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A micro-credential approach for life-long learning in the urban renewable energy sector

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ABSTRACT

The present paper describes the development of a novel framework for the creation of specialised Micro-Credentials supporting the training and re-training of students and professionals on the integration of renewable energy and sustainable fuels in urban settings. The framework is built upon a set of stackable micro-credentials, co-designed with the stakeholders input and it uses advanced natural language processing (NLP) and machine learning algorithms to assess the impact on the job market at regional level. The use of Micro-Credentials are considered to be the optimal methodology for enhancing the knowledge of specific topics especially for life-long learning for professionals. A co-design approach of such an innovative educational framework with relevant stakeholders fosters a tailored educational path for green upskilling. Finally, the framework is validated processing and analysing a large dataset of job descriptions, extracting the skills required by the market, organising the skills in categories and clusters. All this process lead to the creation of a basket of 74 Micro-Credentials oriented to students and professional with both a technical and non-technical backgrounds.

1. Introduction

In response to the escalating threat of climate change and the urgent need to forge a path towards a sustainable energy future, the adoption of renewable energy sources has emerged as an unequivocal imperative. This transformational shift in our energy landscape is underscored by the United Nations Sustainable Development Goal 7.2, which unambiguously recognises the paramount significance of tackling this pressing issue and calls for a resolute commitment to significantly augment the share of renewable energy within the global energy portfolio by the year 2030. By harnessing abundant and replenishable resources, renewable energy system can reduce our current reliance on fossil fuels, thus helping to curtail the detrimental impacts of climate change, but also paves the way for energy security, economic growth, and enhanced resilience in the face of environmental uncertainties [1].

In this context, cities are considered important targets for promoting renewable energy and sustainable fuel technologies since they are home to more than half of the world population while they account for about 75% of carbon emissions and between 60%–80% of energy consumption [2]. It has been estimated that about two-thirds of all humanity will live in urban settlements by 2050 and, as outlined by the Sustainable Development Goals (SDG), sustainable development requires a radical transformation in the way we build and manage our urban spaces [3]. Furthermore, cities are often at the forefront of innovation [4], which makes them suitable as test beds for new technologies and approaches to energy use and sustainable development. Local governments have the power to make local decisions about energy use and sustainability, and by acting, they can play a critical role in driving global progress towards a more sustainable future.

The intricate tapestry of urban environments – where diverse sectors exhibit distinct energy and material demands, as well as different attributes and requisites – presents a challenge in the formulation of holistic sustainable policies. These policies demand a multifaceted approach encompassing technical, social, and economic dimensions, to confront the considerable complexities of cities [5]. Consequently, the pursuit of energy transition strategies necessitates a profound metamorphosis of urban landscapes driven by high-level directives and coordinated efforts. This undertaking demands a dedicated emphasis on strategies tailored to local and urban contexts - encompassing energy-efficient strategies, the incorporation of renewable energy systems (RES), the encouragement of environmentally-friendly transportation

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choices, the establishment of resilient urban infrastructure, and the implementation of circular economy principles and recycling practices, among other multifaceted initiatives. Moreover, future sustainable and smart cities should foster the deep integration and control of multiple energy vectors leveraging the latest scientific research developments and technological advancements, while promoting the deployment of renewable energy sources and fuel technology substitution. Overcoming these numerous challenges and obstacles requires coordinated actions on both social, technical and economic dimensions [6] and the adoption of a comprehensive approach which recognises the *transition* as a multi-sectional process involving different actors and encompassing several disciplines — from engineering, architecture and urban planning to economic, finance and social science. Therefore, such framework should address the challenge of fragmented methodologies by valorising the integration and synergies in a multi-sector and multidisciplinary perspective [7].

In this context, education plays a fundamental pillar since it represents the foundation to unlock the ability of understanding, explaining and addressing the challenges confronted by our society [8]. This aspect is recognised by the SDGs, which included Quality Education as SDG4 with the goal of ensuring *inclusive and equitable quality education and promote lifelong learning opportunities for all*, since it represents *one of the most powerful and proven vehicles for sustainable development* [9]. According to this vision, education has the potential to serve a double purpose: it can enhances the human capital by equipping the workforce with knowledge and skills needed by the job market, while it generates awareness on the sustainable transition [10,11]. The synergy between these two aspects can only be achieved by recognising the intrinsic interdisciplinary characteristic of the sustainable transition, which transcends the current separation between disciplines and sectors in higher education [12]. The development of innovative educational programmes is therefore required to extend and complement traditional higher education courses by adopting a lifelong learning and student-centred approach [13].

One of the most relevant pillar of an educational framework is tailoring its objectives and contents to the specific needs and interests of the target audience. These needs consists of two main aspects: the first is focused on the individual interests and motivations of learners', since understanding their knowledge level, concerns, and motivations can support shaping programmes relevant and meaningful to them, increasing their engagement and willingness to participate [14]. The second aspect is related to the skill needed at job-market level, since prioritising learning objectives and outcomes to these needs support employability opportunities of learners [15]. This alignment of programmes and courses to learners' needs is generally called *student-centred approach*, and it is recognised as a fundamental methodology for a successful design and implementation of educational programmes [16].

Although relevant in educational programmes at all levels, student-centred approach is particular important for long-life learning, which is defined as a continuous, self-directed process of acquiring knowledge and skills throughout one's life. In this context, micro-credentials have emerged as a powerful tool for lifelong learning. Generally, a micro-credential (MC) is the record of the learning outcomes that a learner has acquired following a small volume of learning [17]. MCs can unlock the acquisition of specific knowledge and skills which are on high demand in the job-market by individuals (e.g., students, professionals, etc.), helping them to adapt swiftly to shifts in the job market [18].

Despite the interest raised by micro-credentials for life-long learning and professional growth, a lack of standardised guidelines for their design, structure and size, accreditation and learning methods still occurs [19]. Moreover, procedures for the alignment of MC learning objectives and outcomes to learners upskilling interests and to skills demand by the job market need to be established and tested, as outlined in Ahsan et al. [20].

In this context, the present paper proposes a design procedure for a micro-credential basket aimed at the acquisition of relevant knowledge and skills by students and professionals to support the uptake of renewable energy technologies and sustainable strategies in urban settings. The novelty of the methodology adopted in this paper lies in its utilisation of a co-creation approach (Section 3.1) [21], which is based on the interaction with relevant stakeholders in line with Bologna process principles (Section 2.1), complemented by the integration of an Artificial Intelligence (AI) algorithm (as outlined in Section 3.1.2) employed to interrogate popular platforms for job-advertisement (e.g., LinkedIn, Indeed, etc.). This algorithm is utilised to extract target audience interests and skill demand patterns in the job market. Furthermore, an AI natural language processing (NLP) tool is employed to identify and classify the existing skill needs in the urban energy sector, enabling the formulation of learning objectives and learning outcomes for the micro-credential basket tailored on the specific needs of the current job market landscape related to the renewable energy sector. A detailed description of the procedures used for the MCs design and clustering are provided in Section 3.2. The results of this process (Section 4) consists of a microcredential basket of 74 multidisciplinary MCs tackling the educational needs and knowledge gaps currently demanded by the job-market in the urban renewable energy sector.

2. Strategies supporting lifelong learning in the European union

2.1. The European micro-credential framework

The Bologna process, signed in 1999 in Bologna by the Ministries of Education from 29 countries, established the European Higher Education Area (EHEA) aiming at:

- Harmonising the higher education framework through the introduction of a three-cycle system (i.e., bachelor, master and doctoral studies).
- Introducing the European Credit Transfer and Accumulation system (ECTS), which allows students to acquire credits based on defined learning outcomes and transfer them between recognised academic institutions.
- Enhancing students and educators mobility, while ensuring the mutual recognition of qualifications and learning periods abroad.
- Developing and implementing a quality assurance system for teaching and learning.

Since then, the EHEA has provided a framework and practical guidelines and tools for the definition of learning outcomes, qualification framework, monitoring and evaluation procedures, diploma supplement, etc. – which supported the modernisation and improvement of the quality of higher education provision, leading to a greater compatibility and comparability of the European HE system [22]. One of the main innovations fostered by the Bologna process is the paradigm change for the course design process from a *staff-centred* to a *student-centred* approach (see Table 1). By implementing a "student-centred" approach, the design of course programmes (from the definition of the learning outcomes to the introduction of innovative, transversal and job-oriented skills) must be performed in relation to the students' needs rather than the interests of the academic staff and the specific constraints in terms of resources available at the academic institution. The student-centred approach brings several implications, such as:

- a continuous interaction between academic institutions and external stakeholders is required since the design stage of the program in order (i) to tailor the program learning objectives on the specific skills required to meet the students' needs and boost the graduates' employability, (ii) to monitor and verify the learning outcomes acquired by the graduates, (iii) to update the programme learning objectives and contents in response to a change of students' needs and job market.

Table 1
Summary of the political innovation following the EHEA Ministerial Conferences over the last decades. [24–29].

