RES4CITY

renewable energies system for cities

Deliverable 3.4

Education needs and upskilling opportunities in the renewable energy sector.

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List of Acronyms

Acronym	Meaning
RES4CITY	Renewable Energies Systems for Cities
CEDR	Communication, Dissemination, Exploitation and Replication
GA	Grant Agreement
CA	Consortium Agreement
DoA	Description of Action
WP	Work Package
KPI	Key Performance Indicator
RES	Renewable Energy Sources
FT	Fuel Technologies
NUIM	National University of Ireland Maynooth
UNIGE	University of Genoa
UNISS	University of Sassari
UNIPARTHENOPE	Parthenope University of Naples
UCOI	University of Coimbra
UPV	Polytechnic University of Valencia
DTU	Technical University of Denmark
HU	Halmstad University
UGA	University of Grenoble Alpes
INP-UGA	Grenoble Institute of Technology
CNRS	French National Centre for Scientific Research
FINN	Finnova Foundation
GHNI	Global Hope Network International
UNITAR	United Nations Institute for Training and Research
3OC	Three O'clock
CSO	Civil Society Organisation
SME	Small- and Medium-sized Enterprise
SDG	Sustainable Development Goals
DEA	Danish Energy Agency
ROI	Return on investment
SEPA	Swedish Environmental Protection Agency
SWEA	Swedish Wind Energy Association
EIA	Environmental Impact Assessment
NECP	National Energy and Climate Plan
RESS	Renewable Energy Support Scheme
PPA	Power Purchase Agreements
MSS	Microgeneration Support Scheme
EV	Electric Vehicle
LNG	Liquified Natural Gas
FIT	Feed In Tariffs

1. Executive summary

This document outlines deliverable 3.4 'Education needs and upskilling opportunities in the renewable energy sector' which is developed under task 3.4 ´ Co-design of user-centred educational programme' in M12 (September 2023) of the RES4CITY project. The document is the first version of the deliverable that will be updated in M24.

RES4CITY – Renewable Energies System for Cities[1] was launched in October 2022 as a 36-month project funded by the European Commission under the Horizon Europe programme. This project aims to develop an innovative educational framework to support the mass deployment of renewable energy systems and fill the educational gap for the creation of specialised human capital able to contribute to the green transition.

The **RES4CITY network** aims to increase societal resilience by supporting energy transition through the development and wider deployment of renewable energy sources (RES) and fuel technologies (FT), allowing public and private stakeholders to find ways to acquire new competencies and to self-promote new practices to their working environments and society. The network will co-create and promote an innovative educational framework based on 44 micro credentials mapped into 8 micro-programmes launched on BoostMySkills[2] platform, and develop policy scenarios to ensure stronger uptake, while highlighting mapped best practices and lessons learned, and facilitating open innovation among 160 or more relevant stakeholders and end-users.

This deliverable starts with an introduction that establishes the context and relation to other work packages (WPs). The methodology section outlines the approach taken in the study. Chapter 4 delves into the exploration of barriers to renewable energy adoption in urban areas, with subsections focusing on technical, social, and economic barriers, each accompanied by learning outcomes. Chapter 5 introduces a user-centred educational framework, explaining the rationale, objectives, and stakeholders involved. Chapter 6 describes the co-design process, detailing the methodology, public survey, interviews with various groups, and stakeholder engagement through hubs. The report describes key findings gathered through qualitative research and stakeholder engagement at local, regional and international levels. For such purposes, participatory methods such as 14 interviews, 8 stakeholder meetings and 2 ideation workshops, as well as 3 surveys and desktop research, were implemented. The findings indicate educational and skill gaps considering the technical, social and economic barriers in the RES4CITY countries and urban areas and the ones covered through global reach. In addition, the findings also showcase that stakeholders' needs, ideas and opinions obtained through participatory methods match with the identified gaps collected through desktop research. Both the content and format of the educational framework are evaluated positively by all consulted stakeholders. The deliverable 3.4 was concluded and submitted in September 2023 by 3OC with the support of partners and UNISS, DTU and NUIM as the reviewers.

[1] The official website (Retrieved 20 July 2023): https://www.RES4CITY.eu

[2] BoostMySkills 2023 (Retrieved 28 August 2023): https://www.boostmyskills.eu

2. Introduction

According to the Description of Action, task 3.4 subscribes to the specific objective *3: Co-design of innovative multi-disciplinary teaching approaches targeting different professional profiles and educational* paths. The main contribution of this task is to understand the educational needs in upskilling and training by identifying at least 20 learning outcomes required in the short, medium, and long term to accelerate renewable energy deployment and fossil fuel substitution in cities and its urban areas.

Moreover, the objectives of Task 3.4 are to:

1. Identify the technological, economic and social barriers and challenges that limit the deployment of RES and sustainable fuel technologies in urban areas.
2. Identify the needs, knowledge and skill gaps (and anticipating new skills) required to advance human capital in RES and fuel technologies, which will support the definition of the micro credentials' basket (T2.3).
3. Support the content and format design of the RES4CITY learning and upskilling programmes (T2.4) by collecting input and feedback from the industrial stakeholders and companies mapped in T3.1.
4. Co-design case studies with the three Advisory Boards that will serve both in the educational programme as a learning by doing exercise, and as concrete actions to promote RES and FT, while integrating circularity and sustainability (T4.4); and
5. Validate the RES4CITY educational programmes with the three Advisory Boards. A round of validation measures and a step-by-step approach are implemented to ensure efficiency and pertinence of the content (WP4).

The first three objectives are addressed, and the results are outlined in this version of a deliverable, while the last two objectives are methodologically argumented and will be implemented at the later stage of the project. Therefore, the results will be documented and discussed in the updated version of this deliverable at M24.

2.1 Relation to other WPs

Table 1 outlines the relation between this task and other WPs and their outputs.

Table 1. Relation to WPs and their outputs

Work package	Relationship with WPs and their outputs
WP1, Project coordination and management (M1-M36)	Task 3.4 assesses the needs, interests and skill gaps of all relevant and involved stakeholder networks and actors to ensure educational framework, micro-programmes and micro-credentials correspond to the real needs and green job market. The assessment complies with defined ethical, gender balance and project management procedures defined in WP1.
WP2, Promoting sustainability and circularity: RES4CITY strategies (M1-M24)	Hubs with their stakeholder networks support ideation, prioritisation and validation of existing renewable energy sources, fuel technologies and relevant competencies required to uptake such technologies in different urban areas. Therefore, task 3.4 ensures to voice of the stakeholders' opinions and integrates them into discussions of all tasks within WP2.

Work package	Relationship with WPs and their outputs
WP3, RES4CITY Innovation and Stakeholder Network (M1-M36)	Task 3.4 is based on the T3.1 strategy and aims to create mechanisms for mapping stakeholder educational needs, skill gaps and interests so that hubs can disseminate properly micro-programmes and micro-credentials among their stakeholder networks through project activities.
WP4, Implementation of the RES4CITY Learning and upskilling programmes (M6-M20)	Task 3.4 proposes the co-development of case studies and validation of micro-programmes, namely the upskilling programmes for the industry which supports the development of T4.4.
WP5, RES4CITY Learning and upskilling programmes piloting (M14-M36)	Task 3.4 contributes to ensuring quality in the key exploitable results that will be piloted and tested in WP5.
WP6, Dissemination, Communication, Exploitation and Replication (M1-M36)	The actions planned in WP3 and WP6 are interlinked and complementary. Task 3.4 will ensure that the key messages aimed at dissemination of the RES4CITY progress reflect and include stakeholders' opinions and ideas and correspond to the project's objectives and expected outcomes.

3. Methodology

This deliverable investigates technical, economic and social barriers of the RES and FT in the specific countries that also apply to urban areas represented in this case by the RES4CITY partner universities and global reach stakeholder networks.

The deliverable 3.4 aims to collect and outline knowledge about the challenges in renewable energy uptake at the city level in the European Union countries (and beyond), the common boundaries and opportunities identified through desktop research. These are then matched with skill gaps and educational needs identified through meetings, survey/s and interviews with the stakeholders of the RES4CITY hubs in seven EU countries and nine urban areas. The key insights are then formulated into learning outcomes which correspond to specific micro-programmes (Figure 1).

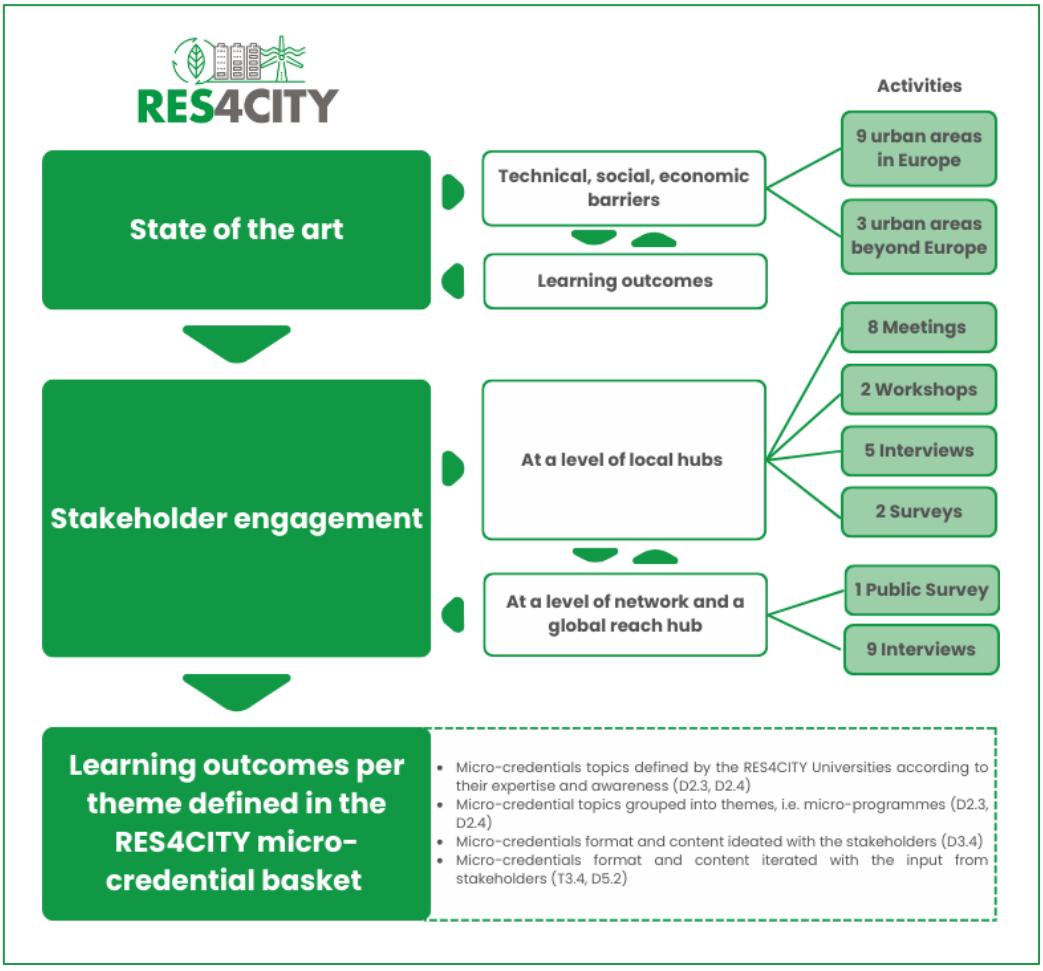

Figure 1. Methodology for elaborating deliverable 3.4

4. Exploring barriers to renewable energy adoption in urban areas

The adoption of renewable energy sources has emerged as a critical imperative in mitigating the adverse impacts of climate change and transitioning towards a sustainable energy future. The United Nations Sustainable Development Goal 7.2 acknowledges the importance of addressing this pressing matter, advocating a substantial rise in the proportion of renewable energy in the global energy mix by 2030. According to the EU's Global Leadership in Renewables report of the European Commission (2021), the EU leads in terms of world market shares particularly in wind energy (67%), geothermal technologies (42%) and hydropower (39%).

In urban areas, where a substantial proportion of the global population resides (e.g. in the EU, there are 75% of EU citizens live in the cities[3] while 55% in the world[4]), the integration of renewable energy technologies poses unique challenges and technical, social and economic barriers. Partly, these barriers arise due to an insufficient understanding of available renewable energy choices and the advantages of utilising locally accessible renewable resources. Improved awareness regarding renewable energy technologies' applications could assist cities in strategising and implementing renewables in urban areas[5]. Urban energy systems have distribution networks and energy management systems providing several services to meet the demand of energy consumers[6]. Most of the focus on energy management is oriented towards buildings, mobility/transport, waste and industry. In the following text, the barriers are outlined and commented on through the lenses of RES4CITY's mission. The study is aimed at identifying key challenges in each country, but it is not the intention to cover all challenges with RES implementation in each country represented by the RES4CITY hubs. Through a global reach hub, the RES4CITY project has also involved stakeholders of the three urban areas in Ethiopia, Thailand and South Korea to contribute to the co-design of the educational framework.

4.1 Technical barriers

The **alternating nature** of renewable energy generation, such as solar and wind, poses challenges in ensuring a reliable and continuous energy supply (Verzijlbergh, De Vries, Dijkema, & Herder, 2017). Urban environments often lack the **necessary infrastructure to effectively store excess energy** during periods of high generation and utilize it during periods of low generation (Blanco & Faaij, 2018). The existing urban infrastructure may not be optimised to accommodate **large-scale renewable energy installations**. In many cities, the availability of **suitable space for solar panels or wind turbines** is

[3] EU Mission: Climate-Neutral and Smart Cities on the European Commission website (retrieved 24 July 2023): https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

[4] IRENA 2020 (Retrieved 25 July 2023): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf?rev=c6c9f67ac61849369f2aaa6f52133bdf

[5] IRENA 2020 (Retrieved 25 July 2023): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf?rev=c6c9f67ac61849369f2aaa6f52133bdf

[6] IRENA 2020 (Retrieved 25 July 2023): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf?rev=c6c9f67ac61849369f2aaa6f52133bdf

limited due to high population density, limited land availability, and stringent land-use regulations. Addressing this intermittency issue necessitates advancements in **energy storage technologies** and sophisticated **grid management systems**. Innovative design approaches and integration of renewable energy systems into existing structures are required to **optimise space utilisation without compromising aesthetics and urban functionality** (Cabeza, de Gracia, & Pisello, 2018).

Urban areas often face higher energy demand compared to rural regions, leading to **increased strain on energy distribution networks**. The existing grid infrastructure may need substantial upgrades to handle the increased capacity and accommodate the integration of renewable energy sources without overloading and frequent power outages (Smith, Cattell, Farcot, O'Dea & Hopcraft, 2022). Furthermore, the **integration of decentralised renewable energy sources**, such as rooftop solar panels, raises challenges in grid management and power distribution. The traditional centralised grid structure may not efficiently handle two-way power flows, demand fluctuations, and variable energy generation. Upgrading grid infrastructure and implementing **smart grid technologies** are essential to enable seamless integration and maximize the benefits of distributed renewable energy systems (Iweh, Gyamfi, Tanyi & Effah-Donyina, 2021).

The **lack of standardisation** and interoperability in the technologies used in renewable energy systems can make it challenging to integrate them with existing energy systems and infrastructure. A **lack of uniformity** in protocols and systems may lead to compatibility issues, inefficiencies, and increased costs, impeding the adoption and widespread implementation of renewable energy technologies.

Table 2 shows how these barriers reflect per RES4CITY urban area and country.

Table 2. Technical barriers for the RES4CITY urban areas and countries

Urban area & country	Technical barriers
Coimbra, Portugal	Portugal is currently the 11th EU member state with the highest reliance on imported energy sources, although this dependence has been on a decline since 2000 when 85% of its energy was sourced from imports. Projections suggest that Portugal's reliance on fossil fuels is expected to decrease to approximately 65% by 2030. In the last two decades, Portugal has made significant investments in the development of wind and solar power. Portugal's national energy and climate plan for 2030 and roadmap to carbon neutrality by 2050 targets at least 80% of electricity production coming from renewables (ITA[7], 2023). To meet this aim, some technical issues worth exploring that also affect Coimbra are: • *Legislation & permits for new projects* Obtaining permits for new Renewable Energy Sources in Electricity projects is a major challenge due to a complex, time-consuming, and costly process involving five ministries that lack coordination. The procedure requires multiple permits, and making project changes restarts the process. The grid connection point is reserved for three years, but progress isn't monitored, hindering other projects (Eclareon[8], 2022). There are

[7] ITA 2023 (Retrieved 25 July 2023): https://www.trade.gov/country-commercial-guides/portugal-energy

[8] Eclareon 2022 (Retrieved 25 July 2023): https://www.eclareon.com/sites/default/files/res_policy_monitoring_database_final_report_01.pdf

Urban area & country	Technical barriers
	numerous small and medium projects in the pipeline for solar parks that wait for permits (PVTECH[9], 2023). Environmental Impact Assessment (EIA) requirements are overly complex, resulting in financial burdens and project delays. On average, it takes about 46 months for wind or solar power plants to secure licenses, according to RES producers affiliated with APREN (Eclareon[10], 2022). • *Grid Integration* Connecting solar and wind parks with the grid system demands financial investments and prediction of future opportunities and needs. Compatibility issues and grid congestion need to be addressed due to the high demand of new and already financed RES projects (PVTECH[11], 2023). • *Storage* Renewable energy sources like solar and wind power can be intermittent. Ensuring a stable and reliable energy supply may require investment in energy storage solutions like batteries or grid upgrades. • *Land Use and Space Requirements* Some renewable technologies, like wind farms or large-scale solar installations, require significant land or space. The compatibility of Renewable Energy Source for Electricity projects with existing land use is not evaluated in advance, often leading to conflicts with Municipal Master Plans and regional land use regulations. These plans and regional land management guidelines specify criteria and restrictions for land use, and because renewable power projects typically repurpose land designated for other uses, they can face local licensing challenges. Sometimes, even with a favourable environmental impact assessment and production license, city councils may refuse project authorization, particularly in agricultural or environmentally protected areas, necessitating negotiations with authorities for permits. Nevertheless, municipalities generally view renewable electricity production positively due to its contributions to regional development, sustainability, and job stability. Wind power plants with Feed-in Tariffs also pay rent to municipalities, fostering local authorities' acceptance of renewables. Additionally, the incompatibility of RES-E installations with forests is a concern, and building permits are a demanding, time-consuming process, requiring previously approved information from EIAs and production licenses (RESMONITOR[12], 2022).

[9] PVTECH 2023 (Retrieved 25 July 2023): https://www.pv-tech.org/portugal-needs-to-step-up-on-permitting-issues-and-grid-connection-challenges/

[10] Eclareon 2022 (Retrieved 25 July 2023): https://www.eclareon.com/sites/default/files/res_policy_monitoring_database_final_report_01.pdf

[11] PVTECH 2023 (Retrieved 25 July 2023): https://www.pv-tech.org/portugal-needs-to-step-up-on-permitting-issues-and-grid-connection-challenges/

[12] RESMONITOR - Portugal (Retrieved 25 July 2023): https://resmonitor.eu/en/pt/barriers/949/

Urban area & country	Technical barriers
Genoa, Naples and Sassari, Italy	Italy's government has prioritised energy and climate issues in its political agenda, setting ambitious targets for renewables by 2030, including 30% of total energy consumption and 55% in electricity generation. The country strongly supports renewable energy, having seen significant growth in this sector and effectively incorporating variable renewable generation. Cost containment is a priority, and policies should aim to match international deployment cost standards. While Italy has made strides in liberalising its electricity market and improving infrastructure, progress in the gas sector has been slower, hindering its goal of becoming a southern European gas hub. Additionally, the energy sector's institutional arrangements need reform and strengthening. The government is also reviewing incentives and subsidies that don't align with decarbonization objectives, while considering taxation changes, with a focus on protecting economically vulnerable groups (IEA[13], 2023). To this aim, there are still barriers to be addressed that also affect Genoa, Naples and Sassari: • *Lack of training among administrative staff operating with RES permits* Stakeholders express concerns that public administrative agencies responsible for authorisations are understaffed and frequently lack the requisite expertise, resulting in delayed administrative procedures. These delays may persist in the future. In 2021, stakeholders emphasised that the fundamental problem lies not in administrative personnel's incompetence but in the complexity and ambiguity of regulations, suggesting that clear, well-defined guidelines would eliminate the need for extensive personnel training (RESMONITOR[14], 2021). • *Lack of regulations for agricultural land use* Clear guidelines exist for Environmental Impact Assessments (EIAs) concerning protected and natural areas, but there is a notable absence of regulations for agricultural areas. The absence of specific rules for agricultural land use poses challenges, as EIAs treat all agricultural areas uniformly without considering their surroundings. This uniform approach fails to account for variations in environmental significance, such as the difference between agricultural land near a highway and land within a fertile agricultural zone. Furthermore, regulations related to RES lack criteria for assessing soil permeability, highlighting the need for new national guidance in addressing these issues (RESMONITOR[15], 2021).
Grenoble, France	France maintains a low-carbon electricity supply, primarily driven by its extensive nuclear capacity, second only to the United States. The nation has enacted a robust energy transition plan, with a 2050 net-zero emissions target established in its 2019 Energy and Climate Act. This strategy includes 5-year carbon budgets and a multi-year energy

[13] IEA 2023 (Retrieved 25 July 2023): https://www.iea.org/countries/italy

[14] RESMONITOR - Italy (Retrieved 25 July 2023): https://resmonitor.eu/en/it/barriers/1635/

[15] RESMONITOR - Italy (Retrieved 25 July 2023): https://resmonitor.eu/en/it/barriers/1634/

Urban area & country	Technical barriers
	investment plan. France plans to reduce nuclear energy's share in its electricity mix from 70% to 50% by 2035 while closing all coal plants by 2024. Aging nuclear reactors require upgrades for continued safe operation. Achieving electricity security and sustainability during this transition will demand investments in efficiency, renewables, and adaptable power systems. A 2021 study by the IEA and RTE explored high variable renewables in the power system. Additionally, France is entirely reliant on oil and gas imports, prompting its oil and gas industry to shift towards low-carbon fuels and electrification. Nevertheless, the country counts with several barriers that also affect Grenoble: • *Ageing of grid at the national level* The national electricity grid in France is aging and in poor shape due to chronic underinvestment. This affects both the transmission and distribution grids, making it challenging to accommodate new grid connection requests, especially in rural areas with inadequate infrastructure and higher connection costs. With the current grid renewal rate of only 1% per year, makes it a serious issue considering the growing number of projects in the pipeline awaiting grid connections (RESMONITOR[16], 2021). • *Bottlenecks in regional grid connection plans for RES* Since April 2012, regional connection plans for RES ("S3REnR" plans) were introduced to better connect renewable energy installations to the grid. However, a fixed connection points are assigned for each renewable energy plant, which can be at the greater distance, resulting in high infrastructure costs for project developers. Additionally, while grid reinforcement costs were supposed to be shared between producers and grid operators for ten years, 82% of these costs have fallen on producers. This has raised grid connection expenses for wind energy projects by an average of 22%, challenging their economic viability. However, there are improvements, such as the "Caparéseau" online system, which allows project developers to assess connection point capacity before starting work. Yet, even when a nearby point is found, it may lack the capacity needed. Amendments to the S3REnR plans may be required, managed by the transmission grid operator RTE, with input from regional authorities and stakeholders as per the Energy Code (art. D321-20-1 to 4, Code de l'Energie) (RESMONITOR[17], 2021). • *Too short time window to connect rooftop PV systems to grid* There is a decree issued on May 9, 2017, and subsequently amended on March 11, 2021 that outlines the terms for purchasing rooftop PV systems with a maximum capacity of 100 kW. It specifies that the installation must be completed within two deadlines, whichever is later: either within 18

[16] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/1664/

[17] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/360/

Urban area & country	Technical barriers
	months from the date of the producer's application for grid connection or within 2 months after the connection work's completion (as declared by the network operator). The producer must meet all network operator requirements to ensure timely connection work. If the deadline is not met, the purchase contract duration is reduced by three times the delay's duration. These rules apply to contracts not yet signed when this decree takes effect. As of 2021, these regulations remain in force (RESMONITOR[18], 2021). • *Digressive revision of the feed-in tariff for PV on buildings* The quarterly reduction of feed-in tariffs (FiT) for rooftop photovoltaic (PV) installations under 100 MW on buildings is causing instability in project planning. The FiT amount is determined by the date of the connection request, making it difficult for developers to predict their potential earnings. Delays in administrative procedures further complicate this issue. Additionally, the FiT decrease doesn't align with the actual number of projects connected to the grid. While reductions are supposed to be based on the number of connection requests from the previous quarter, Enedis data shows that only 40% to 50% of these projects are commissioned, leading to a faster FiT decrease. Installations must be done by a qualified 'RGE' installer, like renewable heating equipment. These rules apply to mainland France, with FiTs adjusted quarterly based on completed grid connections (RESMONITOR[19], 2021). • *Delays in the procurement of grid connection permits* Grid connection delays for PV and wind installations are common due to extended waiting periods between application submission, receipt of technical and financial proposals, and securing grid connection contracts. This delay may result from factors like missing documents or an overload of contract processing by distribution system operators (RESMONITOR[20], 2021). • *Lack of staff and expertise of authorities in charge of RES permits* Despite the streamlined approach of the integrated environmental permitting system, the extensive and intricate application files still demand careful attention from authorities. However, understaffing in these agencies can lead to significant delays, even when procedural timelines are established. Introduced in 2017 to simplify onshore wind projects, the integrated environmental authorization procedure places responsibility with a single authority. However, five years later, the application processing remains complex and laborious due to a lack of expertise among authorities, particularly those responsible for determining application completeness and readiness for review.

