renewable energy projects and provides a level playing field with traditional energy sources. Another common need is access to the latest technology and innovation to improve efficiency and reduce costs. Finally, all renewable energy sectors require skilled workers to design, install and maintain their systems, which highlights the need for adequate training and education programs.

Renewable energy sectors require stakeholders with a diverse range of technical and non-technical skills. **Technical skills are essential, but soft skills such as communication, teamwork, and problem-solving are also critical for success.** Effective communication is essential to ensure that stakeholders understand the benefits of renewable energy projects and the impact they have on the environment and society. Stakeholders also need to work together as a team to develop and implement renewable energy projects, which requires collaboration and trust-building. Additionally, stakeholders need to be adaptable and have problem-solving skills to address unexpected challenges and changes in the industry. Finally, stakeholders need to be passionate about renewable energy and committed to creating a more sustainable future.

5. Good skilling practices in RES education and training

5.1 Circularity-by-design and sustainability principles

This chapter discusses how the principles of the circular economy and sustainability can be integrated into education and training in renewable energy systems (RES). **The circular economy is an important approach to product design that considers factors such as material selection, assembly methods and life expectancy to influence product quality, cost, aesthetics, sustainability and recyclability.** A vivid example of a challenge that needs to be addressed with the circular economy is the wind turbine industry: currently, wind turbines have a life span of 25-30 years, with about 85-90% of the infrastructure being recyclable, including the gearbox, generator, foundation and tower. However, the turbine blades, which are often made of composite materials such as glass and carbon fibres, pose a major recycling challenge. Over the next five years, an estimated 15,000 wind turbine blades will be taken out of service. This equates to a total of 2.5 million tonnes of composite materials that could be difficult to recycle. [23]

Sustainability in renewable energy projects involves a **holistic approach that considers environmental, social and economic impacts throughout the life cycle of the project**. It aims to meet current needs without compromising the ability of future generations to meet their own needs. Through a sustainable approach, renewable energy can reduce the negative impacts of traditional energy sources, create economic benefits and promote social equity.[24] The "triple bottom line" or the "three pillars" are **environmental sustainability**, which includes the protection and conservation of natural resources and ecosystems; **social sustainability**, which includes the social and cultural aspects of sustainability; and **economic sustainability**, which refers to the ability of an economy to thrive and grow without negatively impacting the environment or society. Considering all three pillars helps to develop policies and practises that are environmentally sound, socially just and economically viable, ensuring a more sustainable future for all.

5.2 Established RE skilling practices and programmes

A review of the skills development and training programmes already underway can serve as a valuable basis for other actors seeking to implement clean energy policies and measures. Several public and private institutions, companies and civil society organisations have developed comprehensive education and skills development programmes or established strategies to address the challenges of the energy transition for workers. From the following examples, we can draw important lessons and best practises based on proven cases from the field.

The following sections review current good practices in: 1) Wind energy, 2) Hydrogen sector and fuel cells, 3) Solar energy, 4) Geothermal energy and 5) Electric Vehicles. On top of this, dedicated sections are integrated herein on 6) RE Educational programmes and 7) Green skills for a fair transition.

[23] Webinar circular economy report, p. 5 pdf

[24] Algarni, S., Tirth, V., Alqahtani, T., Alshehery, S., & Kshirsagar, P. (2023). Contribution of renewable energy sources to the environmental impacts and economic benefits for sustainable development. Sustainable Energy Technologies and Assessments, 56, 103098. https://doi.org/10.1016/j.seta.2023.103098

5.2.1 *Wind Energy*

A network of training centres and colleges providing vocational training in wind energy

BZEE e.V., which stands for German Bildungszentren für Erneuerbare Energien eingetragener Verein, or Training Centres for Renewable Energy Non-Profit Association in English, was founded in 2000 by the German wind energy industry, the German Wind Energy Association (BWE) and the German Chamber of Commerce and Industry **with the aim to address the skills gap in the wind industry and initiate needed training activities.** The BZEE Global Training Partnership is a network of 35 training centres and colleges located around the world that specialized in providing **wind energy skills to professionals.**[25] To date, the partnership has trained over 5,000 highly qualified wind energy technicians, with approximately 2,000 company staff undergoing Global Wind Organisation (GWO) training each year. These **training providers differ from traditional classroom-based courses, because they focus on practical training using real components, rather than theoretical instruction.**

One notable example within the BZEE network is the **Renewable Energy School of Skills (RESS)** in Constanța, Romania, which offers a range of specialized courses including the development of wind energy training equipment, module testing under real-life conditions, and the creation of manufacturer-specific safety and rescue concepts. The staff at RESS consist of a team of experts in the wind energy supply chain with backgrounds in wind turbine manufacturing, turbine installation and maintenance, condition monitoring, commissioning and decommissioning in both onshore and offshore environments, rescue operations and accident prevention.[26]

The success of the BZEE Global Training Partnership is not only due to the quality of the training material, but also to the skills and expertise of the training providers. To ensure that these providers are equipped with the necessary knowledge and skills, BZEE provides specialised **training for trainers.** Another important aspect of BZEE as a good example for RES is that it is a global network with training centres in the USA, Europe, Africa, Asia and Australia.

Danish Wind Power Academy: training in wind energy

The Danish Wind Power Academy (DWPA),[27] founded in 2004, is a company dedicated to provide educational solutions in the wind energy sector. A review of the training methods and materials offered by DWPA allow us to draw the following conclusions: a) **trainings are customized** in terms of training needs, location (e.g. on-site or on-line training), learning environment (e.g. in-turbine classes are delivered within clients' operational assets), b) **the trainers are experienced** not only as technicians, but also as educators, c) a **holistic approach** of the issues which drive operational performance is adopted, d) the **trainings provided are divided in following categories**; i) programms in regards to **operational training**, ii) trainings **tailored to specific turbine brands** (e.g. Bonus, Gamesa, GE Renewable Energy), iii) **training by job role** (e.g. Wind Turbine Technicians, Management and Supervisory roles), iv) **trainings tailored to specific needs**.

Stakeholders in wind industry training programmes fall broadly into two categories: **Technicians and Other Stakeholders.** The category of technicians is divided into several subcategories, including new technicians, experienced technicians, technical support staff and those involved in advanced troubleshooting activities. The other stakeholder category includes individuals involved in

[25] The map with all the training centres is available here: https://www.bzee-network.com/netzwerk/. Last accessed: 9/12/2022.
[26] More information available at: https://www.bzee-network.com/netzwerk/ress/. Last accessed: 9/12/2022.
[27] SkillWind, Wind Energy sector skills in Europe, 2015, p. 19. Available at: https://skillwind.com/wp-content/uploads/2017/11/IO1_Wind-Energy-sector-skills.pdf.

managing or overseeing wind turbine maintenance activities, operations and asset management staff responsible for long-term asset management decisions, individuals responsible for conducting wind turbine inspections or analysing inspection reports, and individuals involved in remote control activities. The Danish Wind Power Academy is an example of the current training requirements in the wind energy industry. Furthermore, this academy serves as a model for the crucial role of training providers in effectively communicating key information. It is critical that these providers have not only technical expertise but also pedagogical skills to ensure the effectiveness of their training. Given the ever-changing nature of the modern workforce, it is also critical that the programmes offered by the academy are customisable in terms of both location and content.

Industry and local municipalities implementing educational programs for engineers and wind workers towards circularity by design and sustainability

Vestas, a sustainable energy solutions company specialising in wind turbines, has set itself the goal of becoming carbon neutral by 2030 and producing zero-waste wind turbines by 2040.[28] To achieve this, the company is focusing on education and offers a two-year graduate programme that attracts and trains new talent. In 2021, 67 new Graduates (44% women) were on-boarded. In addition, Vestas has launched two innovative programmes in collaboration with the state of Tamaulipas and educational institutions in the Tamaulipas region of Mexico.[29] The programmes aimed to train the next generation of wind energy engineers and professionals and took a two-pronged approach: theoretical learning and networking, and on-site project learning.[30] Sustainability principles were at the heart of the programme's success and paved the way for other municipalities to develop similar programmes with the participation of technical and polytechnic universities, technological institutions, CONALEP, COBAT and ITACE.[31]

The above-mentioned examples show **how the economic and social aspect of sustainability can be implanted in the industrial sector**: education is the path towards which new job positions are offered or maintained. At the same time, the significant percentage of women involved in the company shows us how can companies be inclusive and reduce the gender gap in STEM, implanting the social aspect of the sustainability principle.

5.2.2 *Hydrogen sector and fuel cells*

Brunel's collaboration with the academic sector to train workers towards the transition from the oil and gas sector to the hydrogen sector

The Netherlands-based energy recruitment company, Brunel[32], along with the Groningen-based business school, The Energy Delta Institute, are about to launch a degree for oil and gas workers to **retrain** them for **jobs in the hydrogen sector**. Brunel decided to launch the degree after receiving the results of a survey it undertook with oilandgasjobsearch.com, which showed a third of oil and gas workers were looking for new jobs in the renewables industry[33].

[28] Vestas, Leading the energy transition, Sustainability Report 2021, p. 64. Available at: shorturl.at/CHJLN. Last accessed: 15/11/2022.
[29] Vestas, Powered By Innovation – Inspiring Wind Education, 7/7/2020, Available at: https://www.vestas.com/en/media/blog/community/powered-by-innovation-inspiring-wind-education. Last accessed: 29/11/2022.
[30] Vestas has committed to respecting human rights within the development of wind energy projects that they contribute to. This was strengthened with the launch of the Corporate Social Responsibility (CSR) strategy "Leading a responsible and inclusive energy transition" in 2020. More information available at: https://www.vestas.com/en/sustainability/corporate-integrity/csr. Last accessed: 8/12/2022.
[31] Vestas, Powered By Innovation – Inspiring Wind Education, 7/7/2020, Available at: https://www.vestas.com/en/media/blog/community/powered-by-innovation-inspiring-wind-education. Last accessed: 29/11/2022.
[32] More information available at: https://www.brunel.net/en/culture-and-values. Last accessed: 8/12/2022.
[33] The survey available at: https://hiring.oilandgasjobsearch.com/energy-outlook-report-2021-22. Last accessed: 13/12/2022.

The course will cover subjects like **the fundamentals of hydrogen, the production, use of hydrogen (mobility, industry and built environment) and the complete value chain**. In the program will be included also topics **related to policies, law and legislative**. It is planned as a part-time course, once a week for nine months, with 25 available spots only for Brunel's clients who have more than five years' experience in engineering and legal roles. After the pilot phase, Brunel plans to launch additional international programmes.[34]

The example of Brunel's collaboration with academic and scientific institutions demonstrates the importance of **incorporating both technical and policy-related courses into renewable energy training programmes**. To effectively meet current skills needs, these programmes must not only focus on the technical aspects of renewable energy, but also ensure that students are familiar with relevant policies and legislation. This multi-layered approach to retraining will ensure that graduates are well equipped to navigate the complex landscape of renewable energy professionally. Finally, this example sheds light on the importance of building synergies between industry and academia.

Renewable Energy Institute's intensive training course in hydrogen energy and fuel cells

The **Renewable Energy Institute** works with top universities (e.g. Edinburgh Napier University, Energy Department Politecnico of Milano, University of London) in the energy sector and the United Nations Environment Programme (UNEP) to promote best practises and knowledge exchange in renewable energy and energy efficiency. It offers professional training courses, qualifications, conferences, publications and the internationally recognised Galileo Master Certificate. The **Hydrogen Energy course** provides participants with the knowledge to assess and manage hydrogen energy projects and understand the hydrogen economy. The course covers various topics including hydrogen production, modelling, storage, fuel cells, mobility, government legislation and policy and is open both to professionals who are new to the hydrogen sector as well as to those who own a well understanding of the sector. Participants include professionals from Mueller UK and Ireland Group, the Greater London Authority and Coca Cola. [35]

Such type of courses, offering a **multifaceted perspective on the hydrogen sector** at both the EU and international levels, including technical, circularity, legal, and financial aspects, are capable of addressing the current and future needs of the hydrogen industry. This serves as a prime example of facilitating the clean energy transition by offering opportunities for experts seeking to enhance their skills and professionals seeking to enter the hydrogen sector.

5.2.3 *Solar energy*

EU-funded projects towards upskilling and reskilling of solar workers

The European Union has supported numerous initiatives aimed at reinforcing solar energy skills. One such example is the "The Solar CV" project, which focused on the training needs in Concentrated Solar Power (CSP) and developed common vocational education and training frameworks for solar field operators, including mobility-enabling EU level recognition and incorporating work-based learning components. This project also emphasized the reskilling of workers from conventional and solar occupations. Another project, "GSS-VET," addressed the deficiency in the continuing education of plumbers and electricians in geothermal, solar thermal, and

[34] Brunel, The World's First Accredited Hydrogen Education Program is Here, Available at: https://www.brunel.net/en/renewables/hydrogen/hydrogen-education-program. Last accessed: 12/8/2022.
[35] The course is available here: https://www.renewableinstitute.org/training/hydrogen-energy-course/.

solar photovoltaic installation through implementing demand-driven training. Lastly, "The Planet Project," which also covered solar thermal and solar PV, employed a flipped classroom methodology combining online training modules, in-class modules, and work-based learning periods, available in five languages.[36]

Such programmes demonstrate the need for addressing skills gaps in the solar energy sector in order to meet the challenges of the manufacturing industry. The various methodologies utilized in these initiatives, including demand-driven training, on-site trainings, and in-class modules, serve as examples of the **flexible and demanding skill development approaches** that are necessary to fulfil the evolving needs of solar professionals.

