Article

Developing a task-based qualification framework for circular skills in construction and its application in training plans (for trainers and SMEs)

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Abstract: We are facing a major skills gap within the construction sector and there is a pressing need for upskilling in circular skills after identifying the existing skills gaps. Using Multi-functional Green Roofs Facades and Interior Elements (MGRFIE) as a pilot case, the BUS-GoCircular project has mapped the circular skills gaps that currently exist throughout Europe. This has created the basis for the development of the task-based Qualification Framework, resulting in 80 Units of Learning Outcomes (ULOs) required to upgrade circular skills. This then supports the creation of training packs and training programs to upskill professionals within the sector. Through our research we discover that there are skills gaps existing within every profession across the sector meaning training must be provided for all professions to bridge these gaps. Training packs for small and medium enterprises (SMEs) and materials were created with this in mind and are now playing an important role in Train the Trainer (TtT) programs as well as mentoring programs being carried out across Europe.

Keywords: Circular Economy, Task-based Qualification Framework, SMEs Training Packs, Train the Trainer (TtT), MGRFIE (Multi-functional Green Roofs Facades and Interior Elements), Units of Learning Outcomes (ULOs), skills gaps in construction, Training Material in Circularity, Upskilling, Skills in Circularity

1 The Circular Economy [1] is gaining traction due to the finite number of raw materials on the planet, we must now take resource efficiency more seriously, especially within the construction sector to ensure these resources are not depleted entirely. According to the European Commission the construction sector is responsible for up to 50% of all materials used on the planet [2] and *"Construction and demolition waste (CDW) accounts for more than a third of all waste generated in the EU"* [3]. The need for a more circular economy has been translated into European directives that are replicated in national regulations [4-5] and, most importantly, are taken on board by industry. Change is difficult within the construction sector, but action must be taken in order to align with EU directives. This is partially due to the fact that there is currently no harmonised and holistic European framework on circularity (regulated courses, certificates schemes of circularity, certificates of competences or micro competence, etc)[9], between EU countries

or even in public administration. New training and skills are needed following the initial study carried out by the BGC partners on the current Circularity on Education' State of Art [6].

The research conducted within the BUS-GoCircular [7] project aimed to tackle the above-mentioned issues and create a more sustainable construction sector by developing a harmonised qualification framework [8] in circular construction and supplying the initial steps for its implementation and replication across the sector. The first step in this process was the skills gap analysis and mapping [9], to understand where skills gaps currently exist within the construction sector in relation to the circular economy and Multi-Functional Green Roofs Facades and Interior Elements (MGRFIE). Based on this analysis of skills, a task-based qualification framework for circular economy in construction [10] was developed which acts as the basis for the design of different training approaches to disseminate and implement this framework: Train the Trainer programs [11], SMEs Training Packs [12] and Mentoring programs between professionals [13].

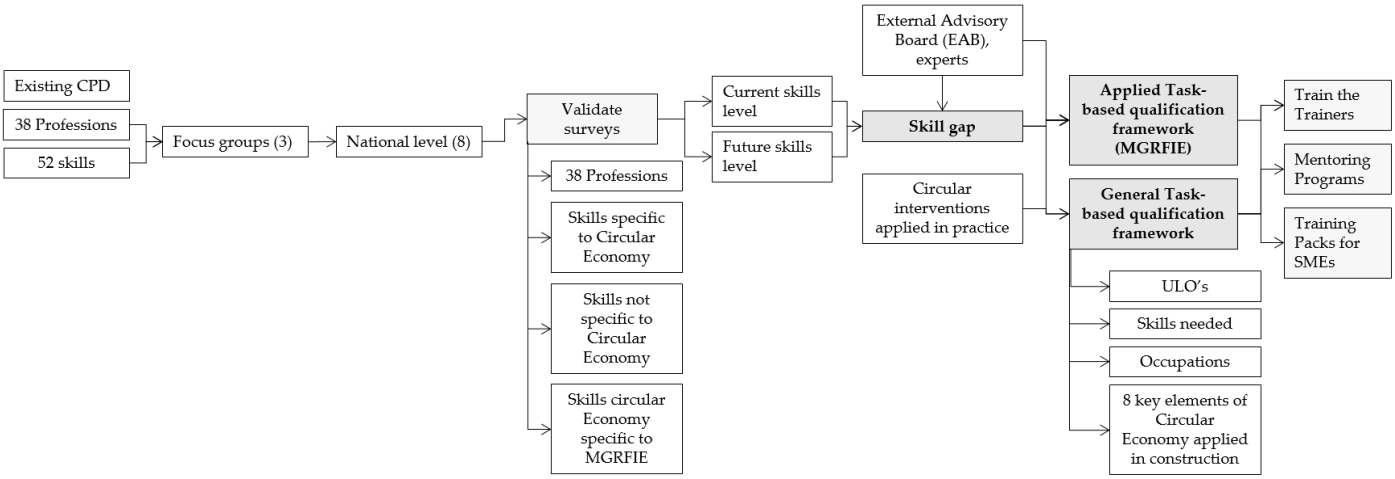
Training packs for SMEs [12] deals with the stimulation of the demand of skills in circularity providing coverage of the basic initial knowledge and competencies required by the workers in circular practices, where training is often limited to higher education or specific single-topic courses having difficulties in the availability of open-source and dispersed training materials. The training packs are created as free access to self-directed material and activities about circular economy to involve the workforce of SMEs in the exploitation and validation of the skill qualification framework.

The approach this project takes is novel and significant due to its focus on workers across the entire construction sector. This research takes a specific element of the built environment (in this case MGRFIE) and identifies what skills are necessary in order to make this process circular. In this we are identifying what skills are necessary, what level each professional must reach to be proficient in this circular task and then provide the training and upskilling needed in order to carry this task out. This process is replicable for all aspects of the built environment and focuses on the entire sector, rather than one subsection, to ensure the circular economy can be implemented properly.

2. Materials and Methods

The methodological approach of this research has been based on the combination of existing European project approaches, such as PROF/TRAC [14], together with the training and construction knowledge and national experience of the participating partners. We utilised the Key Elements Framework [15] created by Circle Economy as a basis throughout the initial steps of the project. In this section we will go through the a. skills gaps and skills mapping [9] , b. task based qualification framework for circular skills [10] and c. Training plans and packs for SMEs [12]. This research has been focused on Multi-function Green Roofs Facades and Interior Elements (MGRFIE) as a focus area for the project yet the methods used within the project should be applicable to any area of the construction process i.e. ventilation, foundations, interior elements. Training packs are developed based on the general task based qualification framework.

2.1 Skills Gaps and Skills Mapping



To close the skills gap existing between current and future circular skills, it is first necessary to define these gaps and identify what skills and professions are not yet in the conversation. To do this, the BUS-GoCircular project has pinpointed 38 professions [Table 11: Appendix A] and 52 skills [Table 1], and then compared these to one another. With the help of experts working in each field, it has been discovered the 'Current' and 'Future' skills levels exist in each profession. This research was carried out by each country involved in the project (Bulgaria, Czechia, Croatia, Hungary, Ireland, Spain and The Netherlands) allowing us to first define the skills gaps which exist within each of these countries, before collating this information resulting in a European wide skills gap profile. It was possible to explore the skills gaps that exist on a general scale but also to understand where these skills are lacking and in some cases why they are lacking in each country. This extensive work allowed us to define the gaps that exist within the construction industry and thus will allow us to begin to close these gaps through training and upskilling programmes.

The PROF/TRAC [14] framework has been utilised for our skills mapping task which enabled us to quickly collect a large amount of data from partner countries across Europe. This methodology was used to identify relevant skills and professions which are related to a given process (in this case Circular Economy in relation to MGRFIE).

Step 1: Collection of existing CPD (Continuous Professional Development) training [9]. The collection of current freely available CPD courses across Europe to indicate what is available and to what level. Each of these courses can provide an indicator of what can be offered to future participants in BUS-GoCircular as well as indicating what can be built upon and what must be created. This also offers an early indication of the gaps which exist within the sector.

Step 2: Identifying relevant professions. This list was tailored to suit the relevance associated with MGRFIE as this was the scope for this project. Often similar roles may have different names in different geographical areas, so we had to add many sub-headings to ensure we accounted for each relevant profession within each country. As MGRFIE is our focus point, we considered all elements of MGRFIE within our project work including

green walls, green facades (interior and exterior), multifunctional roofs, social roofs, water storage (predominantly on roofs), functional roofs and energy collection and storage. These are some of the examples of the areas we are concentrating on, however, this list is constantly expanding and growing as new research is developed. Our list of professions [Table 11: Appendix A] is based directly on these areas and our skills table also arises from this list. The conclusions will be shown in the results section.

Step 3: Identifying the skills. Here the skills are broken up into 3 categories, skills specifically relating to circular economy, skills not specific but that heavily influence circular economy and finally skills relating specifically to MGRFIE.

To identify the skills to be tested in the interviews/questionnaires we have relied on Circle Economy's Keys Elements Framework as this permits us to define a scope for this task using a common language. There are eight main principles to achieve circular economy according to this classification, differentiating between three core elements and five enabling elements. The core elements are the activities that directly handle products or material flow meaning these elements are vital to the success of circular economy practices; these are *Prioritise Regenerative Resources*, *Stretch the Lifespan* and *Use Waste as a Resource*. The enabling elements support the core elements to be implemented and help to engage the sector by ensuring that any obstacles are removed. These are *Rethink the Business model*, *Design for the Future*, *Collaborate to Create Joint Value*, *Incorporate Digital Technology* and *Strengthen and Advance Knowledge*. After analysing the Key Elements Framework, we identified sub skills within each of the eight elements. For example, within the three core elements we identified sub skills such as, *bio-based and regenerative material application*, deconstruction for reuse, *maintenance of building components*, *sustainable drainage systems* and the *production of renewable energy*. Within the enabling elements, we added several sub-skills including, *Apply material passports*, *Collaboration for Circular Economy*, *BIM/Digitisation*, *Design for Adaptability* and *Design/Build for Reuse*. Many of these skills are not specifically related to Circular Economy, however, they are needed to support the design, application and use of circular practices within the construction industry. Finally, we also looked at skills specifically relating to MGRFIE, these skills are of particular importance when looking at our research parameters. The sub-skills here include; *Solar power systems for electricity generation*, *Establishing the cooling and heating function of green roofs* and *Multi-functional Green Roofs Facades and Interior Elements*.