[18] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/354/

[19] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/376/

[20] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/355/

Urban area & country	Technical barriers
	Furthermore, it's worth noting that often the same person evaluates both wind and solar project applications, despite their technological differences, which can impact their assessment (RESMONITOR[21], 2021). • *Restrictions of the regional wind plans* In France, the areas classified as suitable for wind energy development in Regional Wind Plans (SRE) are quite limited, often falling short of the country's wind energy goals. Wind energy projects must align not only with planning regulations but also with the specific favourable zones designated in Regional Wind Plans at regional, departmental, and municipal levels. The criteria for identifying these zones include wind potential, protection of natural areas, technical constraints, and regional guidelines. Additional restrictions, such as aviation and military constraints, may apply within these areas. To enhance coordination and consultation between the government and wind energy developers, there can be established "wind clusters." The Ministry aims to expand these clusters across regions and departments to facilitate state support for projects and identify local challenges and best practices. Importantly, decisions made by these wind clusters will not predetermine subsequent rulings on projects (RESMONITOR[22], 2021).
Halmstad, Sweden	Sweden is a leading nation in decarbonization, with ambitious goals to reduce greenhouse gas emissions by 59% by 2030 compared to 2005 levels and achieve a net-zero carbon economy by 2045. The country pioneered carbon pricing, boasting the world's highest carbon price, which has proven effective in driving decarbonization. Sweden predominantly relies on hydro and nuclear power for its electricity supply, supplemented by an increasing contribution from wind energy. Bioenergy-based district heating and heat pumps play a crucial role in providing heating. Also, the government aims to reduce transport emissions by 70% from 2010 to 2030, actively promoting electrification and advanced biofuels. Sweden is actively supporting industrial decarbonization and is a key player in hydrogen-based steel production projects (IEA[23], 2023). Therefore, some technical barriers that remain also in Halmstad: • *Lengthy administrative procedures for wind power projects* Sweden faces challenges in its wind power permission processes, potentially delaying the shift to renewable energy. Each wind project requires two permissions: one for construction from Lantmäteriet (the Swedish mapping, cadastral and land registration authority) for construction and another for grid connection from the Swedish Energy Markets Inspectorate. These processes, involving multiple consultative bodies and municipal approval, often exceed 10 years, risking outdated

[21] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/1663/

[22] RESMONITOR - France (Retrieved 26 July 2023): https://resmonitor.eu/en/fr/barriers/367/

[23] IEA - Sweden (Retrieved 26 July 2023): https://www.iea.org/countries/sweden

Urban area & country	Technical barriers
	technology and permit expirations. A recent survey reveals a high rate of turbine rejections and a significant decline in permit applications. To address these issues, the wind power industry suggests updating government agency instructions to include climate considerations in decision-making. This could help manage conflicts, such as those related to the Armed Forces' restricted areas, species protection, and reindeer herding. Additionally, amending the Environmental Code to weigh climate benefits in permitting and court processes is proposed. Achieving these goals requires increased cooperation among various agencies, including County Administrative Boards, the Environmental Protection Agency, the Energy Markets Inspectorate, the Swedish Agency for Marine and Water Management, and the Swedish Armed Forces. (RESMONITOR[24], 2021). • *Lack of coordination between national strategy for onshore and offshore wind power* To understand wind power planning in Sweden, aligning the Swedish Energy Agency's strategy with national marine plans is vital. This coordination is especially crucial for coastal regions dealing with both onshore and offshore wind power development. The lack of such coordination has hindered offshore wind expansion, as noted in the National Strategy for Sustainable Wind Power Development (2021). Notably, the coastal zone isn't addressed in these plans due to its limited wind power potential and potential conflicts, particularly with the Armed Forces (RESMONITOR[25], 2021). • *Lack of grid structure and coordinated grid expansion* Insufficient capacity in Sweden's national grid is hampering the rapid growth of wind power. Many rural areas lack the necessary grid strength to accommodate modern large wind turbines without costly upgrades, causing project delays or cancellations. Specifically, the transmission capacity between the north and south of Sweden is a challenge, given the concentration of wind power in the north and high electricity demand in the south. Doubling the capacity from 2020 levels is estimated as necessary but adds costs to wind projects and limits their full potential. The absence of a coordinated government plan for wind power production and grid integration leaves Svenska Kraftnät, the grid operator, uncertain about effective grid expansion. This results in multiple applications for the same sites and hinders future grid planning. Developing national plans for wind power would also benefit nature and biodiversity protection. The primary challenge for sustainable wind energy in Sweden is the coordination between wind power expansion and grid development. A legislative proposal from the Energy Market Inspectorate in February 2020 requires grid companies, including Svenska Kraftnät, to create and publish

[24] RESMONITOR 2021 (Retrieved 26 July 2023): https://resmonitor.eu/en/se/barriers/1175/

[25] RESMONITOR 2021 (Retrieved 26 July 2023): https://resmonitor.eu/en/se/barriers/1674/

Urban area & country	Technical barriers
	network development plans every two years. These plans will enhance coordination among grid operators and energy companies, allowing active participation from various stakeholders in the planning process (RESMONITOR[26], 2021). • *Complex permission process to repower wind power* By 2040, most pre-2015 wind power plants will need replacement. Repowering them with newer technology can greatly increase electricity generation. However, complex permitting processes for repowering without support could be a hurdle, especially in southern Sweden where these older plants help balance the grid. There's uncertainty about permit adjustments or new permits, and the current procedure doesn't align with the streamlined approach sought by the revised Renewable Energy Directive. The Swedish Environmental Protection Agency (SEPA) and the Swedish Wind Energy Association (SWEA) have proposed legislative changes in response to RED II directives (RESMONITOR[27], 2021). • *Lack of transmission capacity to neighbouring countries* The Swedish Wind Energy Association emphasizes the need to enhance the power grid's transmission capacity within Sweden and neighbouring nations to effectively manage the fluctuations in power production and consumption, particularly with the growth of intermittent energy sources. Currently, Sweden's electricity exports account for approximately 15% of its production, but there is potential for further expansion. Addressing the existing shortage of transmission capacity is of utmost importance to seize this opportunity. Expanding transmission capacity will lead to higher electricity prices since it will enable easier exports to market with higher price levels. This increased profitability in the Swedish electricity sector can drive additional investments in renewable energy, allowing for the full utilization of wind and hydroelectric power resources. While some progress has been made, such as the operational cable to Lithuania and a planned link to Germany by 2025, Sweden still needs more development and increased transmission capacity to its neighbouring countries to fully harness its renewable energy potential (RESMONITOR[28], 2021). In Sweden, the certificate system initially boosted wind power growth but is now ineffective due to low certificate prices. It helped wind power expansion for 15 years, making itself obsolete by ensuring cost-effectiveness. Unlike Germany's feed-in tariff system, Sweden's green certificate system was cost-efficient but didn't promote new technology or small-scale wind power growth. The system continues until 2030, with facilities needing commissioning by January 1, 2022, to be eligible. The Swedish Energy Agency suggests allowing new facilities to join until 2030

[26] RESMONITOR - Sweden (Retrieved 26 July 2023): https://resmonitor.eu/en/se/barriers/1152/

[27] RESMONITOR - Sweden (Retrieved 26 July 2023): https://resmonitor.eu/en/se/barriers/1176/

[28] RESMONITOR - Sweden (Retrieved 26 July 2023): https://resmonitor.eu/en/se/barriers/1153/

Urban area & country	Technical barriers
	during its phase-out. However, the SWEA opposes this, as low certificate values may deter future investments in wind power. Low certificate prices also threaten combined heat and power plants, which rely on electricity and certificate sales for revenue (RESMONITOR[29], 2022).
Lyngby, Denmark	Denmark's net-zero commitments and advancements with renewables make it a leader in energy transition (IEA[30], 2023). By 2030, the country aims to cut GHG emissions by 70% as renewables should cover at least half of the country's total energy consumption. Danish Energy Agreement with funding that set the path towards 55% renewables share in 2030 in Denmark and cut of coal in electricity production. However, there are some technical barriers being currently addressed national-wide but also relevant for Lyngby: • *Grid infrastructure and regulation* Danish Energy Agency's Analysis Assumptions for Energinet from 2020 has brought about insights on consumption and production of gas and electricity, which are aligned with the political objectives (Energinet[31], 2022). Denmark is in need to establish an adequate technical and regulatory framework for the integration of fluctuating wind power in large amounts in the energy system (RESMONITOR32, 2022). Renewable energy generation, such as wind and solar, might be in remote areas and require new transmission lines to bring the power to smaller urban areas such as Lyngby. A process of RES plants joining energy grid may be a lengthy process due to variety of factors such as the length of connection construction, complexity of planning a grid system and requirements for RES installations that may differ for each case (RESMONITOR[33], 2022). Maintaining security of supply for consumers as well as reinvestments in the aging power grid are also development needs. • *Energy storage* The management and coordination of various small-scale renewable energy sources, such as rooftop solar panels and local wind turbines, require sophisticated technologies and control systems. • *District heating integration* Over the past several decades, the increased utilisation of district heating and combined heat and power has been a leading factor contributing to Denmark's enhanced energy efficiency and simultaneous reduction in

[29] RESMONITOR – Denmark (Retrieved 26 July 2023): https://resmonitor.eu/en/se/barriers/1143/

[30] IEA – Denmark (Retrieved 25 August 2023): https://www.iea.org/countries/denmark

[31] Energinet – Denmark (Retrieved 25 August 2023): https://en.energinet.dk/media/v3mgezu1/lup22_losningskatalog_el_english.pdf

[32] RESMONITOR – Denmark (Retrieved 25 August 2023): https://resmonitor.eu/en/dk/barriers/267/

[33] RESMONITOR – Denmark (Retrieved 25 August 2023): https://resmonitor.eu/en/dk/barriers/1578/

Urban area & country	Technical barriers
	carbon emissions (DEA, 2023). Municipalities make decisions for preparing and updating municipal heating plans and approving heating projects.
Maynooth, Ireland	In 2018, Ireland ranked second in wind-based electricity generation among IEA member nations. Additionally, it has bolstered energy security by increasing domestic gas production and reducing reliance on oil. Ireland's recovery from the 2008 economic crisis has been impressive, boasting the fastest-growing economy among IEA countries since 2014. Although energy use has risen alongside GDP growth, it remains below the 2006 peak due to a shift towards a service-based economy. However, plans to attract the global digital and data hosting industry may lead to increased electricity demand, necessitating rapid decarbonization. Ireland is currently falling short of its 2020 emissions reduction and renewable energy targets which make the 2030 emission reduction goals uncertain, although recent government policies may impact future emission projections positively (IEA[34], 2023). However, some of the barriers remain, also present in Maynooth: • *Understaffed planning authorities create delays* Planning authorities at both national and local levels have faced resource limitations, and the workload for planners hasn't decreased, posing a risk of planning delays. Furthermore, the Commission for Regulation of Utilities lacks specific internal technical knowledge. In a 2015 survey conducted by the Irish Planning Institute, it was revealed that most local planning authorities saw a reduction in the number of professional planners between 2006 and 2014. Specifically, during this period, local planning departments saw a one-third reduction in staff positions. This issue could potentially hinder Ireland's ambitious goal of achieving 70% electricity generation from RES by 2030. It's essential to address these staffing challenges to support the country's renewable energy deployment plan (RESMONITOR[35], 2021). • *Delays in grid connection* Delays in grid connections and planning permission expirations continue to hinder the effectiveness of wind energy projects in Ireland. Liberal objection policies allow groups, even those not directly affected, to raise environmental concerns and oppose wind projects, often taking advantage of local communities' limited knowledge. Ownership issues involving state-owned land near motorways add further delays, exacerbated by slow processes within local councils, the Planning Board, and the High Court. These persistent delays impact not only renewable energy projects but also energy investments in general, especially those

[34] IEA – Ireland (Retrieved 25 August 2023): https://www.iea.org/countries/ireland

[35] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/1459/

Urban area & country	Technical barriers
	exceeding 1MW in capacity, with no significant changes noted as of 2021 (RESMONITOR[36], 2021). • *Need to regulate the interconnection with Northern Ireland and the GB electricity market* There are no plans or timelines for interconnector operations and post-Brexit trading arrangements. In the Single Electricity Market, trading with Great Britain benefits from access to larger markets, price alignment, and increased RES use. However, current trading arrangements pose challenges for SEM efficiency (RESMONITOR[37], 2021). • *Limited grid capacity leads to increased constraint levels and project costs* The greatest obstacle to renewable energy deployment is the insufficient transmission capacity in regions where numerous renewable projects aim to connect. High constraint levels, especially in the West and North-West, are a result of network limitations, resulting in significant renewable electricity wastage. Without substantial grid infrastructure investment, these constraint levels will double for existing and future projects, impacting project viability and raising overall renewable development costs, which will be passed on to consumers through the Public Service Obligation levy (RESMONITOR[38], 2021). • *Incompleteness of a supply chain for wind energy* To support the wind energy sector's growth, Ireland must strengthen its national supply chain, starting with an investigation into a Marshalling port on the east coast. This move is crucial to establish a domestic supply chain for both onshore and offshore wind energy. Offshore wind energy alone could generate 2,500 jobs in the next decade and attract €42 billion in investments, making it an opportunity that should be pursued urgently (RESMONITOR[39], 2022). • *Unfair charges to solar power in comparison to onshore wind power* In Ireland, the Use of System charges are calculated based on capacity (per MW) rather than output (per MWh), leading to an imbalance favouring onshore wind over solar power. This discrepancy arises because wind farms often have capacity factors three times higher than solar PV in Ireland. If the charges were based on output, it could have lowered the average strike price in RESS-1 by at least €3.76/MWh (RESMONITOR[40], 2021). • *Liberal objections to wind projects*

[36] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/656/

[37] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/1450/

[38] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/1449/

[39] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/1389/

[40] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/de/ie/barriers/1447/

Urban area & country	Technical barriers
	The liberal objection policy in Ireland allows anyone, even those not directly affected, to raise objections to issues like wind projects, leading to environmental concerns and objections from non-local groups with more experience. Ownership issues regarding state-owned land adjacent to motorways further delay wind projects, as landowners need to be consulted. Slow bureaucratic processes, often exceeding the set deadlines, lead to lengthy delays and increased uncertainty in project realization, with most wind farm decisions undergoing Judicial Review (RESMONITOR[41], 2021). • *Conservative grid development planning and substation construction for PV* In Ireland, network planning standards are deemed overly conservative, often based on unrealistic scenarios of maximum renewable energy production. These standards may result in additional and unnecessary expenses for solar PV connections compared to other regions. Additionally, the requirement for traditional brick-built substation buildings rather than cost-effective containerized modular solutions up to 20kV restricts flexibility and adds avoidable costs, despite the success of modular solutions rated for higher voltages (RESMONITOR[42], 2021). • *Revision of Wind Development Planning Guidelines* The slow progress in updating the 2006 Wind Development Planning Guidelines is a significant obstacle to wind energy deployment in Ireland, as it hampers site selection and installation. Delays in finalising the guidelines impact the realisation of additional wind energy projects and create uncertainty around issues like noise levels and shadow flicker, which can increase onshore wind project costs by over 20%. Coordination between local and regional development plans is lacking, and despite collaborative efforts by the Irish Wind Energy Association and the Department of Communications, Climate Action and the Environment, the absence of clear deadlines for guideline updates hinders progress and makes it unlikely that the 8,000 MW of projects will be realised shortly (RESMONITOR[43], 2022). • *Lack of route to market for offshore wind* The urgent need for offshore wind development in Ireland is hindered by a challenging licensing regime, with only 25 MW of capacity deployed so far and 3,000 MW expected soon. Simplifying and speeding up the licensing process is crucial for the future of this technology in the country, as outlined in the updated National Energy and Climate Plan, which targets 3.5 GW of offshore wind by 2030. Delays in implementing these changes

[41] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/1435/

[42] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/1445/

[43] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/665/

Urban area & country	Technical barriers
	could impact investment decisions and jeopardize the achievement of national 2030 targets (RESMONITOR[44], 2022).
Valencia, Spain	In recent years, Spain has addressed the issue of electricity tariffs not covering system costs and closed all its coal mines. This has allowed Spain to prioritize climate change and align its goals with the EU's objectives. Spain's current energy and climate framework focuses on achieving national climate neutrality by 2050, with goals of 100% renewable electricity and 97% renewable energy in the total energy mix. This entails a significant expansion of solar and wind energy, energy efficiency, electrification, and renewable hydrogen. Spain is making progress towards its 2030 targets, particularly in the electricity sector, while phasing out coal and nuclear power generation. Plans include expanding storage, demand-side management, digitalisation, and international interconnections. However, Spain still heavily relies on fossil fuels in its overall energy mix, with the transport, industry, and buildings sectors needing substantial efforts to meet renewable and decarbonization targets. Spain is also committed to ensuring a just transition, especially for communities in traditional energy sectors like coal mining (IEA[45], 2023). In addition, the following technical endeavours still need to be attended that also affect Valencia: • *Lack of harmonisation in administrative procedures* The Spanish legislative framework for renewable energy is intricate and divided among the National government, Autonomous Communities, and local governments, leading to complexity and fragmentation in administrative procedures for renewable energy projects. This complexity introduces confusion and delays as regulations can vary from one location to another. For example, local licenses and permits, like construction licenses, are regulated by individual municipalities, making it essential for project developers to carefully assess the specific requirements at each stage depending on the project's location (RESMONITOR[46], 2021). • *Delays in the access and connection permits* Delays in the access and connection permits process have been attributed to market speculation, where some actors secure permits without immediate projects for potential resale. The lack of expiration deadlines in previous regulations exacerbated this issue. However, in 2020, new regulations, such as RDL 23/2020, were implemented to address this problem by setting expiration deadlines and specifying developer milestones, aiming to reduce the barrier posed by speculative permit acquisition over time (RESMONITOR[47], 2021).

[44] RESMONITOR – Ireland (Retrieved 25 August 2023): https://resmonitor.eu/en/ie/barriers/676/

[45] RESMONITOR – Spain (Retrieved 25 August 2023): https://www.iea.org/countries/spain

[46] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1548/

[47] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1550/

Urban area & country	Technical barriers
	• *Unclear regulations and delays for repowering* The guidelines pertaining to the repowering of existing installations lack clarity, and developers undertaking such projects are required to repeat the entire process, including obtaining access and connection permits. This regulatory approach may serve as a disincentive for repowering efforts within the industry (RESMONITOR[48], 2021). • *Periods for administrative process varies between the national and regional levels* According to the law, administrative procedures for projects with a capacity of 50 MW or less fall under the jurisdiction of Autonomous Communities, while larger projects are handled by the National government. However, there are disparities in the duration of these processes between the two levels, with projects under Autonomous Communities often progressing more swiftly, posing challenges for larger endeavours. This discrepancy in processing times should ideally be minimized to ensure consistency. One contributing factor might be a shortage of personnel and resources to cope with the growing volume of requests (RESMONITOR[49], 2021). • *Lack of a national self-consumption strategy* The Spanish National Energy and Climate Plan (NECP) discusses the potential for self-consumption but lacks a clear national strategy and target for self-consumption by 2030. As of December 2021, the government is working on a National Self-Consumption Strategy, with a target of 9 GW of photovoltaic self-consumption by 2030, although critics argue this is insufficient given the country's solar potential. There is also concern about how this target is divided among sectors, with a need to prioritize residential self-consumption and remove regulatory barriers to achieve these goals (RESMONITOR[50], 2022). • *Unclear regulations for self-consumption in buildings* Collective self-consumption in apartment buildings faces a legal hurdle requiring one-third of neighbours' favourable votes to proceed, as per the Horizontal Property Law. Moreover, the Order TED/1247/2021 introduces predefined hourly coefficients for collective self-consumption, which the Renewable Energy Foundation in Spain views as a significant deterrent due to their impracticality. These coefficients are static and not adapted to the dynamic nature of distributed renewable energy consumption and generation (RESMONITOR[51], 2022). • *Distance limit for self-consumption connection*

[48] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1550/

[49] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1549/

[50] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1381/

[51] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1363/

Urban area & country	Technical barriers
	The Royal Decree-Law 244/2019 allows self-consumption generation units to be in nearby facilities, but it imposes a 500-meter distance limit and requires a low-voltage connection to the self-consumption point. This restriction poses a barrier, particularly for collective self-consumption and Renewable Energy Communities, as it can limit the feasibility of such projects and initiatives (RESMONITOR[52], 2021). The significant overcapacity in Spain's electricity market, stemming from both old and new conventional power capacity, has been a long-standing problem due to inadequate development planning. This issue was exacerbated in 2016 when a decrease in electricity demand occurred during the financial crisis, and it was further highlighted during the COVID-19 pandemic, especially in 2020. Despite recent coal plant closures, overcapacity remains a concern, prompting recommendations to enhance energy system flexibility and reconsider the introduction of a capacity mechanism to address adequacy issues in the medium term. Immature technologies such as ocean energy and offshore wind lack clear regulations, which hinders public technicians from granting administrative authorization. Consequently, these technologies face multiple technical barriers that indefinitely delay the administrative approval process.
Global reach – Addis Ababa, Ethiopia	In Ethiopia, where electricity access currently extends to less than 50% of the populace, significant advancements have been achieved during the last two decades. The introduction of the National Electrification Programme in 2017 has laid out a comprehensive strategy to achieve universal access to electricity by 2025. As part of this initiative, there is a concerted effort to provide off-grid solutions to 35% of the population. Simultaneously, Ethiopia is actively diversifying its energy generation portfolio, which has historically been dominated by hydroelectric power. This diversification includes a greater emphasis on harnessing solar, wind, and geothermal energy sources. This shift is driven by the country's commitment to building a more climate-resilient energy infrastructure and aligning its energy strategy with broader economic development goals (IEA[53], 2023). In addition, the following technical endeavours still need to be attended that also affect Addis Ababa (Tiruye et al., 2021): • *Lack of developed and adapted technologies* Technical challenges in Ethiopia include the absence of locally adapted energy technologies, limited on-the-job training experiences, insufficient funding for energy sector development, and a shortage of skilled manpower for technology maintenance.