Vocational education and training (VET) in solar energy

The Clean Energy Council, a not-for-profit membership organisation in Australia, offers comprehensive courses for **future and current workers in the solar industry to meet the need and fill gaps in solar education**. Some of these courses include the design and installation of grid-connected PV systems with or without batteries, and courses for installers of small solar systems and batteries. In addition to these courses, the organisation also offers **a guide to clean energy careers** where prospective students can search by criteria such as occupation and demand, technology, job type and career path. The solar energy career guide is divided into large and small solar careers and contains detailed information on the relevant qualifications a person needs to pursue a career in solar or to improve their current position. To become a Clean Energy Council accredited solar or battery installer, an installer must be a qualified electrician and complete certain prerequisite units through a Technical and Further Education (TAFE) or private training organisation. The process includes an online examination and a practical component to demonstrate competence in system installation. Accreditation is annual and each year a certain number of points of continuous professional development must be demonstrated through recognised training for the accreditation to remain valid. [37]

The Clean Energy Council in Australia serves as a model for the clean energy transition, providing insight into areas of high demand for specific skills or experience and identifying critical or niche skills gaps. It helps to clarify career pathways in the solar energy sector. For example, obtaining an electrical license, a highly versatile qualification, allows for mobility among various clean energy technologies and employers. Electricians with this qualification may consider career paths that include experience in high-voltage operation, electrical site supervision, management, or as an area superintendent.

5.2.4 *Geothermal energy*

Geothermal education opportunities around the world

The International Geothermal Association (IGA), a global platform on geothermal energy, is providing a dedicated section on education opportunities in the geothermal sector. Intersted parties can navigate in the platform and search training courses and programmes in the geothermal sector by **continent** (Europe, Asia, Australia/Pacific, North-America, Middle- and South-America) and **country** (Croatia, Germany, Hungary, Iceland, North Macedonia, Poland, Romania, Switzerland, Turkey,

[36] European Commission, Skills For The Clean Energy Transition, 2022
[37] The full list of coursed is available here: https://assets.cleanenergycouncil.org.au/documents/accreditation/cec-accreditation-training-organisations-australia.pdf.

Indonesia, Japan, New Zealand, Mexico, USA, EL Salvador, Chile). The information provided is updated every year and it includes the research focus, course language, degree and contact details of the universities.[38]

A review of the training and educational programms listed by the International Geothermal Association allow us to draw the following conclusions:

a. Most educational opportunities in the sector are offered by Germany – by more than sixteen (16) Universities in total all over the country. U.S.A. is following with more than nine (9) universities in total all over the country;

b. Educational opportinities consist of BSc, MSc and PhD programs – with most of them being MSc programms;

c. The courses and programs offered include Geotechnical Engineering, Applied Geophysics, Energy Systems, Architectural Engineering, Civil Engineering, and Geothermal Energy Systems. Other offerings include programs in Hydrogeology, Environmental Management, Renewable Energy Engineering and Management, and Sustainable Energy Engineering.

d. Programs in Geotechnical Engineering, Energy Systems, Geosciences, Renewable Energy Engineering, and other related fields are offered by leading universities and institutes such as the University of Zagreb, ETH Zurich, and Kyoto University, among others.

e. Educational programms offered in the geothermal sector evolved significatly compared to the previous years.[39]

The aforementioned list illustrates the **evolving educational needs in the geothermal sector**. This list, when compared to the one compiled by the GEOELEC project in 2013,[40] reveals the increasing demand for geothermal experts due to the growing global geothermal energy industry. The 2013 report highlighted the shortage of specialists in various areas of expertise, leading to the development of numerous BSc, MSc, and PhD programs in the field. The programs listed above also demonstrate the **importance of multidisciplinary expertise and effective collaboration among various disciplines, including industries, the private and public sector, and universities**, to follow in the pursuit of clean energy transitions.

HP4ALL project: Developing a framework to improve heat pump competence and excellence

The EU co-founded HP4ALL project aims to develop a comprehensive heat pump competence and excellence framework to meet the supply and demand for heat pump skills in three pilot regions and beyond. The project familiarises end users, installers and experts with best practises for heat pump installations and specific competence requirements. The project has developed a **knowledge hub[41] to inform end-users, installers and experts about best practises for heat pump installations and specific competence requirements**. The platform offers information on heat pump installations for non-residential and residential buildings, workshops and a benchmarking tool. The workshop section offers a pool of different workshops and webinars that can be searched by topic and target group. Most of the educational material is available in English, some also in the languages

[38] The full list is available here: https://www.lovegeothermal.org/education/geothermal-education-opportunities/. Last accessed: 22/12/2022.
[39] Angela Spalek, (GFZ), List of European universities offering training and education in the field of geothermal energy, GEOELEC, November 2013, Available at: http://www.geoelec.eu/wp-content/uploads/2014/02/D5.5.pdf. Last accessed: 22/12/2022.
[40] http://www.geoelec.eu/
[41] The platform is available here: https://hp4all.eu/workshop/. Last accessed: 22/12/2022.

of the pilot regions: German, Irish and Spanish. The ultimate goal of the project is to develop replicable solutions at national and EU level.

The Knowledge Hub, created by HP4ALL, is an exemplary model for other actors in academia, civil society, and the public and private sectors who are interested in training their workforce in geothermal energy using digital tools and have geothermal potential in their regions. In addition, this platform is valuable for people interested in a career change into the geothermal sector, as the webinars and workshops are accessible free of charge, allowing those interested to receive initial training and determine whether this is the right career path for them.

5.2.5 *Electric Vehicles*

Training Programs in Sustainable Battery Manufacturing

Northvolt is a Swedish battery company that focuses on sustainability and circular economy in its production. In 2019 they launched Revolt, a battery recycling programme with the aim of recovering metals in an environmentally friendly and cost-efficient way.[42] Northvolt is working with Hydro and two Swedish municipalities to achieve sustainability and circular economy goals. The joint venture with Hydro is called Hydro-Northvolt, and the synergies with the Swedish municipalities are the Northvolt Ett gigafactory in Skellefteå and the Norhvolt Labs research facility in Vaesterås. A multidisciplinary team of scientists, including engineers, mechanical engineers and chemists, is working on the project.[43] Northvolt Ett offers training on environmental legislation, risk assessments, investigations, iChemistry for storing chemical information, TIA for reporting incidents and deviations, and customised programmes for production personnel.[44] Northvolt collaborated with Skellefteå municipality to establish an adult education and vocational schooling program. The first course was called Automation Operator and was launched in early 2021.[45] The 20-week course trained manufacturing staff, including technicians and operators, on industry and technical knowledge. Northvolt has hired over 60% of the graduates since the program's introduction.[46]

The example of Northvolt highlights the value of **partnerships between industries and local municipalities** in achieving a clean energy transition through suitable workforce training. Such collaborations can address resource shortages, increase market power, and facilitate the achievement of goals through the utilization of diverse skills and experiences. In the case of Northvolt, the industry set the goal of manufacturing batteries, and the local municipality provided the necessary training to the workforce to realize this goal. While Northvolt could have independently recruited for their vocational education and training programs, collaboration with the local municipality resulted in benefits for both the community, such as new job positions, and for Northvolt, through reduced time spent on certain tasks.

Volkswagen Academy: Training programme for software developers for electric vehicles

Volkswagen, has set the ambitious goal to transform its vehicle fleet to electric vehicles in the coming decades.[47] To that end the Volkswagen Academy in 2019 set up the “Faculty 73” training programme

[42] Northvolt, Closing the loop on batteries, 18 May, 2022, Available at: https://northvolt.com/articles/revolt/. Last accessed: 15/12/2022.
[43] The iChemistry system is a platform designed for the storage and management of chemical information. The system is widely used in research and academic settings to help chemists and other scientists access and analyse chemical data.
[44] The TIA system is a platform designed for reporting and managing incidents, conduct investigations and analyse data related to incidents and deviations. It is widely used in industries such as healthcare, manufacturing and aviation to improve safety and quality management.
[45] Northvolt, Sustainability Report 2021, p.51.
[46] Skellefteå, Reflections on competence, education and skills supply, October 2020.
[47] High-quality training and eye on the future: Volkswagen Educational Institute, Available at: https://modo.volkswagengroup.it/en/humans/high-quality-training-and-eye-on-the-future-volkswagen-educational-institute.

for software developers to work in the auto sector. Its courses focused on **technical training, management training, leadership, and education itself, as well as EDP (Electronic Data Processing)**. In this programme, students who have completed their vocational training, BSc, MSc, PhD Candidates as well as PhD graduates can participate. Programme's students participate in a **two-year IT education with intensive programming training and project tasks**. Training takes place at the AutoUni and in cooperation with selected partners such as Bredex GmbH, New Elements GmbH and Ostfalia University of Applied Sciences.

In the first year of the program students receive basic training with learning content tailored to the individual level of knowledge. In the second year the programme is focused on in-depth practice-oriented programming and on teaching several programming languages. The scope of training is also oriented towards the requirements of the departments where the participants will later work. During the training students are working on automobile projects, such as: developing vehicles with creative functions and designs; software-controlled Lego production line where the participants were required to coordinate all production steps; obstacle courses which could only be correctly navigated using assistance software developed specifically for this purpose. After the two-year programme, students receive advanced IT education to become a Junior Software Developer.[48]

Volkswagen's Academy serves as a case study of the necessary skills and training to meet the challenges of the twin transition, including the integration of sustainability principles in renewable energy education. The identified programme trains software developers, exemplifying the multidisciplinary approach of renewable energy education, which extends beyond manufacturing fields. This example, similar to the Northvolt case previously discussed, highlights the importance of synergies and collaborations among different renewable energy education providers.

Retraining foundry workers towards the production of electric vehicles

In April 2021, France launched a €50 million fund as part of an updated action plan to support the transformation of the automotive industry, which was announced in May 2020.[49] The fund aims to **retrain foundry factory workers** as the country shifts its internal combustion-based automotive industry towards electric vehicles. The French government will contribute €30 million, while car manufacturers Renault and Stellantis will contribute €20 million.

France currently has 355 foundry factories employing around 30,000 workers, with half of them linked to the automotive industry. A prospective study by the French metallurgy observatory on jobs and skills in the automotive sector will be complemented by an analysis of the skills gap between declining and emerging jobs, in order to offer tailored training to employees who may be at risk of job loss. The training will focus on regional and local employment dynamics. The support measures are planned until 2023 and will be implemented by France's unemployment agency, Pôle Emploi. As part of the broader plan for employment in the sector, the government has also proposed the establishment of four new automotive skills campuses.[50]

[48] Volkswagen starts "Faculty 73" training program for IT specialists, Available at: https://www.volkswagenag.com/en/news/2019/04/volkswagen_faculty_73.html#.
[49] IEA, Recommendations of the Global Commission on People-Centred Clean Energy Transitions, October 2021. Available at: https://www.iea.org/reports/recommendations-of-the-global-commission-on-people-centred-clean-energy-transitions/recommendation-2. Last accessed: 23/12/2022.
[50] Le fonds d'accompagnement des salariés de la filière automobile officiellement établi, 18/06/2021, Available at: https://www-economie-gouv-fr.translate.goog/fonds-accompagnement-salaries-filiere-automobile-etabli?_x_tr_sl=fr&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=wapp#. Last accessed: 22/12/2022.

5.2.6 *RE Educational programmes*

The current subchapter aims to discuss RE education in relation to all renewable energy sources, with a focus on categorising them according to educational criteria. While the previous subchapters discussed categorisation based on the different types of renewable energy sources, this section examines the various educational programmes and initiatives that have been developed to meet the growing demand for renewable energy expertise. These programmes range from specialised master's degrees to international exchange programmes for trainers, and their success is critical to shaping the future of the clean energy sector.

European Master in Renewable Energy by European Renewable Energy Research Centres

The European Master in Renewable Energy[51] was developed by the European Renewable Energy Research Centres (EUREC) and a consortium of universities[52] to train people for skills in renewable energy fields.[53] Created in 2002, this master's degree is intended to meet the job market's growing demand for renewable energy expertise and is accessible to graduate students from scientific disciplines or with relevant work experience. The course is divided into three sections: in the first semester, students learn the foundations of key renewable energy technologies; in the second semester, they choose a technology for specialisation at a separate university; and during the final session, students undertake a six-month practical training or research project. Universities offer different specialisations, such as in photovoltaics, wind energy, grid integration, solar thermal and associated renewable storage, ocean energy, and sustainable fuel systems for mobility. Each university can admit around 8 to 15 students. For the academic year 2019-2020, 59 students participated in the programme. For Academic Year 2022-2023, the course fee is EUR 8 000 for EU students and EUR 13 000 for non-EU students.