EHEA Ministerial conference	Year	Main political innovations
London	2007	– National educational systems compatibility and comparability. – Foster staff mobility, students and graduates. – Strategies and policies supporting the social dimension. – Common data collection framework. – Student-centred and outcome-based learning support.
Leuven Louvain-la-Neuve	2009	– Quality assurance monitoring. – Diversity, equal access and opportunities. – Student-centred learning enhancement. – Lifelong learning. – Focus on employability. – Synergies with research and innovation.
Bucharest	2012	– Joint programmes and degrees. – Access widening for underrepresented groups. – Problem-solving and entrepreneurial skills – Mobility for better learning.
Yerevan	2015	– Digital technologies for learning and teaching. – Flexible learning paths. – Involvement of students as stakeholders. – International mobility for study and placement. – Permeability between education sectors.
Paris	2018	– Open education for lifelong learning. – Interdisciplinary programmes. – Digital and blended education. – Transnational cooperation in HE, research and innovation. – Synergies with the UN sustainable Development Goals (SDGs).
Rome	2020	– Knowledge circulation and outreach principle. – Students' rights. – Learning offer diversification and curricula internationalisation. – Small and flexible learning units (micro-credentials). – Development of digital skills and competence for all. – Secure, efficient and transparent exchange of data.

- Curriculum reforms need to be fostered to ensure high-quality, flexible and more individually tailored education paths on the student specific needs and interests [23]. Important tools aimed at enhancing these aspects are represented by the ECTS and qualification frameworks, which supports the mutual recognition of competences, as well as students' mobility programmes, established under the EHEA. However, student-centred learning also requires the deployment of effective support and guidance structures to empower individual learners in defining their education path, while supporting them in exploring learning and professional opportunities.

The envision shift towards student-centred education is recognised to be a fundamental pillar to support the EHEA lifelong learning policy as a needed strategy to face the challenges posed by job-market turmoil and by new digital technologies on social cohesion, equal opportunities and quality of life. Pillars for an effective development of lifelong learning can be summarised as follows:

- Widening access to higher education.
- Improving the recognition of prior learning, including both non-formal and informal learning activities.
- Improving cooperation with employers, especially in the development of educational programmes.
- Creating more-flexible, student-centred modes of delivery with the introduction of small learning units (i.e. micro-credentials).

In the context of the transformation of the European educational framework, the use of micro-credentials as life-long learning strategy has attracted a lot of interest. Generally, micro-credentials consists of short, focused, and specialised educational programmes that provide learners with the opportunity to acquire and demonstrate specific skills and knowledge that are in demand in the workforce [17]. They are designed to be flexible, in order to provide learners with the ability to pursue their education and career goals and, consequently they are usually shorter than traditional degree programs and focus on providing learners with specific skills and knowledge tailored on their needs.

Micro-credentials may serve as an add-on to the existing provision of continuing education and training and mobility schemes, driving an innovation agenda in higher education, as Massive Open Online Courses (MOOC) have previously done by enabling the development and provision of short courses of applied learning to learners through flexible online courses. The development and implementation of micro-credentials is shaped by the strategies and vision of higher education institutions on the one hand, and the involvement and dedication of forward-thinking professionals on the other hand. The success of micro-credentials depends on the collaboration and interaction between these two groups and society at large and a combination of top-down and bottom-up strategies are usually used.

The European Skills Agenda recognises micro-credential as a promising tool to empowering professionals for tailored and accessible skills (re)development. To create a European approach to micro-credentials which can strengthen the societal mission of education institutions and can be applied to all education sectors, the European Commission has recently issued a policy document [17] to establish a common definition of micro-credentials, to standardise their main elements and provide guidelines on how to design, monitor and assess the learning outcomes (Fig. 1). Ten universal principles, applicable to all sectors or area, have been identified as guidelines on how to design, develop and issue micro-credentials which represent the key characteristic of the European approach [17], as shown in Fig. 2.

3. Methodology

As outlined in Section 2.1, the European Union Micro-Credential Framework [17] aims at promoting the recognition and standardisation of micro-credentials within the EU as part of the EU's wider efforts to promote digital and lifelong learning and to support the development of a highly skilled and competitive workforce. In line with this (Section 2), the present document outlines the results from the EU-funded project RES4CITY, which aims to support the development of

A micro-credential is the **record of the learning outcomes** that a learner has acquired following a small volume of learning.	
Learning outcomes	Provide with specific knowledge, skills and competences that respond to societal, personal, cultural or labour market needs.
Quality assurance	Assessment against transparent and clearly defined standards in the relevant sector or area of activity
Ownership and portability	Micro-credentials are owned by the learner, can be shared and are portable
Stackability	They may be standalone or combined into larger credentials

Fig. 1. Definition and main characteristics of micro-credentials according to [17].

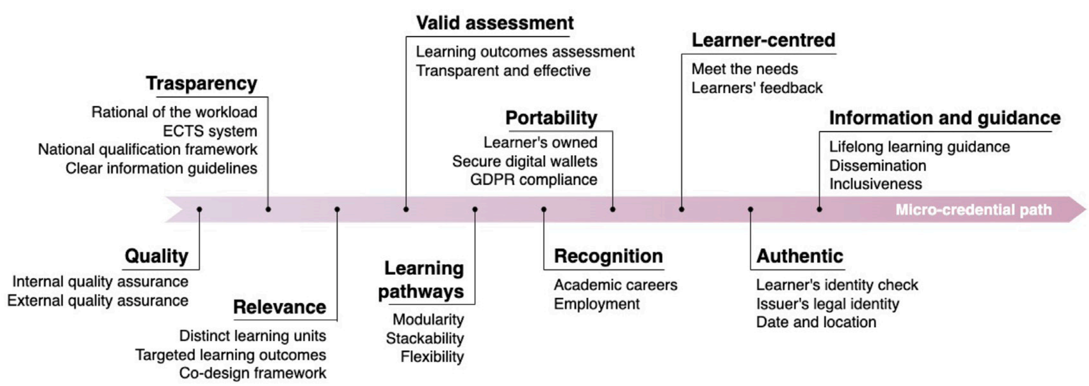

Fig. 2. The European approach to micro-credentials [17].

a highly skilled workforce by promoting sustainability and circularity in the development of renewable and fuel technologies in cities through an innovative educational program co-designed with stakeholders from 8 EU countries and Switzerland. The overall aim of this educational program, is to offer individuals – ranging from Bachelor, graduate and Ph.D. students in STEM and SSH disciplines to professionals already engaged in the energy sector in Europe and beyond – an opportunity to acquire specialised skills and knowledge. The incorporation of micro-credentials aligns with the EU's overarching goal of advancing digital literacy and fostering lifelong learning. These resulted in the development of micro-programmes (MPs), based on a basket of micro-credentials (MCs), which addressed the multidisciplinary dimension of renewable energy and sustainable fuel technologies and strategies for urban areas. To achieve these goals, a design framework for the MC-basket and MPs is developed as outlined in the sections below and summarised in Fig. 3.

3.1. Educational needs identification and co-creation approach

The continuous identification of the educational needs and knowledge gaps is a fundamental step towards the development of user-centred educational programmes and it is therefore embedded in the Bologna process (Section 2.1). Being able to capture the dynamic changes of the skills needed by the job market requires establishing effective and continuous interaction with various stakeholders [21]. In this regard, co-creation is a popular approach to multi-stakeholder engagement and interdisciplinary research and innovation when there is a complex innovation challenge that is not easy to define/understand such as energy transition [30].

In the context of the present paper, co-creation is adopted to co-develop and deliver innovative educational solutions with the direct involvement of relevant stakeholders. The aim is to identify skill gaps and job market discrepancies among their students, professionals, partner civil sector organisations and companies focused on education, local and national authorities, and industry associations. These efforts are driven by the necessity to build individual and organisational capacities in the energy transition and the use of renewable energy sources and fuel technologies. Industry demands, emerging technologies, academic strengths, and career aspirations are thoroughly evaluated to pinpoint specific skill gaps.

Usually, traditional co-design methodologies allow to collect qualitative information which serve as a substantial background to elaborate meaningful programmes and courses. On the other hand, the collected information often reflect the point of views of individuals rather than those of the organisations (e.g., industries, public institutions, etc.). To overcome this limitation and consider more objective data, a multi-faceted methodology was designed for a systematic investigation, comprising data collection, skills extraction using Generative AI, topic modelling, and direct stakeholders interactions by tailored surveys, interviews and local stakeholder meetings (Fig. 3), as outlined in the sections below.