Table 1. Identified skills for skills survey

	Specific to Circular Economy		Not specific to Circular Economy		Circular Economy specific to MGRFIE
PRR	Prioritise regenerative resources	PRR3	Sustainable Sourcing	MF	Multi-functional Green Roofs Facades and Interior Elements
PRR1	Bio-Based and regenerative material application	PRR4	Energy storage and distribution	MF1	Solar power systems for electricity generation
PRR2	Reusable material application	PRR5	Production of Renewable Energy	MF2	Solar thermal systems for domestic hot water and/or heating generation

PE	Preserve and extend what is already made	PRR6	Continuous reuse of water with little or no waste	MF3	Heat Pump
UWR	Use waste as a resource	PE1	Maintenance of building components	MF4	Insulation Installation
UWR1	Deconstruction for reuse	PE2	Upgrade of building components	MF5	Establishing the cooling and heating function of green roofs
UWR2	Material Innovation	UWR5	Grey Water Collection and Use	MF6	Horticulture
UWR3	Reclaiming Energy	UWR6	Rainwater collection and use		
DF	Design/Build for the future	UWR7	Sustainable Drainage Systems		
DF1	Design/Build for Reuse	DF9	Design for Adaptability		
DF2	Design/Build for repurpose of materials	DF10	Modular Design		
DF3	Apply material passports	CCJV2	Collaboration		
DF4	Design/Build for material impact reduction	RBM3	Facades as a services		
DF5	Reduce/Build reliance on critical raw materials	RBM4	Technical Installation as a service		
DF6	Design/Build out waste	RBM5	Interior features as a service		
DF7	Design/Build for Durability	IDT1	Drones Use		
DF8	Design/Build for Cyclability	IDT2	3D Printing		
CCJV	Collaborate to create joint value	IDT3	Prefabrication		
CCJV1	Collaboration for Circular Economy	IDT4	BIM/Digitisation		
RBM	Rethink the business model	SAK1	Research and development		
RBM1	Repairs as a service				
RBM2	Environmental costing models and carbon taxes				
IDT	Incorporate digital technology				
SAK	Communication, Education and information				

Step 4: Mapping the skills gaps. As we are using the PROF/TRAC [14] method we are also using the skills levels that are recommended along with this method. These levels span from 0 to 5 (0 meaning not applicable or no knowledge/skill required while 5 represents an expert in the corresponding skill). The skill gap will be the difference between the future skills and the current skills level.

Table 2. Definition of skills levels according to PROF/TRAC method.

0	Not applicable / no knowledge and skills required
1	Has little knowledge and skills with respect to the relevant field / technology
2	Understands basic knowledge and has practical skills within the field, is able to solve problems by selecting and applying basic methods, tools, materials and information

3	Has comprehensive, factual and theoretical knowledge, is capable of solving problems within the field
4	Has advanced knowledge involving a critical understanding of theories and principles and skills, required to solve complex and unpredictable problems in the field and is aware of the boundaries
5	Has specialised knowledge and problem-solving skills, partly at the forefront of knowledge in the field, in order to develop new knowledge and procedures and to integrate knowledge from different fields

Following the creation of the skills tables and list of professions we began to create focus groups to discuss them with. The rollout of the interview process was split into three categories/groupings throughout participating partner countries in BUSGo-Circular and European wide organisations. These divisions were; Pre-Design Phase, Design Phase and Construction and Deconstruction Phase. These three focus groups were directed independently by each partner country following previous guidelines accorded to ensure the results across Europe could be easily compared. Each partner country was asked to complete at least one group session with each of the three focus groups. The first group session with these focus groups dealt with current skills (189 participants total) and the second session, in most cases containing the same or similar groups of participants, dealt with future skills (173 participants total). This allowed us to tailor our final survey and interview process to the professions involved in order to identify skills gaps. These validated surveys were distributed at a national level. Different feedback was received depending on the profession profile and country as it is shown in the Results section.

2.2. Task-based Qualification Framework for Circular Skills in Construction

Utilising the skills gap analysis [9] and the different circular strategies and interventions that are being applied in practice, we have mapped which occupations are involved within the implementation of these interventions. Based on this work we have started mapping the different skills that are required. A generic framework for Circular Economy interventions in the construction value chain and its first application [16] has been developed for the BUS-GoCircular project.

Based on research by Roland Berger [17] we have condensed the strategies and interventions to the following five stages of a project in the building environment, that, in order are:

Plan - design and commission (new and existing buildings);
Procure - source materials, products and services (new and existing buildings);
Construct - build, install and fit-out (new buildings);
Operate - use, maintain, renovate and manage (new and existing buildings); and
End of service life (EoSL) that covers Deconstruct, dismantle, repurpose, sort and process.

To this, a further stage is added that captures the important role played by industry and public actors in setting ambitions and standards for the built environment. This stage, which sits outside of the value chain, greatly influences attitudes to building projects that, in the linear economy, are typically concerned with ensuring compliance while limiting

costs up to the point of delivery. For the purpose of skills mapping, roles associated with governance are integrated within the planning phase.

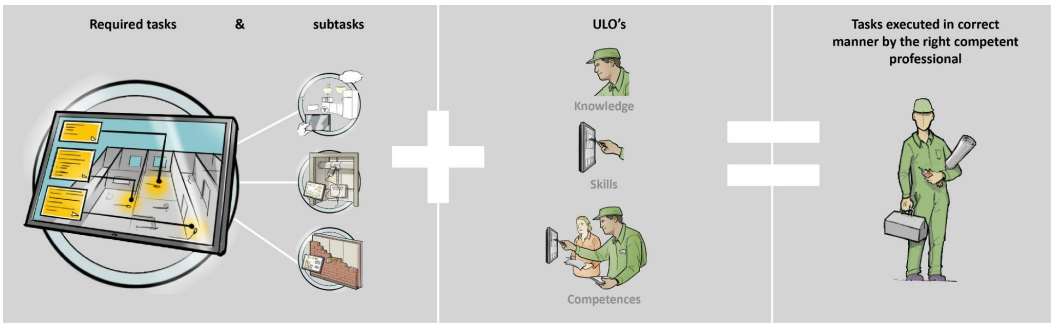


Figure 1: Overview of the methodology

To account for differences in naming conventions for job titles across countries and companies, the work builds on previous EU projects such as PROF/TRAC [14], Construction Blueprint [18] and Train4Sustain [19] to define different work-fields and the reference professions and job roles within these. The different reference professions and trades have been plotted [Table 11: Appendix A], for the different circular interventions across the five stages in the value chain. It is important to note that self-employed workers in the construction value chain and those working in SMEs that share the same reference profession or trade with their counterparts in larger firms may adopt similar tasks. Across multiple stages in the value chain tasks are conducted by specialists or operational staff in larger firms or are contracted out on larger-scale projects. For example, a carpenter on a small renovation project is likely to be responsible for procuring the materials to carry out their work while also being responsible for dealing with waste materials. On a larger project, the procurement of materials and waste management may instead be handled by specialist staff.

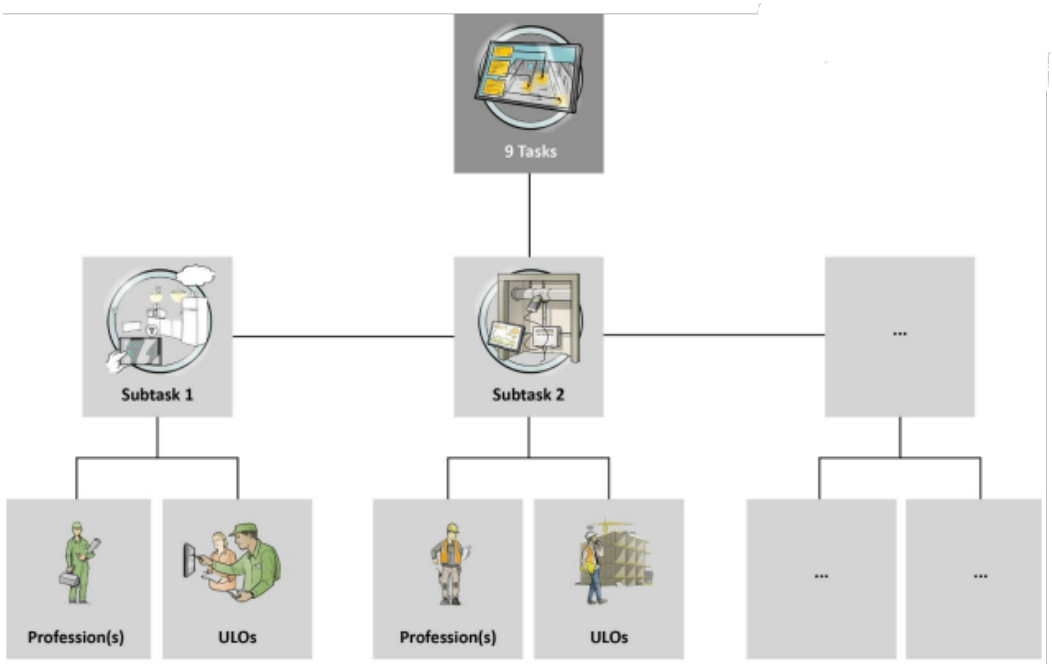
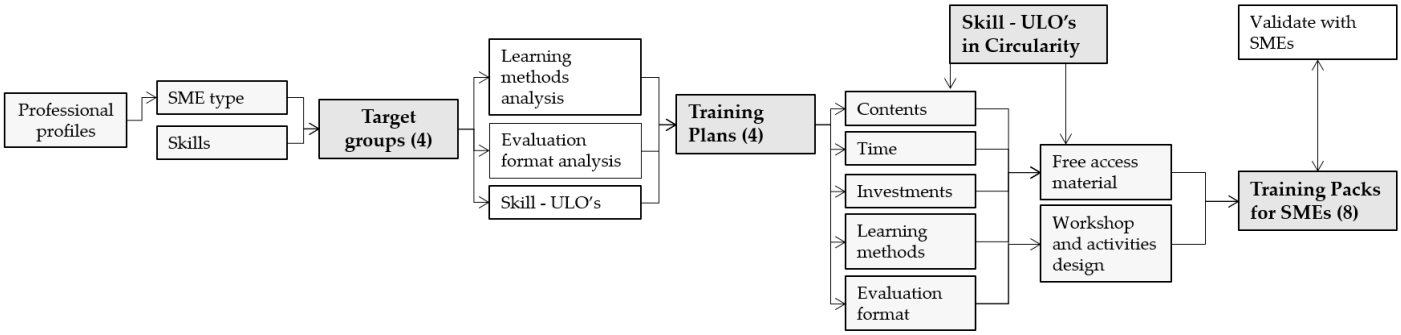


Figure 2: Overview of the results of circular construction task-based qualification framework - Task and subtasks

The framework is based on the eight Key Elements of the circular economy [15], both the general framework and the applied to MGRFIE. The eight Key Elements consist of 25 more specific strategies. For these 25 different circular strategy groups, the professions, trades and roles that are involved with implementing each strategy have been mapped across five stages of the value chain: Plan, Procure, Construct, Operate, and End of Service Life. This serves as the basis to provide an overview of the different roles that are required to implement such a strategy. The result of all of this is a set of archetypical interventions that improve the energy, materials, water, waste and management performance of a building while applying circular key elements (related with each profession). The framework also has then been applied to circular strategies relating specifically to MGRFIE, including strategies evolving around energy efficiency. Structured interviews with relevant external stakeholders has been the main form of validation along with close collaboration with relevant experts from across the BUS-GoCircular project consortium.