[52] RESMONITOR – Spain (Retrieved 25 August 2023): https://resmonitor.eu/en/es/barriers/1362/

[53] IEA – Ethiopia (Retrieved 20 September 2023): https://www.iea.org/articles/ethiopia-energy-outlook

Urban area & country	Technical barriers
	• *Intermittent electricity supply in remote areas* The dispersed rural settlements and low electricity consumption in remote areas make it challenging to develop grid electricity infrastructure, rendering such ventures less economically attractive. • *Limited technical capacity and information* Scarcity of up-to-date technologies and internally generated funds hampers renewable energy growth. A lack of information, awareness, and motivation impedes private sector participation and investment.
Global reach – Chang Mai, Thailand	Thailand's energy strategy emphasizes a reduction in reliance on natural gas to bolster energy security. As the costs of variable renewable energy continue to decline, traditional methods of power generation in Thailand are gradually making room for alternative sources (IEA[54], 2023). Consequently, Thailand's energy policy must adapt and evolve to align with this shifting energy landscape (IRENA[55], 2017; Sirasoontorn & Koomsup, 2017) namely in: • *Power grid planning* Thailand's power generation from Variable Renewable Energy (VRE) sources is currently under 2%, with plans to increase it to 12% by 2036. Concerns arise regarding grid flexibility as VRE penetration increases. The requirement for renewable energy projects to provide firm or semi-firm capacity through hybridization raises cost concerns and project development implications. Thailand should optimise the portfolio of VRE sources to maximise complementarity, adopt intelligent control systems for matching VRE outputs with load, and explore the feasibility of establishing an auxiliary market for regulating power providers. Additionally, consideration should be given to accepting imported renewable energy sources. • *Long-term price guarantee mechanisms for bioenergy feedstock* The supply of biomass feedstock for power generation or biofuel production is subject to market conditions, posing supply risks due to conflicts of interest among sectors. The use of biomass in industrial processes and the building sector may worsen the situation without effective feedstock management mechanisms. Thailand needs clear policy and legal frameworks on land tenure and use. A fair and reasonable market environment with pricing mechanisms, growers' associations, and co-operatives should be introduced to stabilise feedstock prices. Measures should be implemented to minimise the impact of international commodity price volatility on the farmers' economy. • *Fragmented authority and capacity limitations*

[54] IEA – Thailand (Retrieved 20 September 2023): https://www.iea.org/countries/thailand

[55] IRENA – Thailand (Retrieved 20 September 2023): https://www.irena.org/-/media/files/irena/agency/publication/2017/nov/irena_outlook_thailand_2017.pdf

Urban area & country	Technical barriers
	The lack of coordination among energy institutions in Thailand poses technical challenges. There is an involvement of multiple government agencies in energy policy and planning leads to capacity limitations. These entities need to build capacity to implement the Thailand Integrated Energy Blueprint effectively. The incentive structures for SOEs are also in conflict with their roles as operators, affecting the promotion of energy conservation and renewables. • *Lack of coordination between public and private sectors* Effective coordination between the public and private sectors is essential for the implementation of energy efficiency and renewable energy projects. Energy efficiency finance initiatives have faced challenges in transferring financing measures to the private financial sector. Banks in Thailand have been conservative and risk-averse, hindering energy efficiency investments. The involvement of various stakeholders, including project developers, ESCOs, and technology experts, is necessary for successful energy efficiency projects.
Global reach – Seoul, South Korea	South Korea has set an ambitious goal of achieving carbon neutrality by 2050. This involves a significant increase in the use of renewable energy sources, a gradual phasing out of coal, substantial improvements in energy efficiency, and support for the emerging hydrogen industry. However, South Korea currently relies heavily on fossil fuels and has a high dependence on energy imports, with a notable share of industrial energy usage. This has led to a continuous rise in energy-related emissions since 1990, driven by strong economic growth. To address these challenges, South Korea is leveraging the fourth industrial revolution to transition towards cleaner energy and promote green growth through low-carbon technologies and clean energy initiatives. In 2015, the country implemented a nationwide emissions trading system, but more efforts are needed to reduce the carbon intensity of its energy supply, particularly about coal-fired power generation. South Korea's private sector has a strong capacity for technology innovation, and the population's openness to digitalisation is driving investments in energy storage systems, smart grids, and intelligent transport systems. Additionally, the government is actively funding energy-related research, development, and deployment, making it one of the leading OECD countries in this regard (IEA[56], 2021). Some of the following technical barriers are being considered (Energy Tracker Asia[57], 2022; Research Outreach 2021; Kim et al., 2020): • *Regulatory Restrictions*

[56] IEA – South Korea (Retrieved 20 September 2023): https://www.iea.org/countries/korea

[57] Energy Tracker Asia 2022 (Retrieved 20 September 2023): https://energytracker.asia/the-main-barriers-to-the-renewable-energy-transition-in-south-korea/

Urban area & country	Technical barriers
	Over 50% of basic municipalities in South Korea have regulations restricting land available for solar projects, complicating the development of solar energy installations. • *Legacy coal capacity* To meet its renewable energy targets, South Korea needs to retire a substantial amount of coal capacity by 2034. The transition from coal to renewables involves technical challenges in grid integration, infrastructure development, and operational changes. • *Grid integration* As the percentage of renewable energy generation increases, the technical aspects of integrating intermittent sources like solar and wind into the grid become more complex. This requires infrastructure upgrades and advanced grid management techniques. • *Grid and market redesign* Accelerating the transition to clean energy requires redesigning the energy grid, rethinking energy markets, and implementing competitive pricing models for renewables. These technical changes are necessary but complex.

Addressing technical barriers in urban areas requires a holistic approach involving technological innovations, policy support at local, national and EU levels, and public-private collaborations to pave the way for a greener urban future (Sugahara & Bermont, 2016).

4.1.1 Learning outcomes to address technical barriers

The learning outcomes for upskilling the workforce and students to meet the requirements of the green job market based on the so far indicated technical barriers may include:

- **Streamlining permitting processes**: Skills and knowledge to navigate complex permitting processes for renewable energy projects; Skills in project management to expedite the permit application and approval process, ensuring projects move forward efficiently.
- **Grid integration and management**: Understanding the complexities of grid infrastructure and regulatory frameworks in the context of integrating fluctuating renewable energy sources, like wind and solar, into the energy system; Skills in grid optimization and planning to ensure a seamless connection of renewable energy sources to the grid; Skills to plan and execute grid expansion projects efficiently and cost-effectively; Skills in addressing grid-related challenges, including the security of supply, reinvestment in ageing power grids, and the coordination of national and local grid development efforts.
- **Energy storage solutions:** Knowledge of energy storage technologies, such as batteries and grid upgrades, to address the intermittent nature of renewable energy sources; Skills and knowledge to assess the need for energy storage in renewable energy projects and select the most suitable solutions; Skills in designing and managing systems that integrate energy storage with renewable energy generation for maximum efficiency.
- **Land use planning and compatibility:** Skills and knowledge in assessing the compatibility of renewable energy projects with existing land use and regional regulations; Negotiation and conflict resolution skills to address conflicts arising from land use issues.
- **Regulations for agricultural land use:** Skills in assessing soil permeability and creating national guidance for agricultural land use in renewable energy projects.

- **Repurposing and repowering old wind plants:** Skills and understanding of the repurposing and repowering of old wind power plants to increase their efficiency and extend their operational life; Understanding on how to navigate the complex permitting processes associated with repowering projects.
- **Decentralization challenges:** Understanding the management and coordination of small-scale renewable energy sources, including rooftop solar panels and local wind turbines; Proficiency in utilizing sophisticated technologies and control systems to optimize decentralized energy generation and distribution; Skills in overcoming challenges related to the decentralized nature of renewable energy sources, including grid management and energy flow control.
- **District heating integration:** Knowledge of district heating systems and their role in improving energy efficiency and reducing carbon emissions; Understanding the decision-making process for municipal heating plans and heating project approval; Skills in planning and implementing district heating projects to enhance energy efficiency and sustainability at the local level.
- **Administrative procedures and regulations:** Familiarity with the administrative procedures and regulations governing renewable energy projects, including national, regional, and local levels.
- **Licensing and permitting:** Knowledge of the licensing and permitting processes for renewable energy projects, including access and connection permits; Understanding the impact of delays in the permitting process on project timelines and viability; Skills in streamlining the access and connection permitting process to accelerate renewable energy project deployment.
- **Renewable energy technology and policy:** Comprehensive understanding of renewable energy technologies, their potential, and limitations; Familiarity with national and regional energy policies, targets, and incentives related to renewable energy; Skills in aligning renewable energy project development with policy objectives and leveraging available incentives.

These learning outcomes would help individuals and educational institutions prepare the workforce and students to meet the evolving requirements of the green job market in RES4CITY countries and urban areas.

4.2 Social barriers

The uptake of renewable energy sources in urban areas faces social barriers that hinder their **acceptance and adoption by individuals and organisations**. This abstract explores the key social obstacles that impede the widespread integration of renewable energy systems and sustainable fuel technologies in urban environments. **Limited public awareness and knowledge** of renewable energy systems and sustainable fuel technologies act as significant barriers to their uptake. Without a comprehensive understanding of the **benefits and potential of these technologies**, individuals and organisations may be hesitant to embrace renewable energy solutions. Enhancing public awareness through targeted educational campaigns and information dissemination is crucial to fostering informed decision-making and encouraging broader adoption.

The perceived **aesthetic impact of renewable energy systems on urban landscapes** represents a substantial concern, particularly in historically or culturally significant areas (Wüstenhagen, Wolsink & Bürer, 2007). Visual considerations may deter stakeholders from supporting renewable energy installations, fearing that these structures might disrupt the city's architectural heritage or natural beauty. Balancing aesthetics with sustainable energy initiatives calls for **innovative design approaches** that harmoniously blend renewable energy systems into the urban fabric.

Furthermore, **the lack of effective public engagement and participatory processes** can limit the involvement of local communities and stakeholders in decisions related to renewable energy systems and sustainable fuel technologies (Wüstenhagen, Wolsink & Bürer, 2007). The absence of inclusive dialogue can lead to resistance, scepticism, and opposition to renewable energy projects. Establishing

transparent and inclusive decision-making mechanisms allows community members to voice their concerns, share ideas, and actively participate in shaping the energy transition.

Table 3 shows how these barriers reflect per RES4CITY urban area and country.

Table 3. Social barriers for the RES4CITY urban areas and countries

Urban area & country	Social barriers
Coimbra, Portugal	Public is concerned with some aspects of renewable energy sources and fuel technologies among which the most relevant in Portugal and Coimbra area are: • *Public Perception of RES* There is a widespread of false information about RES that influences public perception on the uptake of RES. The 2019 National Energy and Climate Plan (NECP) addresses this barrier by emphasizing two key strategies: firstly, the need to enhance consumer energy literacy by providing clearer information and disseminating knowledge about energy and climate change, enabling citizens to make more informed choices; and secondly, the promotion of improved consumer information to bolster transparency and competition in the energy market. To achieve this, the NECP introduces measures that will establish minimum standards for the content and structure of electricity bills, simplifying and standardizing them. If these measures are implemented as planned and on time, they hold the potential to effectively mitigate this barrier (RESMONITOR[58], 2022). • *Aesthetic Concerns* The visual impact of renewable energy installations in the natural landscape leads to resistance from communities and raises concerns about nature preservation. Residents are worried about how installations influence the disappearance of cultural and natural heritage around them. The solar panel and wind parks are considered too dominant when placed inside the "raw" nature. Working on the proximity between installations and communities and allowing them to co-own the production and distribution could be a way forward to create trust and more direct benefit (Delicado, Figueiredo & Silva, 2016).
Genoa, Naples and Sassari, Italy	The social barriers being tackled in Italy, including Genoa, Naples and Sassari are the following: • *Lack of awareness among end-users on subsidising RES* The end-users/residents are unaware of their contributions to subsidising renewable energies in their electricity bills. The lack of information and detailed cost breakdown does not work in favour of social acceptance (Caporale & De Lucia, 2015). • *Aesthetic Concerns* The preservation of natural landscape leads to resistance from communities and raises concerns about wind turbines instalments and

[58] RESMONITOR – Portugal (Retrieved 29 August 2023): https://resmonitor.eu/en/pt/barriers/948/

Urban area & country	Social barriers
	the impact they have on the nearby local communities (Caporale & De Lucia, 2015).
Grenoble, France	In France, including Grenoble, there are a couple of social barriers that demand closer attention: • *Noise regulation and social acceptance of wind turbines* Wind power projects sometimes face opposition from residents due to noise concerns, even though noise emissions from wind turbines are subject to strict regulations. The acoustics of wind farms in France are governed by the August 26, 2011, Decree for classified environmental protection installations, applicable to all wind farms since January 1, 2012. Complaints related to wind turbine noise include issues like sleep disturbances, headaches, dizziness, among others. The Agency for Food, Environmental, and Occupational Health & Safety does not attribute these symptoms to a specific vibro-acoustic disease but recognises a wind-acoustic syndrome, characterized by environmental intolerance, as the likely cause of these complaints (RESMONITOR[59], 2021). • *Lightning signalling the position of wind turbines affects social acceptance* A survey by the French Institute of Public Opinion in February 2021 revealed that 77% of respondents had a favourable view of wind energy, with 20% having a very positive opinion. However, 53% were against having a wind turbine near their home (including 23% strongly opposed), while 47% were in favour. Notably, those who held a negative view of wind energy were strongly against having turbines nearby (96%), while people already living near turbines were more likely to support additional installations (67%). One significant issue affecting social acceptance is the lighting requirements for wind farms in France. Unlike other European and international regulations, French law mandates specific visible flashing lights for each turbine (2000 cd red at night and 20,000 cd white during the day). This has led to complaints from residents about the disruption caused by these lights, resulting in legal disputes. In response, the government introduced new regulations in January 2018, allowing for a mix of lighting options on turbines, including permanent lights and extended time between flashes for those with flashing lights. This regulation came into effect in February 2019, applying to all new installations and requiring retrofits for existing fleets only when at least half of the turbines are replaced. These changes aim to reduce the inconvenience caused to residents by wind farm lighting (RESMONITOR[60], 2021).

[59] RESMONITOR – France (Retrieved 29 August 2023): https://resmonitor.eu/en/fr/barriers/358/

[60] RESMONITOR – France (Retrieved 29 August 2023): https://resmonitor.eu/en/fr/barriers/370/

Urban area & country	Social barriers
Halmstad, Sweden	In Sweden, the social barriers can be framed into complex concern that provokes more opposition to wind power. Such events also affect Halmstad. In more detail: • *Local opposition to the establishment of wind power plants* Public acceptance is a critical factor in the sustainable development of wind energy. While wind power enjoys popularity in Sweden, there are local citizen initiatives opposing its construction. These oppositions stem from concerns like landscape preservation, noise pollution, climate scepticism, energy reliability, pro-nuclear sentiments, and environmental worries. Support for wind power diminishes when people perceive local disadvantages while others reap the benefits. The SWEA suggests redirecting property tax from wind power to municipalities, providing economic benefits to residents, while noting that increased revenue from energy taxes and VAT at the state level will offset the loss of property tax income (RESMONITOR[61], 2021).
Lyngby, Denmark	In Denmark, it is considered that the societal acceptance is very high, yet some of the social barriers remain active and apply to Lyngby: • *Perceived high costs* Higher system costs require more decentralised power production and more adequate economic incentives for co-owned processes (Bolwig, et. al, 2020). • *Social norms and culture* Communities are reluctant to onshore wind power installation due to the aesthetic, noise pollution and other concerns. Expected onshore wind parks. More solar power and offshore wind should be explored (Bolwig, et. al, 2020). • *Access to information and planning* The lack of local ownership and alienating planning processes are central causes of local resistance to the deployment of RES (Bolwig, et. al, 2020).
Maynooth, Ireland	Ireland is in an excellent position for wind power use, and whilst there are many good examples of social acceptance and energy communities in Maynooth, the country still suffers to some extent: • *Lack of positive public perception towards wind energy* Public perception of wind energy in Ireland poses a significant barrier, particularly for large-scale onshore wind projects. Anti-wind energy and "anti-pylon" groups have united to oppose grid development projects, exploiting planning regulations to halt wind power development. While overall public opinion on renewable energy is positive, rural communities in the West, where much of the renewable energy potential lies, face strong opposition. Addressing this issue requires transmission development to distribute electricity from west to east, and the new Renewable Energy Support Scheme (RESS) offers potential solutions

[61] RESMONITOR – Sweden (Retrieved 29 August 2023): https://resmonitor.eu/en/se/barriers/1151/

Urban area & country	Social barriers
	through increased community benefits and a dedicated category for community projects (RESMONITOR[62], 2022).
Valencia, Spain	Spain has made progress in developing alternatives with residents-citizens who were developing cooperatives and trying to self-sustain their consumption needs. Even so, the future of decentralisation brings more challenges and needs for circular demand-supply from different sources and awareness raising among residents is necessary, including Valencia. The contemporary social challenges are the following: • *Lack of information* Disinformation campaigns have long aimed to manipulate public opinion, originally against renewable energy development and now against a more decentralized and democratic energy system. The National Energy and Climate Plan 2020 acknowledges the need to address information barriers and plans to generate objective knowledge through institutional channels like the IDAE, aiming to establish a common language for RE communication and increase social acceptance among citizens. Additionally, the government's clear support signals for the RE sector are positively impacting public opinion. The historical development of the barrier dates back to the late 1990s when the deficit in the electricity sector began, allowing costs from one year to be deferred to the future. The accumulated debt forced consumers to pay annually. Despite various factors contributing to the deficit, manipulative messaging by the electric oligopoly wrongly attributed it to renewable energy tariffs, damaging the government's image of RES. RES associations in Spain are now combating not only the resistance to change but also misconceptions about the cost-effectiveness of renewable energy technologies (RESMONITOR[63], 2021). • *Lack of training and trust* The lack of training and trust in immature renewable energy technologies like small wind, geothermal, and marine energy is a persistent issue. The National Energy and Climate Plan acknowledges this barrier and proposes education strategies in collaboration with local governments, autonomous communities, and the private sector to address it. However, these measures have not yet been implemented, keeping the barrier relevant (RESMONITOR[64], 2022).
Global reach – Addis Ababa, Ethiopia	In Ethiopia, there are few social barriers that need to be addressed (Tiruye et al., 2021): • *Limited awareness and understanding* Lack of awareness among the general population about the benefits of renewable energy hinders its adoption. • *Cultural practices and traditional energy sources*

[62] RESMONITOR – Ireland (Retrieved 29 August 2023): https://resmonitor.eu/en/ie/barriers/651/

[63] RESMONITOR – Spain (Retrieved 29 August 2023): https://resmonitor.eu/en/es/barriers/1131/

[64] RESMONITOR – Spain (Retrieved 29 August 2023): https://resmonitor.eu/en/es/barriers/1124/

Urban area & country	Social barriers
	Traditional energy practices and cultural factors influence energy consumption patterns, making it challenging to shift from traditional energy sources to renewables. • *Insufficient education and engagement* Education and engagement efforts are needed to inform communities about renewable energy benefits and promote its use, especially in rural areas. • *Political conflicts and instability* Political conflicts, both regionally and internally, hinder renewable energy development, contributing to uncertainty and delays in projects.
Global reach – Chang Mai, Thailand	Thailand is addressing social barriers (IRENA[65], 2017; Sirasoontorn & Koomsup, 2017) such as: • *Incentives for thermal utilisation of renewable energy sources* Renewable thermal energy, particularly biomass, accounts for a significant portion of Thailand's renewable energy goals. However, limited incentives for end-users to adopt modern renewable thermal solutions hinder market development, despite identified technological options. Thailand should establish a policy framework and incentive schemes for renewable thermal energy, collect comprehensive energy metrics, assess demand, and promote feasible applications. The objective is to create biomass supply chains that provide reliable, affordable fuels while diversifying income sources for local farms without compromising food security. • *Policy uncertainty and discontinuity* The slow progress of Thailand's energy transition is attributed to policy uncertainties and discontinuities. Solar power, for example, experienced fluctuations in policy support, leading to a pause in solar power support between 2010 and 2013. Frequent changes in policy direction and a lack of consistent support have discouraged investments in renewable energy. The residential rooftop solar market also faced slow growth due to complex permit processes and a lack of feasibility for residential-scale systems. • *Lack of transparency and accountability* Weak governance in the energy sector has resulted in a lack of transparency, public participation, and accountability. Centralized decision-making by government agencies and regulators has eroded public trust. Limited stakeholder involvement in power planning and development processes, such as the Power Development Plan, has led to public protests and scepticism regarding energy decisions.

[65] IRENA – Thailand (Retrieved 20 September 2023): https://www.irena.org/-/media/files/irena/agency/publication/2017/nov/irena_outlook_thailand_2017.pdf

Urban area & country	Social barriers
Global reach – Seoul, South Korea	At this moment, the most crucial social issue is awareness raising and demystification of energy transition among South Koreans (Energy Tracker Asia[66], 2022; Research Outreach 2021; Kim et al., 2020): • *Public opinion and resistance* Despite acknowledging climate change as a significant threat, the public remains divided on renewable energy projects. Many communities oppose having renewable energy infrastructure near their homes, leading to conflicts, delays, and project rejections. Thus, the workforce and unions of workers have a fear of job losses due to diverging in energy production.

In conclusion, addressing social barriers to renewable energy uptake is vital for fostering sustainable energy practices in urban areas. To overcome these obstacles, efforts must **focus on enhancing public awareness, integrating renewable energy systems aesthetically, and promoting active engagement of local communities and stakeholders in decision-making processes**. By fostering social acceptance and collaboration, urban areas can effectively embrace renewable energy sources and advance towards a greener and more sustainable future.

4.2.1 Learning outcomes to address social barriers

The learning outcomes focused on addressing social barriers to renewable energy adoption are the following:

- **Energy literacy and communication skills:** To combat public misinformation and improve public perception, individuals should develop skills in energy literacy and effective communication. This includes the ability to convey accurate information about renewable energy sources and technologies to the public and engage in transparent dialogue about energy and climate change.
- **Community engagement and collaboration:** Learning outcomes should emphasize the importance of community engagement and collaboration. Individuals should be equipped with skills to work closely with local communities, address their concerns, and involve them in renewable energy projects, potentially through co-ownership and shared benefits.
- **Environmental and aesthetic considerations:** Education and training programmes should cover the environmental and aesthetic aspects of renewable energy installations. This includes understanding the visual impact on landscapes, cultural heritage preservation, and strategies for integrating renewable energy systems harmoniously with nature.
- **Awareness and information dissemination:** Learning outcomes should focus on raising awareness among end-users and residents about the subsidization of renewable energy sources through electricity bills. Individuals should be trained in effective information dissemination and cost breakdown communication to improve social acceptance.
- **Policy advocacy and regulatory knowledge:** To address social barriers related to noise regulations, lighting requirements, and other concerns, individuals should develop skills in policy advocacy. They should also gain in-depth knowledge of relevant regulations and standards governing renewable energy technologies to navigate legal disputes and advocate for appropriate changes.

[66] Energy Tracker Asia 2022 (Retrieved 20 September 2023): https://energytracker.asia/the-main-barriers-to-the-renewable-energy-transition-in-south-korea/

- **Community benefit and economic incentives:** Individuals should be trained in designing economic incentives and benefits for local communities affected by renewable energy projects. This includes redirecting property taxes, revenue-sharing models, and strategies to ensure that the community directly benefits from the projects.
- **Cultural sensitivity and adaptation:** In regions where, renewable energy faces cultural resistance, individuals should develop cultural sensitivity and adaptability skills. This includes understanding and respecting local cultural values and finding ways to align renewable energy projects with these values.
- **Renewable energy technologies education:** To build trust in emerging renewable energy technologies, individuals should receive education and training in these technologies. This includes small wind, geothermal, marine energy, and other less common renewable sources to ensure informed decision-making and project implementation.

These learning outcomes will empower the workforce and students to effectively address the social barriers associated with renewable energy adoption, fostering greater public acceptance and facilitating the transition to a greener energy future.

4.3 Economic barriers

The uptake of renewable energy sources in urban areas faces economic barriers that hinder their widespread adoption and integration. This abstract delves into the key economic obstacles that impede the transition towards renewable energy solutions in urban areas.

One significant economic barrier is the **high upfront cost of implementing renewable energy systems** (Painuly, 2001). Unlike conventional fossil fuel-based technologies, renewable energy technologies often require substantial initial investments in equipment, installation, and infrastructure. The financial burden associated with these upfront costs can dissuade individuals, businesses, and municipalities from pursuing renewable energy projects, especially in economically constrained urban settings.

Additionally, the **lack of access to affordable financing** options poses a considerable challenge. Many renewable energy projects may not meet the stringent requirements of traditional financing institutions, making it difficult for urban stakeholders to secure loans or financial support. The limited availability of favourable financing mechanisms inhibits the scaling up of renewable energy initiatives in urban areas.

Furthermore, **uncertainties related to the return on investment (ROI)** and payback period of renewable energy projects can deter potential investors. The **fluctuating nature of energy prices, changing government policies**, and other market uncertainties can create financial risks that discourage commitment to long-term renewable energy projects.

Moreover, the existing energy subsidy structures and market dynamics may favour conventional fossil fuel-based energy sources over renewables. In some cases, **outdated or misaligned subsidy policies** can provide an unfair advantage to fossil fuels, making **renewable energy less economically competitive in the market**.

Table 4 shows how these barriers reflect per RES4CITY urban area and country.