3.1.1. Stakeholders interaction

Leveraging on the job market analysis (Section 3.1.2) and on the local and international hubs established in the framework of the

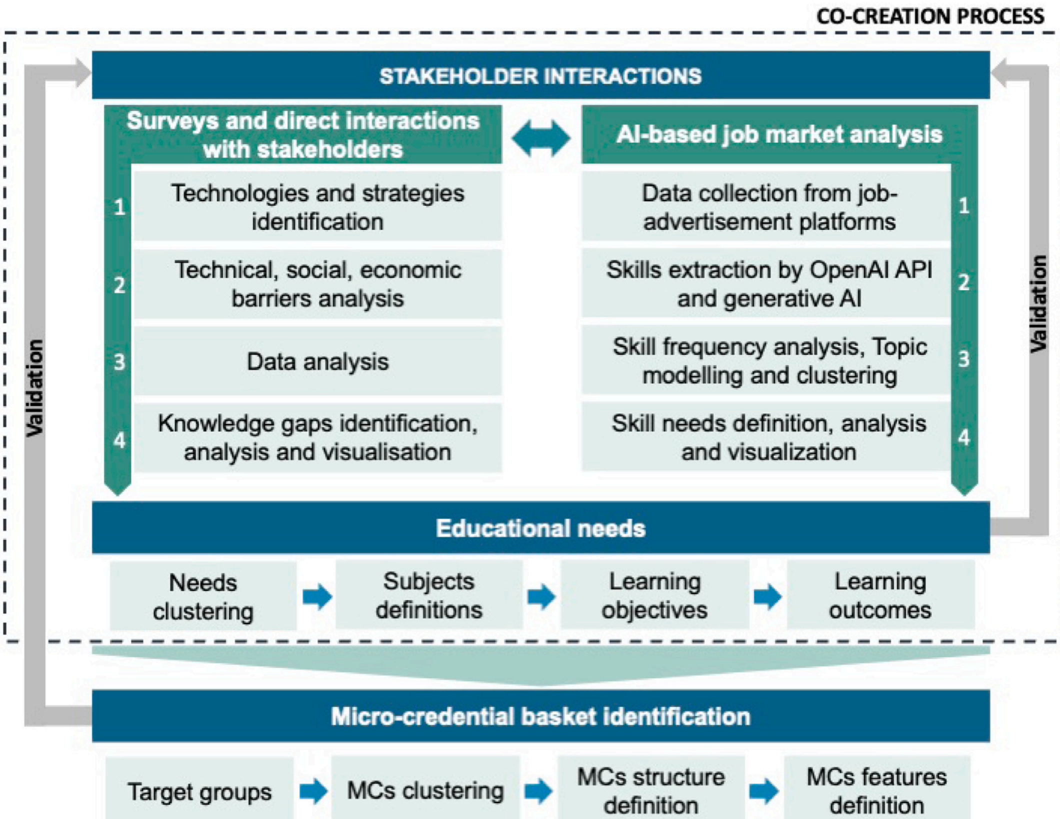

Fig. 3. Co-creation approach and micro-credential basket design process.

RES4CITY project, a co-creation process is used for (i) the identification of educational needs and knowledge gaps currently limiting the uptake of renewable energies and sustainable fuel technologies (FT) in urban areas; (ii) the translation of these educational needs in learning objectives for the micro-credential basket; (iii) the validation of the micro-credential basket developed to ensure its alignment with the educational needs identified.

In this framework (Fig. 3), stakeholder interaction aimed at understanding the current challenges and opportunities was based on a two-step approach: firstly, an online public assessment survey is carried out to gather feedback on required strategies for RES and FT deployment and on the most relevant strategies addressing contemporary needs for the energy transition in Europe and beyond. This online survey, conducted between January–April 2023, collected 112 responses among which 78.8% were responded by students, 4.8% by professors, and 16.3% by professionals in several EU and extra-EU countries. Factors such as proficiency in relevant subjects, previous experience, and/or interest in sustainable energy practices served as a general selection criteria for the target audience and future learners.

Subsequently, stakeholders within the university-led RES4CITY hubs networks were encouraged to provide additional insights on RES and FT strategies in urban areas during periodic meetings and focus groups conducted between June–September 2023. The primary target audience comprises university students, academic professionals (e.g., researchers and professors) and public/private companies as direct and future users of the RES4CITY micro-credentials. Participants were asked to select the most relevant energy-efficiency, renewable energy and fuel technologies strategies enabling decarbonisation in urban areas, as well as to support the identification of the learning outcomes required to fill the educational gaps currently present in the job market. The findings highlight some common priorities in addressing the need for upskilling to drive a sustainable energy transition across diverse urban areas and countries. Participants have underscored the importance of accessible formats and diverse content. Industry professionals have emphasised the need for engineering and safety expertise in implementing new solutions. Incorporating social sciences and humanities topics into the micro-credential offer was recognised as critical for fostering inclusivity, which are reflected in dedicated micro-credentials — such as, P24 Energy management and smart communities and P26 Energy policy. These micro-credentials equip learners with urban planning and human-centred design principles prioritising sustainability.

To ensure relevance, feedback from industry professionals and academics is integrated into the development processes of micro-credentials. Both industry and academia prioritise content that addresses immediate needs and future sustainability trends, such as, for example, micro-credentials P02 Sustainable fashion and P13 Energy markets. The participants value upskilling programmes that incorporate various teaching methods and real-world examples, such as case study education (e.g., P11 Case studies in energy management and P14 Case studies in thermal systems).

Participants outside Europe emphasise the need for comprehensive learning experiences that deepen comprehension of the green transition's impact on the labour market and essential “green skills”. They also prefer concise, easily accessible micro-credentials that are not overly time-consuming or technically demanding which has positively reflected into the micro-credential production. For instance, micro-credential P28 Decarbonisation of thermal energy corresponds to the learner's needs regarding resilient design principles in thermal energy systems, addressing environmental challenges. Through ongoing stakeholder engagement and feedback, micro-credentials develop to meet evolving needs and priorities in sustainable energy transition.

The information collected during direct interaction with stakeholders were further used to interrogate the job-market to extract the educational and skill currently in need, as described in Section 3.1.2.

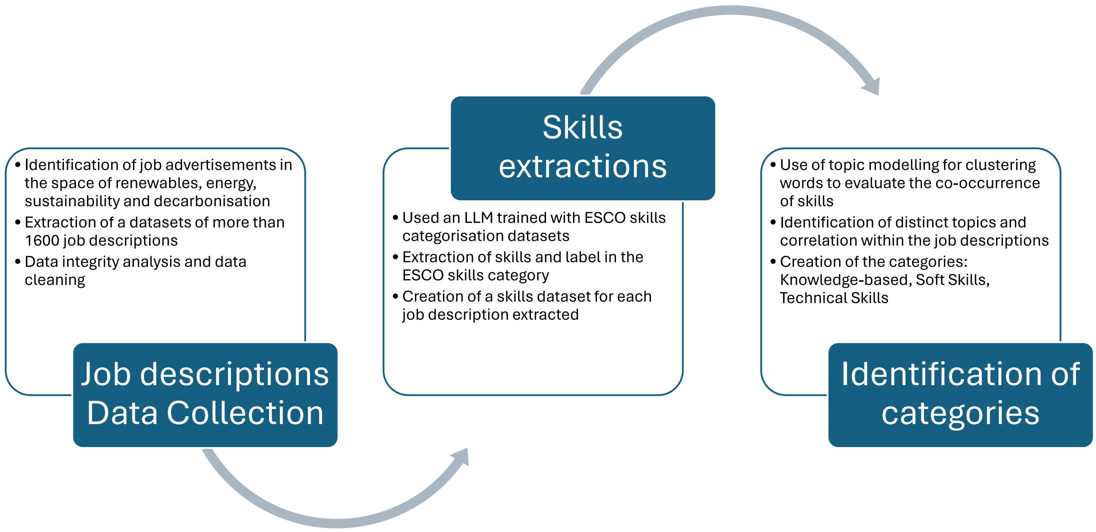

Fig. 4. Description of the data flow and the overall analysis for the dataset of job descriptions.

3.1.2. Job skills identification through AI

The first step towards the identification and validation of skills gaps for the co-creation framework involved the creation of a comprehensive dataset of over 1600 job listings, aggregated from various job boards and recruitment platforms such as LinkedIn, Indeed and similar, during the period March–September 2023 and for selected EU countries (i.e., Ireland, Italy, Germany, France, Spain, Poland). The jobs listings is filtered based on the presence of targeted keywords – e.g., sustainability, energy and decarbonisation – in order to ensure a sharp focus on the sectors of interest.

As described in the data flow Fig. 4, job descriptions were processed using a Large Language Model (LLM) trained with the European Union Skills Categorisation framework named ESCO [31]. Following the extraction of skills according to the EU classification, topic modelling was employed to categorise these skills into coherent groups and to support the delineation of three primary categories: soft skills, knowledge-based skills, and technical skills. This statistical categorisation utilised Latent Dirichlet Allocation [32], which enhanced the correlation and granularity of the analysis, thereby informing a more structured categorisation process. Within the ESCO classification, soft skills included categories such as S1 (communication, collaboration, and creativity), S2 (information skills), and S4 (management skills). These were complemented by key transversal competencies like T2 (thinking skills and competences) and T4 (social and communication skills and competences). Knowledge-based skills were specifically recognised within the "Knowledge" classification of ESCO. In contrast, technical skills, which span both the "Knowledge" and "Skills" classifications, included specific capabilities such as coding and engineering. Therefore, the three resulting categories were defined as:

- Soft skills: set of interpersonal skills which relate to personal attributes and qualities that enhance an individual's ability to interact effectively with others, both in professional and social settings. These skills are typically related to emotional intelligence, communication, teamwork, adaptability, problem-solving, and conflict resolution. It also includes abilities such as critical thinking, long-term vision development and planning, decision-making and leadership skills.
- Knowledge-based skills: they encompass an individual's proficiency in fundamental theoretical knowledge within a specific field or domain. These skills involve the capacity to apply foundational concepts, principles, and theories to address real-world problems and challenges. They are crucial for making informed decisions, solving complex issues, and effectively utilising acquired knowledge to achieve practical objectives in a particular area of expertise. Knowledge-based skills often serve as the intellectual foundation upon which problem-solving and critical thinking are built.
- Technical skills: technical skills are specific abilities and competencies related to a particular field or profession. These skills are practical and typically acquired through training, education, or hands-on experience. Technical skills can encompass a wide range of areas, such as computer programming, graphic design, engineering, data analysis, or any other discipline-specific expertise. They are essential for performing tasks and duties in a profession or industry and are often quantifiable and measurable.