2.3. Training Plans and Packs for SMEs



SMEs training in circular economy approaches and methods can support the integration of the circularity into the construction industry by fostering new skills. As previously outlined the enabling elements of the Key Elements Framework [15] *Rethink the Business model*, *Design for the Future*, *Collaborate to Create Joint Value* and *Strengthen and Advance Knowledge* are key to supporting change and are elements SMEs can relate to. Moreover, with these new skills the SMEs themselves can generate new business prospects and avail of new opportunities could create new professional or SMEs profiles required for increasing the circular construction demands.

Once the skills gaps [9] have been detected and the General Task-based Qualification Framework [8] have been developed, the application of this framework transfers to training plans (TPs) for SMEs [12] workforce (Self-Training Packs). For SMEs, training plans are designed to achieve at least a basic knowledge on circularity in construction on these required competences. The TPs can be adapted to the needs and possibilities of each company as they are structured by profile, stage involved or speciality. They are also divided into independent modules that can be trained separately. In the second stage, these training plans, modelled on SMEs profiles groups, will be expanded into training packs adapted to the countries participating in the project. These are made up of free

access material to be implemented autonomously in the SMEs (self-directed). These also include activity proposals, such as site visits, workshops or product demonstrations, in addition to the training material based on case studies.

To design a training pack for SMEs, the methodology has been:

1. Relate the worker profiles (per BUSGoCircular skills mapping [9]) to relevant SMEs.
2. Find the target groups and their special needs in a training plan.
3. Discover the learning methods best suited to each professional profile, each skill to be trained or what free access material is available. Time, facilities and investment requirements of SMEs will also be considered.
4. Identify the appropriate evaluation approach for SMEs.
5. Develop a workshop methodology for Training Plans focused on practical profiles.
6. Collate the Training Plans: providing the contents, methods, timing and evaluation for achieving at least a base knowledge on circularity.
7. Based on these Training Plans, develop Training Packs designed to be self-directed (materials and activities).
8. Validate Training Packs through focus groups of SME at a national level using pre or post course evaluations.
9. Update plans depending on evaluation results through focus groups of SMEs at a national level.
10. They will be published in open access for dissemination. Available in February 2024.

3. Results

3.1. Skills Gaps and Skills Mapping

While identifying relevant professions in step 2 of skills gaps and mapping, it is vital to ensure that the whole construction process is considered and all construction workers included in this journey towards a more circular construction sector. Among the many professions we identified, we first looked at roles that have existed within the construction industry for centuries such as Architects, Engineers, Bricklayers, Plasterers, Carpenters and many more. These are often the most common professions and collecting data was, in most cases, (particularly for Architects, Engineers and Sustainability Consultants) relatively straight forward. We found that collecting data from on-site workers was considerably more difficult depending on the country as they often can be more difficult to reach due to the kind of work they carry out, this is something we have also highlighted throughout our research. It is important to also include Policy Makers, Financial Managers, Project Developers and a number of other pre-design phase professionals within our research as these professions are a vital part in achieving our climate action goals and in creating legislation and requirements that support and enforce the circular economy. Finally, have been included several new or emerging professions

that we also pinpointed as vital in bridging the current gap. Some of these professions include Green Public Procurers (GPP), Demolition or Deconstruction Auditor, Green Roofer and Repair and Maintenance Operatives. Again, collecting data in these areas was difficult as some countries do not yet have established professionals within these roles.

Concerning the interviews conducted for mapping these skills gaps, we received varied levels of feedback from the focus groups. Some examples of this are; predominantly white collar workers from Croatia and blue collar workers from Spain while information was difficult to collect from Hungary. We also have an imbalance in feedback information based on certain professions, as an example, 23 Civil Engineers filled out our future skills mapping while only 2 green roofers completed this. This was a limitation of the method, consequently we had to rely on expertise to further validate the process. It is assumed that some data is more representative in some countries and construction phases than others.

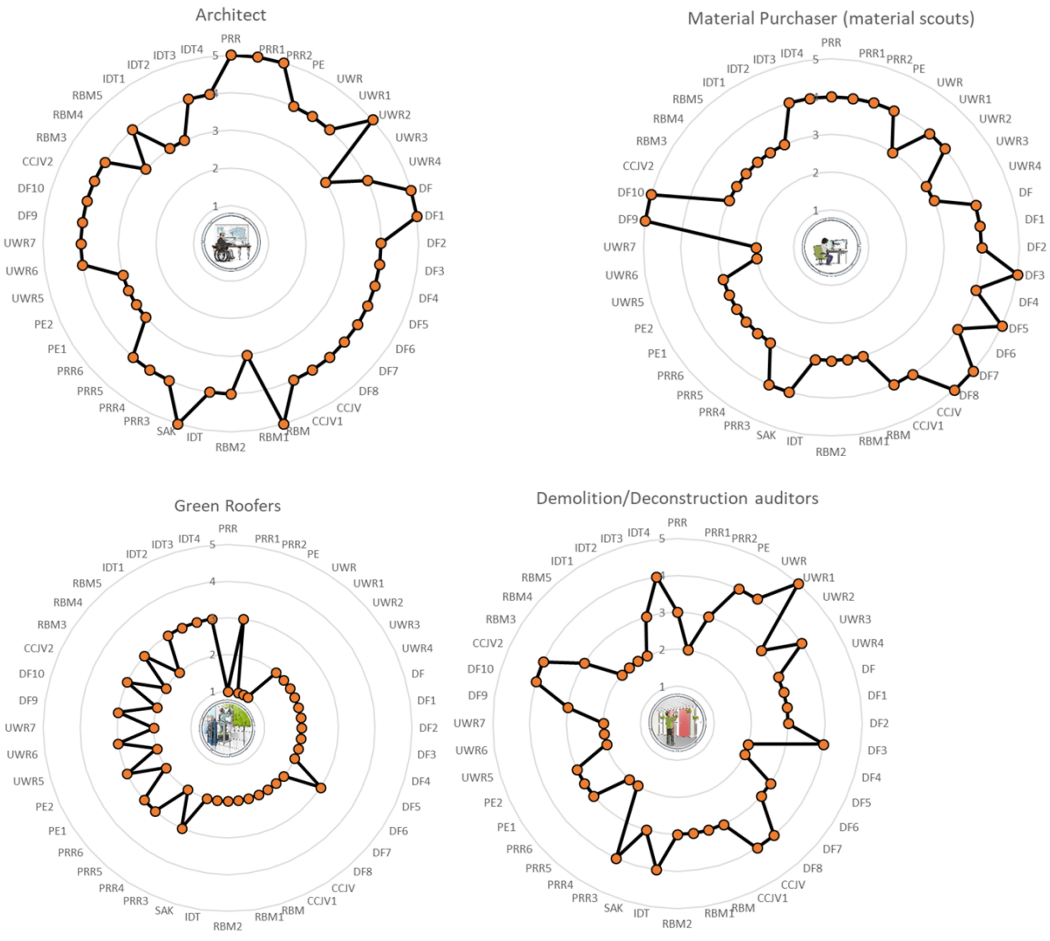


Figure 3: Future Skills detected by profession.

After collating the data, we have created a European skills level for each of our professions by creating a mean of all the results, without weighting by country. We brought in experts (External Advisory Boards, EABs) to help us to remove any outliers and resolve any remaining issues that existed due to the high variance and volume of the data and unique challenges this kind of data brings with it. The EAB was composed of 182 companies and institutions, including training providers (VET and CPD), universities,

government representatives, industry professionals and more, of the seven countries involved and 27 at EU level. This method has been beneficial as it has allowed us to speak with not only experts in the field of Circular Economy but also professionals that are not yet familiar with this work. Following the final validation of the Current and Future skills levels we created skills graphs. In the graphs (Figure 3), the different skills analysed in the surveys are distributed around the circle and the skills levels detected are shown on the axis (radius of the circle). The orange points mark the future skill level for each skill analysed.

When we isolate the skills we notice another pattern, while some of the skills are marked as being outside the scope of knowledge for a given profession, most indicate a gap of some description. We can see from the research that there are variations depending on the countries. Valuable information has been produced at national level across Europe and will feed into the European wide framework reinforcing our premise that a cross sectorial skills programme needs to be created for training to ensure that the skills level is similar across Europe. We have also noted that professionals tended to rate their current skills levels as higher than our External Advisory Boards (EAB) suggested, in some cases a worker may have stated that a current skills level may be 5 and the future skills level required is 4. While this was rare it was often noted that this person may already be an expert in that skill or that they simply exaggerated their skills level. This, however, was not the case with future skills levels according to our EABs as these were generally rated fairer, possibly due to the fact that professionals were not rating their own skills but rather industry levels. The full list of future skills graphs can be seen in complete here [9].