The proposed master's degree program serves as a model of universities cooperation developing higher education programs that address the clean energy transition needs. This tailored approach to education demonstrates the potential for collaborative efforts to meet the demands of this rapidly evolving field. By combining resources and expertise from multiple institutions, the students are provided with a comprehensive and diverse learning experience which equips them with the skills and knowledge needed to succeed in the clean energy sector.

Upskilling educators skills in RES through international learning exchanges

CREATE, in collaboration with the National Science Foundation's Advanced Technological Education program, organized two international learning exchanges for educators across the U.S. in the renewable energy sector. The goal was to learn from international peers and expand their knowledge in the RES sector. The first phase took place in Australia/New Zealand in 2013 and the second in Germany/Denmark in 2014. Participants had the opportunity to meet with technical educators, visit renewable energy teaching labs and installations, review industry partnerships, and talk with policy makers and government representatives. After the visits, three key lessons were learned: the importance of a national vision for energy policy, incorporating renewable energy in the core training material of educational institutions, and the significance of a multidisciplinary and

[51] More information available at: https://master.eurec.be/. Last accessed: 16/11/2022.
[52] The core providers are: Oldenburg University, Mines Paris – PSL, Hanze University of Applied Sciences, University of Zaragoza. The full list of the universities involved in the program is available here: https://master.eurec.be/universities/. Last accessed: 15/12/2022.
[53] IEA, Recommendations of the Global Commission on People-Centred Clean Energy Transitions, October 2021. Available at: https://www.iea.org/reports/recommendations-of-the-global-commission-on-people-centred-clean-energy-transitions/recommendation-2. Last accessed: 23/12/2022.

collaborative approach among education, industry, and trade unions in shaping renewable energy education.[54]

Recommended practices for professional development programs include assembling a strong community of practice, establishing baseline knowledge, building a robust and multifaceted program itinerary, providing structured activities to apply what was learned to instructional practices, planning for dissemination opportunities, and measuring immediate outcomes and longer-term impacts to assess the success of the project. [55]

5.2.7 *Green skills for fair transition*

This sub-chapter shifts the focus from specific renewable energy education programmes to the policy landscape surrounding them. Rather than providing an exhaustive list of policy initiatives in this area, it examines two notable examples of government initiatives to promote green skills. The aim is to show that such initiatives exist and to highlight the importance of government support for the development of green educational programmes.

Greece's example towards a just transition strategy for lignite workers through upskilling and reskilling

Greece's 2021 Recovery and Resilience Plan[56] includes four pillars: a) Green Transition, b) Digital Transformation, c) Employment, Skills, and Social Cohesion, and d) Private Investments and Transformation of the Economy. To support these pillars, the government is implementing measures to improve green skills through training programs in resource efficiency, low-carbon industries, climate resilience, and natural asset management. The plan also includes investments to rehabilitate industrial land and establish the foundations for further low-carbon investment. These measures are designed to ensure a fair transition as the country phases out lignite, particularly in Western Macedonia and Central Peloponnesus. Under the Just Transition Fund (JTF) program and plans adopted in June 2022, Greece will mobilize a total investment of €1.63 billion to mitigate the impact of the energy and climate transition on the local economy and society in the most affected regions. The program will support the decarbonization of Western Macedonia and Peloponnesus, as well as the phasing out of fossil fuel power plants in the islands of North-South Aegean and Crete. Support from the JTF program will promote the diversification and modernization of the economy by creating new jobs and providing training and reskilling opportunities for people affected by the transition. This includes training in digital skills and cutting-edge technologies, with a focus on vocational training, human resource certification actions, and job search assistance.

Spain's educational and training path towards a Just Energy Transition

The Spanish government's Strategic Framework for Energy and Climate,[57] released in 2019, includes the Just Transition Strategy,[58] which aims to support the **transition of workers in coal-dependent regions to new opportunities**. As part of this strategy, **green vocational training** is

[54] Agora (2015). Understanding the Energiewende. FAQ on the ongoing transition of the German power system.
[55] Kenneth A. Walz et al., " International Approaches To Renewable Energy Education – A Faculty Professional Development Case Study With Recommended Practices For STEM Educators", American Journal of Engineering Education, December 2016.
[56] European Commission, Greece's recovery and resilience plan, Available at: https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/greeces-recovery-and-resilience-plan_en. Last accessed: 22/12/2022;
[57] IEA, Recommendations of the Global Commission on People-Centred Clean Energy Transitions, October 2021. Available at: https://www.iea.org/reports/recommendations-of-the-global-commission-on-people-centred-clean-energy-transitions/recommendation-2
[58] Available (in Spanish) here: shorturl.at/hjmFH. Last accessed: 16/11/2022.

considered a key element, including the retraining of workers in vulnerable sectors or those undergoing restructuring. One example of this is the Mining Job Bank, which provides personalized advice to coal mining workers to **improve their employability and search for new employment**. This includes conducting a personal analysis of each individual's employment situation, identifying any obstacles to employment, and developing a personalized learning path to address identified training needs and improve soft skills.

The Spanish Ministry of Ecological Change and the Ministry of Labour and Social Economy are working together to facilitate the process of environmental rehabilitation in Asturias, León and Teruel. This includes safety training, investment in renewable energy and subsidies for green and blue economy projects. An agreement for a just transition for coal-fired power plants has been signed between the government, workers and operators to maintain employment through relocation plans and training/retraining programmes. The ministries are working with the Spanish Labour Administration to provide comprehensive support to workers, including vocational training and job placement.

In Asturias, León and Teruel, training is provided for environmental remediation processes, including safety training for specific tasks. The electricity companies have committed to a support plan to improve the employability of workers in new areas of activity, while the Empleaverde programme gives priority to projects in Just Transition areas. The Just Transition agreement for coal-fired power plants[59] includes relocation plans, training and retraining programmes, and comprehensive support services for workers in affected areas.

[59] Agreement for a just transition for coal power plants: jobs, industry and territories, March 2021, Available at: shorturl.at/rLNPW. Last accessed: 16/11/2022.

6. Interviews with stakeholders

6.1 Objectives and methodology

The interviews aimed to **explore cutting-edge technological innovations**, identify **skills needs**, and **discuss sustainable and circular design principles** in renewable energy development. To achieve this, a questionnaire with 13 core questions divided into five main sections was prepared by White Research (WR), based on targeted desk-research.

Our research team **conducted 32 interviews** with renewable energy stakeholders, **with an equal proportion of male and female participants**. More specifically, fourteen (14) of the thirty two (32) interviewees were women, while eleven (11) were men. The remaining seven (7) did not want to disclose personal data, so their gender was not specified. The interviews were allocated to each partner at a stakeholder group level based on the stakeholder mapping process that was previously described. Moreover, a consent form was distributed to all participants during the interview phase, ensuring them of the safety of their personal data and that all GDPR rules were being followed.

The interviews provided valuable insights into stakeholders' knowledge and perceptions on various topics related to renewable energy and complemented the research findings from the literature review.

Interview findings, presented below, are clustered per stakeholder group and insights are grouped into thematic sub headings (in line with the questionnaire's main categories, see Appendix II, and in line with the findings from the literature review, see Chapters 4 and 5). Specifically, for every stakeholder group, interview results are clustered in: 1) cutting-edge technological innovations; 2) challenges in advancing sustainable and circular practices for renewable energy project development; 3) new skills and green skills; 4) gender (im)balance and skills gap in STEM fields; and 5) current state in RES education/training.

6.2 Interviews results

6.2.1 *Scientific community*

Cutting-edge and traditional technological innovations

According to interviews with participants from the renewable energy scientific community, there are a number of **cutting-edge technological developments** in the RE sector and beyond. These include both traditional and upcoming technologies. Among the traditional technologies mentioned were **wind turbines, gas turbines, fuel cells, and electrolyzers**. Meanwhile, interviews revealed upcoming technologies such as **photocatalytic artificial leaves**, **bioenergy via anaerobic digestion**, **hydrogen via water electrolyzers**, **hydrocarbon reformers**, **building integrated photovoltaics**, **agrovoltaics**, **perovskites in the space industry**, and **lead-free perovskite solar cells**. These technologies are being developed for multiple sectors, including renewable energy and non-renewable industries.

Challenges in Advancing Sustainable and Circular Practices for Renewable Energy Project Development

One of the main financial barriers is the **high cost of electrolyzers** used to produce hydrogen and the lack of an open and competitive hydrogen market. There is also a **lack of availability of green electricity,** and the competition for its use in substituting CO2 is intense. In addition, interviewees noted a **shortage of professionals** to install the necessary technologies. As an example of financial barriers hindering the uptake of more sustainable and circular practices in RE development, an assistant professor of “behaviour, energy community, energy storage” cited the need for government subsidies and social factors related to the importance of community involvement.

Societal barriers such as **lack of awareness** of the benefits of renewable energy, government subsidies and incentives, both in promoting sustainable and circular renewable energy practises and in project development, the **"not in my backyard" syndrome** also mentioned in sustainable and circular renewable energy practises and in project development, resistance to change.

Environmental barriers were also identified, such as the **availability of resources and materials**, as well as **toxicity of materials used in RES production and operation**s such as lead-based perovskite photovoltaics following the answer of an academic research on RES field.

Finally, regulatory barriers mentioned in the interviews include **regulations on special planning for offshore wind, the risk of vulnerable groups being negatively impacted by a single policy** (e.g. policies that do not focus on equality and inclusion, policies that do not take into account the needs and perspectives of vulnerable groups), and the slow uptake of certain renewable energy actors and regulations. For example, some countries still have outdated regulations that favour traditional energy sources over renewables. **The academic community highlights the importance of a standardised regulatory framework at EU level,** political support, stakeholder engagement and a whole life cycle approach to identify opportunities to improve sustainability and the circular economy.

New Skills and Green Skills related to renewable energy sector

According to participants from the renewable energy scientific community, there are several **new skills** linked to technological advances in renewable energy. These include **electricians with the ability to handle electro-chemical systems** and understand their operation, as well as **hands-on practice for installation** of these systems. Design engineers should have **knowledge of the electricity market**, which is not typically part of the training for mechanical or chemical engineers. Other needed skills for technology installation include the **ability to handle electrical systems and apply alternative integration methods**, especially for batteries and in the areas of BIPVs, transportation, agrivoltaics, wearables, and more. In terms of research, professionals need to be fully trained in new materials and alternative use of existing ones, as well as on new production techniques such as printing and coating techniques. These findings suggest that there is a need for cross-disciplinary training and education programs that incorporate a range of skills related to renewable energy technology.

Based on the responses from participants in the renewable energy scientific community, several **green skills** are needed in the sector. Firstly, individuals need **to be able to operate delicate electro-chemical energy systems**, which may involve dealing with issues such as poisoning. Additionally, innovation should be driven by intended technology rather than just material characteristics, with scientists needing to have an understanding of the purposes and not just the material. Furthermore, testing platforms for energy system integration need to be available. Also, **co-creation and participatory design skills** are required. Interviewees also claim that **individuals need to have skills in data management**, including **resource availability and risk assessment**, as well as **the ability to design sustainable and safe renewable energy systems throughout**

their entire life cycle. Finally, researchers should be **aware of methods that enable material recycling and proper disposal** to ensure environmental protection and regulatory compliance.

Gender (im)balance and skills gap in STEM fields

Interviews with representatives of the academic community revealed a consensus that there is a **gender imbalance in technical fields**, especially in relation to green professions, reflecting broader societal and educational trends. The **underrepresentation of female students in technical education** (STEM) exacerbates this imbalance and makes it more difficult to achieve gender balance. This imbalance often results in **fewer women in technical fields** where particular skills are in demand, such as engineering and renewable technologies.

Representatives from the academic community **support the idea of a more balanced gender ratio in these fields,** arguing that this can promote growth and innovation. As a **solution** to the problem discussed, academics and researchers participating in the interviews suggest the following: offering **part-time jobs**; better **access** to **family and childcare facilities**; **training teachers** to motivate women to enter technical professions; the importance **of early education in promoting gender equality**; **joint efforts** by educational institutions, policy makers and employers; creating **equal opportunities** for women and men in STEM / RES to acquire the necessary skills; promoting **a culture of diversity and inclusion in the workplace**.

Current state of education/training in RES

Obstacles to Education and Training in RES

One of the main obstacles, highlighted by an associate professor of multisystem design and operation and optimization,[60] is the **lack of time and competent management**. On the other hand, an assistant professor of behaviour, energy community, energy storage stressed **the importance of involving all stakeholders in the curriculum design process**. An important aspect of the educational process in RES, which was highlighted, is **access to information for sustainable and circular development RE**. Finally, **financial constraints** were also mentioned as obstacles to the progress of education RES of interested stakeholders.