The application of this methodology facilitated the development of an analytical framework aimed at simplifying the inherent complexity of the ESCO classification, making it more accessible and user-friendly. This framework is designed to significantly enhance job orientation tools, enabling job seekers to efficiently identify their skills gaps and better align their competencies with market demands.

3.2. Micro-credential framework development

Following the identification of the educational needs, based on the methodology outlined in Section 3.1, a framework for the development of micro-credentials (MCs) is developed, based on the following steps:

1. *Target audience identification*: Determining who the micro-credential is intended for – such as professionals in a particular industry, students pursuing a specific field of study, or individuals seeking to acquire new skills – is a fundamental preliminary step in designing MCs. In the present work, MCs basket targets two types of audience: (i) Students enrolled in accredited university at Bachelor, Master and PhD level, in both STEM and SSH disciplines and, (ii) young professionals working both in energy and non-energy fields with both STEM and SSH background.
2. *Need assessment*: Since the learning objectives of MCs typically address specific educational needs – thus they are focused on specific knowledge, skills, or competencies that learners are expected to acquire upon completion of the micro-credential – the next steps involved the identification and understanding of the needs and requirements of the target audience. To achieve this objective, a co-creation process involving relevant stakeholders through dedicated surveys and interviews is implemented to identify educational needs and skill gaps to be addressed.

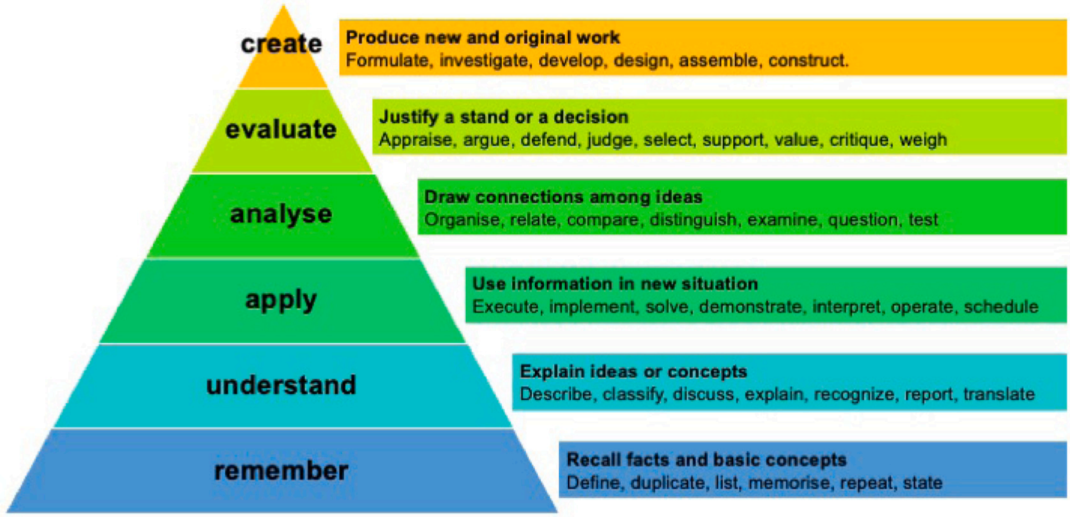

Fig. 5. Bloom's taxonomy adopted for the MCs basket development [33].

3. *Definition of specific competences*: This step requires breaking down the desired overall outcomes into specific learning outcomes, which are measurable and aligned with the overreaching goal of MCs. In the present work, the identified educational needs were translated into specific learning units which forms the MCs. A hierarchical framework for categorising educational goals based on the Bloom's taxonomy [33] (Fig. 5) was used to guide the development of learning objectives and to ensure that the learning objectives span across different levels to promote a comprehensive understanding and application of the subject.
4. *Assessment methods*: appropriate assessment methods that align with the learning objectives and allow learners to demonstrate their proficiency in the targeted competencies, must be established. Different assessment methods – such as, multiple choice questions, projects, practical exams, etc. – were considered for each MCs. However, due to the MOOC nature of these programmes, which was chosen to reach the widest diffusion possible, has led to select multiple choice questions as the preferred assessment method. Notwithstanding, this does not preclude a future implementation of other assessment methods based on the MOOC platform capabilities (e.g., serious games as a test for evaluating the level of achievement of MCs).
5. *Prioritise relevance and real-world applications*: to emphasise practical applications and relevance of the learning objectives in the job market, practical learning with real-life examples and based on case study education was employed across all MCs, by leveraging on the specific case studies, to ensure that the knowledge and skills acquired through the micro-credential can be directly applied in professional or real-life settings.
6. *Quality assurance*: a continuous review and validation of the learning outcomes and MC contents with relevant stakeholder, including feedback from learners, is fundamental to ensure their alignment with the educational needs identified. The developed programmes implemented a co-creation process based a continuous interaction with relevant stakeholders. All MCs must go through both internal and external quality check to ensure relevance of the learning objectives and quality of the teaching material, while learners' feedback must be acquired. It is suggested to establish procedures to collect periodic external feedback.

The co-creation process adopted in the present work is outlined in Fig. 3. This methodology was used to identify a basket of micro-credentials to address the educational needs related to the development of renewable energy sources and sustainable fuel technologies in urban areas. This MC basket – which includes 74 MC-based modules co-created in collaboration with relevant local, national and international stakeholders – is outlined in Section 4.2. In accordance with the procedure outlined above and in Fig. 3, the MC basket is assessed and classified based on several indexes, as follows:

- EQF level: the European Qualification Framework [34] was adopted to classify each MC. The EQF is based on an 8-levels scale defined by a set of descriptors indicating the learning outcomes relevant to the specific qualification possessed by the learners. As mentioned before, the programmes target students at bachelor (EQF 6), master (EQF 7) and PhD (EQF 8) levels, which correspond to the learning outcomes outlined in Table 2. Therefore, EQF level(s) have been assigned to each MC in the basket to identify the qualification level of its learning outcomes.
- International Standard Classification of Education – Fields of education and training (ISCED-F): the ISCED-F framework [35] is adopted as a reference to classify and organise the micro-credential basket based on its fields of education. ISCED was developed by the UNESCO in the mid-1970 and subsequently revised in 1997 and 2011 to reflect the changes in the educational systems occurred over the last decades. The ISCED-F focuses on the fields of education and training, and it was adopted by the EU as reference since 2014 [36]. Referencing to the detailed description of the education fields reported in [35], the ISCED-F codes reported in Table 3 are selected and used to indicate the main discipline (i.e., primary discipline) of each MC. It is important to highlight that due to the intrinsic multidisciplinary of learning programmes identified in the present work, most of the MCs can be related to multiple disciplines. Consequently, secondary ISCED-F codes were assigned to each MC where relevant (i.e., complementary disciplines).

Each MC in the basket is sized according to the European Credit Transfer and Accumulation System (ECTS), adopted by the European Higher Education Area (EHEA) and as suggested in [17] to support the transparency and stackability of the obtained credentials. Currently, no standard ECTS ranges for MCs are currently in place, therefore the following principles are adopted to size each MC: (i) since MC is intended to provide a specific learning outcome, its size must be large enough to allow a precise definition and delivery of its learning outcomes while avoiding to being confused with larger educational programmes. Therefore, a typical range is between 1 and 5 ECTS for

Table 2
Description of the learning outcomes of EQF 6-7-8 [34].

EQF	Knowledge	Skills	Responsibility & autonomy
6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles.	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study.	Manage complex technical or professional activities, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups.
7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field, as the basis for original thinking; critical awareness of knowledge issues in a field and at the interface between different fields.	Specialised problem-solving skills required in research and/or innovation to develop new knowledge and procedures and to integrate knowledge from different fields.	Manage and transform work that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams.
8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields.	The most advanced and specialised skills and techniques required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice.	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research.

Table 3
ISCED-F codes selected for MC basket assessment.

ISCED-F	Subject
031	Social and behavioural science (including economic and finance)
041	Business and administration
052	Environmental science
061	Information and communication technology, data science
071	Engineering and engineering trades
072	Manufacturing and materials
073	Architecture and construction

a single micro-credential. (ii) The total student's effort is estimated in the range of 25–30 h per ECTS [37], including frontal lectures, practical sessions and individual study. Starting from the above, a size of 2.5 ECTS for all MC in the basket was selected as the most appropriate value since it allows to correctly define the learning outcomes of each MC and o to organise each MC in week-based sub-units with an average student effort (total) between 12–18 h per sub-unit and a total duration between 4 and 6 weeks, while ensuring the successful delivery of the MC content. As a rule of thumb, video lectures ranging between 1–3 h are considered for MC of 2.5–3 ECTS delivered online (e.g., through MOOC). This is based on the assumption that a MC must be concentrated and focused on a specific topic, especially for life-long learning purposes when specialised professionals are the target learners.