3.2. Task-based Qualification Framework for Circular Skills in Construction

Within the BUS-GoCircular project, a general task-based qualification framework [16] was developed for circular skills in construction, meaning a set of tasks and corresponding learning outcomes were mapped and connected to relevant professions throughout the construction value chain. By doing so, the project offers a practical interpretation of the Key Elements of the Circular Economy, made applicable to the construction sector.

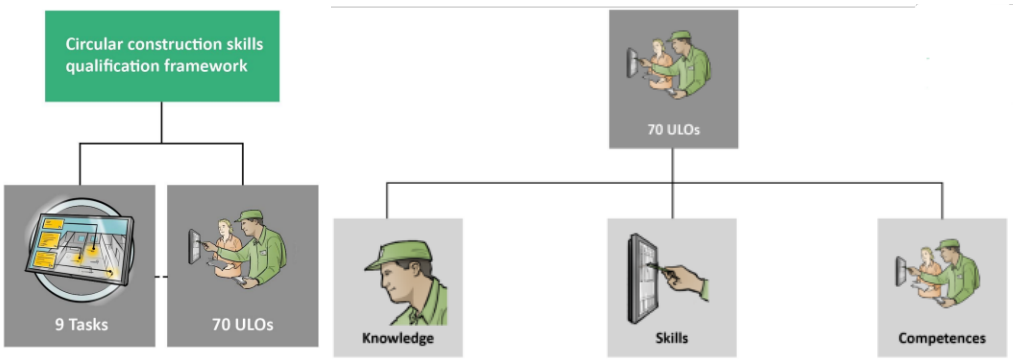


Figure 4 (left) 5 (right): Circular construction skills method

By using the methodology of developing a task-based qualifications framework, the general circular construction skills qualification framework [16] was adjusted to the

applied context of MGRFIE [10]. The resulting qualification framework consists of a list of 9 tasks with 60 subtasks. Each subtask is linked to corresponding Unit of Learning Outcome (ULO) numbers and relevant professions, with a total of 70 ULO's. ULO's, then, consist of a set of competences (70), skills (52), and knowledge components.

Table 3: Overview of the 9 tasks of the circular construction task-based qualification framework.

Tasks	General Task-based qualification framework
1	Prioritise regenerative and efficient use of resources
2	Design for the future
3	Assemble/construct for the future
4	Rethink the business model
5	Stretch the lifetime
6	Use secondary resources
7	Incorporate digital technology
8	Collaborate to create joint value
9	Strengthen and advance knowledge

Table 4: General Qualification Framework

#	Subtask	ULO Nr.	Profession(s)
1	**TASK: Prioritise regenerative and efficient use of resources**	81	
1.1	Design with bio-based, non-toxic and/or non-critical materials	1, 2, 3, 4	AR, MS, ME, CE, EE, UP, AM, C
1.2	Replace energy sources with less impactful alternatives	8	AR, EE, EL, MS, PM
1.3	Apply suitable energy efficiency measures to the building design (taking into account building purpose and climate)	9	AR, EE, EL
1.4	Generate energy from renewable sources - e.g. solar, sustainable biomass	10	AR, EE, EL
1.5	Apply measures that replace freshwater with less impactful alternatives	6	P, Gd, R, EI
1.6	Enact water efficiency measures	7, 15	P, Gd, R, EI
1.7	Source bio-based, reusable, non-toxic and non-critical materials	1, 2, 3, 4, 5, 36	MS, PM
1.8	Source local and lightweight materials	74	MS, PM

The organisation of the applied circular construction skills qualification framework is shared with the general framework, however, in this case there are 84 ULO's. The applied qualification framework can be used in the same way as the general framework: to guide upskilling in order to move towards a circular construction sector, and to inspire professionals and companies to take the next, concrete steps in their journey towards circularity. The applied framework helps in finding or developing the right training for

professionals and craftspeople who (want to) work with roofs, façades, and interior elements specifically. Consequently the applied framework has given insight into the replicability of the general framework to a context that represents a highly complex line of work.

Table 5: Applied Qualification Framework [Table 12: Appendix B]

ULO Nr.	Competence	Skills
1	Design roofs, façades, and interior elements with bio-based materials as an alternative for conventional construction materials	Select bio-based materials for the roof, façade or inner wall Consider the purpose of the building and the context of the entire building solution, as well as construction requirements When biobased materials are not an option, select proper low impact materials Integrate use of the Material Circularity Indicator (make sure it is not higher than X) Ensure use of materials that have little to no volatile organic compounds (VOC) emissions
2	Enact measures that optimise material use to strive for material efficacy	Apply measures that optimise material use to multifunctional green roofs, façades, and interior elements Combat underutilisation or surplus of materials by sharing products or assets and optimising their use
3	Design with non-critical raw materials as defined by EU	Avoid, insofar as possible, use of critical raw materials as defined by EU while selecting materials for multifunctional green roofs, façades, and interior elements
4	Design with non-toxic materials as defined by EU	Avoid, insofar as possible, use of chemicals as defined by EU while selecting materials for multifunctional green roofs, façades, and interior elements
5	Design with products and materials that can be easily reused or recycled after use	Recognise and select materials that can be easily reused or recycled after the building's end-of-lifetime Recognise and avoid composites or other mixed materials that are then hard to recycle/repurpose

3.3. Training Material

Utilising the findings of our skills gap analysis [9], the resulting qualification framework [10] and freely available materials collected throughout the project, a bank of training material which is intended to be used by trainers within the construction industry

in order to upskill their trainees in circular practices, was created to be shared on the BUSGo-Circular website and act as a basis for future training programs. 11 modules [20] were created to ensure that all 52 skills from most of the ULOs (70) and 38 professions were covered for.

Table 6: Overview of modules and topics available in the materials for trainers.

Module Title	Module Topics
Module 1: Circular Economy and its Implementation in the Design and Construction Sector	The Circular Economy and its Application in the Construction Sector - Introduction to the Circular Economy - Circular Economy in the Construction Sector - The Key Elements Framework
	Multi-functional Green Roofs Facades and Interior Elements and the Circular Economy - Introduction to Multi-functional Green Roofs Facades and Exterior Elements - Types of Green Roofs - Benefits of Multi-functional Green Roofs Facades and Exterior Elements
Module 2: Implementing Circular Practice in the Design, Build and Deconstruction Phase of Construction	Modular and Adaptable Design and Construction
	Design For Disassembly (DfD)
	Product-as-a-service (Paas)
	Design and build Multi-functional Green Roofs Facades and Exterior Elements
Module 3: Bio Based Material Implementation and Application in Circular Economy	Bio-based Materials
	Existing Bio-based Materials and Techniques: Earth, Timber, Straw, Wool, Hemp, Stone
	New Bio-based Materials and Techniques: Mycelium, Biochar, Bio-based Concretes and Cement, Bio Plastics, 3D-Printing
	Bio Based material opportunities for Multi-functional Green Roofs Facades and Interior Elements
Module 4: Upgrades and Maintenance for Sustainability in the Design and Construction Industry	Repairs and Maintenance
	Upgrades and Retrofits
	nZEB, Passive Houses and Environmental Certification Schemes
	Sustainable Neighbourhoods
	Upgrades and Maintenance for Multi-functional Green Roofs Facades and Interior Elements
Module 5: Water and the Circular Economy	Water in Construction: Water and the Circular Economy
	Water and Sustainable Use in Construction

	- Sustainable Drainage Systems - Rainwater Harvesting
	Water Management Plan
	Application for Multi-functional Green Roofs Facades and Interior Elements
Module 6: Energy and the Circular Economy	Energy in Construction: Energy and the Circular Economy
	Energy and Sustainable Use in Construction: Renewable energy sources
	Application for Multi-functional Green Roofs Facades and Interior Elements
Module 7: Digitalisation and Material Passports in the Design and Construction Sector	Digitalization in Design and Construction, BIM
	Drones
	3D Modelling
	VR (Virtual Reality)Headsets
	Exoskeleton Suits
	3D Printing and Prefabrication
	Digital Twins
	Material Passports
	Application for Multi-functional Green Roofs Facades and Interior Elements
Module 8: Material Impact in Relation to the Circular Economy	Material Impact Reduction
	Green Public Procurement
	Life Cycle Analysis
	Life Cycle Costing
	Level(s)
	Application for Multi-functional Green Roofs Facades and Interior Elements
Module 9: Waste as a Resource in Circular Economy	Waste as a Resource and Implementing material reuse
	Digital marketspace
	Material Banks
	Application for Multi-functional Green Roofs Facades and Interior Elements
Module 10: Deconstruction as an Element of a Building Life	Pre-demolition survey
	Circular Deconstruction
	Urban mining

	Application for Multi-functional Green Roofs Facades and Interior Elements
Module 11: Circular Economy Across the Value Chain	Collaboration and Knowledge sharing
	Integration and implementation of Circular Economy in the workplace
	Regulation and Definition
	Multi-functional Green Roofs Facades and Exterior Elements

3.4. Training Plans and Packs for SMEs

The BUSGoCircular Fundamentals Training Pack's are developed for workers unskilling in circularity or low-skilled workers who are often faced with the design or installation of systems related to the circular economy. These installations can be required in certain cases by European regulations or by the customers themselves. Without training, unintentional errors may be caused in the application of these systems and hamper further progress towards a more circular construction sector.

To identify the target groups for these training packs, construction sector SMEs and the professionals involved within them were categorised according to their participation in the five main stages in which a construction project is developed, being: Plan, Procure, Construct, Operate and End of service life [17]. They were also divided into two categories of workers: blue-collar workers who are manual labourers often with vocational training (trade school) or no formal education and white-collar, with technical, administrative, or management roles in jobs and more regulatory education degrees like university. For example, SMEs like architecture/technical/public works/interior design offices are in almost all stages except construct and comprise of white collar workers but building/construction companies can be present at all stages except the plan/design stage having both blue and white collar profiles in their staff. On the other hand, companies that are only in the construct and operate stage (practical skills) comprise mostly of blue collar workers like in renovation (masonry, carpenter, plumber, etc.), maintenance, waste management or installations companies but real estate investors include only white collar profiles in the plan stage. The entire classification table of SMEs can be seen below.

Table 7: SMEs involved in the construction sector classify in worker profiles and stages of the built environment.