Types of stakeholders to provide or receive training

Representatives of the academic community have identified stakeholders with valuable knowledge and experience who can contribute to the development of educational programmes and practical training for individuals interested in pursuing careers in renewable energy. These stakeholders may need training to participate effectively in these programmes: **policy makers and politicians, households, researchers and educators in universities and research institutions, individuals working in the renewable energy industry, representatives of government agencies and regulators, students and graduates, members of the public, decision makers in government agencies, decision makers in companies and electricians interested in the topic of electrical energy.**

Best practices

Several **existing courses and training programmes** have been recommended by representatives

[60] E.g. macro grid, hydrogen, electrolyser

of the academic community, including courses at TU Delft, [61] Duke University, Lund University[62] and the Technical University of Denmark.[63] The trainings cover topics such as real-world challenges, participatory decision-making, renewable energy, green entrepreneurship in construction, sustainable materials management, principles of circular economy, multi-system design, energy system operation and electricity. In addition, one of the interviewees mentioned the importance of practical training, citing as an example the training on printing solar cells offered by his institution. Finally, science-based advice and the involvement of experts in policy-making was also mentioned as an important form of training in the topic under discussion, without giving a specific example of such training.

6.2.2 *Renewable Energy Industry*

Cutting-edge and traditional technological innovations

Participants in the renewable energy industry identified a range of traditional and upcoming **technologies** with great potential for sustainable growth and carbon emissions reduction. Among the technologies mentioned the most highlighted ones came from a biogas plant manager who identified **biogas from anaerobic digestion**, **hydrogen production using water electrolysis**, **thermochemical and photocatalytic separators**, and **hydrocarbon reformers**. Moreover, mentioned technologies of a high potential included **biomethane** and **biomethanol production**, **nanomaterials**, **printed photovoltaics for buildings and agrivoltaics**, **flying wind turbines**, **air boards to mitigate atmospheric effects**, **seasonal storage of heat**, and the **utilization of power-to-x technologies in synthetic fuel manufacturing.**

Challenges in Advancing Sustainable and Circular Practices for Renewable Energy Project Development

Representatives from the industrial sector point out that there are a variety of barriers to the adoption of sustainable and circular practises in different areas of energy production, including biogas, renewable energy development, transport, electricity systems and liquid fuel production. As an example of financial barriers to promoting sustainable and circular practises, they cited insufficient funding for projects in the sector, unclear costs and revenues, inadequate financing and investment, and difficulties in financing small-scale and innovative technologies.

In terms of social barriers, an energy strategy consultant explained that the lack of public confidence in renewable energy sources and the "not in my backyard" syndrome (NIMBY) or the "build absolutely nothing anywhere near anything/ anyone " syndrome (BANANA) were among the main social barriers. In addition, several environmental challenges were mentioned, such as ecosystem components and biodiversity concerns, especially for wind energy, as well as life cycle assessment (LCA) of emerging technologies that are not yet fully understood, and sourcing raw materials in an environmentally sustainable way. In addition, respondents acknowledged a number of barriers, including regulatory hurdles such as the lack of a comprehensive legal and regulatory framework, confusing laws and excessive bureaucracy in several countries, and regulatory unpredictability.

[61] The Assistant professor in Behaviours, energy community, energy storage recommends considering courses at TU Delft that focus on real-life challenges and participatory decision-making, although these courses are only offered as electives.
[62] Both courses are suggested by the Researcher in Perovskite photovoltaics. The courses focus on renewable energy, green building entrepreneurship, sustainable materials management, and circular economy principles.
[63] The Technical University of Denmark offers a summer school course on modern challenges in power system operation and electricity, which lasts for one week and provides optimization knowledge.

Solutions to overcome these barriers include improving the availability of funding, simplifying regulations, promoting green awareness and values, and encouraging clear and transparent communication. In addition, lifelong learning, predictable long-term funding and specialised education programmes can help facilitate the adoption of sustainable practises.

New Skills and Green Skills related to renewable energy sector

Interviews with representatives of the renewable energy industry revealed the emergence of **new skills** required for the sector's technological advancement. These include **deeper knowledge of chemical and biological processes** in anaerobic digestion reactors, biogas upgrading, and biomethanol production. Furthermore, **digitalization and its possibilities**, **organizational and social skills**, **cooperation**, **leadership expertise**, and **well-trained blue-collar workers** are considered all critical to the sector's growth as claimed by a Head of Development & Leaderhsip in an energy company. Additionally, **systems thinking** and **multidisciplinary approaches**, **stakeholder management**, and **data analytics and IT skills** are becoming increasingly essential for designing complex energy systems that consider social, environmental, and financial aspects while incorporating all system interactions. Lastly, **project management skills** are necessary to ensure the efficient and timely completion of renewable energy projects, which is aligned to the answers obtained from other stakeholder groups.

Industry experts highlighted the importance of various **green skills** for success in the renewable energy sector, as revealed in interviews. According to respondents, **operation management expertise** is critical for driving changes in organizational structure, implementing lean production methods, and collaborating with external stakeholders. **Effective monitoring and risk management** were also cited as essential skills, involving tracking feedstock material quantity and quality and identifying and mitigating potential hazards in the renewable energy sector. To advance renewable energy projects, a **combination of research and development** with finance is vital. Additionally, interviewees emphasized that professionals in this field must be able to connect technological expertise with business acumen to succeed. Furthermore, a **deep understanding of sustainability and ethical considerations is necessary** to ensure that renewable energy projects align with broader environmental and social objectives. Finally, developing innovative and sustainable solutions in the renewable energy industry also requires expertise in alternative feedstock processing.

Gender (im)balance and skills gap in STEM fields

Five out of six representatives from the industrial sector who participated in the interviews **confirm the gender skills gap at RES / STEM**, as do the representatives from academia and the SME sector. One representative, an R&D&I manager in a Finnish company specializing in RES, refers to the country's longstanding efforts towards gender equality and that the situation in the sector RES is well balanced between men and women. Stakeholders **suggest** the following **measures** to close the gender gap: **Investing in quality education** and **reducing bureaucracy**; the need to **diversify technical curricula** and training to make the energy sector more attractive to all genders; **systemic changes in industry training**, education and practice.

Current state of education/training in RES

Obstacles to Education and Training in RES

The analysis of the interviews with the representatives from the industrial sector revealed an important aspect of the obstacles on the way to RES education: **the role of politics**. One HSE & Facility Manager is quoted as saying, "I believe that politics plays an important role in encouraging or hindering the acquisition of new skills, especially when it comes to strategic sectors such as renewable energy". Political will and political interest need to be aligned to pursue effective, enabling policies. In addition to this interesting aspect of the topic discussed, representatives from the industrial sector mentioned the following obstacles: non-adequate funding to sustain training and retraining programmes; high prices for relevant training; lack of cooperation between industry and training institutions; lack of time; lack of interest or budget for employees to develop beyond their core business; lack of clear development opportunities; limited availability of quality training; lack of flexibility in training programmes and/or work-life balance; lack of easy access to content.

To overcome the above obstacles and achieve the educational goals, industry representatives suggest **continuous learning** and training, **networks**, **peer learning** and **interaction with experts** are recognized as essential components to achieve the educational goals. In addition, **microlearning** through means such as **podcasts** is seen as effective, with minimal cost and flexible and accessible to almost everyone. Industry representatives have recognized that the **industry itself needs to invest more in education and training**, with a focus on engaging professionals and consultants with a strong background in the industry as educators to drive innovation and growth. By investing in training and development, stakeholders can ensure that individuals and organizations stay abreast of the latest developments in the field, improve their skills and knowledge, and foster innovation and growth in the sector. According to industry representatives, these trainings can target the following groups: biogas workers, biogas managers, entrepreneurs, non-specialist technicians, industry professionals and engineering scientists.

Types of stakeholders to provide or receive training

An energy strategy advisor cites examples of universities offering different courses and programmes in the field of renewable energy: "*For example, TU Delft, Leiden University and Wageningen University in general are doing a great job offering different courses and programmes (including online courses and MOOCs)*." Examples of the training material offered include the following: Solar Energy, Sustainable Energy, Technology for Smart and Integrated Energy Systems, Critical Raw Materials: Managing Resources for a Sustainable Future, From Fossil Resources to Biomass. The other stakeholders, while not providing specific examples, provided valuable information on training needs: relevance of industry-oriented content; programmes focusing on biogas plant operations, including cutting-edge technologies and biochemical reactions; training programmes; and influence of social media in the face of labour market polarisation.

Best practices

The interview findings show that the industrial sector pays special emphasis on the continuous education as most of the participants also **listed training and other capacity-building courses related to their professional domain. In particular,** a biogas plant manager received lubrication training from Mobil 1 to address a gap in mechanical engineering skills; an HSE Facility Manager mentioned an in-house training for the HSE Facility, which aimed to explore the latest innovations in the field and acquire working knowledge of them. The value of in-house trainings tailored to the specific needs of the organization, which can be conducted with internal or external service providers, was highlighted as a good practice by other stakeholders too.

Finally, the representatives of the industrial sector stressed that it is important that training offers are attractive in order to draw a larger number of potential trainees. One of the most attractive criteria for selecting an educational programme is the flexibility and accessibility of education and training programmes for sustainable development professionals in terms of time and place RE. The HSE

Facility Manager and a Branch Manager both emphasize the importance of using webinars and e-learning technologies to meet the training needs of target groups while allowing flexibility and accessibility for professionals who have limited time for structured courses.

6.2.3 *SMEs*

Cutting-edge and traditional technological innovations

Interviewees have highlighted several **cutting-edge technological developments** in the RES sector and beyond. Among the upcoming technologies mentioned were **agrivoltaics, printed photovoltaics, building-integrated photovoltaics, floating solar panels**. Additionally, participants mentioned smart grid technology as potential game-changers in the RES sector.

Challenges in Advancing Sustainable and Circular Practices for Renewable Energy Project Development

Financial barriers such as **high and uncertain project development costs**, **high cost of recovered materials and the lack of performance guarantees for reused materials, high capital costs**, **lack of financing**, and **unprofitability** were also mentioned.

Societal barriers such as **NIMBY syndrome**, **lack of public participation and stakeholder engagement**, and **deficiencies in sociological and communicative skills, lack of awareness, knowledge and understanding of circular economy practices** among those promoting or installing renewable energy systems were also identified as significant hurdles.

Finally, environmental barriers such as **resource limitations**, **intermittency and storage**, and **the environmental burden of producing PV panels and batteries** were also highlighted. The interviewees **emphasized the importance of decentralizing electricity production and distribution to bring renewable energy to the local level**.

The **authorization process for renewable energy projects** was identified as particularly difficult and bureaucratic, while in many countries the **lack of a complete legal and regulatory framework** complicates the development of new projects, such as the lack of polluter pays legislation and denial of permits. This lack of a cohesive set of laws and regulations specifically tailored to renewable energy creates uncertainties and ambiguities for project developers. Without clear guidelines and standards, navigating the regulatory landscape becomes a daunting task.

One particular issue arising from the incomplete legal and regulatory framework is the absence of polluter pays legislation. This principle holds that those who cause pollution or environmental damage should bear the costs associated with mitigating or remedying such harm. In the context of renewable energy projects, the absence of polluter pays legislation can lead to inadequate accountability and financial responsibility for environmental impacts, potentially burdening the public or future generations.

Overcoming these barriers according to the representatives of the SME sector requires a holistic approach that includes collaboration across the supply chain, a well-developed advocacy system for policy makers and training for policy makers. Information campaigns and science-based lobbying of policy makers and institutions are also needed. **Regarding the social barriers in particular** concerted efforts required from various stakeholders, including governments, communities, investors and renewable energy developers.

New Skills and Green Skills related to renewable energy sector

During the interviews, participants identified a range of **new skills** that are becoming increasingly important in this sector. Among these skills are communication and participation skills, **basic knowledge of climate science and biology** mainly at the stage of research and development, **conflict management**, and **data management skill** set. **Technical skills in advanced materials**, such as energy storage systems, and skills in areas like battery technology, energy management systems, and grid integration were also mentioned as essential for success in the renewable energy industry. Interviewees also stressed the importance of **analytical skills**, **critical thinking**, and **skills in Internet of Things (IoT)**, such as machine learning, artificial intelligence, cloud computing, programming languages, and data management. Furthermore, **soft skills** such as communication, leadership, and management were identified as crucial for individuals and organizations operating in the renewable energy industry.

Interviews also revealed that **green skills** are critical to success in the industry. These skills include **knowledge of urbanistic and legal frameworks, expertise in efficiency and management of energetic systems**, **financial analysis**, **research skills**, **energy management**, **quantification**, and **monitoring**. **Environmental impact assessment**, **material use and impact quantification,** and **risk management** are also essential skills for renewable energy professionals. **Technical skills** related to installation, operation, and maintenance of renewable energy systems, ecosystem management, environmental policy, and sustainable development are also considered green skills. These skills contribute to corporate social responsibility and promote circular design and material recycling. Finally, **safety and risk management skills are crucial** for ensuring the safety of workers and protecting the environment from potential risks associated with renewable energy projects.