4. Results and discussion

4.1. Skills and educational needs identification

The co-creation process adopted to identify skills and educational needs involved both (i) the analysis of current skills requested by the job market by means of AI techniques as outlined in Section 3.1.2 and (ii) the interaction with relevant stakeholders through dedicated online surveys and direct stakeholders engagement (Section 3.1.1).

Anonymous data about all participants were collected to analyse their profiles in term of age range, educational background (i.e., STEM and SSH disciplines), professional sector and expertise level on energy and energy-related topics. First of all, it is worth mention that about 18% of the respondents were fully employed professionals, while 77% declared themselves as professionals enrolled in an academic course (EQF7-8); the remaining 5% of respondents were teachers and educators in higher education. The outcome of this profiling exercise is shown in Fig. 6, where it is possible to observe that the majority of the participants are in the 18–34 age range (i.e., 71.5%, Fig. 6a), with a STEM background (i.e., 72.3%, Fig. 6a). All participants were asked to indicate one or more professional fields they are professionally involved. The results showed that the majority of stakeholders related their professional field (Fig. 6c) in the energy sector (22.3%), followed by education (21.7%), mechanical (15.9%) and electric/electronic industries (9.6%) and IoT (6.4%). Moreover, when asked to self-assess their level of expertise on renewable energy sources and fuel technologies (Fig. 6d), more than a third of respondents have high/very-high expertise (about 38%), while the majority indicated a medium level of expertise (about 47%).

Fig. 7 shows the results obtained by the interactions with the stakeholders. First, participants were asked to grade, in a scale between 0 (not important) to 4 (crucial), the most relevant fuel technologies among a given basket to support the implementation of decarbonisation strategies in urban settings. It can be observed in Fig. 7a that hydrogen and biogas are perceived among the most prominent sustainable fuels, followed by biomass and syngas. Then, the respondents were asked about the relevance of several energy strategies in supporting the urban energy transition (Fig. 7b). In this case, energy excess recovery and the implementation of energy communities are perceived as the most relevant with a score greater than 3, followed by demand flexibility and net-positive energy districts. Finally, to identify the most relevant enabling technologies, participants had to evaluate the relevance of several options in supporting the sustainable energy transition in urban areas. The results are shown in Fig. 7c, where it is possible to observe that batteries and smart grids are perceived as the most relevant technologies, followed by thermal storage, cogeneration/tri-generation and heat pumps.

Survey participants and interviewed stakeholders were asked to identify the three major obstacles that, in their opinion, are limiting the uptake of RES in urban settings. It can be seen in Fig. 8(a) that the lack of public awareness and education on sustainability topics (about 28.5%) is perceived as one of the major obstacles to the implementation of RES technologies and strategies in cities, followed by insufficient public policies and incentives (about 25.5%). Moreover, about 22% of the interviewed stakeholders indicated a lack of support on sustainable practice by traditional industries and high upfront costs of RES (about 16%) as other majors challenges.

Then, considering the education aspect, participants were asked to list the educational gaps and upskilling needs to be addressed in order to enhance the human capital in the urban RES sector. The outcome is shown in Fig. 8b, where all responses where classified based on the specific topic to be addressed. It is possible to observe that energy efficiency and conservation is flagged by the majority of participants (with more than 14% of occurrences), followed by energy and resource management (about 11%) and policy and regulation (about 10%). Moreover, enhancing specific technical skills related to solar energy, green architecture, sustainable transportation and life-cycle assessment were highlighted as fundamental for technology development and uptake. On the other hand, broader multidisciplinary skills related to

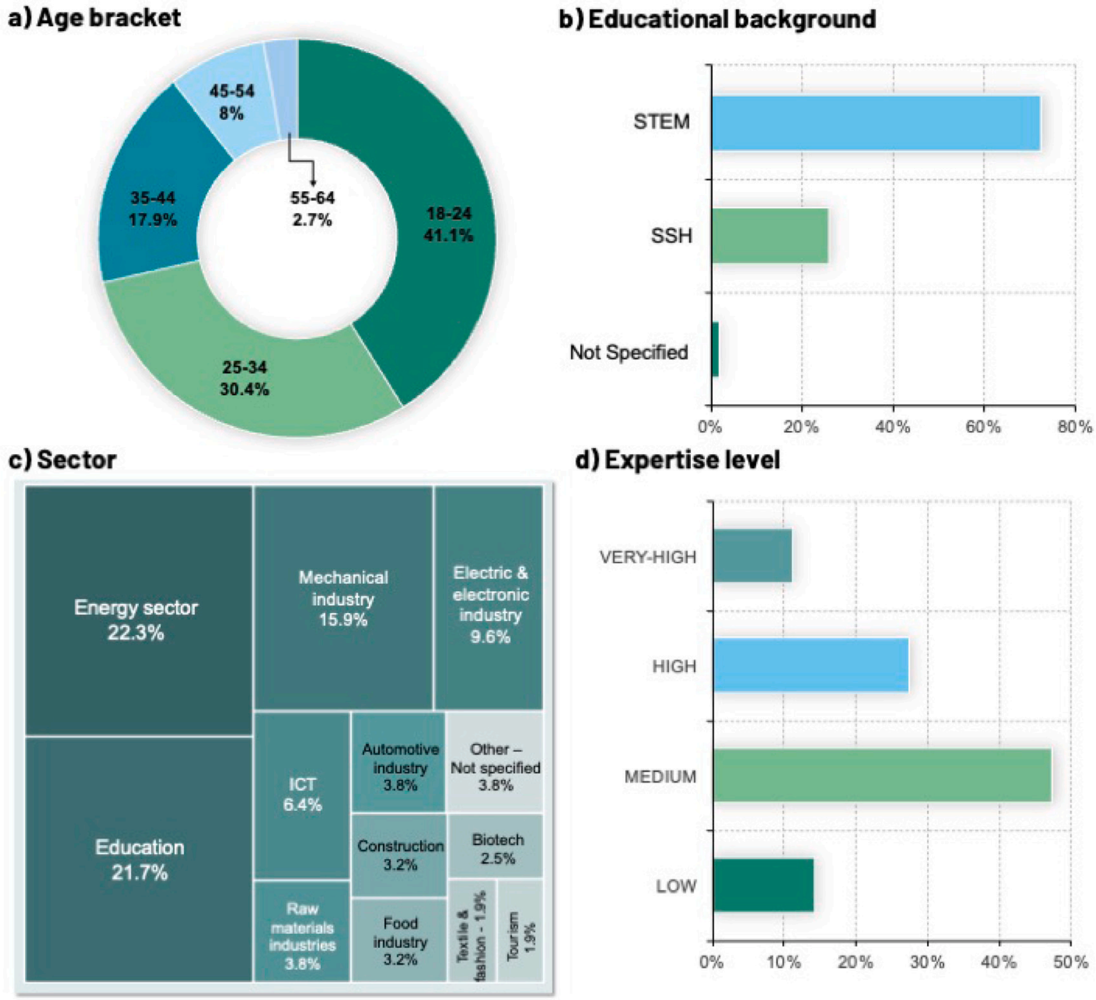

Fig. 6. Stakeholder profiles: (a) Age range, (b) Educational background, (c) Working sector and (d) Expertise level on RES technologies of the enrolled stakeholders.

circular economy, sustainable business, environmental awareness and stakeholder engagement strategies have been flagged as relevant in driving the sustainable transition in urban areas.

Starting from the information collected from the stakeholders through the surveys, a job-market analysis was carried out by interrogating the most common job advertisement platforms (see Section 3.1.2) to identify the current skillsets requested in a selection of EU countries. The deployment of OpenAI and generative AI allowed a more granular extraction of relevant skills and their clustering in three main categories (i.e., soft skills, knowledge-based skills and technical skills). The results is shown in Fig. 9, where a qualitative clustering of the most recurrent skills (top-10) identified is illustrated. It can be observed that the majority of soft skills are related to interpersonal skills, stakeholder engagement and management, problem solving, leadership and negotiation. In terms of knowledge-based skills, a strong focus on business development and sustainability, financial and business analysis, and budget management. Finally, regarding the technical domain, project management and analytical skills, data analysis, problem solving and risk management modelling were the most frequent.

The implementation of a “co-design” framework is ideal in theory, but, as demonstrated by the RES4CITY project, its practical implementation may result complicated. The main challenge is to keep high the interest of the stakeholders so that they are willing to dedicate effort to the participatory design, development and validation process of the micro-credentials. Thus, a careful selection of stakeholders with high interest and commitment is paramount. Notwithstanding, the loss of interest which might occur during the co-creation (e.g., high interest is typical at the initial stage while it may decrease as the co-creation process proceeds), more objective instruments, such as the AI tool, need to be used to gather relevant information.

The take-away message from RES4CITY experience can be summarised as follows: (i) flexible frameworks are needed to adapt to the evolution of the circumstances; (ii) more tools should be integrated in the co-creation process – e.g., AI tool and direct interaction with stakeholders as for RES4CITY case – to meet the targets; (iii) although fundamental, direct stakeholder engagement should be reserved for very relevant parts to limit the decrease of interest naturally occurring at the final stage of the co-design process. For example, objective data should be collected through documental analysis, databases consultation, AI tools, etc., while personal feedback is valuable in: (a) the interpretation and analysis of the collected data in order to orient micro-credentials definition; (b) contributing to micro-credentials development, e.g., by suggesting specific learning outcomes and corresponding contents; (c) validating the final product to double check its coherence and quality.