Table 4. Economic barriers for the RES4CITY urban areas and countries

Urban area & country	Economic barriers
Coimbra, Portugal	In Portugal, there are already incentives for the use of renewable energy sources and favourable incentives and/or deduction systems, however, economic barriers that keep being troublesome such as: • *Initial Costs* While the operational costs of RES are quite low, the capital costs to installing main technological components such as solar panels and wind turbines is expensive. Financial incentives and subsidies may be needed to make these technologies more accessible. In 2019, Portugal introduced Decree-Law 76/2019 to address issue of market design that was less favourable for RES. This law aims to promote a stable and sustainable energy mix, control price volatility, and facilitate the transition from fossil fuels to renewables. It allows for capacity allocation through auctions, increasing transparency and reducing costs for consumers when new plants are operational. While solar PV auctions with support schemes have helped address barriers for solar technologies, other RES technologies still face challenges in this transition (RESMONITOR[67], 2023). • *Lack of development strategy for power line corridors* There's a disconnect between the Portuguese Environment Agency (APA) and municipalities regarding the placement of transmission lines. APA prefers clustering them in one corridor, while municipalities favour separate placements to minimize visual impact. This misalignment causes delays and escalates costs due to multiple power line crossing projects, with these crossings almost matching the expense of the lines themselves (RESMONITOR[68], 2023). • *Lack of strategy for repowering wind capacity* There is a lack of strategy to repower wind capacity considering that the more than half of the wind fleet will be more than 20 years old by 2030. There is also no indication of tender schedules for such endeavour. In projects that benefit from an ongoing feed-in tariff, repowering may not be economically viable. Consequently, it is crucial to establish a well-defined regulatory and compensation framework specifically for repowering initiatives (RESMONITOR[69], 2023). • *Lack of support to offshore technologies* The absence of supportive policies, regulations, and incentives can be a significant economic barrier for continuation of pilot projects such as the emerging offshore technologies. For example, the *Windfloat* offshore farm in Portugal has received public funds as it is based on the demonstrated technological novelty such as submarine cable. This makes it the first

[67] RESMONITOR – Portugal (Retrieved 28 August 2023): https://resmonitor.eu/en/pt/barriers/985/

[68] RESMONITOR – Portugal (Retrieved 28 August 2023): https://resmonitor.eu/en/pt/barriers/1641/

[69] RESMONITOR – Portugal (Retrieved 28 August 2023): https://resmonitor.eu/en/pt/barriers/1380/

Urban area & country	Economic barriers
	floating offshore wind plant of continental Europe. It enables the harvesting of abundant wind resources in deep waters where mounting foundations on the seafloor is not possible. Yet, such demonstrated technology still requires investments and loans (RESMONITOR[70], 2023).
Genoa, Naples and Sassari, Italy	At the national level, Italy suffers the economic barriers such as: • *Compensation for the imbalance of production forecasts* The Italian Regulatory Authority for Energy, Networks, and Environment introduced a significant change in electricity dispatching conditions for intermittent renewable energy sources like wind, solar, and run-of-river hydropower plants starting from January 1, 2013. This change involves producers being financially responsible for the discrepancies between their production forecasts and the actual energy delivered to the grid, which has a substantial economic impact. To address concerns, Resolution no. 522 was issued in October 2014 after a public consultation, which introduced tolerance bands and differentiated deductible percentages for various renewable technologies like wind, photovoltaic, hydroelectric, and geothermal energy, with different rules for units over and under 10 MW. These changes aim to improve forecasting accuracy and reduce penalties (RESMONITOR[71], 2021). • *Challenges for Power Purchase Agreements* Power Purchase Agreements (PPAs) are vital for ensuring steady profits and increasing the bankability of RES in Italy. However, the Italian RES market is primarily characterized by smaller installations benefiting from the net-metering scheme rather than PPAs due to limitations in Article 18 of the FER Decree, which restricts PPAs to single end-users, excluding many sectors. The slow authorization process has also hindered PPA adoption, although some improvements were made through the Simplifications Decree. Despite this, as of 2021, the Italian PPA market is still emerging, with most contracts lasting 0 to 5 years, although notable deals, like Telecom Italia's 10-year contract with ERG for 3.4 TWh of wind energy, indicate growing promise in this sector (RESMONITOR[72], 2022). • *Imbalance of financial incentives for RES technologies* In 2019, the Italian government introduced the Renewable Energy Decree 2019-2021 (commonly known as "Decree Fer1"), which outlined eligible energy sources, including onshore wind, specific hydroelectric and landfill gas plants, and certain photovoltaic installations, but excluded offshore wind, geothermal, and solar thermal energy. A follow-up decree, FER2, initially delayed, is anticipated to be implemented by early 2022, focusing on more advanced technologies and community energy initiatives. The need for new incentives arises from previous regulations, like the "DM 23

[70] RESMONITOR – Portugal (Retrieved 28 August 2023): https://resmonitor.eu/en/pt/barriers/990/

[71] RESMONITOR – Italy (Retrieved 28 August 2023): https://resmonitor.eu/en/it/barriers/689/

[72] RESMONITOR – Italy (Retrieved 28 August 2023): https://resmonitor.eu/en/it/barriers/693/

Urban area & country	Economic barriers
	June 2016," which reduced incentives for small wind and mini-hydropower plants while discontinuing incentives for offshore wind, favouring waste incineration. Stakeholders in the renewable energy sector are calling for incentives to be directed away from non-renewable sources like incinerators and mega biomass plants and are advocating for simplifications to support businesses and citizens' self-generation of renewable energy, which they hope to see in FER2 (RESMONITOR[73], 2021). • *Access to bank loans* Stakeholders in renewable energy are concerned about difficulties securing bank loans due to unstable incentive systems. Despite the National Fund for Energy Efficiency offering support, many projects still struggle. Solar PV is an exception but faces slow permitting processes. Wind power heavily relies on support schemes, but banks are cautious, and limited auctions and political resistance hinder access. The complex administrative process compounds the issue, making a stable and accessible incentive system crucial. The National Fund for Energy Efficiency and PPAs offer potential solutions, but PPAs are still rare in Italy. Past incentive scheme changes have added uncertainty, with stability vital for financing. Administrative requirements and plant limitations complicate matters, particularly for wind power (RESMONITOR[74], 2021). • *Lack of consistency in providing financial incentives* Italy's renewable energy incentives have had a stop-and-start history due to political changes, making it challenging for project developers to plan. Recent improvements include the Renewable Energy Decree (Decree FER1) with a three-year duration (2019-2021) but criticized for excluding geothermal and solar thermal energy. A forthcoming FER2 Decree is expected to support innovative technologies like geothermal. Solar PV is thriving independently of incentives, projected to grow significantly. However, wind power remains vulnerable to the unstable incentivising system. Italy's past incentive system consisted of sporadic availability, with changes to eligibility criteria and support mechanisms adding complexity for renewable energy projects (RESMONITOR[75], 2021).
Grenoble, France	The strong dependency on nuclear energy and monopoly by specific suppliers bring about the following economic challenges: • *Increase offer of alternative suppliers on the market* The French electricity market is heavily dominated by a major player, EDF, which hinders market liberalisation and diversity. Independent power producers face limited financial opportunities in this context. However, there's a shift happening as independent electricity suppliers are gaining importance. In Q1 2021, CRE data revealed that 67% of residential

[73] RESMONITOR – Italy (Retrieved 28 August 2023): https://resmonitor.eu/en/it/barriers/685/

[74] RESMONITOR – Italy (Retrieved 28 August 2023): https://resmonitor.eu/en/it/barriers/679/

[75] RESMONITOR – Italy (Retrieved 28 August 2023): https://resmonitor.eu/en/it/barriers/678/

Urban area & country	Economic barriers
	customers still use EDF's Tarif Bleu, a decrease from 2018. Alternative electricity suppliers are growing in France and competing with EDF's regulated tariff. In the residential segment, approximately 100 companies are competing for a 29% market share, which is a 4% increase from 2018. As of March 31, 2021, roughly 71% of electricity consumption comes from market offers, with 43% supplied by alternative suppliers. This indicates a gradual shift towards a more diverse and competitive electricity market in France (RESMONITOR[76], 2021). • *Lobbying from nuclear energy advocates impairs RES* In June 2021, the French government held 83.77% of EDF, the national energy supplier, and a significant 86% of continental France's electricity production came from nuclear power in 2020. This suggests a relatively weak commitment to developing renewables. In this context, solar and wind energy are often viewed as expensive and inefficient, a sentiment reinforced by the Court of Auditors' critical reports on renewable energy policies, such as those from 2013 and 2019. It's important to note that the costs of solar PV and wind plants have significantly decreased over the past decade, making them cost-effective alternatives in many areas of France. The most recent Court of Auditors report from December 2021 continues to heavily focus on nuclear energy, further undermining the potential of renewables. Additionally, the energy operator RTE suggests that scenarios relying solely on renewables may be less competitive than those incorporating nuclear power. However, RTE also indicates that new nuclear plants would be more expensive overall than renewables in 2050. While nuclear energy's prominent role challenges renewable energy development in France, the government's current emphasis on green growth and energy transition presents an opportunity for renewables in the near future. The government must provide clear, long-term signals to attract renewable energy investors to the country (RESMONITOR[77], 2022).
Halmstad, Sweden	Sweden has been very proactive in developing renewable energy systems yet when it comes to wind power technology, there are still some economic barriers to be tackled: • *Lack of financial support for wind power technology* Offshore wind power is vital for Sweden, aiming to generate 100 TWh of wind energy by the 2040s, split between 80 TWh onshore and 20 TWh offshore. However, Swedish offshore projects pose higher risks for developers who must cover development and grid connection costs. To boost offshore wind development along Sweden's coast, efforts include reducing grid connection fees, expanding the transmission network, and

[76] RESMONITOR – France (Retrieved 28 August 2023): https://resmonitor.eu/en/fr/barriers/372/

[77] RESMONITOR – France (Retrieved 28 August 2023): https://resmonitor.eu/en/fr/barriers/363/

Urban area & country	Economic barriers
	offering new guidelines, as announced by the Swedish government in October 2021 (RESMONITOR[78], 2022). • *Barriers to cooperatively owned wind power* The findings from the study "Come Together—The Development of Swedish Energy Communities" indicate that Sweden has seen fewer community energy initiatives compared to other European countries. Despite a somewhat challenging institutional environment, community energy, especially in the form of wind cooperatives, has emerged. While these initiatives may have limited quantitative impact on the energy transition, they play a vital role in knowledge sharing and can inspire future projects. In Sweden, most wind turbines are owned and operated by large corporations. One significant obstacle to the development of wind turbines with cooperative ownership is the uncertainty surrounding the withdrawal tax. This tax increases the cost of electricity sold to cooperative members to match market prices, even if the actual production cost is much lower. Consequently, the withdrawal tax reduces the economic benefits of participating in a wind energy cooperative. The SWEA points out that barriers to cooperatively owned wind power can also negatively impact public acceptance of wind projects in general, affecting both large and small wind farms (RESMONITOR[79], 2021). • *Unnecessary costs for small-scale wind power producers* There are too little areas dedicated to the small-scall wind power production. There is also insufficient number of product providers that can maintain and repair (RESMONITOR[80], 2021).
Lyngby, Denmark	• *Sustainability of wind power performance* Over the last forty years, wind energy production has experienced losses due to the declining performance of wind turbines as they age, resulting in curtailments and failures. This decline in performance is characterised by a reduction of more than 10% in the average annual energy production during the later years of a wind turbine's lifespan, which cannot be regained before the turbine is taken out of service (Renewables[81], 2023). • *Energy efficiency retrofitting* Some substations require retrofitting. They enable the power to find its way through the system from inbound to outbound cables. Today, they are outdated and require extensive upgrading and retrofitting to increase

[78] RESMONITOR – Sweden (Retrieved 28 August 2023): https://resmonitor.eu/en/se/barriers/1322/

[79] RESMONITOR – Sweden (Retrieved 28 August 2023): https://resmonitor.eu/en/se/barriers/1146/

[80] RESMONITOR – Sweden (Retrieved 28 August 2023): https://resmonitor.eu/en/se/barriers/1145/

[81] RESMONITOR – Denmark (Retrieved 28 August 2023): https://renewablesnow.com/news/world-to-add-380-gw-of-offshore-wind-by-2032-gwec-forecasts-832199/

Urban area & country	Economic barriers
	capacity and minimise the risk of bottlenecks as more green energy enters the electricity grid (Ramboll[82], 2023). • *Cost competitiveness with fossil fuels* There is a low price of carbon credits of Emissions Trading System on the European market in Denmark. This may have a negative influence on export opportunities for Danish renewable energy producers. There is a proposal to introduce a new greenhouse gas tax in Denmark with a price of DKK 1,500 (EUR 200) per ton in 2030 (RESMONITOR[83], 2023). • *Insecurity among investors in nearshore wind energy* At present, individuals residing near offshore wind turbines situated within a 16-kilometer radius from the shoreline have similar rights to those living near onshore turbines. They are eligible to receive compensation from the investor and can participate in a local ownership initiative. This initiative stipulates that a minimum of 20% ownership shares must be made available for purchase by residents, enabling them to partake in the profits generated by the wind farms. Nevertheless, these initiatives raise concerns among investors regarding their potential influence on the risk premium associated with nearshore tenders (RESMONITOR[84], 2023). • *Uncertainty in regulation hinders investment in natural gas phaseout* The district heating and heat pump sectors have faced uncertainty due to stop-go subsidies. Further, the mix between monopoly regulation of district heating and simultaneously opening the district heating areas for competition with heat pumps, has generated an investment environment where district heating companies are hesitant to comply with targets for transition from natural to district heating. This is due to the uncertain business case in areas potentially undermined by heat pumps.
Maynooth, Ireland	• *Increase of costs for PV deployment* The Irish market faces cost factors that result in extensive higher prices compared to other European markets. To make ground-mounted PV technology more competitive, it is imperative to conduct a thorough investigation to uncover and address the underlying reasons behind these elevated prices (RESMONITOR[85], 2021). • *Double counting of development contributions* This pertains to methods by which developers can support local infrastructure expenses in a specific area, often calculated on a per MW (megawatt) basis. These contributions can significantly impact project earnings and vary from one local authority area to another. According to the Irish Solar Energy Association, these development contributions can

[82]Ramboll 2023 (Retrieved 28 August 2023): https://www.ramboll.com/projects/energy/energinet-overhauling-the-danish-grid

[83] RESMONITOR – Denmark (Retrieved 28 August 2023): https://resmonitor.eu/en/dk/barriers/269/

[84] RESMONITOR – Denmark (Retrieved 28 August 2023): https://resmonitor.eu/en/dk/barriers/268/

[85] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/1461/

Urban area & country	Economic barriers
	range from 7% to 17% of a project's first-year revenues. Additionally, the RESS-1 programme has introduced a local Community Benefit Fund, which guarantees a minimum of €2 per MWh for each successful project, creating a potential issue of double counting (RESMONITOR[86], 2021). • *Restrictive planning regulation for PV rooftops* Existing domestic regulations stipulate that planning permission is necessary when a solar installation covers an area larger than 12 m2 or exceeds 50% of the total roof area. These regulations hinder the potential for maximizing self-consumption of rooftop PV. Additionally, commercial users encounter unnecessary constraints, as solar installations are capped at 50 m2 before requiring planning permission. This planning process can take 3-5 months, adding both cost and time to installations (RESMONITOR[87], 2021). • *Low support level of Microgeneration Support Scheme* The expected Microgeneration Support Scheme (MSS) may provide homeowners with an average annual benefit of €104, but this relatively low support level could deter widespread adoption of microgeneration. Consequently, the growth of rooftop photovoltaic (PV) installations in Ireland may be limited. However, more ambitious policies could potentially result in rooftop PV capacity reaching five times the expected amount under the current conservative policy by 2030 (RESMONITOR[88], 2021). • *Complex connection process for micro-generators* The process for connecting micro renewable energy systems with capacities ranging from 11 kWp to 50 kWp (used in sectors like schools, agriculture, food, and retail) is slow and problematic. Customers must apply along with a fee of €773, and it can take 1-2 years to receive a connection date, which may be further delayed by another year. The application process itself is uncomplicated, but service providers typically charge an average of €1,000 to €1,500. In addition to the equipment and connection expenses, small-scale generators must invest in protective equipment, which can cost as much as €4,000. These expenses can have a detrimental impact on the ability of smaller entities to participate in the micro-RES sector (RESMONITOR[89], 2021). • *Dispatch and curtailment issues for RESS projects* Successful RESS projects can't control variables like constraint levels, curtailment, energy balancing, or changes in Transmission Loss Adjustment Factors and Transmission Use of System Charges. These

[86] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/1460/

[87] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/1456/

[88] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/1457/

[89] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/1455/

Urban area & country	Economic barriers
	factors are volatile over a 35-year project lifecycle, creating uncertainty and risk for developers. This leads to inefficiencies in RESS auctions, as developer estimates impact consumer costs for 15 years, regardless of improvements. It also requires a higher investment hurdle rate to compensate for this risk (RESMONITOR[90], 2021). • *Increase of commercial property rates* The increase in commercial property tax rates, which have doubled or even tripled in some cases since 2016, has posed a significant barrier to wind energy projects in Ireland. This increase nullifies the expected decrease in capital costs and challenges the argument for lower energy costs. The wind energy sector has taken legal action against this tax hike, viewing it as an indirect subsidy to fossil fuels, and the European Court of Justice is now involved in the dispute. Additionally, the rise in commercial rates is affecting PV projects, potentially jeopardizing the viability of renewable energy initiatives (RESMONITOR[91], 2022).
Valencia, Spain	Spain has capsized the opportunity to create strong market for renewable energy sources but also took some financial decisions that extended economic barriers to: • *High grid connection costs* The main challenge in grid connection for renewable energy projects is the significant connection costs, which can deter investment due to their upfront burden. In underdeveloped grid areas, developers must bear the additional expense of strengthening networks, and if multiple producers' benefit, they must negotiate cost-sharing with the system developer and distribution system operator. High connection costs are particularly problematic for medium voltage grid-connected RES-E plants due to the lack of clear interconnection rules, while outdated guidelines can cause issues in low voltage grids. This problem also arises when developers seek to build in areas with good resources but limited grid capacity or electricity demand (RESMONITOR[92], 2021). • *Excessive and unfair tax regime* Taxes in Spain, including the controversial IVPEE tax on renewable energy sources, have been steadily increasing each year, not only from the central government but also from regional and municipal authorities. The IVPEE tax, which was introduced in 2013, has faced legal challenges for potentially violating European rules by imposing additional excise duties on energy production without financing specific public spending, as required by Directive EC 2008/118. Furthermore, construction and urban licensing taxes imposed by municipalities can be quite substantial,

[90] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/1452/

[91] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/ie/barriers/661/

[92] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/es/barriers/1102/

Urban area & country	Economic barriers
	accounting for approximately 4% of the total project budget. Although a temporary suspension of the IVPEE tax provided some relief for renewable energy producers, it expired in April 2019, and experts argue that its impact on the market and renewable energy support schemes has been manageable (RESMONITOR[93], 2021). • *First tenders ever launched in Spain with a low realisation rate* In 2016, Spain held its first wind and biomass tenders, but they faced issues such as winning projects setting their prices to zero and the absence of a pre-qualification stage, which raised concerns about project viability. In 2017, Spain conducted more successful solar and wind power auctions by implementing improved auction rules, including requirements for bidders to demonstrate their ability to complete projects on time, enhancing project realization security. In 2020, a new auction scheme for renewable energy technologies was introduced, with its effectiveness still to be assessed, while in 2021, a new law allowed for tendering processes for post-coal plant closure power allocation, considering socio-economic and environmental criteria, though concerns exist about the mandatory implementation of these criteria. (RESMONITOR[94], 2022)
Global reach – Addis Ababa, Ethiopia	Ethiopia does not have an exit to sea but has good geographical coverage in sense of climate and landscape which could support future use of wind and sun energy. Even so, it lacks behind due to the few relevant economic barriers (Tiruye et al., 2021): • *High cost of geothermal and wind energy technologies* Ethiopia faces economic barriers due to the relatively high initial costs associated with geothermal and wind energy technologies, limiting their widespread adoption. • *Lack of funding for feasibility studies* Insufficient funding for feasibility studies hampers geothermal energy project development. • *Underdeveloped rural energy infrastructure and markets* Underdeveloped rural energy infrastructure, coupled with weak energy markets, restricts private sector involvement and commercial operations.
Global reach – Chang Mai, Thailand	Thailand is addressing economic barriers (IRENA[95], 2017; Sirasoontorn & Koomsup, 2017) such as: • *Long-term plan for electric mobility* Thailand aims to promote biofuels and electric vehicles (EVs), creating uncertainty for the automobile industry. Concerns exist about competition between EVs and biofuel vehicles if policies are not carefully designed.

[93] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/es/barriers/1098/

[94] RESMONITOR – Ireland (Retrieved 28 August 2023): https://resmonitor.eu/en/es/barriers/1099/

[95] IRENA – Thailand (Retrieved 20 September 2023): https://www.irena.org/-/media/files/irena/agency/publication/2017/nov/irena_outlook_thailand_2017.pdf

Urban area & country	Economic barriers
	Thailand should develop a long-term strategic plan for the transport sector, covering vehicles, fuel types, and infrastructure. The plan should ensure the gradual penetration of EVs into the market, supported by technological innovation, research and development, and consistent policy frameworks. Additionally, Thailand should consider tapping into the electric two- and three-wheeler markets, incentivize the replacement of obsolete vehicles with EVs, and invest in charging facilities to facilitate EV adoption. • *Distorted fiscal and regulatory policies* Distorted fiscal and regulatory policies hinder energy conservation measures. For instance, energy-saving policies in public schools have lower priority compared to direct educational projects. Some public schools do not bear the cost of their energy bills, leading to indifference toward energy consumption behaviour. The fiscal and regulatory policies do not incentivize energy-saving efforts in these institutions. • *Unsuccessful energy reforms* The electricity sector in Thailand is dominated by three state-owned enterprises operating in a monopolistic manner. Attempts to introduce structural reforms in the electricity sector have failed. The lack of unbundling of state operators and bureaucratic regulations by the ERC create obstacles for renewable energy producers to access the grid and trade electricity. These factors hinder the growth of decentralized renewable energy projects.
Global reach – Seoul, South Korea	The most pressing economic barriers in South Korea are related to transition from fossil fuels to renewables and underinvestment in the necessary infrastructure (Energy Tracker Asia[96], 2022; Research Outreach 2021; Kim et al., 2020): • *Stranded assets* South Korea has significant legacy assets tied to coal and other fossil fuels that require a transition to cleaner energy sources. According to Carbon Tracker, the country has the highest stranded asset risk globally, which poses economic challenges. • *Liquid natural gas dependency* Instead of transitioning to renewable energy, South Korea may opt for liquefied natural gas (LNG), which is seen as uncompetitive compared to renewables in terms of Levelized Costs of Electricity. This reliance on LNG could lead to economic risks and hinder carbon emissions reduction goals. • *Infrastructure Underinvestment* The government's emphasis on promoting Fuel Cell Electric Vehicles faced a significant hurdle due to underinvestment in refuelling infrastructure for hydrogen-powered vehicles, making it challenging for FCEVs to gain traction. In addition, government finance bureaucrats expressed concerns

[96] Energy Tracker Asia 2022 (Retrieved 20 September 2023): https://energytracker.asia/the-main-barriers-to-the-renewable-energy-transition-in-south-korea/

Urban area & country	Economic barriers
	that the increased adoption of Electric Vehicles (EVs) would reduce petrol consumption, impacting petrol tax revenue, which was a substantial source of income.

In conclusion, the transition to renewable energy sources in urban areas is hampered by various economic barriers, including high upfront costs, limited access to affordable financing, ROI uncertainties, and unfavourable subsidy structures. Governments and financial institutions must implement supportive policies, incentives, and innovative financing models to promote renewable energy adoption and make it economically viable. Addressing these economic challenges requires innovative financial solutions, policy adjustments, and market reforms that level the playing field for renewable energy technologies. By overcoming economic barriers, urban areas can unlock the vast potential of renewable energy sources and accelerate their journey towards a sustainable and resilient energy future.

4.3.1 Learning outcomes to address economic barriers

Addressing economic barriers depends a lot on the local, regional and national government, yet some of them can be resolved with joint forces of policymakers, industry and academia through acquiring more knowledge, skills, attitudes and behaviour in:

- **Renewable energy technology knowledge:** Students and the workforce should gain a comprehensive understanding of various renewable energy technologies, including solar, wind, offshore technologies, and biomass. This knowledge should encompass their advantages, disadvantages, costs, and regulatory frameworks to address economic barriers.
- **Energy grid management and development:** Education and training programs should emphasize grid management, particularly addressing challenges related to grid connection for renewable energy projects. This includes understanding grid capacity, grid strengthening, and strategies to reduce grid connection costs.
- **Policy and regulatory proficiency:** Learning outcomes should focus on understanding the evolving policy and regulatory landscape in the renewable energy sector. This includes knowledge of incentives, subsidies, tax regimes, and government initiatives designed to promote renewable energy adoption.
- **Financial literacy and project financing:** Individuals in the green job market should be equipped with financial literacy skills to evaluate the feasibility and financial viability of renewable energy projects. This should include knowledge of financing options, such as subsidies, grants, and loans, as well as risk assessment and cost-benefit analysis.
- **Community energy initiatives:** Learning outcomes should address the importance of community energy initiatives, including wind cooperatives and energy communities. This includes understanding the legal and financial challenges associated with cooperative ownership and strategies to overcome them.
- **Sustainability and maintenance of renewable energy systems:** Individuals should gain knowledge about the long-term sustainability and maintenance requirements of renewable energy systems, especially in the context of ageing wind turbines. This includes strategies for repowering wind capacity and maintaining performance over time.
- **Market analysis and export opportunities:** Education and training programmes should cover market analysis, including the assessment of carbon credits and market dynamics affecting the export of renewable energy products and services. Understanding how economic factors influence competitiveness in the global market is crucial.

- **Stakeholder engagement and advocacy:** Recognising the role of advocacy and stakeholder engagement is important for individuals working in regions with political challenges related to renewable energy. Learning outcomes should include skills for advocating for supportive policies and regulations.
- **Grid integration and energy efficiency:** Understanding grid integration techniques, energy balancing, and the impact of transmission loss adjustment factors is essential for professionals working in the renewable energy sector. This knowledge helps optimise the efficiency of renewable energy projects.
- **Legal and regulatory compliance:** Training programmes should emphasise the importance of compliance with local, national, and international regulations, including tax regimes and environmental standards, to ensure the success and sustainability of renewable energy projects.