Gender (im)balance and skills gap in STEM fields

The analysis of the responses of the representatives of the SME sector has shown that the opinion of this stakeholder group is in line with that of the academic community: **It is clear that the gender gap in STEM is a comprehensive problem that encompasses many cultural areas in Europe and that women are underrepresented, underpaid and undervalued in the labour market.** The SME representatives added that the gender gap is not only observed in technical fields but also in non-technical fields, which was also suggested by the academic community. Another interesting aspect regarding the green gender gap is related to the COVID -19 pandemic: a high-level executive at a company specializing in energy storage solutions powered by AI and smart energy management systems cited the Global Gender Gap Report 2022 as indicating that **the pandemic has widened the gender gap.**[64]

In addition, experts point out that while **women are** interested and active in green jobs, they are **in the minority in the purely technical sector and in leadership positions**. Women may face barriers in accessing human resource development and training programmes for green jobs, such as **lack of access to education and training opportunities or lack of flexibility to balance work and family commitments**. An interesting aspect of stereotypes and prejudices in the STEM sector has to do with **language**. The head of the technical department of a non-governmental organization responsible for developing innovative projects says: "*Language should be revised and adapted (at least in some languages);* ***language can influence the way we think***." In order to reduce the gap mentioned above, SME stakeholders made the following **suggestions**: targeted training; better

[64] Further data from the UNESCO Institute of Statistics shows that less than 30% of researchers worldwide are women and only a fraction of female students choose STEM -related subjects in higher education. Moreover, women are less likely to enter or leave the workforce than men STEM.

schooling from an early age; higher qualifications; reducing stereotypes; continuing the example of prominent female figures in all sectors; language should also be revised and adapted as it can shape the way we think; linking school and professional competitions to reduce the gender gap.

Current state of education/training in RES

Obstacles to Education and Training in RES

One common obstacle to the successful education pathway in RES is **the lack of a specific training offer** that is transversal and synergistic, meaning training programs that cover a broad range of topics and are designed to work together. The **cost of training,** as suggested also by the group of the stakeholders from the academic community, is also an issue, as some programs may be too expensive for individuals or organizations to participate in particularly in low-income areas. Additionally, some stakeholders may not be aware of the importance of sustainable and circular practices in the RE sector, which can limit investment in training and education. Another common barrier identified is a **lack of cooperation**, both between industry and academia and across the entire supply chain. **This lack of cooperation can lead to a shortage of professionals in the field, as well as a lack of awareness and capacities. Digital skills and logistics** are also highlighted as areas where there is a need for improvement. Finally, some experts point to more specific challenges such as **linguistic skills and training programs that are not family-friendly**.

Types of stakeholders to provide or receive training

SME representatives identified a variety of s**takeholders who can serve as educators in education/training programmes at RES**: educators with deep knowledge in energy communities; energy companies and utilities; renewable energy scientists, technicians and industry experts; academics and NGOs; industry and NGOs providing green finance expertise; industry and technology providers offering training on green IT skills, quantification and monitoring, and the use of AI and machine learning; and NGOs representing specific RES sectors. An important point raised is once again **the need for collaboration between these actors** to ensure a comprehensive and rounded approach to renewable energy training. High quality education and training can produce a skilled and competent workforce that can drive the transition to a sustainable future.

On the other hand, interviews from the SMEs highlighted various **recipients of training** in the renewable energy sector who can benefit from learning about new technologies and practices: **Municipalities** can participate in training programs to gain knowledge on integrating renewable energy systems into their infrastructure and operations; **Farmers** and **agricultural workers** can benefit from training on agrovoltaics and how to incorporate renewable energy systems into their farming operations; **Manufacturers** and **suppliers** can participate in training programs to learn about new technologies and practices in the renewable energy sector, and can also provide training to their employees; **Energy companies and utilities** can also participate in training programs to expand their knowledge of renewable energy systems and provide training to their employees; **Educational institutions**, such as universities and technical schools, can provide training and education on renewable energy systems to their students and professionals seeking to expand their knowledge; **Students**, including those pursuing a master's or PhD degree, as well as **NGOs**, **policy makers/public administration, SMEs, and citizens** interested in adopting the respective RES technology can also benefit from these training programs.

An important issue raised by a person working in a social cooperative specializing in RES relates to **stakeholders' lagging behind in accessing RES education and training programmes**. As an interesting example, the case of staff lacking technical know-how and therefore unable to control/supervise such units in the communities that manage electric lighting and generally large facilities (e.g. drinking water treatment and supply units and waste treatment plants) with high energy consumption was mentioned.

Best practices

The analysis of the obstacles to training on RES and the actors who could be trainers and trainees was complemented by **references to good practices and programmes** in the field concerned, which are as follows: Circular Energy Storage program; Solar Energy International's Renewable Energy for the Developing World program; the Green Circular Academy 2023, which aims to provide training and education on renewable energy systems; DIDACTA in Germany, which has been promoting sustainable education and training for around 50 years; CYRKL , a marketplace where you can sell or buy industrial waste, by-products, secondary raw materials or used materials; Design, Installation, and Operations Course, which provides training on agrovoltaic systems to managers of departments.[65] Finally, the SME representatives stressed the importance of continuous education and training, with the person working in the social cooperative citing participation in technical seminars, licencing seminars and gender equity workshops as an example, while also acting as a trainer on topics such as legal aspects and marketing with a focus on energy communities.

As mentioned by the SME sector representatives, **it is also important that the programmes are attractive to the participants in their professional environment so that they can keep up with technological advances and participate in the training/education programmes**. An expert on solar energy points out the **importance of the government addressing issues such as energy community management and business models for energy communities**, to give an example. A staff member of a non-governmental organization stresses the **need for transversal and contextual skills** to develop a holistic understanding of project development in areas such as solar energy and the fight against climate change. An expert in energy storage solutions stresses the importance of **skilled training, creative ideas, different methods of knowledge presentation, interactive learning experiences, continuous marketing, inclusive training design and encouraging interaction between participants to make the programme attractive.**

6.2.4 *Energy authorities and associations*

Cutting-edge and traditional technological innovations

Interviews with stakeholders from the renewable energy authorities and associations community revealed several cutting-edge technological developments in the sector. **Digitalization and the use of digital tools** to enhance the efficiency and management of renewable energy systems, as well as the **development of new digital technologies**, were identified as crucial areas of innovation. In addition to digitalization, various technological developments were identified in different renewable energy sectors. For instance, **smart materials and nanostructured materials in renewable energy systems** were highlighted in the materials sector. For solar energy, **printed photovoltaics, building-integrated photovoltaics, and agrivoltaics** were seen as particularly promising.

Challenges in Advancing Sustainable and Circular Practices for Renewable Energy Project Development

[65] This three-month course covers topics such as solar panel installation, crop selection and management, and system optimization for maximum energy and crop yield.

According to interviewees from energy authorities and associations **high investment costs**, **lack of financial resources and support schemes** that vary substantially across EU member states and at regional levels hinder the growth of renewable energy. Social barriers including safety and reliability concerns, **false assumptions**, and **aesthetic - visibility issues** have been identified.

Representatives of energy agencies and associations point to the challenges facing the renewable energy sector in adopting more sustainable and circular practises. Against this backdrop, a senior labour market advisor has proposed **promoting business expertise in renewable energy and sustainability, increasing uptake through corporate social responsibility campaigns, updating the knowledge of decision-makers on renewable energy, and giving more attention to the skills needed for the green transition in the education system.**

However, another representative points to a **significant gap between the requirements of the energy transition and the outdated educational provision.** Many current education programmes do not meet the needs of the renewable energy sector, which poses a major challenge to the growth and sustainability of the sector. To close this gap, **concerted action is needed to update education programmes to better match the needs of the industry and equip graduates with the skills required for the green transition.**

New Skills and Green Skills related to renewable energy sector

Stakeholders from the renewable energy authorities and associations community have identified several **new skills** that are critical for the renewable energy sector's growth. The industry requires a mix of technical and business skills, including **advanced engineering skills in chemical, mechanical, or material science**. **Digital skills and data analytic skills** are also claimed to be essential, given the increasing use of digital technologies and the need for advanced data analysis to optimize renewable energy systems. Soft skills such as **project management**, **interaction**, and **continuous learning capabilities** were also identified as crucial. Additionally, a senior advisor claimed that there is a **shortage of skilled craftsmen who can install, maintain, and repair increasingly complex renewable energy technologies**.

Interviewees have also emphasized the importance of **green skills** for success in the renewable energy sector. For example, **comprehensive knowledge of renewable energy systems** at both macro and micro levels has been identified as crucial skill. This includes **knowledge of various renewable energy technologies, their strengths and weaknesses**, and how they can be integrated into the wider energy landscape. **Manufacturing, installation**, **operation**, and **maintenance** of renewable energy systems require a range of technical knowledge and specialized expertise, as was highlighted by a bioenergy specialist. The interviewees also emphasized the significance of other green skills such as **certification and standards** in ensuring the safe and effective installation and operation of renewable energy systems while minimizing environmental impact. In addition, **environmental impact assessment** was identified as another crucial green skill needed to evaluate and mitigate potential environmental impacts resulting from renewable energy projects.

Gender (im)balance and skills gap in STEM fields

According to the opinions of the representatives from the Energy authorities and associations there is a gender skills gap in STEM, but research shows[66] that emphasising green values and

[66] IRENA (2019), Renewable Energy: A Gender Perspective. IRENA, Abu Dhabi.

sustainability in renewable energy can help reduce this gap. While interest and skills in STEM are not necessarily linked to gender, the same research shows that people who are more interested in sustainability are also more likely to be interested in renewable energy. **Therefore, highlighting the environmental benefits of renewable energy could encourage a more diverse group of people, regardless of gender, to pursue careers in the field.**

Current state of education/training in RES

Obstacles to Education and Training in RES

Barriers to acquiring new skills in sustainable and circular development identified by this stakeholder group discussed RE include the **importance of public funding at all levels of training/education practise, problems with personal motivation for lifelong learning and the need to recognise one's own competences**. The **types of stakeholders that could participate as trainers or recipients in RES training/education** programmes include the energy industry association, the energy industry, policy makers, industry/business and citizens.

Types of stakeholders to provide or receive training

Stakeholders from energy agencies and associations expressed the need to **integrate circular economy and sustainability principles** into renewable energy education and training as an important step in promoting more sustainable and equitable forms of energy. Although no specific best practises and education/training programmes were mentioned, there was consensus among stakeholders that subscription training for specific needs, cooperation with educational institutions and special seminars could be effective strategies to integrate these principles into existing programmes. In the highly regulated bioenergy sector, stakeholders recognise the importance of strict sustainability guidelines, but also acknowledge that social justice can be a challenge in the transition from traditional to modern forms of energy. In order to successfully train and educate sustainable development professionals in the renewable energy sector, it is crucial to design the programme in a flexible way that appeals to participants from different professional contexts.

Best practices

For the future, stakeholders see the industrial sector and bioenergy as potential areas for recruiting professionals. By emphasising the importance of sustainability and circular economy principles in these sectors and promoting flexible and innovative training programmes, stakeholders believe the renewable energy sector can continue to grow and adapt to changing needs while supporting a more equitable and sustainable future.

6.2.5 *Policy makers*

Cutting-edge and traditional technological innovations

The policy makers' interviews revealed several technological advancements in the renewable energy (RE) sector, including **advanced materials** and **green hydrogen**. Advanced materials are emerging technologies in the RE sector, while green hydrogen is a well-established technology for electricity storage and hydrogen production by electrolysis.

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High and uncertain project development costs and a **lack of alternative finance** to financial institutions were noted as financial barriers.

Social barriers, including a **lack of awareness and education** about renewable energy sources and their benefits were also identified.

Environmental barriers were also claimed to be significant, including **land use conflicts**, **negative impacts on wildlife and habitats**, and **emissions and pollution** associated with renewable energy production.

Regulatory barriers, such as **lack of long-term planning**, **incomplete and opaque legal and regulatory frameworks**, **uncertain and unpredictable legislation**, and **incompatible regulations**, as well as the **lack of experienced professionals** in the authorization offices, were also distinguished as significant barriers.

To address these concerns, one policymaker suggests **implementing education initiatives on the circular economy and building capacity at all levels, from kindergarten to higher education and vocational training**. In addition, one politician suggests transposing the EU Sustainable and Circular Technologies Directive RE into national law, possibly complemented by incentives such as tax breaks for companies. However, the biggest challenge in introducing sustainable and circular products is the financial aspect, where demand and pricing are often compared to other benefits, such as environmental sustainability.

New Skills and Green Skills related to renewable energy sector

Stakeholder interviews have revealed that the renewable energy sector requires a range of **new skills** to keep up with technological advancements and changing needs. The critical areas include **advanced materials skills**, battery technology, energy management systems, **smart grid technology skills**, **data analysis**, and **visualization skills**. Other areas requiring new skills include **project development**, **maintenance and operations**, and soft skills like **analytical skills**, **critical thinking**, **communication and participation skills**, **sociology**, and **conflicts management**. Thus, a range of technical and soft skills will be essential to support the growth and development of the renewable energy sector in the coming years.