4.2. The micro-credential basket

Starting from the knowledge needs and skill gaps identified in the previous sections, a curated collection of 74 multidisciplinary micro-credentials was identified to create a MCs basket that cater to a diverse

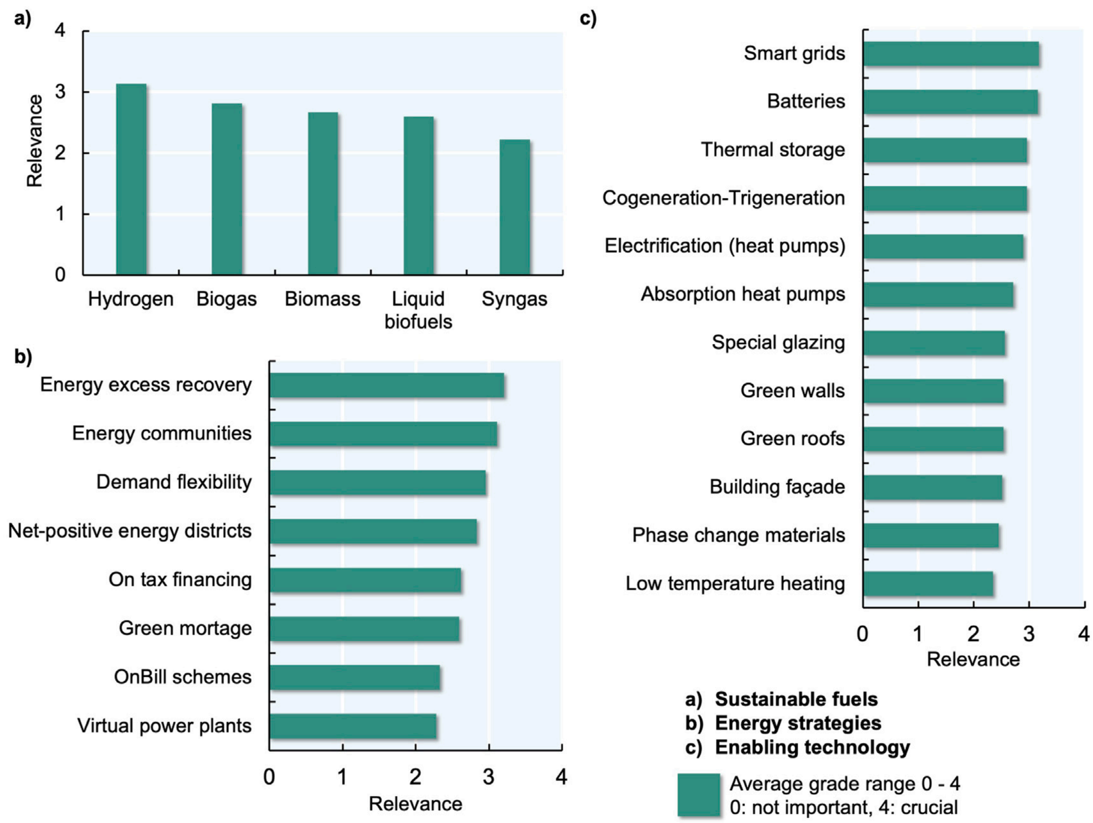

Fig. 7. Result of the stakeholder engagement: ranking of (a) sustainable fuel technologies, (b) energy strategies and (c) technologies enabling renewable energy integration and sustainable fuel technologies for the green transition of urban areas.

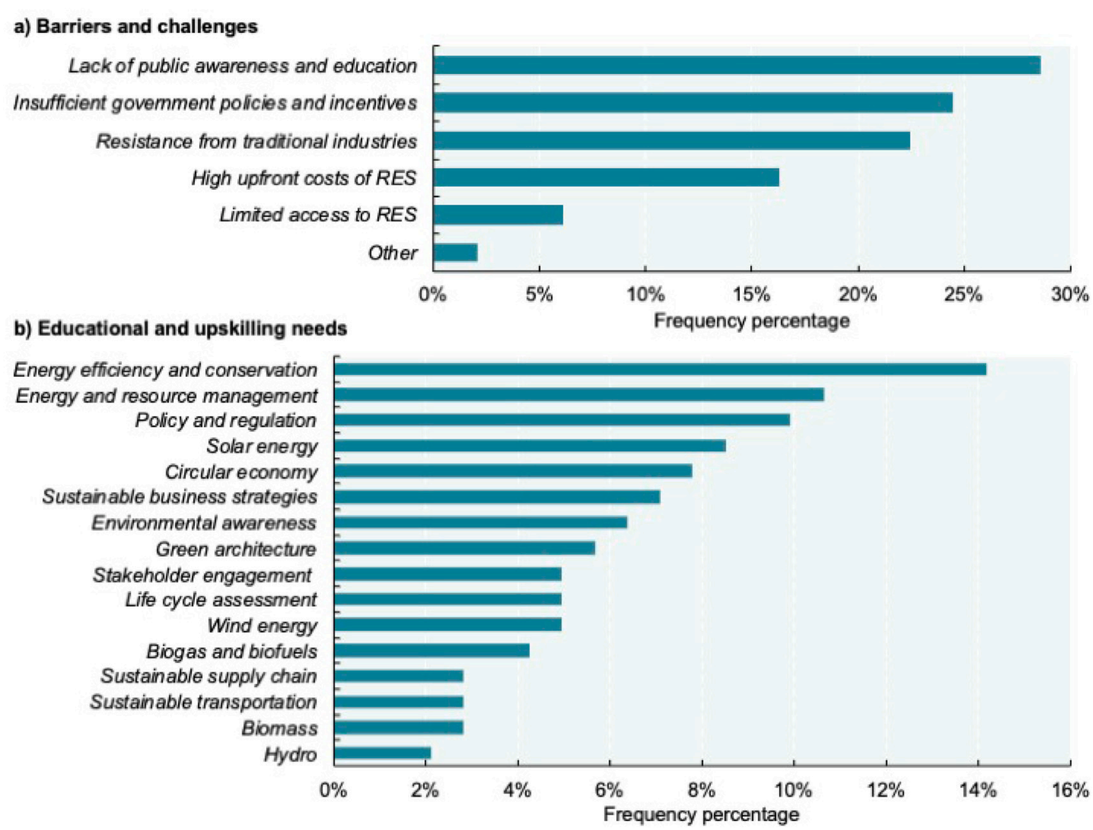

Fig. 8. (a) Barriers and challenges currently limiting the uptake of RES technologies in urban areas. (b) Subjects with detected educational needs and skill gaps.

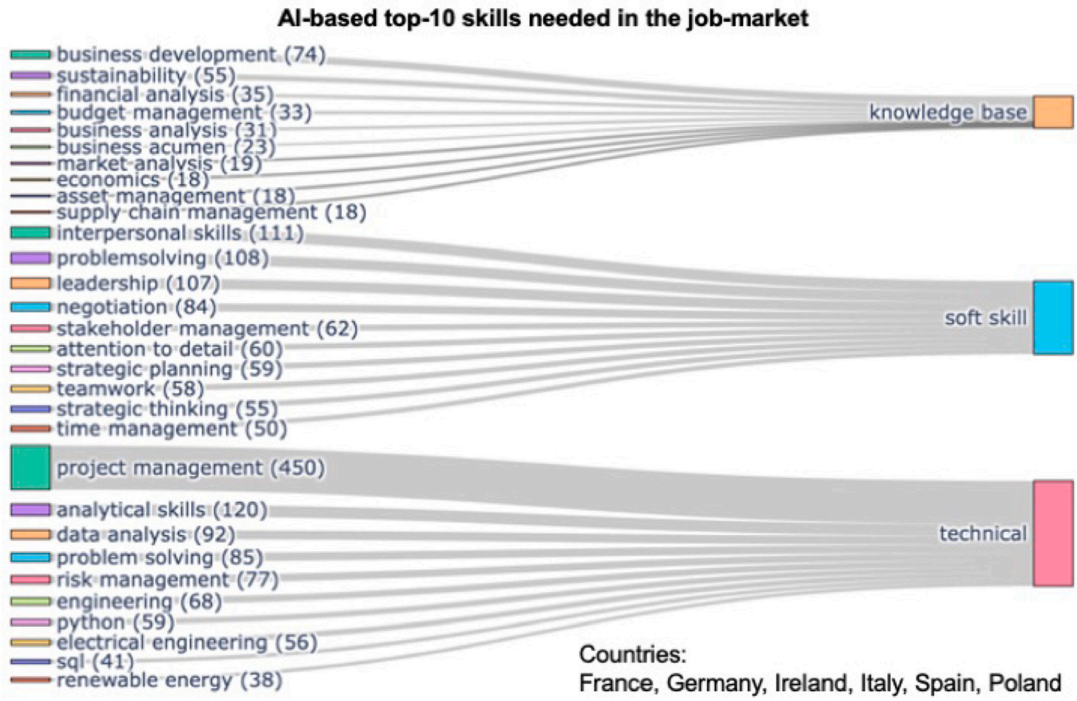

Fig. 9. Example of clustering and classification based of top-10 job-market skill needs identified and processed by the AI-based tool. Target countries: France, Germany, Ireland, Italy, Spain and Poland.