PROFILE		PLAN	PROCURE	CONSTRUCT	OPERATE	EoSL
White -collar	**GENERAL**	Architecture/public works/technical architecture or interior design offices			Architecture/public works/technical architecture or interior design offices	
			Building company			
		Real estate investor- Project developer			Real estate investor- Project developer	

		Urban-planning offices / Administration(governance)					
	SPECIALIST		Materials companies / producers				
			Industrial intermediaries suppliers / distributors				
			Insurance providers				
			Housing software companies				
		Landscape offices					
		Sustainable consulting or engineering			Sustainable consulting or engineering (including specialists in energy, materials, LCA)		
		Engineering office			Engineering office		
		Specialist architects' offices: façadists, structural engineers					
		3D makers office					
Blue-collar	**GENERAL**				Maintenance company		
			Building company				
	SPECIALIST					Demolition companies (usually building companies)	
						Waste management companies	
						Waste treatment and recycling companies	
			Electrical installation company				
			Water installation company				
			HVAC installation company				
			RE installations company				
			Companies specialised in specific material systems				
				Masonry company			
				Carpenter (wood) company			
				Specific professions (welder, plasterer,			

				gardener) company				

We also observe some companies cover multiple stages. These companies incorporate from specific profiles of professionals to a wide variety in the same company. There are companies that are only involved in the initial phases of the project, such as planning, but need to have professionals with cross-craft knowledge to deal with all the subsequent stages they must design, even if their companies are not directly involved in them. Such packs will have to be more comprehensive and cover more building stages in a generic way. Blue collar workers tend to have more specialised companies and professions, making it easier to provide them with subject-specific training packages making it important to design more defined packs. These packs may incur some costs due to having to include tailored workshops for these trades.

For professions like sustainability consultants, who may need a higher level of knowledge in specific content on circularity (deconstruct, waste management,etc.) it is important to combine more specific detailed modules with short generic ones containing circular economy principles in construction. This last one will act like a common introductory module and will be recommended as an introduction in all training packs in order to acquire a shared knowledge base across all trades/professions. After this analysis, we conclude with the following target groups [Table 8].

Table 8: Training Plans for each target group. Future packs will be developed based on these plans to cover all target groups if possible.

TRAINING PLAN PROPOSAL (TP)		Stages	Profile	SMEs	Modules	DURATION of all modules	EQ LEVEL	FUTURE PACKS
TP1	STARTING CIRCULARITY	Plan and Procure	White-collar	-Architecture/public works/technical Architecture or interior design offices - Building company - Real estate investor- Building promoter (Procure stage part) - Urban planning offices - Landscape offices (only some modules) - Specialist architects' offices: façadists, structural engineers	10	24	3	4 Pack (CZ, ES, EU, IE, HR)
TP2	CONSTRUCTION WORKS IN CIRCULARITY	Construct	Blue-collar	- Company specialised in specific material systems -installers - Masonry company - Carpenter (wood) company - Another specific professions (welder, plasterer, plumbers, etc) company	10	55	3	2 Pack (BG,HU)

				- Maintenance company - Building company				
TP3	CIRCULARITY IN INSTALLATIONS	Construct and operate		- Electrical installation company - Water systems installation company - HVAC installation company - RE installations company - Engineering office - Maintenance company	10	42	3	
TP4	ADVANCING IN CIRCULARITY	Plan, Procure and EoSL	White-collar & Blue-collar	- Sustainable consulting or engineering Architecture's office - Public management/ governance Engineering office (some modules only) (Procure and EoSL part) - Demolition and/or building companies - Waste management company - Material producer	22	50	4/5	1 Pack (NL)

The first target group is composed of white collar workers involved in mainly plan, procure and EoSL stages and the content provided is an initial solid base of knowledge in shorter packs. The second and third group focuses on blue collar workers involved in the construction and operation stages with content more specific and practical for their profile. The last group provides both workers profiles in plan, procure or EoSL stages with more in depth and specific content in a longer pack. For these target groups, four training plans have been designed with the common introductory module of the eight key elements of circularity. It should be highlighted that these fundamental training packs are focused on acquiring introductory and broad concepts. The diagnostic assessment part is considered before the start of the pack, if the enrollment and initial skills test is done in the application BUILD UP Skills advisor-app [21].

Once we identified what the TP's needed to cover and mapped most of the profiles in the construction sector, we analysed the training methods that best suited each target group and skills to be trained. We also considered the time and investment requirements of SMEs and the free access material available to then elaborate the packs. The results must be attractive, simple, low-cost and accessible training. There are a variety of teaching approaches which we have classified into three main methods: digital, face-to-face education and hybrid. We assessed the main advantages and disadvantages of each one. For example, the digital method we call *Information Pills* [22] which are flexible (being able to do it in small daily time like in breaks), asynchronous (no need for all the workers to coincide in time, individual basis), repeatable, dynamic (mainly video format, visual presentation, testing online tools or podcast) and highly economical (free access material selected online). *Information or training pills* are short (3-10 min.) messages of specific concepts where the most essential points are summarised in a precise way in audiovisual format that capture the attention of students. This format however, makes it impossible

to have direct feedback or interactions, is less customised and usually contains more generic content. Even so, rapid learning is often the fastest way to train people with busy work schedules. The formats considered will depend on the material found but will prioritise videos. An introductory microlearning course available in English and Dutch languages [23] is also included in the digital methods chosen. Both digital methods will be carried out individually.

It must be recognised that a number of competences and skills, particularly in construction are practical, mainly in bluecollar profiles and these cannot be omitted from the packs. In total three methods were selected: short product demonstrations and two types of workshops. The idea with product demonstrations of 30 mins is also to introduce rapid learning, but instead of videos/*pills*, utilising products from material suppliers that promote circularity face to face, *"touching knowledge"*. It consists of a visit from a supplier of materials or circular products who will give a free demonstration and explanation of their product, if possible with real samples to touch, in exchange for the publicity they get for their product. An alternative option is workshops that contain practical knowledge and proactive activities but require more effort, planning (logistics), time and money than digital training or shorter demonstrations. The methodology of these two workshops have been developed within BUSGoCircular [12]; one consisting of a demonstration by constructing one construction technique or HVAC systems that promotes circularity and a practical exercise for participants and the second consisting of an internal competition within the company, in which a problem is proposed and has to be solved in different groups previously formed. The problem posed can be a real company problem related to the circular economy. All the face-to-face methodologies introduced will be in groups and all except one are based on project based learning.

Finally, we have prioritised providing knowledge by case studies because it is a method in which theoretical concepts relate to existing real-life examples and are not limited to the presentation of the facts, being more direct and attractive material for these initial levels or practical profiles. The learning methodologies included are mostly project-based learning, micro-learning (problem-solving), learning by doing, gamification and classical learning. The training methods chosen for the packs are shown in the following table.

Table 9: Classification of all the methodologies included in the packs [12]

TYPE OF METHODOLOGY		AIM	SKILLS	FORMAT			DURATION	LEVEL	EVALUATION FORMAT	PROFILE			COST	COMMENTS
DIGITAL	Microlearning courses	Modules (several	Theoretical and conceptual	Presentations with interact	Self lead	Individual	6 -7 h	Initial - Intermediate	Quiz - gamification	White / blue collar	All stages (more Plan, Procure and EoSL)	General	Medium (one material inversion or	Introducing cases study (real

		ULO's)		ive quizzes									maintenance of the web)	applications)
	Information pills	ULO	Theoretical and conceptual	Videos, podcast	Self lead	Individual	3-10 min	Initial - Intermediate	-	White / blue collar	All stages	General / Specialist	Low (videos free access already online)	More effective with cases study - applications
FACE TO FACE	Workshops- practical	Modules (several ULO's) / ULO	Practical skills	Demonstration + construct prototype	Tutor lead / Self lead	Group	4 h	All	Practical Exercise	Blue collar	Construction and operation stage	Specialist	Elevate (materials, tutor, time: sponsors?)	They can be cheaper if they are contracted by various SMEs together
	Workshops- SME internal contest	Modules (several ULO's) / ULO	Manage - Design and plan	Contest (diverse)	Tutor lead / Self lead	Group	2 -4 h	Intermediate	Presentation Exercise	White / blue collar	All stages	General / Specialist	Medium (tutor, time: sponsors?)	Cheaper if already there is a specialist inside the SME
	Visits/ Visits a case study with "detective game"	Modules (several ULO's)	All	Explanation Discover the answers in the building (game)	Tutor lead / Self lead	Group	1:30 - 2 h	All	Photos, draws, quiz	White / blue collar	All stages	General / Specialist	Elevate (transport, time, maybe tutor)	Lower if organised in your company buildings or without transport
	Short demonstration of circular products or materials	ULO	Design and plan	Oral and Touch Demonstration	Tutor lead	Group	45 min	All	Oral questions	White / blue collar	Plan, procure and construction	General / Specialist	Low (publicity of material/product in exchange)	

HYBRID	Information pills (video) + discussion with an expert	ULO's	Theoretical and conceptual - Design and plan	Mix	Individual / group	Videos + 1 h	All	Oral questions	White / blue collar	Plan, procure, operate and EoSL stage	General / Specialist	Medium (expert tutor)	
	Digital packs + Trivia quizzes	Modules (several ULO's)	Theoretical and conceptual	Mix	Group	-	All	Quiz (questions)	White / blue collar	Plan, procure, operate and EoSL stage	General / Specialist	Medium (trivia, time)	Lower once the trivia quizzes are created
	Digital packs + SME's Mentoring	Modules (several ULO's)	All	Mix	Individual	-	Initial - Intermediate	Following of the mentor	White collar	-	General / Specialist	Low (because is digital pack and mentoring is by volunteering)	

For modules in TP1, Starting Circularity, as it is entry-level content and less practical profiles, have included mostly digital methods and consequently are more economical. Instead modules in TP2 and TP3, Construction and Installations works, digital and face-to-face methods have been combined due to the specific characteristics of practical profiles; implementing workshops, tutorials and product demonstrations along with some theoretical content outlining the main strategies of circularity. Due to this, they are less economical. Finally, the modules included in TP4, Advancing Circularity plan, hybrid methodologies have been considered in some cases due to the need for specific knowledge with a one-time tutor in some punctual content. This results in a variable economic investment depending on the activity and time required with the tutor. All the training plans developed recommend a visit to a case study when finalising some modules.