Regarding **green skills** linked to the renewable energy sector, respondents from the renewable energy policy makers community noted several key areas of knowledge and expertise. These include **green procurement knowledge and skills**, **management systems related to installation**, **operation, and maintenance of renewable energy systems**, **knowledge and skills related to material use** and **impact quantification**, **risk management**, **legal expertise in environmental law**, and **knowledge of circular design and material recycling**.

Gender (im)balance and skills gap in STEM fields

Policy makers suggest that the energy transition is inevitable and will create thousands of jobs in various sectors, mostly in STEM, in which women are historically underrepresented. One person focused precisely on the case of Slovakia, where there is a significant gender gap in the ICT sector: only 15% of ICT graduates and 13% of ICT specialists are women. Even in the high-tech sectors, only 17% of scientists and engineers aged 25-64 are female. While some offices, such as the Slovak Innovation and Energy Agency (SIEA), employ more women than men, others, such as the Regulatory Office for Network Industries (ÚRSO/RONI), are predominantly male. In managerial positions, where leadership skills are valued more highly than technical expertise, women are more likely to be found in middle management.[67]

Current state of education/training in RES

Obstacles to Education and Training in RES

The policy makers discuss the barriers to adopt **new skills** in renewable energy development. An environmental expert highlights a lack of relevant training, awareness, and supportive legislation as major challenges. Resistance to change is also noted as a potential hurdle. On the other hand, another policy maker identifies several barriers, including limited access to education and training, high costs, technological challenges, lack of cross-sectorial knowledge, work force shortage, inadequate vocational and/or professional training, and insufficient legislation in some green areas. Both emphasize the importance of promoting continuous education and raising awareness of the benefits of sustainable and circular practices in the renewable energy sector, as well as the need for flexible training programs and supportive policies to overcome these barriers.

Types of stakeholders to provide or receive training

A wide range of individuals and organizations **can serve as trainers** in the field of renewable energy sources, as mentioned by the policy makers. These can include **industry professionals, civil society groups, technology providers, public bodies, NGOs representing specific RES sectors, administrative staff, and policy makers**. **As for the recipients of training**, anyone who is willing to learn and adopt new RES technologies, such as citizens or public administration officials from authorisation offices, can benefit from such training. Administrative staff can also participate in training to gain knowledge and skills related to RES. Additionally, some individuals and organizations may serve as both trainers and recipients, such as civil society groups that both provide training and receive training from others. **Overall, the diversity of potential trainers and recipients in the field of RES allows for a broad range of knowledge sharing and collaboration.**

However**, some stakeholders may lag behind** in gaining access to these programs. For example, according to environmental expert that took part in the interview process, **policy makers and citizens/civil society groups may not have adequate access to RES educational and training programs, which can hinder their ability to contribute meaningfully to the sector**. Similarly, project managers in RES may identify civil society, especially citizens, as lagging behind in accessing relevant training programs. Additionally, authorisation offices may face challenges in interlinking theoretical knowledge with practical applications and field visits. Addressing these gaps in access to educational and training programs is crucial to ensuring a more inclusive and sustainable transition to renewable energy sources.

Best practices

Training and capacity-building courses are crucial for professionals in various domains to keep up with new developments and technologies in their field. Environmental expert emphasizes the importance of continuous education in the topic but may not have taken specific courses. For instance, the Slovak Association of Photovoltaic Industry and RES offers a training program for renewable energy installers, covering topics like photovoltaic and photothermal system installations under the Green Households project. By attending such courses, professionals in the renewable energy industry can enhance their skills and knowledge, enabling them to better contribute to the sector's growth and development.

[67] Some interesting information may be found following this link: https://www.globalwps.org/data/SVK/files/Gender%20Equality%20Index%202020.pdf.

6.2.6 *Civil Society: Climate & Energy NGOs, General Public*

In our analysis, we categorized the climate & energy NGO stakeholder group and the general public stakeholder group as "civil society." This classification was based on the fact that despite these two groups are significant in the renewable energy sector, their responses did not provide any additional or noteworthy information compared to those from other stakeholder groups. However, it is still essential to pay attention their responses as it enables us to cross-examine their perspectives with those of the other targeted groups involved in the interviews phase.

Cutting-edge and traditional technological innovations

Based on interviews conducted with civil society, the interviewees have identified a range of **promising technologies** with potential to enhance renewable energy systems, such as **nanomaterials** and **perovskite photovoltaics**. The interviewees assert that several technologies possess the capability to enhance efficiency and reduce costs. Innovations like **taller wind turbine towers** and **bladeless wind turbines** can capture more wind energy with minimal impact on bird populations, ensuring that new technologies harmonize with the natural environment. Another way to get the most out of RES, and in particular of solar energy in the built environment, were claimed to be photovoltaic windows and roof tiles. A Strategic Planning and Communication Advisor also highlighted the importance of advanced batteries and long-term energy storage methods to address the volatility of renewable energy sources such as solar and wind. However, as most of the experts point out, some of the above technologies are not yet affordable and accessible enough and therefore cannot be fully integrated and used. Additionally, traditional technologies such as **biomass conversion and combustion processes** are seeing significant improvements, leading to greater efficiency and cost-effectiveness as was stated by an Energy Community member from general public. The interviewees also mentioned technological advancements in the traditional sector, including **hydrogen electrolyzers** for hydrogen gas production and innovations related to expanding transmission capacity.

Challenges in Advancing Sustainable and Circular Practices for Renewable Energy Project Development

Stakeholders from NGOs have identified several **social barriers** to RE project sustainable development. These include a **lack of awareness and understanding** of renewable energy sources, a **lack of interest** in STEM education, and a **shortage of professionals with the necessary soft skills**. Participants from general public were also aligned with this statement.

The interviewees from civil society also highlighted the **need for further research and development** to bring these technologies to a more environmental friendly scale and make them more widely accessible.

Interviews participants noted that regulatory barriers, such as **changing incentives**, and **heavy regulatory requirements**, also pose significant challenges.

New Skills and Green Skills related to renewable energy sector

Stakeholders from civil society in the renewable energy sector have identified **essential skills** required for developing renewable energy projects. These skills include **data management**, **analytical, critical thinking**, **technical expertise**, **innovation**, and **interdisciplinary knowledge**.

Additionally, **business acumen and the ability to integrate different skills** are crucial for managing projects and organizations effectively according to interviewees from general public. **Understanding start-ups** was also highlighted as bringing valuable experience to the field.

In terms of **green skills** needed for the renewable energy sector, stakeholders emphasized the importance of **monitoring**, **quantification**, and **measurement of renewable energy systems**, as well as **knowledge of sustainable material use** and **energetic systems' efficiency**. Crucial skills include **financial analysis**, **fund and investment research**, and **risk management**, *quality control and monitoring*, **impact assessment**, **quantification and monitoring of waste, energy, and water,** and **waste, energy, and water management systems**. **Procurement and selection of materials**, along with the ability to quantify their impact, were also seen as necessary skills. The development and implementation of renewable energy systems require a diverse range of skills, including **technical expertise**, **financial analysis**, and **environmental impact assessment**. Furthermore, stakeholders from the general public identified effective **management of feedstock**, **logistics for biomass transfer**, **communication of the advantages of renewable energy**, **cooperation with industrial stakeholders**, and **research and development skills** associated with the financial aspects of the sector as green skills of key-importance.

Gender (im)balance and skills gap in STEM fields

All representatives from civil society acknowledge the existence of a gender gap in green jobs, **particularly in technical positions and STEM education**. A strategic planning and communications consultant referred to an OECD study[68] which showed that 17% of jobs were classified as green jobs, with a gender distribution of 72% men and 28% women. On the other hand, one campaigner with a specialization in decarbonise heat supply suggests that there should be no distinction between RES experts, energy specialists, professionals, whether male or female, because of the general lack of them (high demand and no supply). Although he agrees that there is a gender gap, be it in skills or positions - women are underrepresented on STEM.

In order to eliminate gender differences in STEM, **it is important to start at primary school**, as the campaigner from Slovakia notes. In this country, children and their guardians have access to educational counselling that addresses their personal, educational, vocational and social needs and also provides career guidance. The campaigner suggests that **educational counsellors should be trained to identify current market needs, including green skills and positions, and refer children, regardless of gender**, to study science and to secondary vocational schools that teach subjects related to renewable energy systems (RES).

In addition, representatives of non-governmental organizations propose other measures, such as **promoting vocational education and training, advising students and producing videos on dual training**. A manager of a company specialized in green chemistry based in Italy suggests that a **cultural change is needed to increase respect towards people in general, regardless of their gender**.

Current state of education/training in RES

Identified obstacles

One of the main barriers to promoting more sustainable and circular practices in renewable energy development is the **lack of cooperation and communication among stakeholders**, including

[68] https://www.oecd.org/employment/action-on-jobs-skills-and-regional-disparities-vital-for-the-green-transition.htm

industry, academia, public bodies, and even companies themselves. **Financial challenges** such as high education costs and the price of cutting-edge RE advances are also significant obstacles. It is crucial to consider **social equity**, **environmental protection, and economic viability** when promoting and implementing sustainable practices in renewable energy development.

Types of stakeholders

NGO Representatives have identified a diverse group of stakeholders who may serve as trainers, recipients of training or both for educational programmes on renewable energy and sustainability. Trainers include academics, industry, policy makers/energy agencies, certification bodies, specialized RES NGOs, circular economy NGOs, innovators/promoters/communication and participation experts, and enlightened policy makers. These trainers can provide training to a wide range of beneficiaries, including policy makers/administrators, citizens, academics, SMEs, NGOs, students (university, masters, PhD), farmers, high-level policy makers, PA officials and managers, all those working in industry, supply chain actors, business consultants, and manufacturers and installers. **Some stakeholders can serve as both trainers and recipients of training**, such as SMEs/industry/technology providers, civil society, and public administration officers responsible for permitting and licensing processes/authorization offices. **The exchange of knowledge and expertise among these diverse stakeholders is crucial to advancing renewable energy and sustainability practices and achieving a more sustainable future.** Participants from general public were also in agreement with this statement.

Despite the efforts to provide education and training on renewable energy and sustainability, there are still some stakeholders who are left behind, as mentioned by the NGO representatives. **Public administration** is one such group, as courses are rarely organized, and technological advances are too fast for them to keep up with. Similarly, **policy makers** may struggle to keep up with technological advances and may lack the necessary skills to make informed decisions about renewable energy and sustainability policies.

Best practices

Stakeholders, both from NGOs and general public, provided a list of the following good practices: an environmental education center in the Czech Republic that operates almost entirely on renewable energy sources, thanks to intelligent building renovation and a combination of commercial and non-commercial activities; Fiusis, an awarded biocircular economy installation in **CALIMERA**, and Leona, a sustainable agriculture company in Codigoro; training in circular economy-related topics such as the Circular Academy, green public procurement, subsidy schemes, best practices for sustainability education, the **Banska Bystrica Sustainability Strategy, SAŽP, and SIEA**.

7. Conclusions

This report focuses on identifying key actors in the quadruple helix, exploring the integration of circular economy and sustainability principles into education and training, and identifying current education and training needs. By combining secondary research with interview findings, our analysis confirms the need for new and green skills in the renewable energy sector. Additionally, the barriers that hinder the uptake of renewable energy projects are reflected.

Overall, the report identifies key areas for future development and improvement of education/training in the renewable energy sector. The main conclusions are summarized below:

Cutting-edge technological advances

A variety of technological advancements in the renewable energy sector have been identified. In **solar energy**, significant progress has been made with the development of innovative solutions like agrivoltaics, "Insolight" panel coating, and photocatalytic artificial leaves, as well as the use of heterojunction technologies, floating solar farms, building-integrated PVs, perovskite SCs, and organic photovoltaics. Meanwhile, **wind energy** has also seen remarkable development through the implementation of airborne wind energy systems (AWES), freshwater mill-wind turbines, flying wind turbines, air edges, Balmoral FiberFlexTM, EnergyPods, Marinecrete Mattresses (Marinematts), the Ogab Sustainable Braking System, air boards to mitigate atmospheric effects, and modular hydropower. The **bioenergy** sector has also made significant progress in biomass direct-combustion processes, biomass co-combustion processes, thermochemical conversion of biomass, and biomethane and biomethanol production. In the **hydrogen sector**, advancements in water electrolysis, thermolysis, and thermochemical water splitting, photonic processes, biomass treatment, and hydrocarbons reforming technology have been seen. Further advancements in **hydro and ocean power** have also been observed through the use of marine and hydrokinetic (MHK) technology, turbines, and modular hydropower. These technological advancements have the potential to **revolutionize energy production and consumption, and it is clear that the renewable energy sector is rapidly evolving**.