Table 4
Overview of the MC basket developed.

MCs basket overview							
MCs number	74						
Single MC size	2.5 ECTS						
Time for completion	4–6 weeks						
Average student effort	12–18 h/week						
Target groups		**STEM**		**SSH**		**Both**	
Number of MCs		27		15		32	
EQF levels		**EQF 6**		**EQF 7**		**EQF 8**	
Number of MCs		45		55		39	
ISCED-F codes	**031**	**041**	**052**	**061**	**071**	**072**	**073**
Primary	8%	30%	5%	3%	41%	9%	4%
Secondary	15%	16%	14%	14%	19%	10%	12%

audience encompassing both students and professionals, regardless of whether they possess a STEM or SSH background. As mentioned in Section 3, each MC has a size of 2.5 ECTS, organised in sub-units for an average student effort (total) between 12–18 h per sub-unit and a total duration between 4 and 6 weeks. An overview the whole MC basket is presented in Table 4, where the main features and indexes are reported at aggregated level, while the list of all MCs is included in Table 5, together with the result of the assessment and classification, based on the learning objectives and contents of each MC.

Since the programmes targets students and professionals with both STEM and SSH background, the suitability of each MC for STEM/SSH learners was assessed based on the MC contents and learning outcomes. Therefore, a first classification of the MCs basket was carried out based on the target audience, by evaluating their suitability for STEM and/or SSH students and professionals, and in terms of qualification level needed for their successful completion. The results are presented in Fig. 10, where the distributions in terms of target groups (Fig. 10a) and EQF level (Fig. 10b) is depicted. It can be noted that, STEM-oriented and SSH oriented MCs account for 37% and 20% of the total MCs available in the MC basket (Fig. 10a). This higher share of STEM oriented MCs is related to the specific sector targeted by the MCs basket – i.e., renewable energy and fuel technologies in urban areas – which often favours a focus on vertical hard skills in technical subjects. Notwithstanding, the majority of MCs inside the identified basket are classified as suitable for both STEM and SSH audiences, which highlights the need of horizontal skills with a multidisciplinary approach.

Regarding the qualification level of each MC (Fig. 10b), it can be observed that the majority of the MCs (40%) are classified as EQF7 of the European Qualification Framework [34], equivalent to a Master degree, followed by EQF6 (32%), equivalent to a Bachelor degree. Finally, 28% of the MCs in the basket are suitable for students and professionals at EQF8, which corresponds to a doctorate degree. It is important to state that, due to the multidisciplinarity approach followed in the MCs design, some MCs may be suitable for more EQF levels. This happens in particular for MCs classified as both STEM and SSH oriented, where learning outcomes cover horizontal and interdisciplinary skills.

In order to track the discipline(s) covered by each micro-credential, a classification based on the ISCED-F codes was carried out (Table 3) to indicate its primary discipline and the complementary disciplines, as outlined in Section 3. Fig. 11 reports the resulting ISCED-F classification based on the number of occurrences of both primary and complementary ISCED-F codes assigned to each MC in the micro-credential basket. It can be observed that engineering (ISCED-F 071), business and administration (ISCED-F 041) and manufacturing and material (ISCED-F 072) are the most frequent primary disciplines of the MCs basket. On the other hand, social and behavioural science (ISCED-F 031), environmental science (ISCED-F 052), and information and communication technologies (ISCED-F 061) are represented mostly as complementary disciplines, which highlights the multidisciplinary approach adopted by RES4CITY in designing the MCs basket.

This is also confirmed in Fig. 12, which shows the share in percentage of primary and complementary disciplines of the MCs basket. Observing the share of primary disciplines (Fig. 12a), it can be noted that 41% of all MCs fall into the engineering field (ISCED-F 041), while 30% have a core discipline in business and administration (ISCED-F 041). The remaining MCs (i.e., 29%) are classified as manufacturing and

Table 5
List of MCs identified and included in the MC basket with their classification based on disciplines (ISCED-F), target audience (STEM/SSH) and qualification level (EQF).

#	MC title	ISCED-F		Target audience		EQF
		Main	Complementary	STEM	SSH	
P01	Enacting a circular economy	052	072	X	X	7-8
P02	Sustainable fashion	072	041, 052	X	X	6-7-8
P03	Introduction to sustainable finance	041	031	X	X	6-7-8
P04	Tools, Strategies and Trends in Sustainable Finance	041	–	X	X	6-7-8
P05	Investing in sustainability	041	–	X	X	6-7-8
P06	Climate risk and climate investing	041	–	X	X	7-8
P07	Data analytic for the energy sector	061	–	X		7-8
P08	Electric Mobility and power system integration	071	061	X		7-8
P09	Introduction to Sustainability in agriculture	072	052	X	X	6-7-8
P10	Analysis of energy consumption	071	031	X	X	7-8
P11	Case studies in energy management	071	041, 072	X		7-8
P12	Convection heat transfer	071	–	X		7-8
P13	Energy markets	071	031, 041	X	X	7-8
P14	Case studies in thermal systems	071	041, 061	X		7-8
P15	Basics of investment analysis	041	–	X	X	6-7-8
P16	Conduction heat transfer	071	–	X		7-8
P17	Energy efficiency financing	041	071	X	X	7-8
P18	Heat transfer in buildings	071	071, 073	X		7-8
P19	Energy utilisation and storage	071	041, 061	X		6-7-8
P20	Energy consumption characterisation	071		X		6-7-8
P21	Thermal simulation of buildings	071	061, 073	X		6-7
P22	Advanced modelling of buildings and energy systems	071	061, 073	X		7-8
P23	Energy strategy and energy transition	041	052, 071	X	X	6-7
P24	Energy management and smart communities	071	031	X	X	7-8
P25	Sustainable development	031	041, 052, 071, 072	X	X	6-7-8
P26	Energy policy	041	052, 071, 072	X	X	6-7-8
P27	Thermal energy storage	071	–	X		6-7
P28	Decarbonisation of thermal energy	071	073	X		7-8
P29	Efficient building techniques	073	071, 072	X		6-7
P30	Electricity storage	072	071	X		7-8
P31	Energy communities	071	031	X	X	6-7
P32	Fuel poverty solutions	031	071		X	6-7
P33	Nature-based solutions	073	052, 072	X	X	6-7
P34	Positive energy districts	071	031, 073	X		7-8
P35	Smart energy systems	071	031, 073	X		7-8
P36	Tools for cities decarbonisation	061	031, 052, 071, 073	X		7-8
P37	Energy consumption in buildings	071	073	X		6-7
P38	Fundamentals of thermodynamics and heat transfer	071	–	X		6
P39	Fundamentals of energy systems	071	052	X	X	6-7
P40	Introduction to renewable energies	071	052, 072	X	X	6-7
P41	Urban metabolism strategies	073	052, 072	X	X	6-7
P42	Digital payments and smart city platform	041	061	X	X	6
P43	Circular materials for a sustainable manufacturing	071	052	X	X	6-7
P44	Introduction to life cycle analysis of raw materials	071	052	X		7-8
P45	Understanding critical raw materials	071	052	X	X	6
P46	How sustainable is your city?	052	031, 072, 073		X	6
P47	Sustainable development goals for cities	052	031, 072, 073		X	6
P48	Network industries regulation and pricing	041	071		X	7-8
P49	Introduction to industrial organisation	041	–		X	6
P50	rene120660 Building sustainable cities: the role of renewable energies	071	031, 052, 073		X	6-7
P51	Urban renewable energy: decision making methodologies	041	031, 071		X	7-8
P52	Energy economics and policy	041	031, 071		X	7-8
P53	Energy justice and poverty	031	041, 071		X	6
P54	Regulatory framework conditions for Power-2-X	071	041	X		8
P55	Social acceptance of technologies	031	041		X	6
P56	Hydrogen technologies for urban areas	072	041, 071	X	X	6
P57	Cost and energy modelling	041	061, 071	X	X	6-7
P58	Decision-making for energy projects under uncertainty	041	061	X	X	6-7-8
P59	Strategic behaviour in energy markets: options and games	061	041		X	6-7-8
P60	Energy Policy and flexible technologies	041	071	X	X	7-8
P61	Renewable energy investments	041	071	X	X	6-7
P62	Electricity network regulation	041	071	X	X	7
P63	Positive energy buildings	071	061, 073	X		7-8
P64	Physics of Energy	071	–	X	X	6
P65	Economics and physics of energy storage	071	041, 072	X		7-8
P66	Biogas systems for climate transition	072	052, 071	X		6
P67	Circular economy for sustainable cities	052	072	X	X	6
P68	Management of innovation projects	041	031	X	X	6
P69	Small scale wind power	071	052	X		6-7
P70	Low-temperature district heating	071	–	X		6
P71	Gender mainstreaming and intersectionality	031	041		X	6
P72	Leadership development	041	031		X	6
P73	Sustainable business models	041	072		X	6
P74	Bank's financing of entrepreneurial firms	041	–		X	6