5. User-centred educational framework

5.1 Rationale for a user-centred approach

The rationale for a user-centred approach to educational framework, micro-programmes and micro-credentials (MOOCs) development is grounded in the recognition that a successful energy transition depends on widespread adoption and skilful engagement from relevant stakeholders across energy and related value chains in cities that include different existing infrastructures, operations and behaviour patterns.

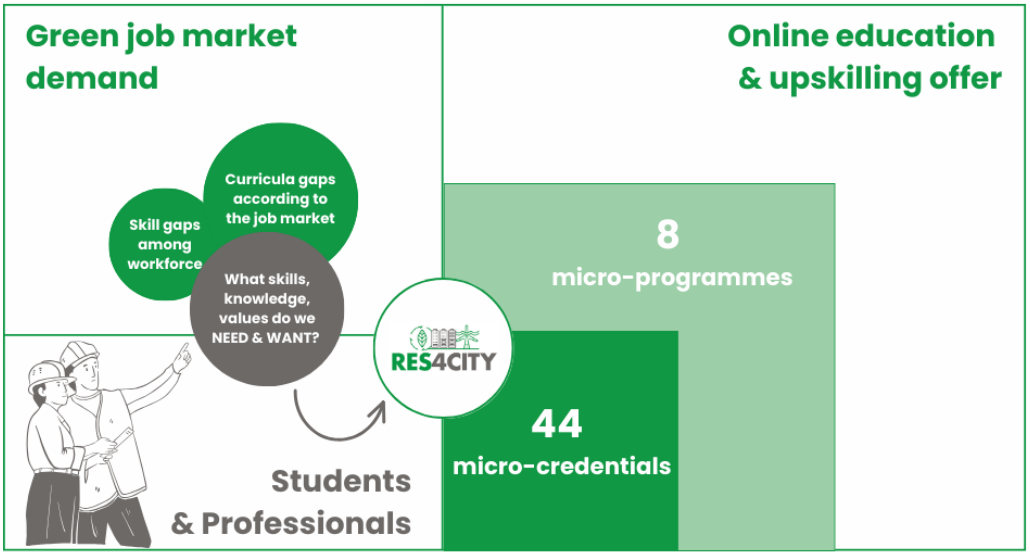

Figure 2. User-cantered approach

The user-centred approach ensures that the educational framework composed of micro-programmes and micro-credentials is tailored to the specific needs and interests of the target audience. By understanding their knowledge level, concerns, and motivations, the micro-programmes can be designed to provide information that is relevant and meaningful to them, increasing their engagement and willingness to participate. For example, energy producers, distributors, retailers, researchers, teachers, students, energy users, regional energy agencies and local authorities have specific and shared needs, preferences, and aspirations in upskilling to meet the demands of the sector and industry they operate.

Energy transition often requires changes in behaviour and lifestyle choices such as resilience and adaptability to occurring situations besides the usual upskilling of more technical and operational skills. A user-centred approach identifies the barriers and drivers for behavioural change and designs educational content that addresses these factors. This can lead to more successful adoption of sustainable energy practices and technologies. Involving the target audience in the development process empowers them to take ownership and responsibility for training and further uptake of acquired competencies. When individuals feel their voices are heard and their needs are considered, they are more likely to become active participants and advocates for sustainable energy solutions.

The energy transition can sometimes face resistance due to scepticism or misconceptions. A user-centred approach allows for the identification and addressing of these concerns, leading to greater acceptance and support for renewable energy initiatives. Also, different communities and demographics may have varying perspectives and priorities regarding energy transition. By embedding a user-centred approach in the co-development of an educational framework and micro-programmes it is possible to acknowledge and respect the diversity of needs, learning journeys and styles, as well as content, ensuring that educational micro-programmes are inclusive and accessible to all segments of the population.

The energy transition in urban areas is a complex and ongoing process. Trust is crucial in promoting behaviour change and acceptance of renewable energy technologies. A user-centred approach builds trust by demonstrating empathy, transparency, and accountability of citizens and community in specific urban areas. Educational micro-programmes that resonate with the user are more likely to be sustained and embedded into community practices over the long term. This sustainability is vital for the continuous advancement of energy transition goals.

5.2 Aim and objectives of the educational framework

According to the DoA, the RES4CITY educational framework aims to introduce inclusive teaching approaches to sustainable RES and FT and foster the creation of innovative study 8 micro-programmes and 44 micro-credentials for studying and upskilling. As a main key exploitable result of the project, it is expected that the content, format and distribution channels make it personalised, flexible, comprehensive, focused, intuitive, cost-effective and accessible to any individual or group eager to exploit it and acquire new knowledge, skills, attitude, values and dispositions toward circularity and sustainability. The RES4CITY micro-programmes and micro-credentials will be open access and available to anyone, at any time. This is possible through digitalisation and elaboration of the massive open online courses which may require internet and digital tools for their application yet will offer lots of liberties such as self-paced, learner-centred and certified learning experiences.

5.3 Stakeholders as end-users

RES4CITY primarily focuses on early-career professionals such as STEM and non-STEM (i.e. Social Sciences and Humanities) students in their graduation and master courses, as well as early researchers and technical professionals at the more advanced stage of their careers. These users can utilise the RES4CITY micro-credentials and micro-programmes as individuals but also as members of the public and private universities, businesses, non-profit and civil society organisations eager to uptake the RES4CITY educational model and appropriate it to their teaching, in-house upskilling and capacity-building of local and global communities.

5.4 Format and content development

To reach the largest possible impact and to provide equal opportunities, independently of gender, income, location, and experience-level, RES4CITY is creating content, format and dissemination

strategies according to the user types to make micro-credentials and micro-programmes freely accessible to all the interested participants according to the open education principles bolstering SDG4 and SDG10.

The content of the micro-courses and micro-credentials is co-produced by the nine universities that belong to the RES4CITY consortium and represent hub leads. Each university has its expertise in considering energy transition, circularity, sustainable cities, innovation strategies and management, policy design, and sustainable finances, among others. According to the knowledge and understanding of the current green job market, the universities have elaborated micro-credentials to meet those standards. The format considers the accessibility of micro-programmes and micro-credentials through a MOOC platform entitled BoostMySkills on which for each micro-credential there will be a set of videos, reading materials and exchange forums to increase the active involvement of the user-learners. The available resources will be downloadable from any digital device so that learners can go through them even when they have no access to the internet.

6. Co-design process

6.1 Methodology for co-design

According to deliverables 3.1 and 3.2 on the co-creation framework, co-design is defined as ideation, planning and strategising of the micro-credentials and micro-programmes. The co-development phase is about hands-on experimentation and feedback loops of real-life solutions which is possible once the first versions of the micro-credentials are available. The exploitation and upscaling measures are discussed and outlined at the early stages of co-creation so that the solutions are feasible and timely, conveyed through exploitation actions with interested and target multipliers (other universities, companies, and cities).

Figure 3 demonstrates an approach to co-design with hubs' stakeholder networks, a process composed of tasks such as an assessment of the educational needs and upskilling gaps among the students and professionals and not only, identification of the relevant topics and competencies, and planning of the future use and testing. These tasks were implemented through quantitative and qualitative research methods and tools such as public surveys, interviews and stakeholder meetings with stakeholder networks of the eight hubs. Some of the tasks were implemented both at the local/regional and international level whilst others were delivered only at the local/regional level.

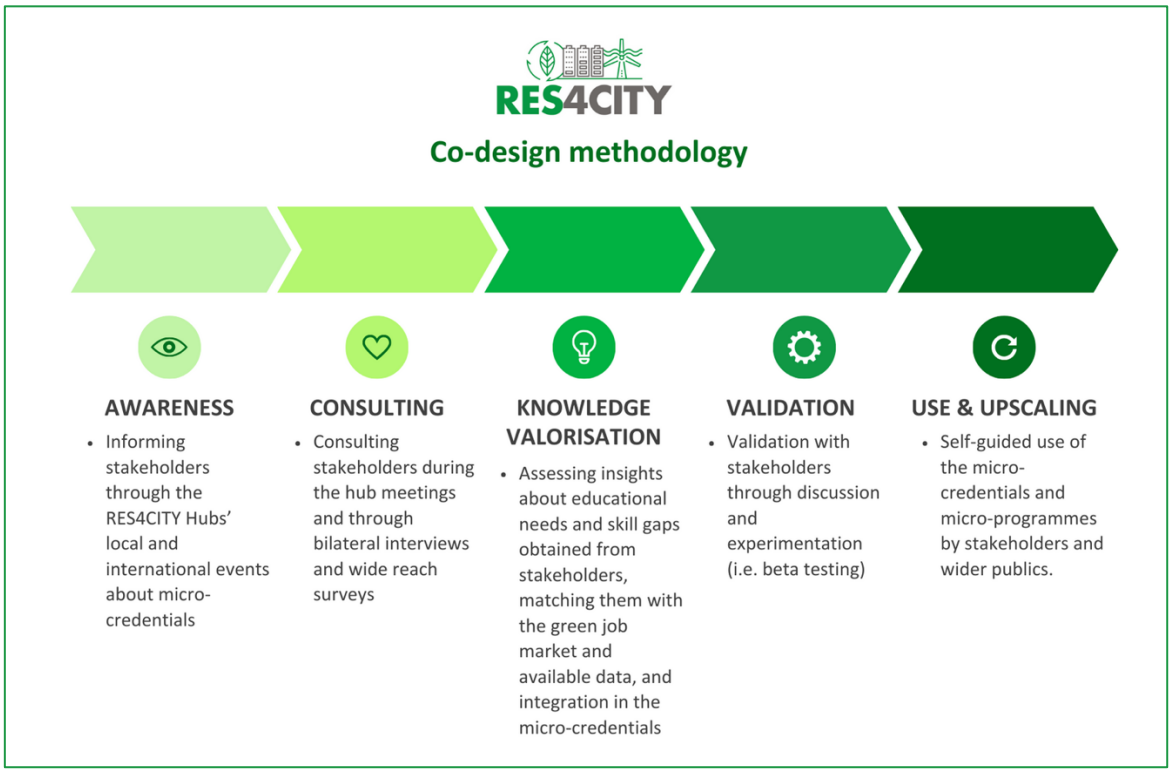

Figure 3. Co-design methodology of RES4CITY micro-credentials and micro-programmes

In the following text, the methods are explained and discussed in more detail.

6.1.1 Public survey

In deliverable 3.2, the preliminary results of a public assessment survey implemented between February and April 2023, aimed to gather feedback on required strategies for RES and FT deployment and the most relevant micro-programmes addressing contemporary educational needs for the energy transition in Europe and beyond. In deliverable 3.2 the results with 88 responses are presented, yet, in this deliverable, an update of results with a total of 112 responses is presented and discussed.

A. Among 112 responses collected, most of the responses were submitted from Ireland (34%), Portugal (31%), Italy (22%) and France (9%). In addition, there were contributions from Spain, United Kingdom (UK), Poland, Switzerland (CH), Romania (RO), United Arab Emirates (UAE) and Netherlands (NL) (see Figure 4).

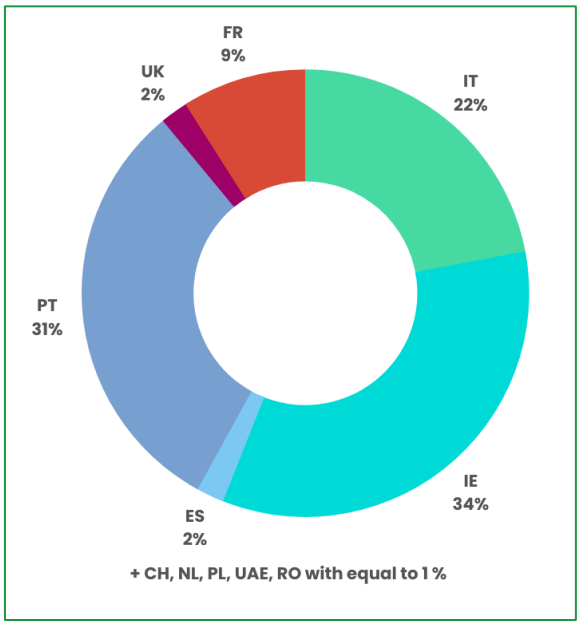

Figure 4. Countries that participated in the survey

B. According to Figure 5, there were 32.1% female and 66.1% male respondents.

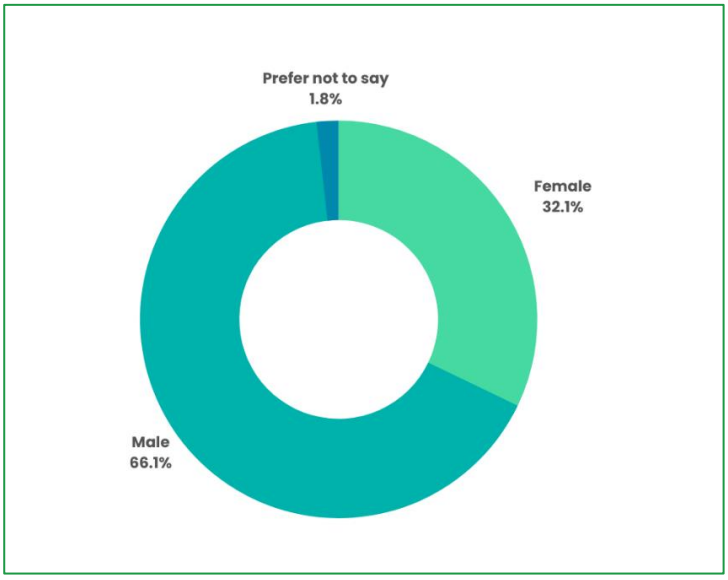

Figure 5. Gender among respondents

C. Figure 6 shows that more than 40% of respondents are 18-34 years old (majority of them are students (70%)), more than 30% are 25-34 years old, more than 17% are 35-44 years old, less than 10% are 45-54 years old and almost 3% are older than 55 years.

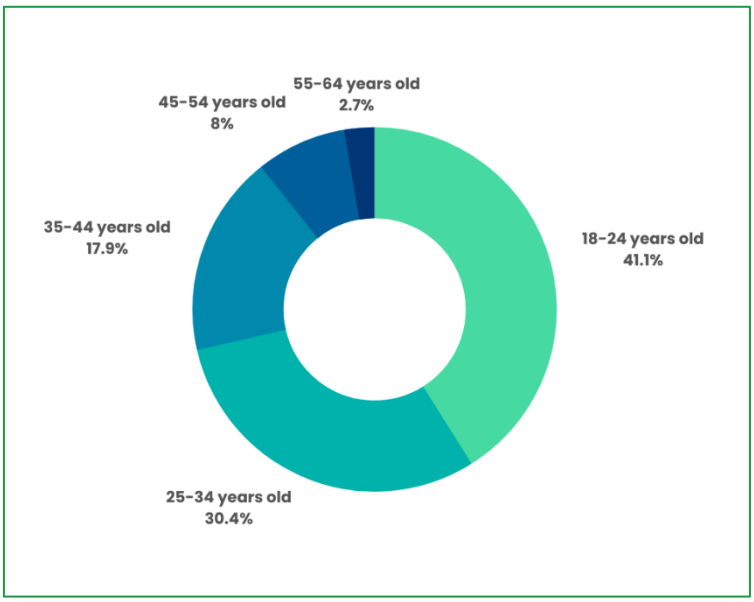

Figure 6. The age bracket of respondents

D. Among the respondents, more than 70% have a STEM background and 25% non-STEM backgrounds, whilst almost 2% did not indicate any (Figure 7).

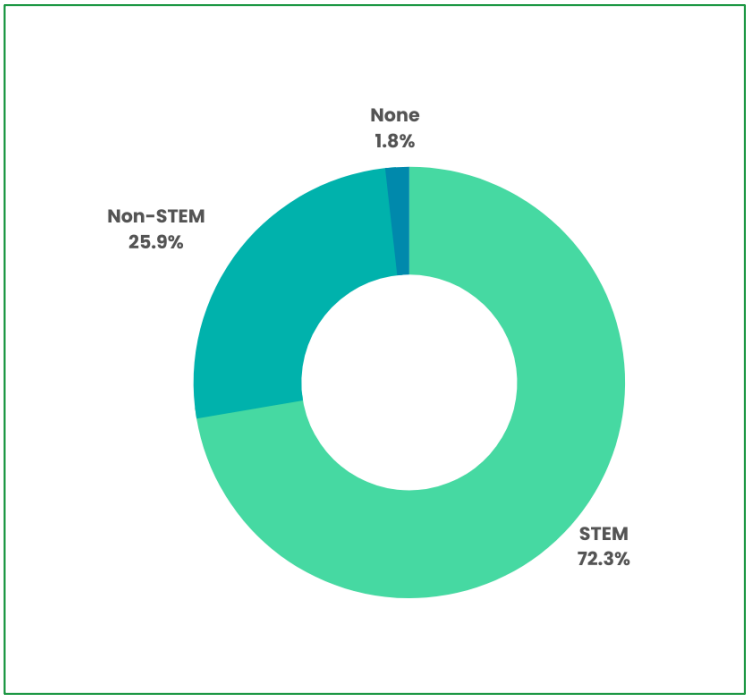

Figure 7. STEM vs. NON-STEM background

E. On Figure 8, the respondents indicated one or more sectors in which they work. The most common is energy sector (22.3%), followed by education (21.7%) and mechanical engineering (15.9%).

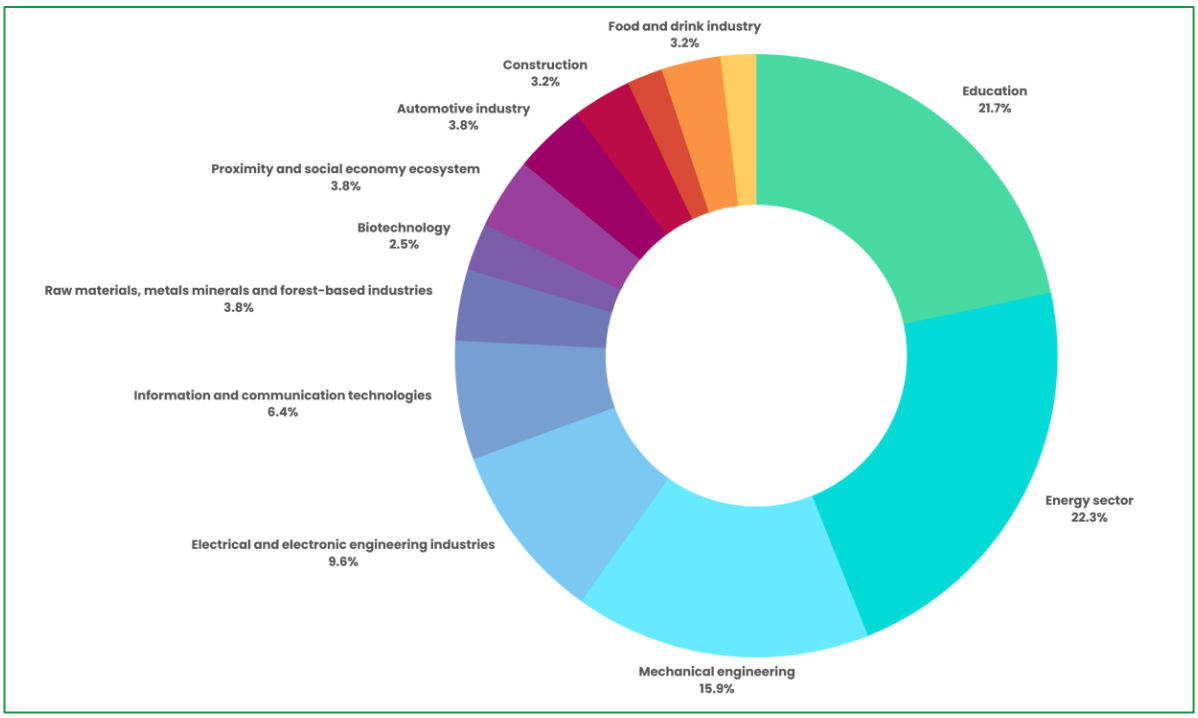

Figure 8. Sectors in which respondents work

F. The respondents evaluated their expertise of renewable energy sources and fuel technologies according to Figure 9 which shows that more than a third of respondents have high expertise, almost half have a medium and less than 15% have low expertise.

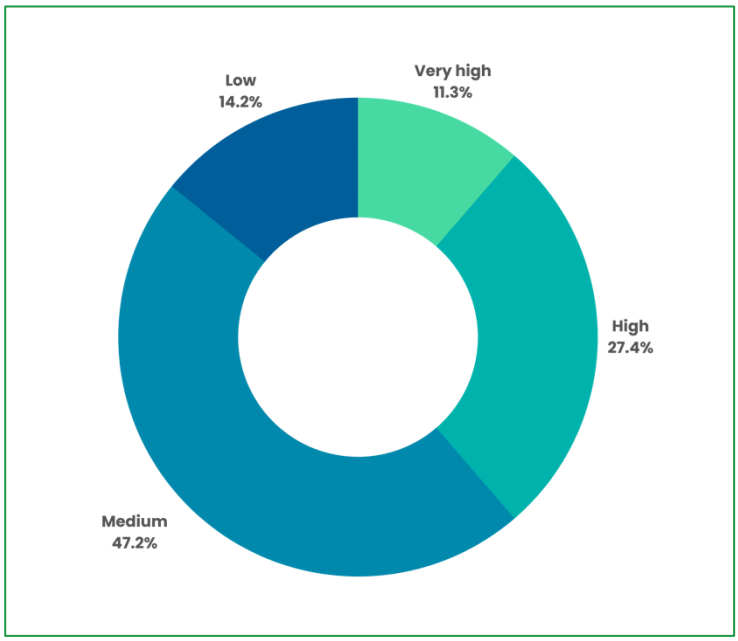

Figure 9. Expertise levels of respondents

G. To identify the most relevant enabling strategies, renewable energy sources and strategies, for each suggested item, the respondents had to evaluate between 'crucial', 'very important', 'important' and 'not important'. Their results were graded from 1-4, in which the highest score was attributed to 'crucial' and the lowest one to 'not important'. The total scores were transformed into average grades to allow ranking. According to the results, among the 12 enabling technologies, the most relevant are batteries, smart grids and thermal storage (Figure 10).

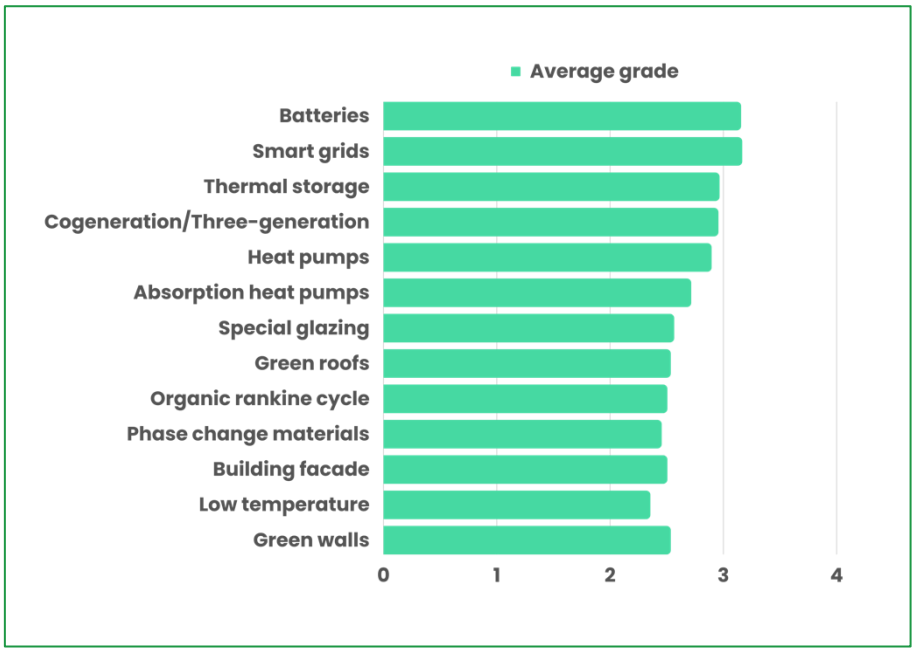

Figure 10. Enabling technologies ranking

H. Figure 11 demonstrates that hydrogen, followed by biogas and biomass, are among the most prominent RES fuels.

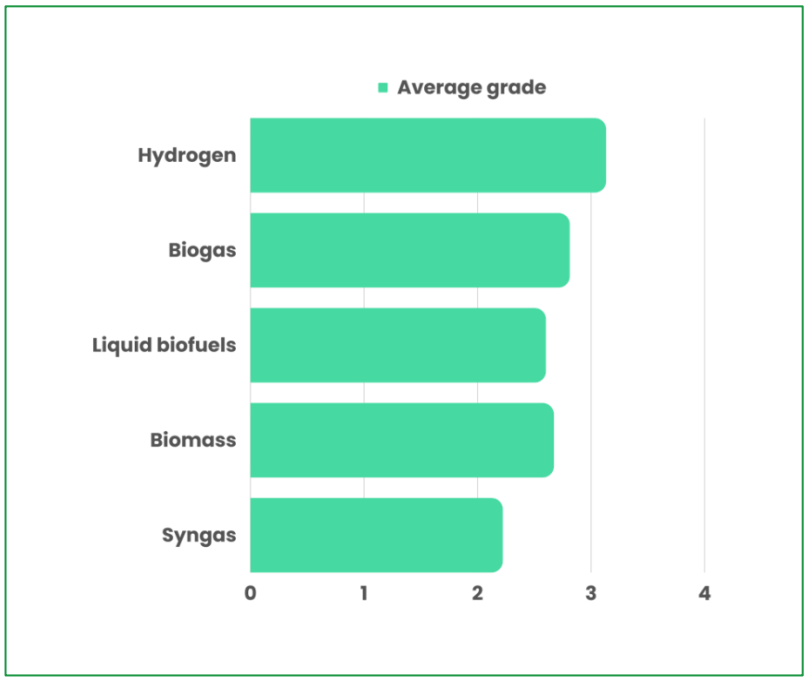

Figure 11. RES ranking

I. Amongst the strategies for energy transition, on average, the most notable are energy excess recovery, energy communities and demand flexibility (Figure 12).