Challenges in Advancing Sustainable and Circular Practices for RE Project Development

The proliferation of renewable energy initiatives is obstructed by an array of hurdles, including those of a financial, environmental, social, and regulatory nature. The **financial roadblocks** can be attributed to the steep costs associated with launching these projects, as well as the shortage of funding available to support them. **Social impediments**, on the other hand, stem from insufficient understanding of the benefits renewable energy brings and the "not in my backyard" (NIMBY) mentality. **Regulatory barriers** include the lack of a comprehensive legal framework, convoluted regulations, and bureaucratic hurdles. Furthermore, **ecological limitations** pose yet another set of challenges, such as the availability of resources and materials, biodiversity concerns, and the ecological costs of manufacturing PV panels and batteries. In addition, unfavourable public and political attitudes towards renewable energy, insufficient trained professionals to execute requisite technologies, and the influence of political agendas on investment and funding exacerbate the problem.

New Skills and Green Skills related to renewable sector

The renewable energy industry is in a constant state of flux, and as a result, the **requisite skills needed to keep up with the sector's technological advancements are ever-changing**. Our interviews with a diverse array of stakeholders, encompassing scientific communities, SMEs, NGOs, energy authorities, policy makers, and the general public, have highlighted a number of **critical**

skills. To excel in the renewable energy sector, professionals must possess **cross-disciplinary knowledge that encompasses a range of technical abilities**, specific to the energy sector in which they work. For example, in the solar energy sector, professionals must have expertise in managing electro-chemical systems and understanding electricity markets. Additionally, in the bioenergy sector, expertise in biogas upgrading and biomethanol production are essential. **Soft skills**, such as communication, leadership, conflict management, stakeholder management, project management, and business acumen, are equally indispensable. Given the breakneck pace of innovation in this field, these new skills are imperative for success in the renewable energy industry in the years to come.

This flourishing sector necessitates also an array of proficient **green skills**. Professionals working in this field must exhibit technical prowess, possess knowledge of regulatory frameworks, and exhibit effective interpersonal skills. Key competencies include operational management, monitoring, risk management, financial analysis, and environmental impact assessment. Proficiencies related to the technical aspects of renewable energy systems such as installation, operation, and maintenance, ecosystem management, environmental policy, and sustainable development are also recognized as green skills. Moreover, understanding green procurement, material utilization, impact quantification, circular design and material recycling, and legal expertise in environmental law are crucial for achieving success in the renewable energy sector. Effective communication and collaboration with diverse groups is also pivotal in promoting the widespread adoption of renewable energy technologies.

Gender skills gap

The stakeholder interviews revealed that despite the efforts and improvements made to address the gender gap, almost all stakeholders agree that there is still a gender skills gap in the RES / STEM sector. In some countries, such as Slovakia, there is a significant gender gap in the ICT and high-tech sectors, with a very low proportion of women among ICT graduates, ICT specialists and scientists and engineers in the high-tech sector. In other countries, such as Finland, where there is a long-standing commitment to gender equality, there is no gender skills gap in this area, as supported by the representatives of the country who participated in the interview process.

Overall, women are more likely to be found in middle management positions, where management skills are favoured over technical expertise. An important conclusion is that the underrepresentation of women in STEM begins in primary school, where, **due to societal prejudices and stereotypes, they are not encouraged to pursue STEM careers and are instead more likely to be considered for other positions, such as teachers**. To close the gender gap STEM, promoting STEM education at all levels and targeted training, including highlighting successful women in the renewable energy sector, is a step in the right direction. Several companies such as Vestas, Northvolt and Volkswagen have taken positive steps to achieve greater inclusion in their recruitment and training practises, taking into account different identities beyond gender. **By continuing to prioritise inclusion in education and training, we can ensure that a more diverse and talented workforce is equipped to transition to a sustainable energy future.**

Sustainability and circularity by design in RE education/training: identified barriers, best practices, stakeholders involved

All stakeholders involved in the interviews process agree that renewable energy has an increasingly important role to the transition to a more sustainable future. **To ensure that the workforce is equipped with the necessary skills and knowledge to facilitate this transition, renewable energy education and training programmes (RES) are essential.** However, the introduction of renewable energy education programmes is not without challenges. The most common barriers mentioned by almost all stakeholders are: lack of cooperation between different types of stakeholders, financial barriers, lack of awareness and education about sustainable and circular practises, lack of leadership from policy makers and long-term commitment to sustainability, and lack of transparency. As mentioned above, the gender gap is also an important challenge for the RES labour market in Europe.

Our desk research and interviews revealed effective practices that show the possibility of overcoming the above-mentioned obstacles. A common theme highlighted by several stakeholders is the **importance of involving more interested stakeholders in the curriculum design process**. An excellent example of this is the collaboration between Mexican municipalities and Vestas, which offers a two-year graduate programme in partnership with municipalities and has implemented innovative programmes in Tamaulipas, Mexico. Another example of a partnership between municipalities and industry is the sustainable battery manufacturing training programmes run by Northvolt and Swedish municipalities. Another good example is Brunel and Volkswagen's collaboration with the academic sector to train workers for the transition from the oil and gas sector to the hydrogen sector. In conclusion, it is clear that overcoming barriers to STEM education and career opportunities requires collaboration between various stakeholders, including among other industry, academia, and government entities. The aforementioned examples of successful collaborations demonstrate the positive impact of involving all stakeholders in the curriculum design process and promoting sustainability principles. ***By replicating and building upon successful models, it is possible to increase the representation of underrepresented groups, such as women and minorities, in STEM fields and ensure a more diverse and inclusive future workforce.***

Despite the lack of political will in some countries, as mentioned by several stakeholders, **there are encouraging examples of governments taking action to promote and support the clean energy transition.** The efforts of the Greek and Spanish governments show that they are committed to a just and fair transition for workers in coal-dependent regions. Through training and retraining programmes, green jobs training and comprehensive support services, affected workers are provided with personalised learning pathways to help them transition to sustainable careers. ***It is imperative that more governments prioritise education and training for the clean energy sector to ensure a smooth transition to a sustainable future for all.*** The examples of the Greek and Spanish governments give hope that political will can be mobilised to help workers make the transition to sustainable careers. ***By prioritising green vocational training and personalised learning pathways, these governments are demonstrating their commitment to a just and equitable transition. It is important that more countries follow their lead and prioritise education and training to facilitate the transition to a sustainable future.***

Financial constraints, inflexible programmes and the associated time and cost barriers have traditionally hindered access to education and training in sustainable energy, according to stakeholder representatives. However, there are promising examples of EU-funded programmes that provide accessible information and training opportunities to interested individuals. For example, the Knowledge Hub provides information on heat pump systems through the EU co-founded HP4ALL project.

The transition to clean energy requires the **participation and engagement of various stakeholders, from researchers and academics, government, local municipalities, policy makers, NGOs and social cooperatives, to households and the general public**. As highlighted in this report**, education plays a critical role in ensuring that all stakeholders are equipped with the knowledge and skills they need to contribute to the transition**. While the best practises mentioned are not a panacea, they show that positive steps have already been taken towards a sustainable energy future. **By building on these practices and continuing to prioritise education**

and training, we can ensure that the transition to clean energy is equitable, inclusive and successful.

In summary, promoting sustainable practices and the circular economy requires the cooperation and political support of all stakeholders. Education and training programmes in the renewable energy sector are particularly important to equip the workforce with the necessary skills and knowledge to transition to a more sustainable future. By investing in continuous learning and development, stakeholders can acquire new skills, keep up with the latest innovations and fill knowledge or skills gaps in different areas. This will enable all stakeholders to build a more skilled and knowledgeable workforce capable of meeting the challenges of the clean energy transition and ensuring a sustainable future for generations to come.

This information is vital for SKILLBILL to effectively focus and adjust their upcoming actions, such as the Stakeholder Joint Initiative, EU Specialization Program, and VET Program. The results of the analysis can play a significant role in identifying what information needs to be communicated to raise awareness and increase the interest of all stakeholders. This includes taking into account the latest technological advancements, the new skills required in the renewable energy sector, and the best practices for integrating circularity-by-design and sustainability principles into renewable energy education and training.

Annexes

Annex I. Stakeholder mapping template

Table 8. Stakeholder mapping template

	Drop down menu	*Please fill in*	*Drop down menu (if menu list appears blank, please scroll up)*	*Drop down menu (if menu list appears blank, please scroll up)*	*Please fill in*	*Drop down menu*	*Drop down menu*	*Please fill in*	*Please fill in*	*Please fill in (Name, role, email or other contact informaton)*	*If necessary, provide any additional comment*
No.	**SKILLBILL Partner name**	**Stakeholder name**	**Stakeholder group**	**Stakeholder subgroup**	**Potentially related expertise** (if applicable)	**Influence**	**Impact**	**Channel of communication**	**Stakeholder's Contribution**	**Contact**	**Comments**

NOTE: Each SKILLBILL partner should first give the name of their organisation. For each identified stakeholder, partners should list its name, place it in one of the predefined stakeholder groups and indicate any relevant subgroups. If the stakeholder has relevant expertise, partners should also note this. Partners were also asked to rate the level of influence** and impact** of the stakeholder within the project. In addition, partners were asked to indicate the communication channel through which they had engaged with each stakeholder and to describe their contribution to the project. Finally, partners were asked to provide any additional comments they felt were relevant to the report.

** **Influence** is the capacity of each stakeholder group to affect the achievement of our project's results. Please rate low - very high (drop down menu)

** **Impact** refers to the effect the project has on each specific group of stakeholders. Please rate low - very high (drop down menu)

Annex II. Interviews' Guidelines

Introduction

This task aims to collect, synthesise and deliver the knowledge required to inform the stakeholder-driven design of the stakeholder joint initiative (WP2) as well as of the education and training programmes (WP4 and WP5). Following a targeted desk study by WR, 30 semi-structured interviews will be conducted by each consortium partner in accordance with the guidelines and the material provided by WR.

Synthesizing the data collected from the desk-research and the interviews, a report will be delivered by WR (D2.1), including:

- The results of the stakeholder mapping to facilitate the development of SKILLBILL's programmes for higher education (WP4) and Vocational Education and Training (WP5);
- The desk research findings to map the stakeholder community, along with the key-groups across the quadruple helix, and to identify RES technological advances, skills needs as well as RES education / training best practices;
- The results of the 32 semi-structured interviews.

In accordance with the above description, **each partner is in charge of carrying out 3 interviews**, **based on a semi-structured questionnaire, which is designed, developed and distributed to partners by WR.** The aim of this interview-based analysis is to enquire more about cutting-edge technological advances, the potential of them creating the need for new skills and the current best practices for integrating 'circularity-by-design' and sustainability principles in RES education and training.

Interview methodology

The methodology applied for investigating novel technologies, skill needs and current skilling practices, is comprised in following paragraphs:

2.1. Interview and Sampling Methodology;

2.2. Participant target groups;

2.3. Interview Questionnaires Overview;

2.4. Procedure to be followed.

The following sections provide a comprehensive description of each one of the elements embodied in the methodology applied.

Target groups

The targeted stakeholders for the SKILLBILL interviews are divided into the four categories based on the basis of the Quadruple Helix:

- **Category 1:** Industry (e.g. planners, renewable energy systems engineers, technicians, technology providers, energy industry standardization internal / external auditors, manufacturers and installers etc.),
- **Category 2**: Science and academia (e.g. educational staff, administrative staff, researchers, scientists etc.)
- **Category 3:** Government & public sector (e.g. experts on international climate, environment and energy affairs, experts on energy legal affairs, experts on green finance and sustainable economy, crisis managers and energy officers etc.)

- **Category 4**: Civil society (e.g. non-governmental organisations, consumer associations, communication managers/officers, Renewable Energy Communities-RECs, Citizen Energy Communities-CECs or Renewable Energy Cooperatives-RESCoops etc.)

❖ **The consortium partners have agreed on 3 interviewees per partner, hence 30 in interviews total.**

❖ **Participants are asked to interview stakeholders based on the interviews allocation included in Table 1.** E.g. **AzzeroCO$_2$** will interview one (1) policy maker, one (1) SME representative and one (1) from climate and energy NGO. **Q-Plan** one (1) from the industry sector and two (2) from the general public etc.

	Scientific Community	*Policy makers*	*Energy authorities and associations*	*SMEs*	*Industry*	*General public*	*Climate and energy NGOs*	*Total / partner*
A0		1		1			1	*3*
QPLAN					1	2		*3*
WR	1			1			1	*3*
UNITUS	2	1						*3*
USE	1		1		1			*3*
METROPOLIA			1		2			*3*
UU	1			1	1			*3*
EREF		1	1				1	*3*
SINERGIE			1	1		1		*3*
PC		1		1			1	*3*
TOTAL	5	4	4	5	5	3	4	*30*

Interview Questionnaire Guidelines | Max. duration : 40-45'

The first step of the interview is introductory and it aims at breaking the ice. To that end you can introduce yourself, the project and provide with relevant information about the interview process.

You can use the following as an introductory phrase: "You have been invited to participate in this interview in order to support our effort on identifying new skills required in RES sector related to novel technologies and give us your point of view on best practices for integrating "circularity-by-design" and sustainability in renewable energy education and training".

Note: At this stage, if deemed necessary, interviewers should be ready to give an overview of **(i) the 3 pillars of sustainability** and an easy-to-grasp definition of **(ii) the circular-by-design concept** and **(iii) green skills** to encourage interviewees to participate in a targeted discussion.