The evaluation recommended utilises a qualitative methodological approach, as the intention is to implement competences and skills of the company so, at first, no certificates are granted. In the future, it would be interesting to relate the TP's modules to existing European Qualification Framework (EQF) levels to create certifications and micro-credentials. Digital training doesn't have a direct evaluation, however, it is highly recommended to conclude the modules with a site visit to a building implementing a *detective game* that makes it possible to evaluate the participants verbally determining whether the participant has acquired the knowledge or not. This *Visiting a case study with*

detective games evaluation consists of searching for answers to previously prepared questions by examining the building visited (30-45 minutes). Questions must relate mainly to construction techniques or circular economy strategies implemented. The first group to answer all questions correctly, *"win"*. To reduce the cost of this activity for SME, they may choose buildings constructed or designed by the company themselves. Learnings can be achieved even if it is not a good example of circular construction by identifying ways to make the building more circular. Usually, training related to the specific site on which the blue-collar professionals are currently working is the most efficient and impactful. In the practical workshops, there will be a formal and continuous evaluation with a final group presentation to evaluate what has been learnt while doing the practical exercise and to reinforce those aspects that have not been sufficiently assimilated. This assessment is possible due to the tutor-led, face-to-face format.

Independently of the packs, it is recommended to consider the evaluation of the acquired knowledge with gamification to avoid the possible lack of motivation of the workers and promote an engaging and fun experience. The introduction of achievement insignias/badges for workers from the company or rewards related to the module (i.e. paid short courses of specific training), the incorporation of a ranking system or points published in a company newsletter, appearing on the company's Instagram profile or include a *"serious game"* methodology like trivia-type questions setting time limits for answering, are some applicable examples of both qualitative evaluation and motivation to carry out these TPs attractively within SMEs. In fact, some gamification proposals for each module are already incorporated in the training plans designed.

In parallel, the index of context of the training plans have been developed based on the Circular construction task-based qualification framework explained in *3.2. Task-based Qualification Framework for Circular Skills in Construction*. Each module of the TP will correspond to the main competencies and skills of the framework and the corresponding ULO's will be linked for this content. The structure of the modules for the training plans are divided into stages of the construction process: Plan, Procure, Construction, Operate and/or EoSL [17]. Then, it is divided into the three main resources or flows to which it relates: Materials & waste, energy and water. Within that distribution, the TP is organised in modules. It is recommended not to divide but select and combine the modules to tailor the plan for your specific objectives and interest. We aimed to create flexible TPs. Meaning there is no sequence to be followed for the modules and each can be completed independently, however, each module contents must be completed from beginning to end. The exception is the common introductory module of the eight key elements of circular economy in construction that is recommended to begin each pack. Some other modules will also be considered essential for particular profiles.

After this methodology analysis, four complete training plans for the four target groups have been designed to guide the creation of future packs; defining: related profiles, appropriate index of content and proposed training methods for each one, minimum time, the evaluation approach and the qualitative economical inversion. The method proposed could be changed when creating the packs if no national available materials are found for the specific content. Some materials will need to be created to configure the pack, such as

face-to-face methodologies like workshops, *detective games* and trivia quizzes. The recommended visits could be changed to case studies in video format or similar, if there is not enough economical resources to develop in the SMEs.

Below is a part of the example developed for the TP1, Starting Circularity. All the developed TPs in detail are here [12].

Table 10: Extraction of the Training Plan 1 proposed - Starting circularity. [Table 13: Appendix C]

STARTING CIRCULARITY	TP1			24 hours		
Contents	ULO's	Format for contents	Training methodology	Minimum Time	Cost qual.	Evaluation
COMMON MODULE						
Module 1. INTRODUCTION TO CIRCULAR ECONOMY IN CONSTRUCTION				6 h	€	
8 Key principles of circular economy	All	Reading material + quizzes	8 Microlearning courses			
Circularity definition and different flows: Materials, energy, waste and water	51	Videos /schemes	Information pills	5 min		
PLAN						
MATERIALS & WASTE				6:20 h	€€	
Module 2. STRATEGIES OF CIRCULAR DESIGN IN MATERIALS				5:40 h	€€	
Main strategies related with materials in circular construction	51	Reading material	Information pills			
DESIGN TO CLOSE THE LOOP OF MATERIALS: 1 Case study to chose from renewable materials (bio-based): wood structure, cork exterior isolation, straw bricks, rammed earth or bio "concrete"(hemp)	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO CLOSE THE LOOP OF MATERIALS: 1 Case study : recycled aggregates in concrete, recycled cotton isolation, steel, aluminium windows, etc.	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO CLOSE THE LOOP OF MATERIALS: 1 Case of study in reuse of materials in national level if possible: close loop, high quality reuse	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO REDUCE IMPACT: LOCAL, LOW IMPACT AND/OR NON-CRITICAL MATERIALS: 1 Case study of low impact materials: at least one material not repeated and preferably biobased and/or local	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO REDUCE IMPACT: NON-TOXIC MATERIALS: Types of non-toxic construction materials (alternatives to anti-flame retardants used on wood, low formaldehyde panels, COV's free paints, etc)	4	Video	Information pills	5 min		

DESIGN TO REDUCE WASTE IN SITE AND IN EOSL: 1 Case of products demonstrations of modular and/or prefabricated (dry solutions) to deconstruct	26	Video	Information pills	5 min		
DESIGN TO REDUCE WASTE IN SITE AND IN EOSL: 1 Case study of renovation (showing savings versus NB) + Subsides or incentives EU or national.	45	Video	Information pills	5 min		
2 Products demonstration	1, 2, 3, 4, 26, 36	Visual presentation	Demonstration of circular products	3 h		
Maintenance plan example	11, 17,42, 64, 68	Reading material	Information pills	extra material		
1 Visit with detective game to a different case study (from list)	1, 2, 3, 4, 26, 36, 45, 64, 68	Visit + quiz	Visit + "detective games"	2 h		
Module 3. TOOLS TO SUPPORT CIRCULAR DESIGN IN MATERIALS				40 min	€	
How to read an EPDs	36	Video	Information pills	5 min		
2 Cases study: two EPD's to compare (one high impact like plastic element and other low impact)	36	Reading material	Information pills	10 min		
Material Circularity Indicator	1	Reading material	Information pills	5 min		
How to read material passports and its use	47	Example	Digital / self-led	5 min		
2 Cases study: examples of LCA assessment (one new building, other renovation)	25	Videos	Information pills	10 min		
BIM modelling applications to building to aid circular applications	57	Video	Information pills	5 min		
ENERGY				3:30 h	€€	
Module 4. DESIGN TO REDUCE ENERGY DEMAND				3:00 h	€€	
1 example with climate consultant analysis of 2 different climates and main strategies of psychometric chart	9,1	Video	Information pills	10 min		
1 case study with design strategies for hot climates or hot season (can be historical examples)	9,10, 56	Video	Information pills	10 min		
1 case study with design strategies for cold climates or cold season (can be historical examples)	9,10, 56	Video	Information pills	10 min		
1 Visit with detective game to a case study with cool and hot bioclimatique strategies and PV panels	56, 63	Visit + quiz	Visit + "detective games"	2 h		
Module 5. TOOLS TO SUPPORT ENERGY EFFICIENT DESIGN / DIGITIZATION				30 min	€	
Software for energy simplify models (National energy certifications, CE3x, etc)	26	Video	Information pills	15 min		
1 practice with Tools such as R10 from IVE for renovation, triplea-reno to get some initial advice	54	Exercise	Digital tool self-led	15 min		
WATER				30 min	€	

Module 6. DESIGN TO REDUCE WATER CONSUMPTION				10 min	€	
1 Case study (national level) of Harvesting greywater and rainwater	6,7	Video	Information pills	3 min		
1 Case study (national level) of purify water with Plant-based biofilters	7	Video	Information pills	2 min		
1 Case study (national level) of draining pavements for public spaces or green roofs/facades	6, 27	Video	Information pills	5 min		
Module 7. TOOLS TO SUPPORT WATER EFFICIENT DESIGN / DIGITIZATION				20 min	€	
1 practice with tool with tips for reducing water consumption (Drive 0)	6,7, 27	Exercise	Digital tool self-led	20 min		

4. Discussion and conclusions

The skills mapping identified skills gaps throughout the construction sector. It is apparent through this research that gaps must be bridged within each profession depending on the skills that most relate to them for a more circular industry. It is also important to note that while not all professions must be an expert in every skill it is vital that every skill must be accounted for within any construction project. The project has identified an overview of the situation in Europe however as the surveys were carried out at a national level initially there is data available for each of the partners involved in the project. The volume of this data varies depending on the country and in some cases many professionals are missing within that country. For the national situation to become apparent and useful further research must be carried out to build on this existing work. The results of this skills mapping has allowed professionals to understand the circular skills they will need using the BUS advisor app as well as allowing the BUSgo-Circular team to create task based qualification framework and the training material targeted at filling these gaps.

Both the general and applied circular construction skills qualification framework have multiple purposes. A framework based on 9 tasks was created that is the practical application of the 8 principles and 25 subtasks. These are related to skills, competentes and knowledge resulting in a total of 70 ULO's. Firstly, within the BUS-GoCircular project, the qualification framework was used as a baseline for setting up the Train-the-Trainer and mentoring programmes between professionals, as well as the fundamentals training packs for SMEs. The resulting 70 ULO's in the general qualification framework and 84 ULO's in the applied framework can either be utilised as the basis for creating these programmes or can be incorporated into existing programs where the BUSgo-Circular findings and outputs can create added value. The findings of this work will inform further research carried out on different elements of construction related to circular economy. In the coming months we will continue to carry out further Train the Trainer courses and mentoring programs which will be created and delivered by our trainers throughout Europe, utilising the materials and information collected and shared by the BUSgo-Circular consortium. These programmes will provide more outcomes about the utility of the task based qualification developed. Secondly, the qualification framework will be used for extending the Build Up Skills (BUS)-Advisor app, enriching skills repositories,

and connecting skills and skill sets to relevant upskilling and eLearning opportunities. The availability of a set of general qualifications for circular construction can be used for recognition of skills across countries and develop certificates of professionalism or of micro competencies needed in the sector. In order to test the applicability of the framework to specific fields in construction, it is applied to the subject of MGRFIE.