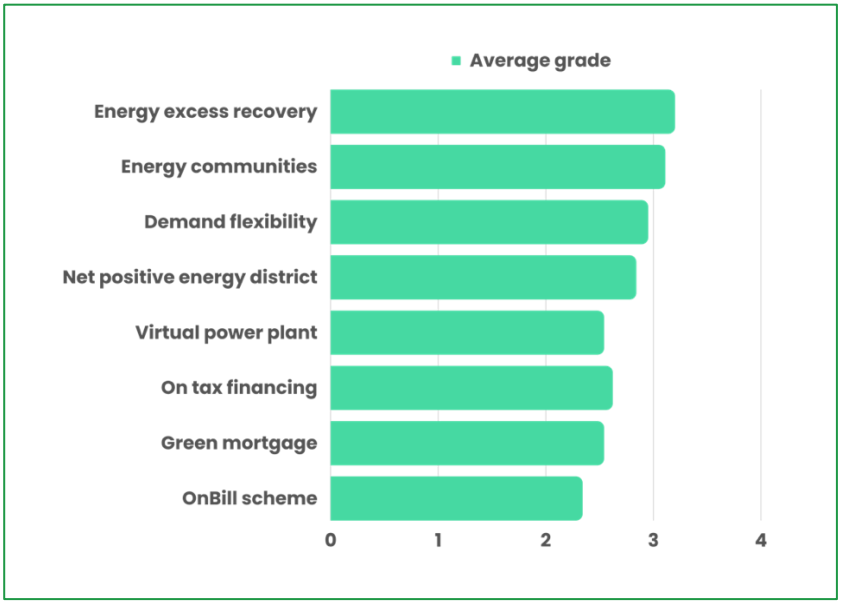

Figure 12. Strategies ranking

J. The respondents have also prioritised a selection of micro-programmes/learning modules according to their understanding of how these micro-programmes would address the most contemporary educational needs and skill gaps in developing and bringing renewable solutions to urban areas. According to the results, the most important areas of focus, to drive the acquisition of a wide span of competencies, are electricity and energy; natural environment and wildlife; economics, finance, banking and insurance; as well as management and administration; and

environmental protection technology. More in-depth analysis is developed in deliverable 2.3 'A multidisciplinary micro-credential basket for the sustainable transition in cities'.

6.1.2 Interviews

To collect and validate end-users' views on the urgent upskilling needs, as well as expected contents and formats to simulate self-centred learning, the RES4CITY team has identified and conducted nine interviews from June until mid-September 2023. Among the interviewees, there were representatives of the university (1), businesses (5) and professionals interested in upskilling (3).

According to each end-user type, an interview grid was developed and utilised during the 40-minute process. The interviews were conducted in English, Spanish and Portuguese languages (see 9. Annexes).

University

The interview was conducted with a recently retired professor from one of the nine RES4CITY universities who is not involved in the hub's lead. The insights are summarized per key topic in Table 5.

Table 5. Summary of an interview with a professor and expert in energy efficiency in buildings

Stakeholder	Results
Area of interest and expertise	The interviewee is a retired professor **in the field of energy efficiency in buildings, covering various aspects from design to end-user equipment**. **They have expertise in building management systems, technologies related to energy efficiency, as well as pumping and heat transfer systems for energy efficiency. They also know Portuguese and European regulatory frameworks related to energy efficiency.** Their expertise is focused on stationary energy systems and demand-side management, which involves influencing energy consumers to modify their behaviour in response to economic, physical, and communication stimuli. They have been involved in this field since 1994 and have worked on demand response and flexibility management of energy demand. **The interviewee has experience in shaping public policies to promote the rapid adoption of energy-efficient technologies, which includes programmes for tax reduction, incentives, and various regulations.** They have also researched topics such as building technologies, electrochromic glazing, building management systems, policy strategies for efficiency improvement, and flexibility in network management. Additionally, the interviewee mentions involvement in interdisciplinary research and knowledge management within science teams.
Competencies of relevance	The interviewee's expertise lies in the intersection of technical aspects and policy within the electricity industry. They are concerned with the structure of the electricity business, particularly the relationship between industry players and consumers. They highlight the various ways electricity businesses are organized globally, ranging from integrated models to fully unbundled ones. **The interviewee emphasizes the importance of benchmarking and constant evaluation of these different business models to ensure they benefit consumers and promote sustainability.** They stress that efficiency should be measured in terms of the lowest overall cost to consumers rather than just

Stakeholder	Results
	the lowest price per kWh. Demand-side management is just one aspect of achieving this goal. The interviewee recognises the challenges posed by renewable energy sources, such as managing fluctuating supply and their impact on electricity prices. They suggest that pricing structures may need to be revised to reflect the changing cost of supply, and consumers are likely to react rationally to these changes. **The interviewee believes that preparing technicians and engineers for future changes in the industry is crucial, with a focus on maintaining competence and awareness of ongoing developments.** They emphasize the importance of a citizen-centred approach in influencing consumers to behave rationally and efficiently in response to these changes. Ultimately, they see this approach as instrumental in both preserving the species and achieving harmony with natural resources.
Key challenges to RES and FT uptake	The interviewee emphasizes the need to integrate renewable technologies into the circular economy transition. They note that about 30 years ago when wind generators were being widely deployed, there wasn't much concern about their impact on the circular economy. Now, as these wind generators are reaching the end of their life cycle, there is a challenge in finding sustainable ways to deal with their materials, which are difficult to repurpose. **One significant issue raised is the importance of energy storage for effectively utilizing RES. The interviewee highlights that energy storage is essential for the seamless integration of RES into the energy grid. However, they point out that this poses challenges in terms of regulation, standardization, and pricing.** Additionally, the interviewee raises a social perspective on energy storage. **They question whether the current economic model of buying energy when it's cheap and selling it when it's expensive is the fairest approach, especially in terms of individual economic activity.** **The concept of self-sufficiency is also mentioned, suggesting a desire for greater independence in energy generation and consumption.** Lastly, the interviewee suggests that it's crucial to find alternatives to traditional methods of addressing issues like network inertia. They propose that energy storage is one potential solution but not the only one. They also emphasize the importance of considering the obsolescence of systems in the context of the circular economy.
Skill gaps	The interviewee discusses the lack of awareness among common citizens and decision-makers regarding the latest developments in the energy industry, while noting that the energy industry and academia are well-informed. They emphasise several key points: • **Student involvement:** Students have the potential to play a significant role in researching and understanding technological advancements in the energy sector. This includes being aware of both technological and non-technological aspects, such as market dynamics and adaptability to change.

Stakeholder	Results
	• **Collaboration with industry:** The interviewee has experience working on various projects with the energy industry, focusing on topics like cogeneration, tariff design, and demand-side development. They believe that collaboration between academia and industry can help equip individuals with the necessary skills and knowledge. • **Co-Creation and knowledge sharing:** The interviewee suggests that industry professionals and decision-makers should collaborate and complement each other knowledge and skills related to energy developments. They stress the value of co-creation and highlight that there are many knowledgeable individuals interested in these topics. In summary, the interviewee advocates for increased awareness and understanding of energy industry developments, with a particular emphasis on involving students, collaborating with industry, and co-creating educational initiatives to bridge the gap between academia and practical applications in the energy sector.
First ideas and feedback on the RES4CITY micro-credentials format and content	The interviewee has limited experience with distance learning but acknowledges the potential usefulness of micro-credentials. They stress the importance of preparing individuals for changes in the field and staying informed about current and upcoming developments. **The interviewee believes that the RES4CITY micro-credentials have significant potential utility, particularly in preparing individuals for changes in their field.** The interviewee emphasizes the importance of keeping the big picture of climate neutrality in people's minds. They believe that citizens often underestimate how far we are from achieving climate neutrality, with 70% of the journey still ahead. **They stress the need to educate everyone about trends in renewable energy penetration and the transformation of fossil fuel usage in the energy transition**. The interviewee underscores the significance of energy efficiency. They explain that the more efficient energy use is, the less reliance there is on renewable energy sources. Efficiency can reduce the overall energy demand even without a significant investment in renewables. **The interviewee suggests that MOOC content should cover the operating principles of energy conversion systems. This knowledge is vital for understanding the challenges and opportunities in the energy field. The interviewee mentions that energy storage and current trends in the energy field are important topics to consider.** The interviewee points out that the built environment is responsible for a significant portion (40%) of energy consumption. They emphasize that efficient building design and end-use devices should be core competencies covered in MOOCs. In summary, the interviewee provides insights into the content that should be included in MOOCs related to energy and climate change. **They emphasize the importance of awareness, energy efficiency, understanding conversion systems, the built environment, and emerging trends in the field.**
First ideas about the engagement boost	**The interviewee mentions the use of serious games as a valuable tool, particularly within the context of a campus energy network focused on sustainability.**

Stakeholder	Results
	As a co-founder and volunteer involved in making the network operate, the interviewee sees the potential for serious games to be a good tool in disseminating sustainability-related information.

Companies

The five interviews were conducted with public and private companies. One of them was representing Advisory Board from Industry panel. The insights are summarized per key topic in Table 6.

Table 6. Summary of interviews with professionals from private and public energy sectors

Stakeholder	Results
Area of interest and expertise	**Interviewee 1** represents an association that provides services to its members, including representation before public authorities and disseminating information. **They aim to promote the positive image of renewable energies and their social benefits for small municipalities and specific social sectors.** The association serves as a bridge between society and companies in the renewable energy sector. **Interviewee 2's** company follows a business model that eliminates local transition friction by offering zero-cost energy solutions through financing. **They focus on integrating IoT and building management systems to create communities and make clean energy more accessible to users.** Their approach involves going to households and utilizing clean energy efficiently. **Interviewee 3** emphasizes the importance of environmental considerations in European projects. They select topics related to their products and the environment, aligning with environmental protocols and regulations. **Their projects often involve energy transition and reducing carbon footprints, such as monitoring renewable energy installations and improving energy efficiency.** **Interviewee 4** discusses their energy consumption plan, which includes building retrofitting, component replacement, and solar panel installations. **They engage in research projects related to construction and collaborate with partners. The focus is on improving energy efficiency and reducing consumption footprints.** **The interviewee's 5 organisation deals with the use of biofuels and has a close relationship with government bodies.** They do not regulate but provide research and ideas to the government when needed. **Communication and sensitization are crucial, especially for small companies, as the market for biofuels can be challenging due to import restrictions and varying biofuel percentages. The organisation investigates and reports on companies' compliance with biofuel regulations to legal bodies.**
Competencies of relevance	The interviews provide valuable insights into the skills and competencies required in the field of renewable energy and sustainable technology. These insights emphasize the need for a multidisciplinary approach and the

Stakeholder	Results
	importance of combining technical expertise with social, business, and management skills to successfully navigate the challenges of the energy transition: • **The importance of non-technical skills:** Interviewee 1 stressed the significance of non-technical skills in technical jobs. **They argued that a more holistic and humanistic perspective is crucial for understanding the societal aspects of the energy transition.** This perspective complements the technical competencies that already exist within the industry. Therefore, it is imperative to incorporate individuals with a broader range of skills, including communication and societal understanding, into the renewable energy workforce. • **Technical expertise across various domains: Interviewees 2, 3, and 4 emphasized the need for technical expertise in various areas, including software development, engineering, project management, finance, and materials science.** This diversity of technical skills is essential for designing, implementing, and maintaining renewable energy systems effectively. A well-rounded technical team is essential for success. • **Transversal and presentation skills:** Interviewee 3 highlighted the importance of transversal skills, such as presentation and communication abilities, for professionals in the renewable energy sector. **This underscores the need for individuals who can not only develop technical solutions but also effectively communicate these solutions to diverse audiences, including stakeholders and the public.** • **Multidisciplinary collaboration:** Interviewee 5 pointed out the benefits of multidisciplinary collaboration. **In a rapidly changing market, where new technologies and challenges constantly emerge, having teams with a mix of skills and backgrounds becomes invaluable.** The integration of expertise in raw materials, geology, law, and other fields fosters innovation and adaptability. The energy transition is not solely a technical endeavour. It requires a blend of technical, social, and business competencies to succeed. Policymakers, educators, and industry leaders should take these insights into account when shaping strategies, curricula, and workforce development initiatives to support the transition to sustainable energy systems. By fostering a workforce with a diverse skill set and a holistic understanding of the energy transition, the challenges and opportunities in this crucial field can be addressed more effectively.
Key challenges to RES and FT uptake	The interviews with various stakeholders in the energy transition shed light on critical issues and challenges facing cities, regulators, building owners, and energy professionals. These insights can guide policy decisions, urban planning, and technological advancements in the pursuit of a sustainable energy future:

Stakeholder	Results
	• **Urban challenges and responsibility:** Interviewee 1 emphasized the role of cities in the energy transition. While resources and space constraints pose challenges, cities must understand their responsibility in driving this transition. **Considerations like aesthetics and preserving countryside landscapes are vital. Furthermore, the focus should not only be on energy generation but also on changing energy consumption habits and promoting energy-saving measures.** • **Regulatory and permits hurdles:** Interviewee 2 highlighted regulatory challenges that can hinder progress in the energy transition. The readiness of cities to embrace new energy sources and regulatory delays in permitting processes can slow down the adoption of renewable energy solutions. **Understanding the role of renewable energy projects, such as rooftop solar, in the larger energy grid is also crucial.** • **Awareness and retrofitting challenges:** Interviewee 3 pointed out the need for greater awareness of energy efficiency and alternative solutions, especially at the building level. **Inefficient existing building stock and a lack of awareness about available incentives can obstruct progress.** New buildings incorporate energy-efficient features, but addressing older structures remains a challenge. • **Technological and scale issues:** Interviewee 4 highlighted various challenges related to technology, scalability, and legal considerations. **These include network adaptation, city restrictions, legislation for new solutions, and the costs associated with prototypes and start-ups.** These challenges need to be addressed to facilitate the growth of renewable energy projects. • **Urban vs. rural energy transition:** Interviewee 5 discussed the contrast between urban and rural areas in the energy transition. **In cities, electric vehicles (EVs) and renewable energy have gained traction, thanks to incentives and infrastructure. However, challenges persist in rural areas, including insufficient charging infrastructure and the need for alternative fuels like hydrogen.** Anticipatory measures and proactive adaptation to new technologies and regulations are essential to stay ahead of the curve. Cities, regulators, building owners, and professionals in the field face a complex set of challenges, from regulatory hurdles to technological advancements. Addressing these challenges requires a concerted effort, proactive planning, and a holistic approach that considers both urban and rural contexts. By understanding and acting upon these insights, stakeholders can pave the way for a more sustainable and energy-efficient future.
Skill gaps	The insights from the interviews with the professionals highlight the diverse set of competencies and skills required for success in the renewable energy sector. These competencies encompass technical, social, and management skills, reflecting the multifaceted nature of the industry:

Stakeholder	Results
	• **Holistic understanding of renewable energies:** Interviewee 1 underscores the need for a comprehensive understanding of renewable energy and the broader energy system. **This involves appreciating the impact, advantages, and disadvantages of renewable energy projects.** It emphasizes the importance of bridging the gap between technical knowledge and the societal aspects of the energy sector. highlights the significance of **geopolitics in the energy transition**. While not typically a central focus, an understanding of geopolitical dynamics is crucial in shaping energy policies and strategies. Thus, some examples of practices from different cities and companies could be beneficial to have inside the educational modules. • **Skills for global engagement:** Interviewee 2 highlights the importance of internationalisation, language skills, and digital competencies. In a globalised world, professionals in the renewable energy sector need to adapt to diverse environments. Additionally, soft skills such as problem-solving, communication, critical thinking, and resilience are crucial for navigating complex and evolving challenges. • **Local capacity-building:** Interviewee 2 suggests that also **mayors and municipal leaders as potential end-users of the RES4CITY's educational framework should receive training in energy basics to better understand the complexities of the energy transition.** This includes knowledge about energy measurement, different energy units, and the fundamentals of energy generation processes. Providing such training can empower local leaders to make informed decisions about renewable energy projects. • **Bridging the technical-management gap:** Interviewee 3 points out the challenge of transitioning from a purely technical career to one that involves management and business aspects**. They suggest that while social skills can be developed over time, technical skills are harder to acquire later. Therefore, introducing management education for technical professionals can enhance their effectiveness in leadership roles.** • **Data analytics and visualisation:** Interviewee 4 emphasises the importance of **data analytics and visualization tools in the energy sector. Implementing dashboards and AI data analytics can facilitate decision-making and make progress more visible to stakeholders.** • **Information flow and organizational competencies:** Interviewee 5 raises concerns about information flow and organisational competencies within public entities. **Improving strategies, internal organisation, and information flow is crucial for efficiency and effectiveness.** Furthermore, **training in digitalization and IC**T is essential to keep pace with technological advancements in the energy sector.

Stakeholder	Results
	The renewable energy sector requires professionals with a diverse skill set that encompasses technical knowledge, social skills, management abilities, and adaptability to international and interdisciplinary contexts. Addressing the challenges of the energy transition necessitates a holistic approach to education, training, and collaboration. By nurturing professionals with these competencies, the sector can effectively contribute to a sustainable and clean energy future.
First ideas and feedback on the RES4CITY micro-credentials format and content	The interviews with the company representatives provide valuable insights into the key factors that they consider when evaluating training courses for their employees and others. These insights shed light on the preferences and priorities of organisations in the context of employee training and development: • **Emphasis on uniqueness and innovation:** Interviewee 1 emphasises the value of training courses that **bring something different and innovative to the table.** They prioritise real-world case studies and a diverse selection of contributing companies. For them, content innovation is more crucial than the format. • **Relevance and accessibility: Interviewee 2 highlights two key factors: content relevance and accessibility.** They stress the importance of courses that are relevant to the company's needs and that can be easily accessed, given the busy schedules of employees. Shorter, digestible formats and supplementary resources are also appreciated. • **Compact and coherent content: Interviewee 3 values courses that are compact, coherent, and logically structured**. They emphasise the need for content that makes sense and is enjoyable. Having experienced teachers and speakers who can provide real-world examples is essential. A clear table of contents, up-to-date content, and a mix of teaching methods are also crucial. • **Flexibility and diverse topics: Interviewee 4 seeks quick access to diverse topics related to the energy transition in cities.** They prefer courses that are easily accessible and offer flexibility in terms of timing and duration. The depth and breadth of topics are important considerations. • **Focus on immediate needs and future vision: Interviewee 5's criteria for training courses are based on immediate needs and future vision.** They look for courses that address current challenges and provide insights for the future. This includes considering emerging technologies like MP6 and MP8. **They also highlight the importance of engineering and safety in bringing new solutions to market.** **These interviews reveal that companies value training courses that are unique, innovative, relevant, coherent, and accessible. Organisations prioritise content that addresses their immediate needs while also considering future trends and technologies. Training programs that offer a mix of teaching methods and real-world examples from experienced professionals are particularly valued.** By understanding these preferences,

Stakeholder	Results
	training providers can tailor their offerings to better meet the needs of organizations and their employees in the ever-evolving field of energy transition.
First ideas about the engagement boost	All interviewees expressed interest in receiving more news and participating in beta-testing with their employees and discussing the application of MOOCs for their internal capacity-building and promoting it further, to their collaborators.

Professionals working with priority groups beyond Europe

Through the RES4CITY Global Reach Hub and support of GHNI and UNITAR, there have been conducted three other interviews with professionals who work directly with the priority groups such as students, rural community and families, refugees and industry. The summaries of their inputs are outlined in Table 7.

Table 7. Summary of interviews with professionals who work with priority groups beyond Europe

Stakeholder	Results
Area of interest and expertise	**Interviewee 1** works at a vocational training foundation and their priority groups are students, single parents and women, as well as refugees in Myanmar and Thailand. Has not much experience in RES and FT. **Interviewee 2** is working closely with seven universities, government ministries, and industries in South Korea to address renewable energy conversion. Funding comes from both government ministries and local authorities, aiming to prepare potential job seekers for careers in renewable energy. The interviewee emphasises the importance of creating an ecosystem for energy and vocation, particularly in Seoul, where renewable energy is strong. Their consortium has introduced innovative educational methods, such as MOOCs and gamification, to effectively teach sustainable development goals and raise awareness about climate change challenges. **Interviewee 3** works with the Global Hope Network International in Ethiopia, focusing on priority groups that include farm and rural communities, university students with an environmental connection, and refugees. Their primary focus is on rural communities, where students play a key role in educating these communities. Additionally, they mention the translation of MOOC content from UNESCO into multiple languages to enhance accessibility.
Relevance of RES uptake	The interviewees have different level of expertise and understanding of the RES uptake in their areas and countries: • **Energy access and climate change in remote areas:** Interviewee 1's account of limited access to reliable energy in remote areas and reliance on fossil fuels in both cities and remote regions underlines the urgency of transitioning to renewables. This situation reflects a pressing need to expand renewable energy infrastructure to reduce reliance on polluting energy sources.

Stakeholder	Results
	• **International commitments and collaboration:** Interviewee 2's discussion of South Korea's alignment with the Paris Agreement and collaboration with organisations like GHNI and RES4CITY demonstrates the government's commitment to climate action. This alignment with global climate goals can serve as a model for other nations, emphasizing the importance of international cooperation in addressing climate change through renewable energy initiatives. • **Environmental and economic benefits of RES:** Interviewee 3's insights into the environmental advantages of renewables, their potential for income generation, and the importance of energy security underline the multifaceted benefits of transitioning to renewable energy sources. These benefits extend beyond environmental considerations and can positively impact communities both economically and in terms of national security. In summary, the interviews highlight the pressing need for renewable energy solutions, not only for mitigating climate change but also for improving energy access and security. They underscore the importance of international cooperation and the manifold advantages of embracing renewables for both local communities and national governments.
Knowledge and skill gaps and use of MOOC	The three interviewees provide valuable insights into the existing skill gaps and relevance of Massive Open Online Courses (MOOCs) and sustainable energy strategies, particularly in urban environments. **Interviewee 1** highlights the significance of sustainable energy technology and urban strategies for creating organised and eco-friendly cities, emphasizing the benefits for everyone. Also, they express a willingness to engage with MOOCs and a specific interest in trying out the RES4CITY MOOC, demonstrating a personal motivation for online learning and dissemination of such opportunities among the students. **Interviewee 2** emphasizes the convenience and accessibility of MOOCs as a learning management platform for students and professionals, advocating for the utilisation of existing MOOC systems. They recognise the need to introduce MOOCs in regions like Mongolia, where technological development education is not highly prevalent, and discuss potential language barriers. They thus suggest the use of translation technologies to overcome language obstacles and underscore the adaptability of MOOCs to different educational contexts. **Interviewee 3** mentions the availability of MOOCs from UNESCO and their translation into two languages, highlighting the use of MOOCs as a resource. They discuss alternative approaches to MOOC delivery, including printing course materials for communities and using a computer as a server for offline access. In addition, they recognise the importance of preparing rural areas for the transition to sustainable energy sources, emphasising the potential for income generation from renewable energy.