(i) The 3 pillars of sustainability:[1]

- **Environmental protection** | involves regulations, laws, and other tools used to deal with environmental facts and issues such as the management of land, freshwater, oceans, forests, air, natural resources, and wildlife. Environment protection further includes adapting to climate change, such as mitigation measures to protect biodiversity and landscapes from impacts caused by heatwaves, droughts, heavy storms etc. A useful example in this pillar, which requires special attention, is that of energy decarbonization as it represents 75% of the EU GHG emissions.
- **Social equity** | refers to initiatives, public policies, planning, and regulations supporting social issues. These include things such as fighting poverty, social justice, peace, promoting diversity, quality of living, access to healthcare, education, community development, cultural sustainability and heritage, and some aspects of religion.
- **Economic viability** | essential for the business's existence: a business needs to be economically viable to be sustainable. At the same time, a sustainable business should look at profitability as just one component of the company's strategy.

(ii) Circularity-by-design:[2]

The concept of circularity-by-design represents pathways to adjust energy transfer to renewable energy fields . Moving away from linear models (take-make-dispose) of energy production and consumption the goal is to adopt circular approaches where materials and resources are preserved through maintenance and repair, reuse, remanufacture and recycling.

(iii) Green skills:[3]

"Simply put, green skills are the knowledge, abilities, values, and attitudes needed to live in, develop and support a sustainable and resource-efficient society.
A lower carbon economy is a must as climate change continues unabated worldwide, causing severe economic and social concerns. However, as it is obvious, such a transition needs time and can't happen overnight as it requires investments, infrastructure, skills, etc. That's why the EU has set climate targets, one for 2030 and another one for 2050, which is the deadline to realize the European Green Deal."

Tip: Questions such as "How are you?" and expressions, such as "You can express yourself freely" can make the interviewee feel comfortable and break the ice. The goal is to create rapport.

Procedure to follow

As discussed in the previous section, the sampling frame should include stakeholders across various specializations and domains, particularly from the following sectors: industry, science and academia, government, public sector and civil society. Consequently, each partner is fully responsible to get in touch with them and explain thoroughly the scope of this project and the interview, and eventually, invite them to participate over a phone/skype/teams interview or even a face-to-face, depending on the availability and convenience of the respective participant.

Extra tip: Make sure that you make clear to the interviewee that there are no wrong or correct answers, and that he/she should freely express his/her opinion. In case the interviewee does not understand the question, you should make sure to elaborate on the question.

[1] https://www.investopedia.com/articles/investing/100515/three-pillars-corporate-sustainability.asp

[2] https://circulareconomy.europa.eu/platform/sites/default/files/circular_by_design_products_in_the_circular_economy.pdf

[3] https://www.unido.org/stories/what-are-green-skills

The following tables outline thoroughly the entire interview process.

Phase I: Contact the potential interviewees and try to involve them in the interview process. Estimated time: 1 week (25 Jan. 2023 – 1 Feb. 2023)

Phase I	Step 1	• Send the "**Invitation Letter**" to potential interviewees, inviting them to participate in interviews' process, either in person or remotely. • Make sure to inform them that the interviewee will remain anonymous throughout the process in order to protect their personal data.
	Step 2	• To those who respond positively, provide the "**Consent Form**" **prior to their participation in the interview**. • Participants **are expected to sign and send back the Consent Form**, before participating, so that **the procedure fully complies to GDPR**.
	Step 3	• When the participants return the consent form filled-in and signed, contact them to schedule the date and time of the interview. • Clarify from the beginning the time required to complete the interview (**max. duration: 40'-45'**).
	Step 4	• Prepare for the interview by being fully familiar with the questions in order for the interview to get the flow of a natural conversation. • There is a **core set of 13 questions** that **must be posed**. Then, **depending on interviewee's profile and time** availability, interviewer can pose additional questions such as the ones indicatively presented as **back-up questions.** • Have the style of a natural dialogue, you should be able to move from one question to another when the interviewee answers something that can trigger a fruitful dialog remaining focused on interview's questionnaire.

Phase II: Carrying out the interviews

Estimated time: 5 weeks (25 Jan. 2023 – 1 Mar. 2023)

Phase II	Step 5	**Make sure you have all the necessary materials for the interview and note-taking.**
	Step 6	**Inform the interviewee about the content and objectives of the project, the organizations and countries involved** in it as well as interview's purpose, so that they feel as familiar as possible.
	Step 7	**Proceed through the interview process using the questionnaire.** The interview **should last max. 40-45 minutes**. When the interviewee answers a question, repeat

		the answer by summarizing it to make sure you fully understand the answer and thus giving the participant an opportunity to expand their thinking and give more details.
	Step 8	**Conclude the interview by asking the interviewees to give their impressions and explaining to them that their contribution to the project's evolution is of particular importance and plays a decisive role in its results.** The aggregated anonymised gathered information will be included in the type of a report/deliverable by the end of this research activity. Also, ask if they'd mind contacting them via a quick e-mail or phone call in case you have a quick question to answer and invite them to follow SKILLBILL social media accounts, as well as subscribe to the newsletter.

Phase III: Share the reporting templates with White Research for analysis and send the consent forms to the project coordinator for safekeeping. Share the reporting templates by 8 Mar. 2023.

Phase III	Step 9	**Include** your notes in the Reporting Template. **Please make sure that you fill in the reporting file in the form of a coherent text - your notes should be complete and clear so that a non-interviewer can understand their content.**
	Step 10	**Send** the completed report **to the interviewee** for proof-reading, ask him/her to share comments if an answer is not included clearly or correctly. Give a deadline **of 2 days for feedback** and inform interviewee that **"no answer or feedback will mean consent ".**
	Step 11	**Send** the completed reporting template to White Research for its data analysis **by 8 Mar. 2023.**

Note: The total time for the realization of all the above actions is more than three weeks, taking into account the overlap of actions from one phase to the next. Therefore, we are led to the completion of the process on 8 Mar. 2023 where the partners are expected to submit the completed templates. The integrity and privacy of the participants must be assured at all stages of the study, in compliance with the principles of GDPR.

Annex III. Interviews' Questionnaire

Total duration: max. 40-45'
Each answer's approx. time is indicative and aims to help interviewer keep track on time

A. Intro

Please, tell us a few things about your **background**

1. Which category of the following stakeholder types does your current occupation fall under? (**approx. <u>less than *1 minute*</u>**)

   ❑ Scientific Community (e.g. educational staff, administrative staff, researchers, scientists, full time student etc.)

   ❑ Policy Makers

   ❑ Energy authorities and associations

   ❑ Industry / Technology providers (e.g. planners, renewable energy systems engineers, technicians, technology providers, energy industry standardization internal / external auditors, manufacturers and installers, SMEs etc.)

   ❑ Potential Investors

   ❑ Civil society (e.g. consumer associations, communication managers/officers, Renewable Energy Communities-RECs, Citizen Energy Communities-CECs or Renewable Energy Cooperatives-RESCoops)

   ❑ NGO

   ❑ Other

2. Is there a **specific Renewable Energy (RE) sector** that you are specialised or interested in (e.g. solar, wind, hydro, bioenergy etc.)? (**approx. <u>*less than 2 minutes*</u>**)

B. Cutting-edge technological innovations and respective challenges

3. Are you familiar with **cutting-edge technological developments (both on traditional and upcoming technologies)** , in RE sector or beyond, that can empower a **more sustainable** and circular by design RE development? (**approx. <u>1–5 minutes</u>**)

   Examples of technological advances in:

   - Materials: nanomaterials, smart-materials, nanostructured materials, etc. use in RES development or implementation
   - Solar energy: printed photovoltaics, building photovoltaics, agrivoltaics, etc.
   - Wind energy: wind turbines carrying flying blades or wings, air edges to reduce weather impact, new maintenance systems (e.g. break cooling systems), etc.
   - Bioenergy: Organic Rankine Cycle (ORC) or Stirling Engines, large-scale gasification, anaerobic digestion, etc.
   - Geothermal energy: heat pumps, surface nuclear magnetic resonance and closed-loop exchangers, etc.
   - Hydrogen: water electrolyzers, thermochemical and photocatalytic water splitters, photoelectrolysis devices, hydrocarbon reformers, etc.
   - Ocean and hydropower: marine and hydrokinetic technology, improved turbines, modular hydropower, etc.

4. According to you, what are the
   (i) **financial,**
   (ii) **environmental,**
   (iii) **regulatory and**
   (iv) **social barriers**

   hindering the development of more projects of such kind (employing a specific cutting-edge technology)? **(approx. <u>1–5 minutes</u>)**

C. Skills Needs Identification

5. Can you **identify new skills** highly linked to the (previously discussed) cutting-edge technological advances that are strongly needed in the current labour market? **(approx. 1–5 minutes)**

6. In your point of view, which are the major **green skills required for each phase of a RE project development**? (e.g. indicative RE project phases to explore: research and development, environmental impact assessment, permitting and licensing, stakeholder involvement, design, manufacturing, installation, operation, maintenance, disposal) **(approx. 1–4 minutes)**

   Examples of generic green skills:
   - Quantification and monitoring (waste, energy, water)
   - Management systems (waste, energy, water)
   - Procurement and selection
   - Material use and impact quantification
   - Impact and use minimisation
   - Impact assessment
   - Risk management

7. What are the most **required green skills in your professional context**? **(approx. 1–3 minutes)**

   7.1. What green skills would you feel ready and available to acquire in order to improve your current position at work? Please list at least 3 skills:
   - Skill n°1:
   - Skill n°2:
   - Skill n°3:

8. Do you think there is a **gender skills gap** in the domain of green jobs (energy / RES, sustainability, etc.)? **(approx. 1–5 minutes)**

   8.1. If yes, how do you think the gender skills gap **could be reduced** through targeted training?

D. Sustainable and circular by design RE development

9. According to you, what would **enhance** the uptake of **more sustainable and circular practices** (e.g. social, financial, regulatory, environmental factors) in RE development? **(approx. 1–5 minutes)**

E. Training / Education Practices

10. According to your opinion, what are the **major barriers that may hinder the acquisition of new skills** in the sustainable and circular RE development domain? Please elaborate. (e.g., lack of relevant capacity building programs, lack of cooperation between industry and academia, supporting policy frameworks, lack of funds, lack of personal motivation etc.) **(approx. 1–4 minutes)**

11. Please identify **the types of stakeholders that could participate as (a) trainers and (b) recipients** of training in each of the previously identified needs. **(approx. 1–4 minutes)**
    - Skill n°1: Trainers: ……. Recipients:
    - Skill n°2: Trainers: ……. Recipients:
    - Skill n°3: Trainers: ……. Recipients:

12. Can you particularly identify **current good practices / show cases** and/or specify educational or training programs **that successfully integrate "circularity-by-design"** and **sustainability principles in renewable education and training**? Please elaborate. **(approx. 1–4 minutes)**

13. Have you **attended training and other capacity-building courses** related to your professional domain so far? Yes/No? **(approx. 1–4 minutes)**

    13.1. If yes, please elaborate on the type/content/provider/duration of attended training courses and the reason why you attended them (for skilling, upskilling, reskilling etc).

The project

SKILLBILL's overall objective is to develop a large and strong foundation for the growth and acceleration of renewable energy's deployment, thanks to engaging with stakeholders of the whole chain, diffusing scientific culture and skilling multi-level workers. The basic idea underling the project is that the knowledge should be diffused at several different levels and qualitatively appropriate both to train the adequate number of workers and to increase RES awareness and to reach a more social and inclusive Europe. The project aims at creating several pathways to induce target groups to get interested or involved in RES besides their initial level of education and their working positio. It's important, beside the creation of instruments for the upskilling and reskilling of workers, technician and designers, to have awareness modules for unspecific public in order to fight against ignorance, fake news, gender gap and the phenomenon of functional illiteracy: it is widely documented that lifelong suitable learning process is the fundamental driver to support the development, maintenance and update of skills. Thus, SKILLBILL proposes concrete actions to accelerate the deployment of renewable energy at different levels to analyse and involve all the interested parts in open discussion using adequate language; create several different pathways to increase skills after having mapped knowledge gap and without gender prejudice; develop and implement innovative learning method; and evaluate the work performed.

Coordinator: **AZZERO CO2 SRL (AzzeroCO2)**

PARTNER		SHORT NAME
	AZZERO CO2 SRL	AzzeroCO2
	Q-PLAN INTERNATIONAL ADVISORS PC	Q-PLAN
	WHITE RESEARCH SPRL	WR
	UNIVERSITA DEGLI STUDI DELLA TUSCIA	UNITUS
	UNIVERSIDAD DE SEVILLA	USE
	METROPOLIA AMMATTIKORKEAKOULU OY	METROPOLIA
	UNIVERSITEIT UTRECHT	UU
	EUROPEAN RENEWABLE ENERGIES FEDERATION	EREF
	SINERGIE SOC CONS ARL	SINERGIE
	PEDAL CONSULTING SRO	PC