One of the implementation actions of the task based qualification framework developed has been the Training packs for SMEs that will serve to stimulate the demand for circular skills and practices in the construction sector upskilling the workforce. Four training plans [12] have been created for the target groups detected to guide the creation of future packs, serving also as a basis for other future training developments. These training plans define the appropriate index of content for achieving the basic knowledge on circularity (related to ULO's) and propose the best suited training methods for each one, the minimum time expected, the evaluation approach and the qualitative economical inversion. The best learning methods for SMEs have been detected, the most appropriate being digital formats based on case studies (project-based learning) without being able to avoid, for some imminently practical profiles, the need to incorporate face-to-face methods with practical workshops and site visits (learning by doing). For the digital methodologies it has been considered appropriate to propose qualitative evaluations and for the face-to-face practical ones, a formal and continuous evaluation, being convenient to include in each module gamification either with visits with questions, acquisition of badges or prizes or company trivia quizzes to avoid the possible lack of motivation. The modules and contents have been structured in a way that is easy to understand and flexible to be adaptable to different profiles,or divided according to the needs or time of the SMEs and the limitation of the national materials available. In addition, existing available materials have been selected for the creation of packs, activities have been proposed to serve as qualitative evaluation of the contents and methodologies have been designed for the two proposed workshops (construction techniques and HVAC installation and internal contest for SMEs).

The training packs for SMEs are still under development in the BUSGo-Circular project. Seven self-directed packs adapted to the national level of each country involved in the project will be created in their national language and one at European level. During their elaboration, they will be validated by SMEs in each country involved through interviews and on a larger scale at European level through questionnaires and will be adapted to the inputs collected if necessary, always taking into account the stakeholders of the project. These packs will consist of attractive training material and activities proposals and once completed they will be freely accessible to any company to upskill their employees in the field of circularity in construction. These packs will be published on the BUS-GoCircular website[7], for their desired dissemination and implementation in the countries participating in the project and at a European level.

Training Packs should be developed to incorporate certificates or microcredentials. These actions will increase the attractiveness of the packs. Relating some modules and specially some practical workshops to microcredentials of projects such as BUS League or other existent certificates could be good opportunities for growth. Other options will be

to incorporate these key competences developed in the task based qualification framework in current national certifications related to circular practices.

Finally, the project is also rolling out mentoring programs [13] during 2023 and 2024 to offer circular support and guidance between professionals for current and future projects. The method used within this project to map skills gaps within the construction sector in order to understand what upskilling is necessary, is intended to be replicable and should be utilised within other areas of the construction process and sector in future, allowing this method to become a blueprint for other elements of the built environment.

Appendix A

Table 11: List of professions

Reference Profession / Trade	Enter national name for profession / type of profession	Definition of the professions (proposal, change if necessary)
Architect	Architect / building designer, project manager, building construction manager, director of the execution of the works, urban architect, structures' calculist, health and safety coordinator, Building Energy Auditor, Building Energy Chief Auditor) technical architect	Architects investigate, design and oversee the implementation of buildings taking into account functional, architectural, aesthetic, structural, technical, regulatory, cost and contextual requirements with due regard to public health and safety.
Civil Engineer	Designer, Mechanical engineer, Electronics engineer , Electrical engineer, Structural/Building/Installations engineer, Energy engineer, Management engineer, technical engineer	Designer of materials and structures, considering the limitations imposed by practicality, regulation, safety, and cost. Specialisation is possible on topics like construction safety, thermal performance, acoustics, building physics.
Mechanical Engineer	Energy engineer, Multifunctional use for solar PV / Urban wind turbines	Designer of materials and systems for HVAC and sanitary equipment, considering the limitations imposed by practicality, regulation, safety, and cost.
Electrical Engineer	ICT engineer, Building automation engineer, Sensoring and Building Management Systems	Designer of power, lighting, data and or communication installations, considering the limitations imposed by practicality, regulation, safety, and cost. Designer of building automation systems, system engineer / system integrator, considering the limitations imposed by practicality, regulation, safety, and cost.
Construction Engineer	Construction design engineer, building construction engineer, building engineer, engineering support manager, construction project engineer, site engineer, Building Surveyor	Engineer of the building construction safety
Environmental engineer	Air protection environmental engineer, environmental engineering expert, environment engineer, industrial environmental engineer, water pollution engineer, environmental engineering adviser, chemical environmental engineer, environmental engineering specialist, environmental engineering consultant, sanitary engineer, pollution engineer, environmental	Designer of solutions to protect human health, nature's beneficial ecosystems, and to improve environmental-related enhancement of the quality of human life.

	analyst, environmental specialist for water management, agricultural conservation engineer	
Data analyst (Software Engineer)	BIM programmers, BIM designers, BIM Software engineers, 3D image technician / engineer, Building Information Modelling/management, Digital twin, Predictive maintenance as roof has shorter lifespan than building	Building Information Modelling, Digital twin, Predictive maintenance as roof has shorter lifespan than building
Material Purchaser (material scouts)	Procuring and buying bio-based and secondary materials for MGRFIE	Procuring and buying bio-based and secondary materials for MGRFIE
Project manager	Management engineer, Industrial Engineer / Project manager Building company or Project manager Installation company, Cost engineer, Quality assurance	The person responsible for the planning, execution and closing of any building project
Project developer	Management engineer, Industrial engineer / Project manager Building company or Project manager Installation company	The project developer takes responsibility for the associated risks involved in the building process for the customer and hands over the project to the tenant / buyer after completion and use of the building
Onsite Manager (building process)	Architect, Structural/Building engineer, Construction manager/ Building Surveyor	The person responsible for quality assurance during on-site construction works in the realisation of MGRFIE
Building owner/Operator	Facility manager, housing corporation, Asset manager, Real estate investor	The person responsible to maintain the real estate as it was realised at the end of the MGRFIE building process (including facility management). The person responsible for management, monitoring and improvement of operation of facilities.
Financial manager	Cost expert	The person responsible for all finances involved during planning, execution and closing of any building project
Procurer co-ordinator (Tenders)	Buyer, chief procurement officer	The person responsible for facilitating the process of MGRFIE tenders and (sub)contracts
Landscape Architect	Landscapes architect, landscape engineer, landscape design expert, landscape artist, landscape design specialist, landscape specialist, landscape expert	The person responsible for the construction of gardens and natural spaces in MGRFIE design. Design multi-functional green roofs and facades, Specific plant design based on size, weight, water needs etc
Insulation Installers	Lagger, cavity insulation installer, energy saving materials installer, insulation installation worker, insulator	Insulation workers install a variety of insulation materials to shield a structure or materials from heat, cold, and noise from the environment. Roof insulation (on top / below), Root Resistant material selection
Plasterer, Facade worker	Heritage plasterer, fibrous plasterer, wall finisher, solid plasterer, plaster labourer, plaster worker, stucco mason, wall plasterer	Finishing (Suitable finishing for MGRFIE), Innovative facade design using easily repeatable designs
Roofers	Roofing carpenter, cladding installer, asphalt roofer, roof tiler, tinsmith, felt roofer, house roofer, roof slater	Roofers cover structures with roofs. They install the weight-bearing elements of a roof, either flat or pitched, then cover it

		with a weatherproof layer. Waterproofing and water collection, Design to reduce flooding, Roof insulation (on top/below)
Landscaper (roof and facade)	Interior planter/landscaper, exterior planter/landscaper	Plant selection, Soil selection (Lightweight)
Plumber	Commercial plumber, gas fitter, domestic plumber, pipe worker	Plumbers maintain and install water, gas and sewage systems. Solar PV, cables and mounting of sensors, Roof accessibility (Lighting)
Electrical installers and technicians	Installation electrician, electrical services installer, electrical maintenance technician, maintenance electrician, electrical systems installer, electrical maintenance worker, electrical installer, electrical worker	Electricians fit and repair electrical circuits and wiring systems. They also install and maintain electrical equipment and machinery. Solar PV, cables and mounting of sensors, Roof accessibility (Lighting)
Renewable energy systems installers (electric)		Solar PV, cables and mounting of sensors
Renewable energy systems installers (thermal)		Solar thermal systems
Heat pump installers		Placement of outdoor unit heat pump
Demolition/Deconstruction auditors	Demolition expert, Urban miners, Waste Recovery and salvage	Site analysts, Material Recovery, Material Reuse
Repair and maintenance operatives	Maintenance planner, Safety maintenance operative (check on safety measures)	
Ventilation installers	Heating, ventilation, air conditioning engineers design and develop heating, ventilation, air conditioning and possibly refrigeration systems	Placement of air handling unit
Painter and decorator	Specialist painter, decorator, commercial painter and decorator, construction painter and decorator, painter (construction), industrial painter, commercial decorator, construction decorator, Interior designer	They may use standard latex based paints or specialised paints for decorative effect or protective properties. Building painters are skilled in using brushes, paint rollers and paint sprayers for different applications.
Wood manufacturer and finisher	Prefabricated building assembler, Truss assembler	
Building energy consultants	Energy assessors, energy saving consultant, energy procurement consultant, energy advice consultant, energy procurement advisor, energy saving equipment advisor, energy and sustainability consulta, energy saving advisor, energy and environmental consultant, sustainability consultant, energy advisor	Energy consultants advise clients on the advantages and disadvantages of different energy sources. They help clients to understand energy tariffs and try to reduce their energy consumption and carbon footprint by using energy efficient products and methods.
Policy maker for building		Setting ambition and providing regulation. Advising on advantages (and disadvantages) of multi-functional roof use policy

Green Public Procurement (GPP) advisor in construction		Advising on how to make use of GPP for stimulating MFGRIE in combination with other climate goals
Carpenter	Craftsperson carpenter, commercial carpenter, heritage carpentry, craft carpenter, joiner, woodworker, carpentry framer, frame-maker, joiner supervisor, joinery worker, timber worker	Carpenters cut, shape and assemble wooden elements for the construction of buildings and other structures.
Window installers / glazers	Window installation team worker, window fitter, window installation team member, window technician	Window installers/glazer place windows into structures and service them. They take out old windows if present, prepare the opening, mount the window, and attach it in place plumb, straight, square and watertight.
Stonecutter and mason	Stone carver, structural stoneworker, artisanal stonemason, stoneworker, craft stonemason, stone setter, heritage stonemason, memorial mason, stone finisher, fixer mason, stone cutter, architectural stonemason, craft mason, building mason	Stonemasons/mason manually carve and assemble stone for construction purposes. While CNC operated carving equipment is the industry standard, artisanal carving for ornamental stone is still done manually.
Bricklayer	Industrial oven brick mason, trowel occupation worker, bricklaying labourer, specialist bricklayer, brick laying worker, bricklayer	Bricklayers assemble brick walls and structures by skilfully laying the bricks in an established pattern, using a binding agent like cement to bond the bricks together. They then fill the joints with mortar or other suitable materials.
Green Roofers		Design specifically for green roof and facades. Material, weight, water etc specialist when consideration is made for green roof design