Stakeholder	Results
First comments about RES4CITY MOOC and micro-credentials	The interviewees demonstrate a genuine interest in follow-up with the RES4CITY MOOC launch and testing. They provide the first comments about the RES4CITY MOOC and micro-credentials: • **Complexity of topics:** Interviewee 1's observation that the topics covered in the MOOC may be too high-level and complex for their community raises an important consideration. It suggests that the content should be tailored to the educational background and needs of the target audience. This highlights the importance of adapting course content for different learner levels. • **Government initiatives and vocational structures:** Interviewee 2's emphasis on government initiatives and vocational structures as essential components in addressing urban energy issues underlines the role of policy and infrastructure in supporting sustainable urban development. This aligns with the broader goal of Res4City and suggests that such elements should be integrated into the educational content. • **Anticipating vocational system changes:** Interviewee 2 also anticipates dramatic changes in vocational systems, especially in renewable energy sectors. This underscores the importance of preparing individuals for job transitions and social transformations related to changes in the job structure. The RES4CITY MOOC and micro-credentials can play a role in facilitating this transition. • **Exploring interdisciplinary topics:** Interviewee 3's mention of "NEXUS" and "low-tech technology development" hints at the value of interdisciplinary knowledge and practical, accessible technology in urban sustainability. This suggests that the MOOC could benefit from a diverse range of topics that appeal to a broader audience. In summary, the interviewees' comments highlight the need for adaptability in course content, the role of government initiatives, and the anticipation of significant changes in vocational systems. **Additionally, there is a suggestion to explore interdisciplinary topics, low-tech solutions and relevance of green transition for job market and demand of specific professions-in-making in the RES4CITY MOOC and micro-credentials to make them more accessible and relevant to a wider audience.**

The conducted interviews with stakeholders outside of the urban areas of RES4CITY highlight a crucial need for understanding the requirements of the content and format of the MOOC. The current topics may seem too complex for certain communities, emphasising the necessity to tailor the content to a wider audience, including those outside urban areas, if possible. Additionally, stakeholders stress the importance of government initiatives, vocational structures, and adaptability in addressing urban energy issues. This feedback underscores the significance of making the MOOC accessible to priority groups, especially in rural or less technologically advanced regions, who can benefit significantly from the knowledge provided for employment opportunities. Thus, the interviews collectively call for a

more inclusive and adaptable approach in designing the MOOC to ensure its effectiveness and relevance for a broader spectrum of learners and communities.

6.1.3 Stakeholder engagement through hubs

The seven hubs hosted and led by the universities in Maynooth (Ireland), Coimbra (Portugal), Genoa, Naples and Sassari (Italy), Grenoble (France), Halmstad (Sweden), Lyngby (Denmark) and Valencia (Spain) have ongoing stakeholder engagement that includes meetings, interviews, workshops and other events aimed at informing, exchanging and ideating pathways for energy transition through local cooperation in urban areas. Between April and September, the hubs conducted online and physical stakeholder gatherings to ideate micro-credentials and lighthouse case studies, as well as disseminate the hub's progress and results. Also, Global Reach Hub has implemented stakeholder meeting in Geneva to disseminate progress of the RES4CITY project. The hubs received positive feedback about micro-credentials as the stakeholders considered them useful and complete for the members of the hubs. In some cases, such as the Polytechnic University of Valencia, the stakeholders expressed that for less technical and more generalist micro-credentials would be relevant to translate them into other languages beyond English, to facilitate access to students, professionals and other potential users who would learn more effectively in their native language. Maynooth University organised a meeting with the Mid-East Regional Skills Forum (Ireland) in Maynooth University in May 2023. A network of Regional Skills Fora was created as part of the Irish Government's National Skills Strategy and provides an opportunity for employers and the education and training system to work together to meet the emerging skills needs of their regions – aligning with the "Low-carbon economy" objective of the Mid-East Regional Enterprise Plan to 2024. Italian hub composed of three Italian universities has held and participated in local and international events in which it raised awareness towards innovative training tools, serious games and micro-credentials, and acquired first-hand comments from students, professionals and other relevant stakeholders.

Grenoble Alps University have made the strategic decision to undertake and document video interviews with their students, as exemplified in Figure 13.

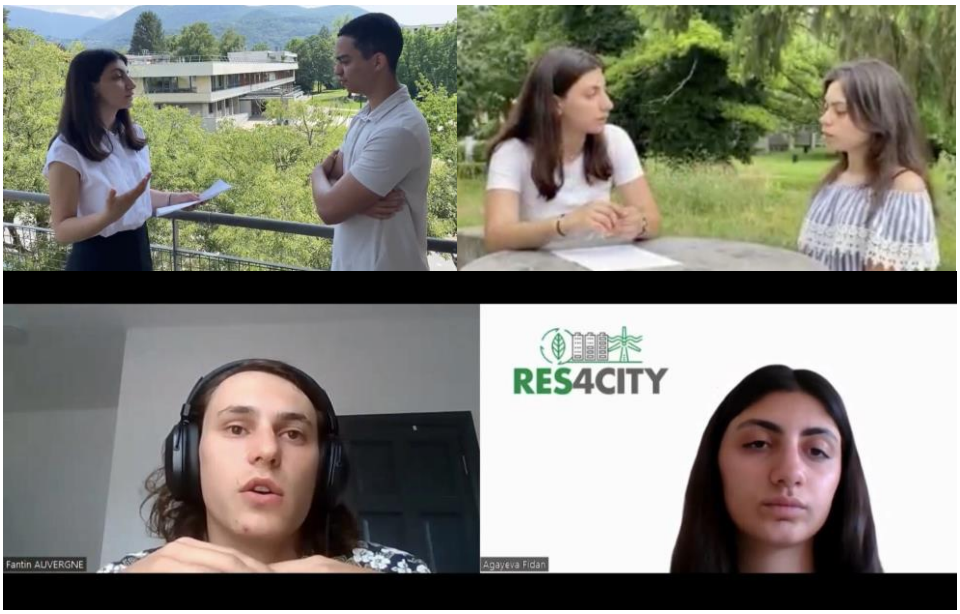

Figure 13. Video interviews with UGA students

These interviews serve the dual purpose of evaluating how the educational curriculum addresses the challenges associated with the energy transition, constituting an integral component of the European initiative known as RES4City. The primary objective of RES4City is to advance the adoption of renewable energy sources and the displacement of fossil fuels within urban environments. In response to these interviews, students expressed a consensus that they perceive a need for further training. They also noted that the MOOC approach is particularly suitable for this endeavour. Additionally, students conveyed that the most effective means of disseminating information about this opportunity for upskilling is by engaging in classroom interactions and sharing relevant updates with their peers.

In addition, local/national surveys and assessments of the educational needs and skill gaps to inform their micro-credentials development were applied. The public survey targeting students, professors and SME representatives was implemented by the University of Coimbra with a total of 22 responses of which 46% were students, 36% were professors and 18% were the representatives or employees of the companies (see Figure 14).

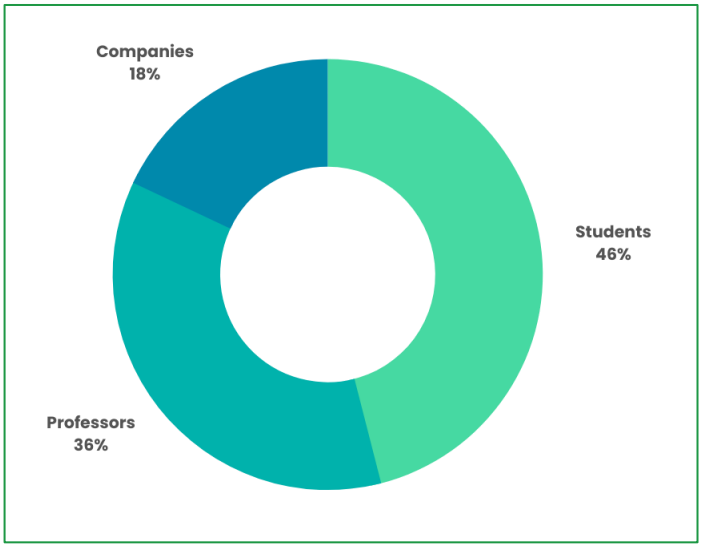

Figure 14. Respondents' profiles

Students

A. Among 10 PhD students, 90% study in STEM field and 10% study in non-STEM field (see Figure 15). All of them considered that the RES, green transition and a low carbon economy are extremely important.

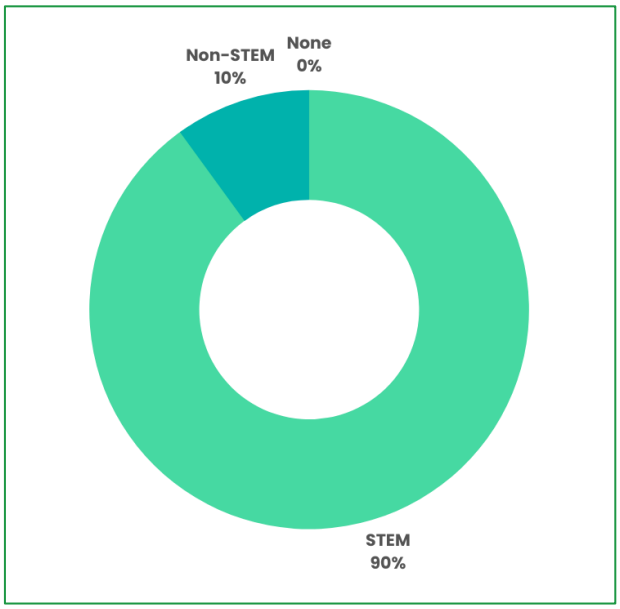

Figure 15. STEM vs. Non-STEM

B. Once the students were asked about the relevance of acquiring knowledge and skills related to renewable energy and the green transition, 80% evaluated as extremely important, 10% as important and 10% was neutral (see Figure 16).

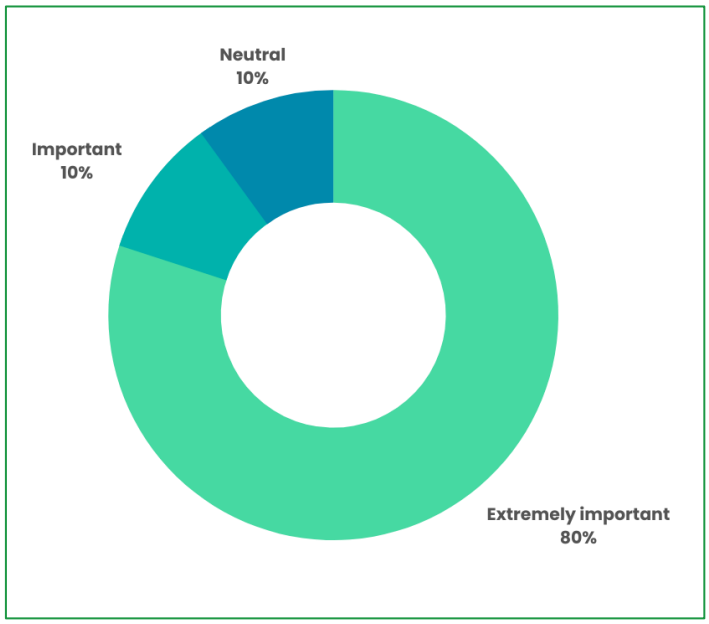

Figure 16. Relevance of upskilling in renewable energy and green transition

C. Once asked about their interest in expanding competencies in specific topics, the students responses shown (see Figure 17) that they favoured learning about energy and resource management, energy efficiency and conservation and policy and regulations related rather than other remaining topics.

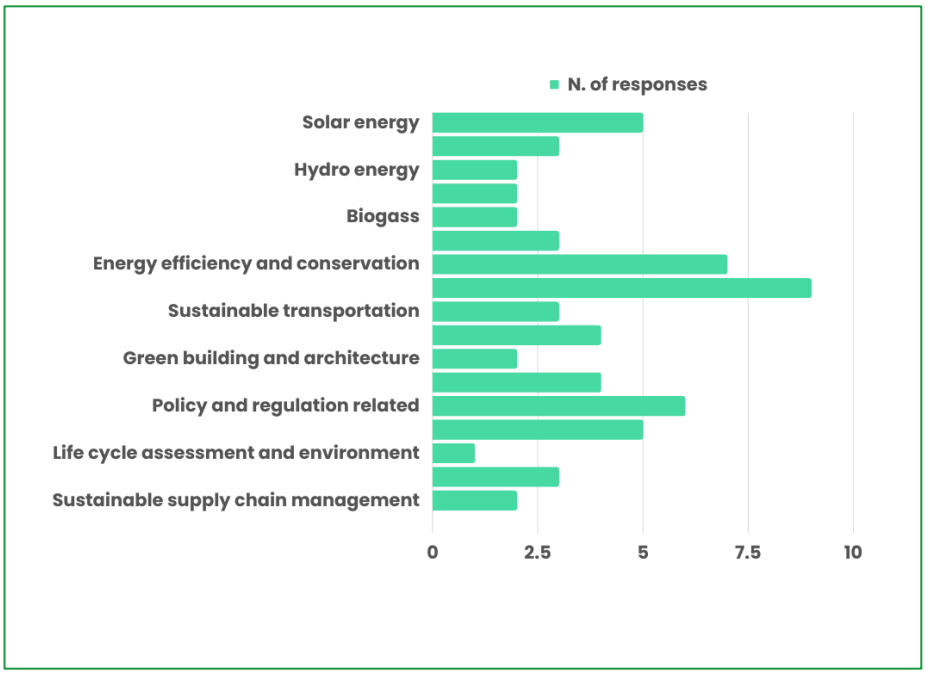

Figure 17. Topics of relevance for acquiring new or upgrading existing knowledge, skills and behaviours

D. The students were asked to reflect on their readiness to apply sustainable practice and technologies in their future careers. Figure 18 demonstrates that 60% of students feels very confident and 40% feels moderately confident.

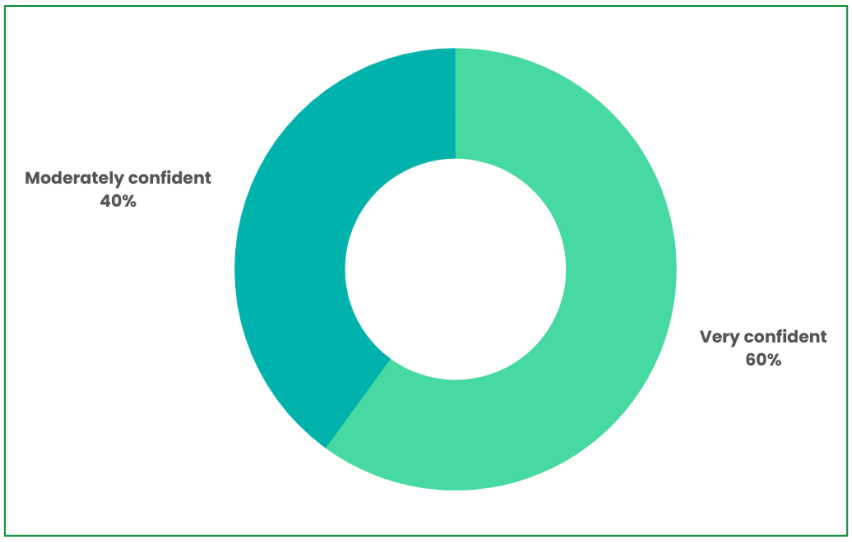

Figure 18. Sense of confidence to apply RES and FT as a professional

E. Figure 19 shows that the biggest challenges in transitioning to sustainable renewable energy and a low carbon economy demands addressing lack of public awareness and education, resistance from traditional industries and insufficient government policies and incentives.

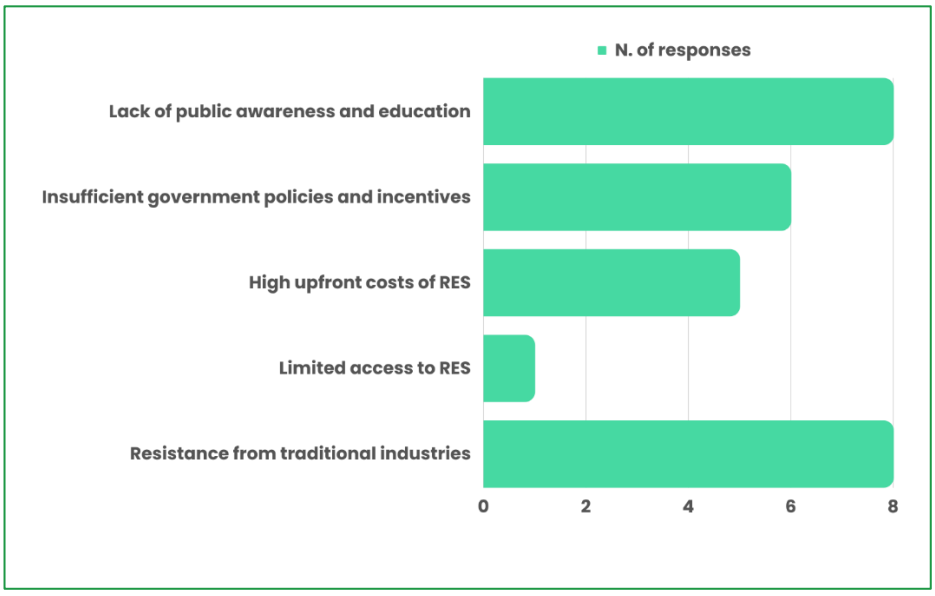

Figure 19. Challenges in transitioning to a sustainable renewable energy and a low carbon economy

F. According to the identified needs and gaps, as well as challenges, the students were inquired to confirm to what extent did curricula address the concepts and principles of sustainable renewables and the green transition. Figure 20 shows that 50% expressed that this was done moderately well, 40% very well and 10% thought it was done slightly well.

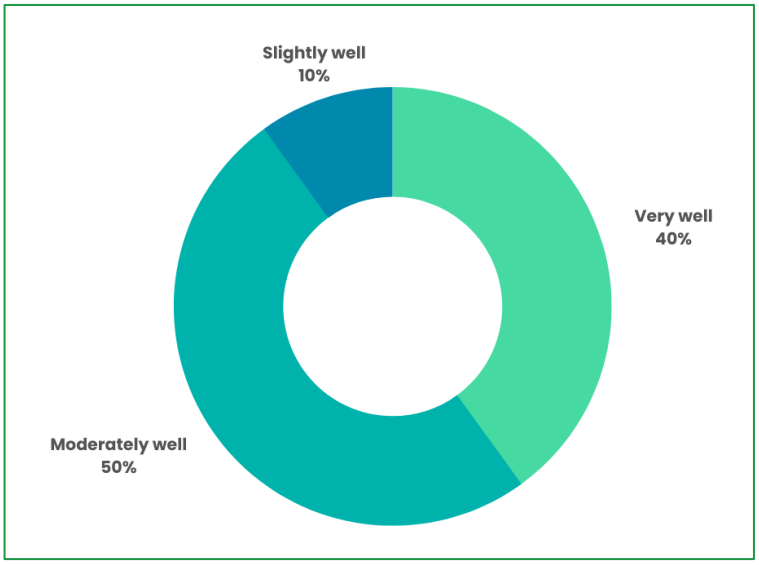

Figure 20. Curricula vs. real needs

G. Students confirmed that they are somewhat familiar with the existing educational programmes or initiatives focused on sustainable renewables and the green transition (see Figure 21).

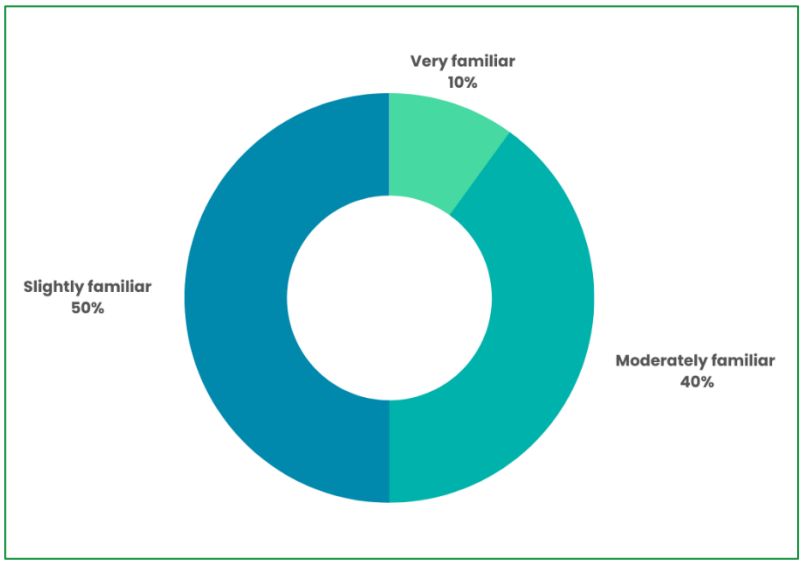

Figure 21. Familiarity with existing educational programmes and initiatives in RES

H. Finally, the students showed great interest in participating in workshops and training programmes related to renewables and the green transition (see Figure 22).

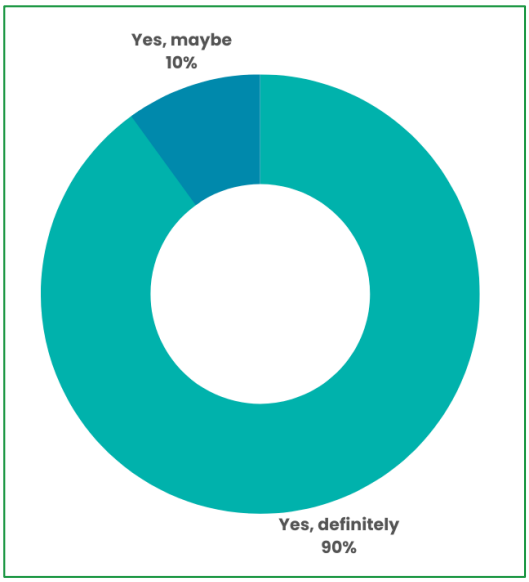

Figure 22. Interest in upskilling opportunities

Professors

As professors are not the primary target of the micro-credentials, their input of relevance is in the overall sense of the students' capacities and needs for upskilling. Among 8 professors, 6 said that energy efficiency and conservation is a priority, and half of them said that solar energy, energy and resource management, circular economy, policy regulations, environmental awareness and life cycle assessment are also relevant (see Figure 23).

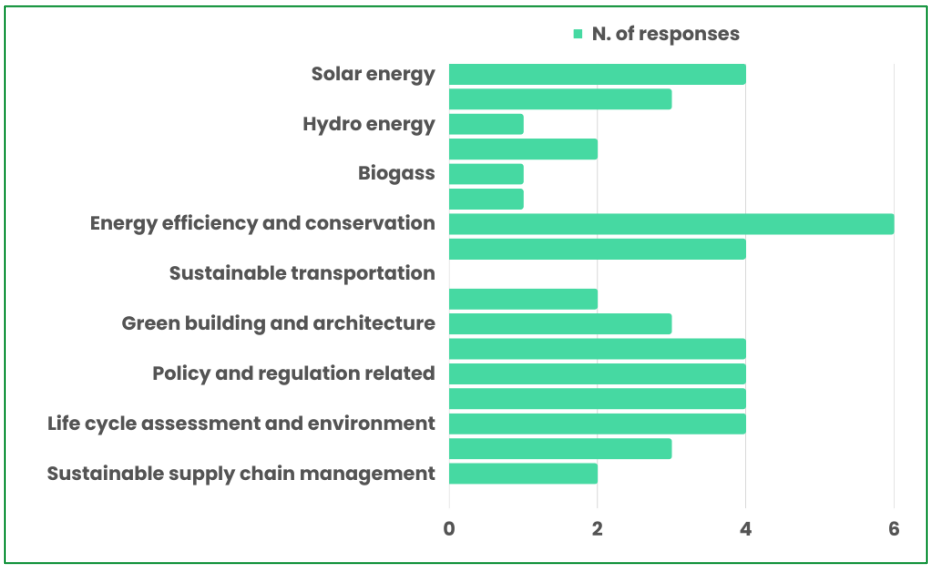

Figure 23. Upskilling priorities according to professors

Companies

A. Among 4 company representatives, 50% of them operate in STEM field, while others are technicians (25%) and public servants (25%) in the construction and energy sectors (consult Figure 24).

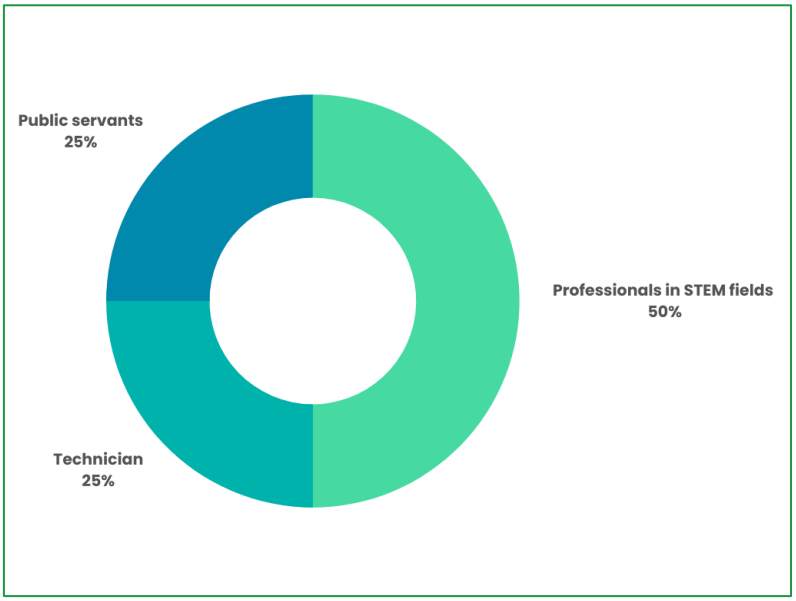

Figure 24. Companies' profiles

B. When asked about their familiarity with sustainable renewables and low carbon economy, 75% respondents said they are very familiar and 25% said they are moderately familiar (see Figure 25).