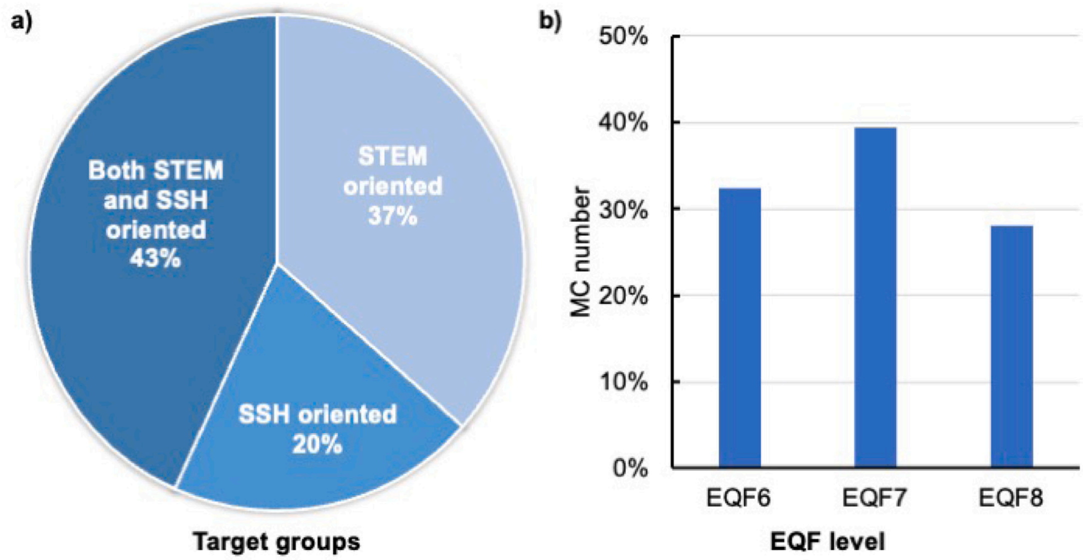

Fig. 10. Target groups (a) and EQF level (b) distributions of the MC basket.

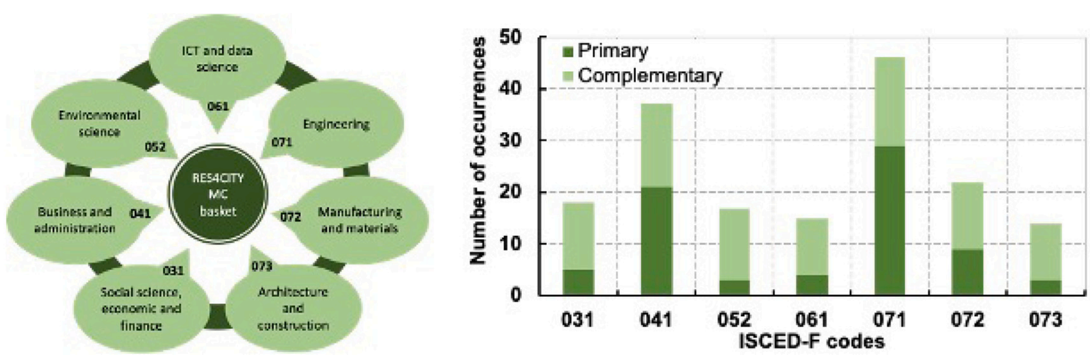

Fig. 11. ISCED-F classification of the micro-credential basket.

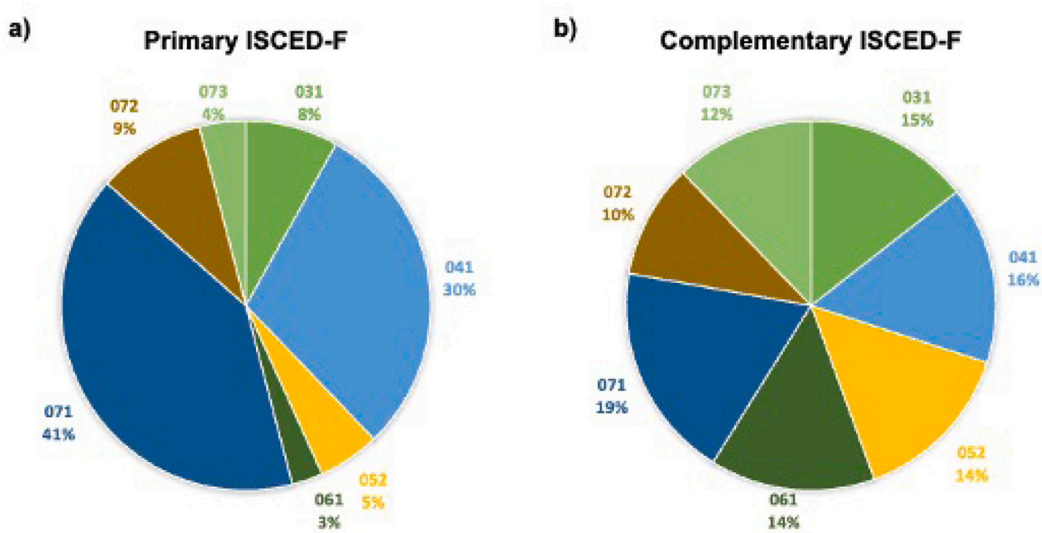

Fig. 12. Share of primary (a) and complementary (b) ISCED-F of the Micro-credential basket.

materials (ISCED-F 071, 9%), social and behavioural science (ISCED-F 031, 8%), environmental science (ISCED-F 052, 5%), architecture and planning (ISCED-F 073, 4%) and information and communication technology (ISCED-F 061, 3%) as core disciplines.

The multidisciplinary aspect of the proposed micro-credential basket is highlighted by the complementary disciplines assigned to all MCs, where relevant (Fig. 12b). It can be observed that the all ISCED-F codes show a similar share of occurrence across all MCs, from 10% of manufacturing and materials (ISCED-F 042) to the 19% of the engineering discipline (ISCED-F 071). Notable is the share of information and communication technology (ISCED-F 061, 16%), which highlights the need of acquiring transversal digital skills across all MC in the basket.

5. Conclusions

The present work illustrated an innovative framework for the training and upskilling of students and professionals at EQF 6–8 on the integration of renewable energy and sustainable fuels technologies in cities. A novel framework is introduced based on the innovative concept of Micro-Credential. The framework consists in the application of participatory methodology such as co-creation enhanced with the application of Artificial Intelligence. Based on this the following conclusions can be obtained:

- Micro-Credentials can be seen as the optimal tool to integrate existing study courses (e.g., Bachelor, Master, or PhD) on relevant and up-to-date topics that cannot be included in the traditional programmes for time constraints. Topics related to renewable and sustainable fuels are certainly among these since during the last years science and technology is quickly advancing and more and more knowledge is generated. For instance, according to the stakeholders' feedback, technologies like batteries and thermal storage systems currently have a high priority. On the other hand, it may prove difficult to include these contents in a structured way in traditional courses (e.g., engineering degrees) due to the limited flexibility such courses offer. Moreover, the detailed analysis of the skills needed by the job market – based on the analysis through AI of the most common job advertisement platforms in France, Germany, Ireland, Italy, Spain and Poland – showed that transversal skills such as risk management, business development, strategic thinking, etc., are currently on high demand on the job market, despite these contents are rarely included in STEM oriented degrees. Micro-credentials may represent the solution to fill this skill gap, since, through them, students and professionals with STEM orientation may acquire this knowledge and competences, complementing their technical background. The same principle can be applied to SSH students and professionals: while there is a lot of discussions about energy and sustainability at different levels, SSH students and professionals hardly have the fundamentals to grasp the challenges and opportunities posed by the current energy transition based on new enabling technologies and strategies. Micro-credentials can fill this gap with tailored "knowledge pills'' which can unlock the critical thinking and competence synergies among disciplines required to achieve the sustainable goals.
- Co-creation approach is necessary when interactions with stakeholders is mandatory or highly desirable. In the considered case, stakeholders are primarily students and professionals on one side, and private/public institutions on the other side. The scope of students and professionals is to upgrade their skills in order to obtain a better job position, whereas the scope of private/public institutions is to recruit personnel with the needed skills. Thus it is necessary to understand which are the gaps on the side of the learners and which are the needs on the side of the recruiters. The continuous interaction through different tools such as surveys, interviews, local focus groups support the definition of a strong narrative representing the instances of both groups in order to find a matching solution.
- A data analysis of the job market with the extraction of relevant skills using advanced NLP and machine learning algorithms supported the use of the co-creation approach, providing a clear validation of the results and limitation of the work. Both soft and hard skills are categorised and prioritised with the support of AI capability which are substantial also in the interpretation of the job postings. This unprecedent capability now freely available to everybody consents to collect and interpret specific data which were not easily available before. Based on this specific dataset it is possible to identify targeted learning outcomes for the micro-credentials to develop.

To conclude, the research presented in this paper not only offers valuable insights into EU job market skill needs but also presents a framework for MCs co-creation. This framework has high replication potential and its application is encouraged. In this context, a collaborative effort between the academic community and relevant stakeholders is fundamental to expand the present research to different contexts and, eventually, develop a standardised co-creation framework for educational life-long programmes based on MCs.

CRediT authorship contribution statement

Mattia De Rosa: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Olga Glumac:** Writing – review & editing, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Vincenzo Bianco:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Fabiano Pallonetto:** Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used OpenAI tool in order to (i) analyse the job-market needs as outlined in 3.1.2, and (ii) for improving the quality of the written text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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