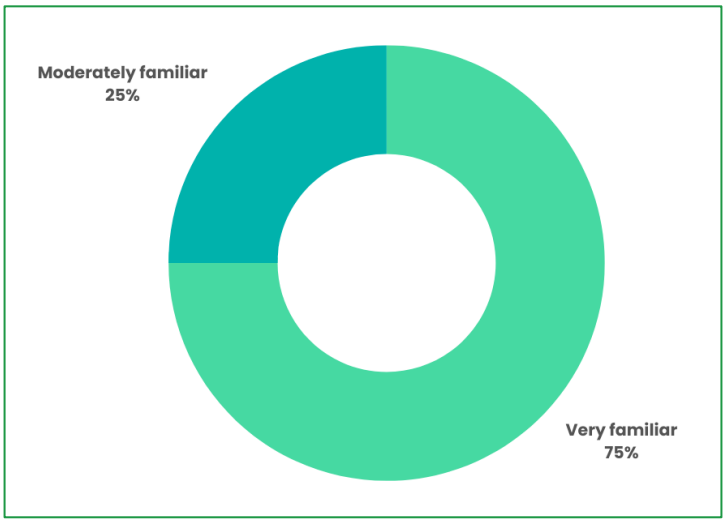

Figure 25. Familiarity with RES and low carbon economy

C. Figure 26 shows that 75% of company representatives thinks that is extremely important that their employees have knowledge and skills related to sustainable renewable energy and the green transition, while 25% stayed neutral.

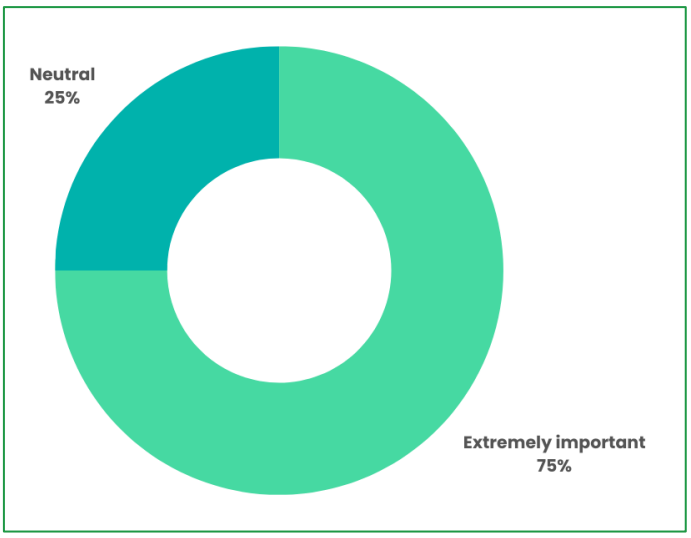

Figure 26. Relevance of green skills

D. Companies considered that the biggest challenges in transitioning to sustainable renewables and a low-carbon economy was lack of public awareness and education, insufficient government policies and incentives and high upfront costs of renewable technologies (see Figure 27).

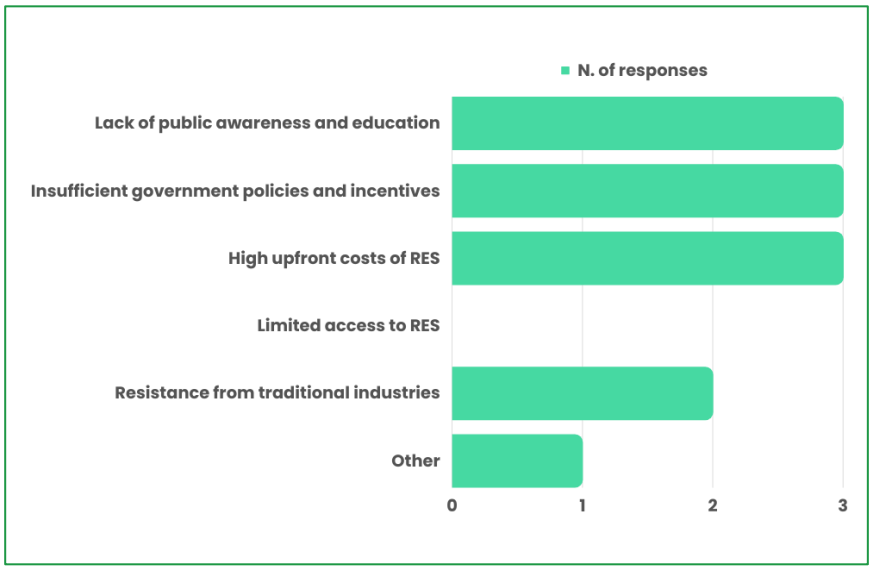

Figure 27. Challenges in uptaking RES

E. 50% of companies indicated that the current education of their employees demonstrates very well the concepts and principles of sustainable renewables and energy transition practice, while 25% indicated slightly well and 25% indicated that it does not at all (see Figure 28).

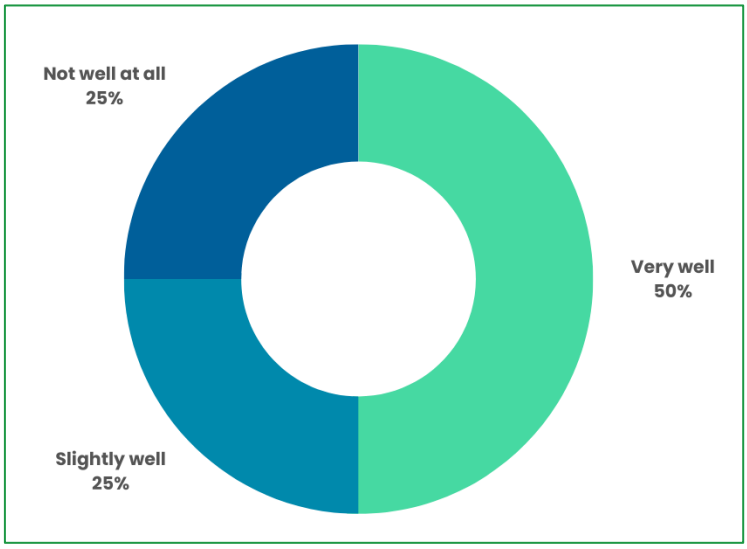

Figure 28. Employees education vs. green job market

F. On the upskilling requirements, companies indicated that energy efficiency and conservation, as well as policy and regulations, circular economy and specific technologies like solar panels and green buildings and architecture are imperative for their contribution and growth in green transition (see Figure 29).

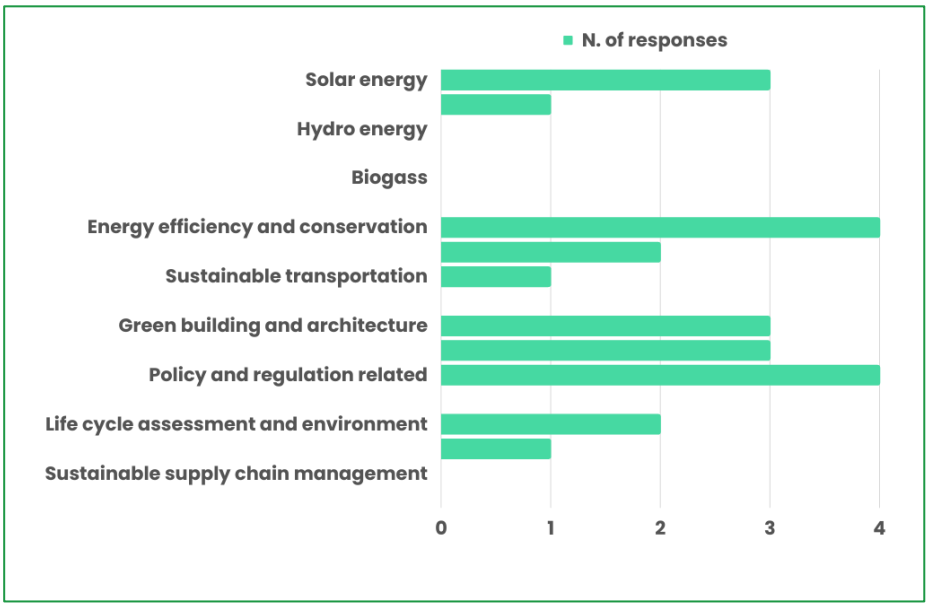

Figure 29. Upskilling needs

6.2 Feedback collection and analysis

The research findings from both desktop and user research indicate common priorities across different countries and urban areas regarding addressing individual, organisational, and community upskilling needs. These priorities include ensuring that micro-credentials are not overly time-consuming or technically demanding and exploring the possibility of offering content in languages other than English. Additionally, there's a preference for concise, easily accessible formats and supplementary resources. The presence of experienced educators and speakers who can provide practical examples is deemed crucial. Learners seek quick access to a wide range of energy transition topics in cities, with flexibility in course timing and duration being essential. The depth and breadth of micro-credential and micro-programmes topics are also significant factors. Furthermore, interviews with industry professionals underscore the importance of engineering and safety in introducing new solutions to the market. Companies value training courses that are unique, innovative, relevant, coherent, and accessible. Both industry and academia prioritise content that addresses immediate needs while also considering future trends and technologies. Training programmes that incorporate various teaching methods and real-world examples from experienced practitioners are highly regarded. Serious games are appreciated and a valid format for individual and group engagement and a positive learning experience. Representatives from priority groups outside of Europe have emphasised the vital need for students and professionals to access a comprehensive learning experience that deepens their comprehension of the impact of the green transition on the labour market and the essential prerequisites known as "green skills." In doing so, they underscore the critical importance of incorporating non-STEM topics (i.e. Social Sciences and Humanities) into the curriculum, making it more inclusive and approachable for individuals with limited prior experience. This inclusion allows learners with varying levels of expertise to commence their educational journey from fundamental principles and build a solid foundation for further exploration. To accelerate renewable energy deployment and fossil fuel substitution in cities, various learning outcomes are needed. They are introduced further and encompass knowledge, skills, attitudes, and behaviours necessary for individuals and organisations, and communities to support sustainable energy transition. At least 24 learning outcomes are co-designed and will be discussed and validated with the micro-credential and

the micro-programme owners and main contributors, namely regarding their expertise and appropriation of the content and the format to the primary end-users.

6.2.1 Learning outcomes

The expertise of the nine RES4CITY universities and their portfolio of curricula was matched with the insights gathered through interactions with stakeholder networks at local, regional and international levels as described in this deliverable. The universities have developed micro-credentials first concepts and enhanced them with the input obtained from stakeholder engagement, namely students and workforce. This process is not straightforward and demands flexibility and responsiveness of individual micro-credential owners to have the capacity to systematically obtain feedback from stakeholders and timely integrate it before the first version of the developed micro-credential. Yet, in some cases, it was shown, that some universities have proffered to make first versions of micro-credentials and would have validated them with the stakeholders through beta-testing and validation focus groups. There is no one format to fit all, and depending on the advancements of micro-credentials, the universities selected the most suitable research methodologies.

For each cluster topic which is the title of the micro-programme as the largest learning unit, the summary of a maximum of three learning outcomes per cluster topic was defined in Table 8:

Table 8. Learning outcomes

Cluster topic	Learning outcomes
Sustainable energy technologies and strategies in urban environment	Students and the workforce (learners) will: 1. Gain an understanding of various sustainable energy technologies and their applications in urban settings. 2. Develop the ability to assess the feasibility and potential impact of sustainable energy solutions within urban environments. 3. Acquire knowledge and skills in the integration of renewable energy sources and energy-efficient technologies to create environmentally friendly urban energy systems.
Decarbonisation strategies and social innovation for cities and communities	4. Learn about effective decarbonization strategies and their role in mitigating climate change at the community level. 5. Develop skills in social innovation and community engagement, enabling them to mobilise support for sustainable practices and policies. 6. Gain an understanding of the socio-economic implications of decarbonization efforts and the importance of equity in sustainable transitions.
Advanced design of sustainable cities	7. Gain expertise in urban planning and design principles that prioritise sustainability, including green infrastructure and energy-efficient building practices. 8. Acquire the ability to analyse and optimise urban layouts for energy efficiency and environmental resilience. 9. Develop skills in utilising technology and data for urban design, fostering sustainable and liveable cities.
Business strategies for a sustainable urban transition	10. Learn about sustainable business models and strategies for urban development, focusing on economic viability and environmental responsibility. 11. Gain expertise in financing mechanisms and incentives to support sustainable urban projects.

Cluster topic	Learning outcomes
	12. Develop skills in stakeholder engagement and partnership building to drive sustainable economic growth in cities.
Sustainability by design: developing a resilient built environment	13. Understand the principles of resilient design and the importance of designing built environments to withstand environmental challenges. 14. Gain knowledge in sustainable building materials and construction techniques. 15. Develop the ability to assess and retrofit existing structures for improved sustainability and resilience.
Innovation in the urban energy sector: strategies and management	16. Learn about innovation trends and emerging technologies in the urban energy sector. 17. Develop skills in technology assessment, adoption, and management to drive energy sector innovation. 18. Gain an understanding of regulatory and policy frameworks that support innovation in urban energy systems.
Sustainable energy solutions for cities: policy and implementation strategies	19. Acquire knowledge of policy development and implementation strategies to promote sustainable energy solutions in urban areas. 20. Develop skills in policy advocacy and engagement with government and stakeholders to drive policy change. 21. Understand the importance of regulatory knowledge and compliance in implementing sustainable energy projects.
Sustainable finance and energy transitions in cities	22. Gain expertise in sustainable finance mechanisms and investment strategies for urban energy transitions. 23. Develop skills in financial literacy and risk assessment for sustainable energy projects. 24. Understand the role of financial incentives and market analysis in facilitating energy transitions within cities.

These general learning outcomes align with the respective cluster topics, yet they are not necessarily exhaustive and there might be micro-credentials that bring expertise not envisioned in these outcomes. According to the gathered data, at this moment it is hard to notice large discrepancies between students (early-stage career professionals) and the workforce. This is why the learning outcomes are more general as they address the needs of both students and professionals with no indication of their experience and expertise levels. The process of assessment will continue, and progress will be reported in M24 with more insights about validation results.

7. Next steps

The next critical steps to ensuring effective implementation, inclusivity and accessibility will be to focus on validation and beta testing of the first versions of micro-credentials with primary end-users such as students and professionals. A validation workshop with the RES4CITY Advisory Board will be organised later this year (Q4 2023), seeking their expert insights and recommendations to refine the strategies and objectives of our educational framework. Continuous collaboration with industry experts will help align efforts with industry standards and needs. For example, the team will organise beta-testing with companies selected among the stakeholder networks of eight hubs, and actively involve them in the development and fine-tuning of micro-credential and micro-program offerings (Q4 2023). Real-world feedback from these organisations will be instrumental in enhancing educational and upskilling approaches. Similarly, there is planned a validation workshop with the Regional Skills in Ireland (Q1 2024), an organisation that is responsible for advocating and operationalising assessment of local skills needs and workforce development, aiming to adapt micro-credentials and micro-programs to meet specific regional requirements. Lastly, beta-testing within RES4CITY universities will allow the project to validate the effectiveness of educational offers to individual and collective learning experiences among students and classes of different disciplines and education levels (WP5, Q4 2023 - Q1 2024). This comprehensive approach underscores RES4CITY's commitment to creating a versatile, industry-academia-driven framework that benefits all stakeholders involved in these specialised educational endeavours.

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9. Annexes

Annex 1. An assessment survey to assess relevance of strategies in RES and educational needs

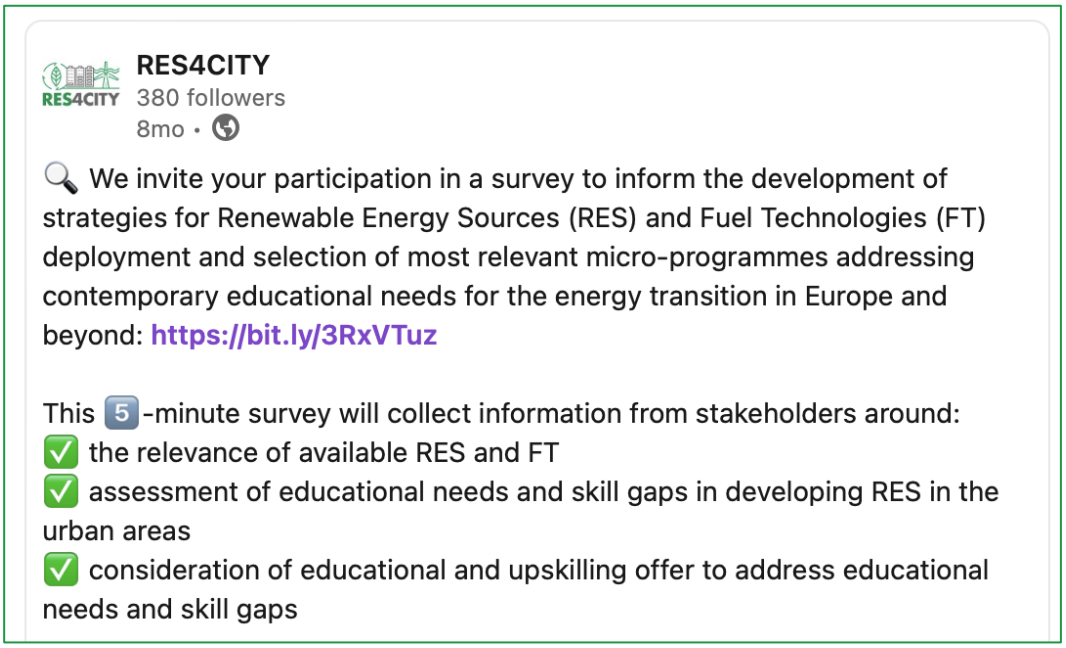
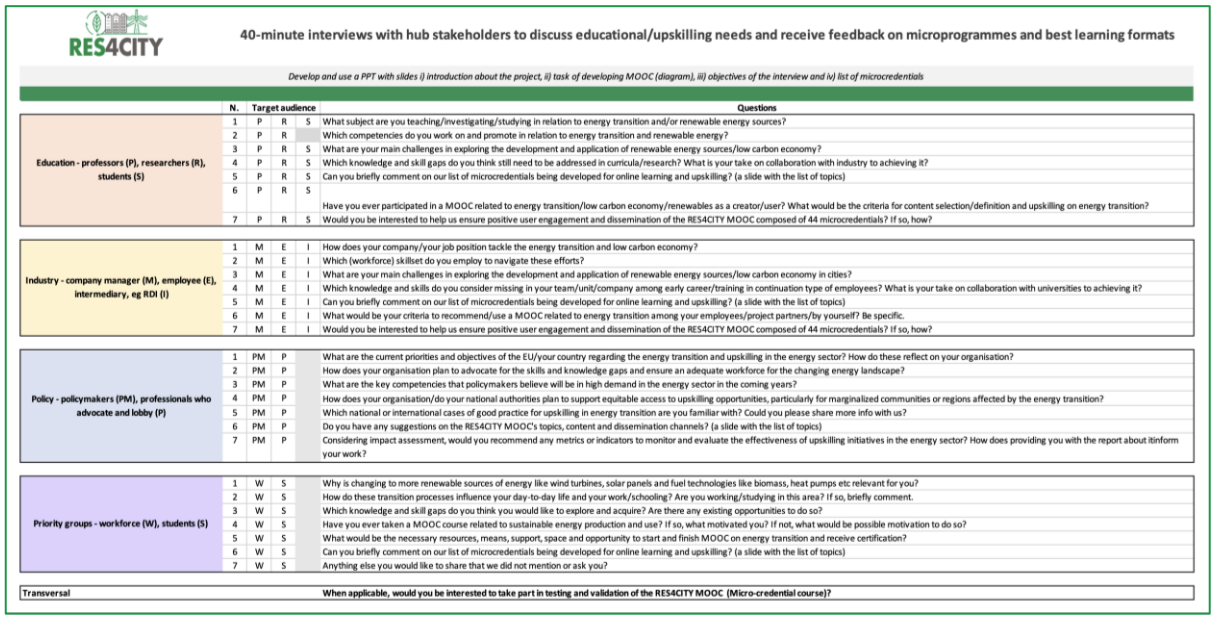


Figure 30. Public posting to encourage filling out of the survey

Figure 31. Survey caption

Annex 2. Interview grid



RES4CITY

40-minute interviews with hub stakeholders to discuss educational/upskilling needs and receive feedback on microprogrammes and best learning formats

Develop and use a PPT with slides i) introduction about the project, ii) task of developing MOOC (diagram), iii) objectives of the interview and iv) list of microcredentials

	N.	Target audience				Questions
Education - professors (P), researchers (R), students (S)	1	P	R	S		What subject are you teaching/investigating/studying in relation to energy transition and/or renewable energy sources?
	2	P	R			Which competencies do you work on and promote in relation to energy transition and renewable energy?
	3	P	R	S		What are your main challenges in exploring the development and application of renewable energy sources/low carbon economy?
	4	P	R	S		Which knowledge and skill gaps do you think still need to be addressed in curricula/research? What is your take on collaboration with industry to achieving it?
	5	P	R	S		Can you briefly comment on our list of microcredentials being developed for online learning and upskilling? (a slide with the list of topics)
	6	P	R	S		Have you ever participated in a MOOC related to energy transition/low carbon economy/renewables as a creator/user? What would be the criteria for content selection/definition and upskilling on energy transition?
	7	P	R	S		Would you be interested to help us ensure positive user engagement and dissemination of the RES4CITY MOOC composed of 44 microcredentials? If so, how?
Industry - company manager (M), employee (E), intermediary, eg RDI (I)	1	M	E	I		How does your company/your job position tackle the energy transition and low carbon economy?
	2	M	E	I		Which (workforce) skillset do you employ to navigate these efforts?
	3	M	E	I		What are your main challenges in exploring the development and application of renewable energy sources/low carbon economy in cities?
	4	M	E	I		Which knowledge and skills do you consider missing in your team/unit/company among early career/training in continuation type of employees? What is your take on collaboration with universities to achieving it?
	5	M	E	I		Can you briefly comment on our list of microcredentials being developed for online learning and upskilling? (a slide with the list of topics)
	6	M	E	I		What would be your criteria to recommend/use a MOOC related to energy transition among your employees/project partners/by yourself? Be specific.
	7	M	E	I		Would you be interested to help us ensure positive user engagement and dissemination of the RES4CITY MOOC composed of 44 microcredentials? If so, how?
Policy - policymakers (PM), professionals who advocate and lobby (P)	1	PM	P			What are the current priorities and objectives of the EU/your country regarding the energy transition and upskilling in the energy sector? How do these reflect on your organisation?
	2	PM	P			How does your organisation plan to advocate for the skills and knowledge gaps and ensure an adequate workforce for the changing energy landscape?
	3	PM	P			What are the key competencies that policymakers believe will be in high demand in the energy sector in the coming years?
	4	PM	P			How does your organisation/do your national authorities plan to support equitable access to upskilling opportunities, particularly for marginalized communities or regions affected by the energy transition?
	5	PM	P			Which national or international cases of good practice for upskilling in energy transition are you familiar with? Could you please share more info with us?
	6	PM	P			Do you have any suggestions on the RES4CITY MOOC's topics, content and dissemination channels? (a slide with the list of topics)
	7	PM	P			Considering impact assessment, would you recommend any metrics or indicators to monitor and evaluate the effectiveness of upskilling initiatives in the energy sector? How does providing you with the report about itinform your work?
Priority groups - workforce (W), students (S)	1	W	S			Why is changing to more renewable sources of energy like wind turbines, solar panels and fuel technologies like biomass, heat pumps etc relevant for you?
	2	W	S			How do these transition processes influence your day-to-day life and your work/schooling? Are you working/studying in this area? If so, briefly comment.
	3	W	S			Which knowledge and skill gaps do you think you would like to explore and acquire? Are there any existing opportunities to do so?
	4	W	S			Have you ever taken a MOOC course related to sustainable energy production and use? If so, what motivated you? If not, what would be possible motivation to do so?
	5	W	S			What would be the necessary resources, means, support, space and opportunity to start and finish MOOC on energy transition and receive certification?
	6	W	S			Can you briefly comment on our list of microcredentials being developed for online learning and upskilling? (a slide with the list of topics)
	7	W	S			Anything else you would like to share that we did not mention or ask you?
Transversal						When applicable, would you be interested to take part in testing and validation of the RES4CITY MOOC (Micro-credential course)?

Figure 32. Interview grid per stakeholder type

Table 9. Interviewees' details

N.	Country	Stakeholder type	Date of interview
1	Portugal	Clean technology energy company	14 July 2023
2	Portugal	Private RDI organisation	28 August 2023
3	Portugal	University	10 July 2023
4	Spain	Public entity for energy sector	20 July 2023
5	Spain	IT tech company	26 July 2023
6	Spain	Cluster for energy sector	21 July 2023
7	Thailand	Vocational training foundation working with migrants' students	14 September 2023
8	South Korea	Advisory for public policy with reach to industry and academia	14 September 2023
9	Ethiopia	Civil society organisation working with communities and refugees	15 September 2023