Appendix B

Table 12: Applied Task Based Qualification Framework, ULOs

ULO Nr.	Competence	Skills	Knowledge
1	Design roofs, façades, and interior elements with bio-based materials as an alternative for conventional construction materials	Select bio-based materials for the roof, façade or inner wall Consider the purpose of the building and the context of the entire building solution, as well as construction requirements When biobased materials are not an option, select proper low impact materials Integrate use of the Material Circularity Indicator (make sure it is not higher than X) Ensure use of materials that have little to no volatile organic compounds (VOC) emissions	Types of bio-based materials suitable for roofs, façades, and inner walls (such as hemp, straw, bamboo, sustainably sourced wood, agricultural residues) Advantages and disadvantages of biobased materials Seven functional requirements of building walls Alternative forms of concrete Wood or thatch/straw panels for rainscreen cladding and insulation on façades

2	Enact measures that optimise material use to strive for material efficacy	Apply measures that optimise material use to multifunctional green roofs, façades, and interior elements Combat underutilisation or surplus of materials by sharing products or assets and optimising their use	General knowledge about measures that optimise material use in construction, such as 3D printing or accurate structural design/industrialised prefabricated products (keep design lightweight)
3	Design with non-critical raw materials as defined by EU	Avoid, insofar as possible, use of critical raw materials as defined by EU while selecting materials for multifunctional green roofs, façades, and interior elements	Types of non-critical raw materials as defined by EU
4	Design with non-toxic materials as defined by EU	Avoid, insofar as possible, use of chemicals as defined by EU while selecting materials for multifunctional green roofs, façades, and interior elements	Types of non-toxic construction materials, such as alternatives to anti-flame retardants used on wood
5	Design with products and materials that can be easily reused or recycled after use	Recognise and select materials that can be easily reused or recycled after the building's end-of-lifetime Recognise and avoid composites or other mixed materials that are then hard to recycle/repurpose	Reusable and/or recyclable materials, such as glass, plasterboard, steel, gravel (aggregates), rammed earth walls Recycling requirements for specific products and materials for safety and functionality (and regional/local infrastructure capacity)
6	Replace freshwater use with alternative water sources	Use alternative water source applications that are suitable for the project at hand Harvest greywater and rainwater on roofs or façades for certain applications Design sustainable drainage systems Stimulate the cooling of the city/building by slowly releasing rain water	Alternative water sources such as rainwater, fogwater, seawater, grey water etc. When are roofs and façades suitable for applying alternative water sources Sustainable drainage systems
7	Enact measures that optimise water use for water efficiency	Apply plant-based biofilters/ phytopurification in green roofs, façades, or interior plant walls Create water cascading systems Stimulate the sponge function of green roofs and façades for peak moments of water Harvest greywater and rainwater for certain applications	Sustainable water technology Plant-based biofilters to purify wastewater Criteria for reuse of water Cascading water for efficiency Innovative measures, such as using recycled textiles as roofing materials to catch water
8	Select sources with less impact to apply to operations in buildings	Select best energy solution that is less impactful based on current situation in country (e.g. convert fossil fuel based operations to electric)	Fossil fuel based operations vs. electric operations Renewable fuels, such as biomass How circular economy works with regards to materials and sources, renewability Current state of affairs and regulations with regards to energy sources Options like waste heat/district heating

9	Enact measures that reduce and optimise energy use through solutions on roofs and facades whilst taking into account building purpose and climate	Include energy efficiency measures in design of roofs, façades, and interior elements (e.g. insulation of roofs, roof ventilation) Include passive design techniques in design of roofs, façades, and interior elements (e.g. solar orientation, skylight windows, shading)	Smart solutions to spread demand throughout the day Measures such as draught-proofing, airtightness, insulation, ventilation Materials with lower thermal conductivity (e.g. sheep's wool, cellulose, earthwool)
10	Generate energy or heat/cold from renewable sources in design of multifunctional green roofs, façades, and interior elements	Include renewable energy technologies in building design	Options for renewable energy, e.g. solar/PV panels, solar thermal collectors, heat pumps, waste water heat recovery Systems that generate power or heat/cold
11	Provide repair services or maintenance services for multifunctional green roofs, façades, and interior elements	Renovate buildings or parts of buildings to maximise their lifetime Conduct regular checks and repairs for multifunctional green roofs, façades, and interior elements	Renovation techniques Renovation of bio-based, non-critical and non-toxic materials
12	Provide upgrade programmes or upgrade services for roofs and façades	Educate home-owners and facility managers on the possibilities of upgrading roofs and façades Provide upgrade services	Which (local) organisation can help upgrade roofs and façades Upgradeability of roofs and façades at hand
13	Provide DIY repair kits or spare part programmes for enabling self-repair of roofs, façades or inner walls.	Describe information to building users and facility managers about how to repair and maintain green roofs, façades, and interior elements (e.g. maintenance of greenery, cleaning solar panels)	DIY techniques for repair and maintenance
14	Extract and reuse parts from end-of-life roofs, façades, or interior elements for use in new buildings	Dismantle built structures whilst maintaining value of products and materials Read construction details for detachability of building components	Dismantling for re-use Detachable construction details
15	Arrange a safe working environment and continuously consider health and safety requirements, especially for working on roofs and facades	Arrange a safe working environment at the construction site Consider health and safety requirements Assure sufficient environmental air quality Arrange the right measures to ensure safety for roof and façade workers	Health and safety requirements specific to biobased and secondary materials (construction) Requirements specific to renewable energy technologies and smart solutions (installation) Hazards of certain materials and their compositions Rooftop safety and hazards
16	Enable second hand sale of multifunctional roof/façade products through marketplaces or services	Make use of (digital) marketplaces to find a new use for disassembled materials (construction) Make use of (digital) marketplaces to find a new use for disassembled products and parts of products (installation)	Potential new purposes for construction materials and products

17	Manage and preserve biological products on the construction site to stretch the lifetime materials	Preserve and manage biological products Keep green roofs and living walls in a healthy state maximising green / biodiversity impact	Preservation and management of biological products on site Periodic treatment and maintenance of wood, straw and other bio-based materials used for the building.
18	Collect products and materials for reuse or recycling in roofs, façades or interior elements from the construction industry	Source demolition materials for construction of new multifunctional green roofs, façades, or interior elements Select waste products and materials for construction of new structures Prioritise local demolition materials to save resources Use digital marketplaces to collect products and materials	Usable and suitable waste products and materials Allocation of local demolition materials Collection programmes that process materials for reuse or recycling within the construction sector Closed loop waste streams
19	Transform waste products and materials from multifunctional roofs, façades or interior elements for reuse, or as a last resort into lower value products in the same industry	Transform demolition materials into products that can be used in new built projects Conduct activities to clean and restore products back to working condition for original or new purposes	Upcycling methods Closed loop waste streams Cleaning, documentation, refurbishment or any physical/chemical treatment to allow reuse Strategies to clean and restore products and materials
20	Use waste products and materials from construction demolition projects that have been processed and recycled	Reuse demolition materials as a resource for new multifunctional green roofs, façades, or interior elements	Different functions for waste materials in new roof, façade, or interior element application Closed loop waste streams
21	Collect products and materials for reuse or recycling in roofs, façades or interior elements from outside construction	Source demolition materials for construction of new multifunctional green roofs, façades, or interior elements Select waste products and materials for construction of new structures Prioritise local materials to save resources Use digital marketplaces to collect products and materials	Usable and suitable waste products and materials Allocation of local demolition materials Collection programmes that process materials for reuse or recycling outside the construction sector Open loop waste streams
22	Transform waste products and materials from multifunctional roofs, façades or interior elements for reuse outside construction, or as a last resort into lower value products outside construction	Transform demolition materials into products that can be used in other ways outside construction Separate waste created during construction Conduct activities to clean and restore products back to working condition for original or new purposes	Open loop waste streams Strategies to clean and restore products and materials
23	Use waste products and materials from outside construction that have been processed and recycled	Reuse materials as a resource for new multifunctional green roofs, façades, or interior elements	Open loop waste streams
24	Enact measures to use and store energy more efficiently in buildings	Employ batteries for storing renewable electricity produced	Storage of heat and cold, storage of excess power

		Utilise a thermal tank to store excess hot water stored on site Make use of phase change materials to store excess heat or cold.	
25	Evaluate and assess life cycle impacts of buildings, construction products and materials on the environment (emissions, soils, water, biodiversity, etc.)	Apply a lifecycle assessment tool to evaluate the embodied energy and carbon footprint of a new building or the renovation upgrade of an existing building	e.g. One ClickLCA tool Awareness of new circular economy legislation as is currently passing through Irish parliament
26	Design multifunctional green roofs, façades, and interior elements for prefabrication so that as little waste as possible is produced during construction	Design prefabricated solutions If applicable, 3D print building components Use CNC and/or robotics for prefabrication	Prefabrication (incl. relevant software) Alternative prefabrication methods such as 3D printing (incl. digital rendering) Sustainable insulation materials in prefabricated walls
27	Design products so they use as little materials, water, energy, etc. as possible during use phase	Reduce the consumption of total raw materials needed for construction Consider resource efficiency for design of all life cycle stages (e.g. minimum energy consumption during use phase)	How to minimise raw material use for roof, façade, or inner wall construction project
28	Design modular structures for multifunctional green roofs, façades, and interior elements, so that the components can be disassembled and reused after end of service life	Design modular structures Write and interpret detachable construction details Prioritise standardised solutions and systems to increase possibilities of reuse	Why custom made structures should be avoided (more difficult to reuse after disassembly) Detachable construction details
29	Design multifunctional green roofs, façades, and interior elements to enable reuse and recycling	Design multifunctional green roofs, façades, and interior elements that consist of multiple parts that can be easily disassembled Enable easy recyclability for the designed building component Design with reuse for the same or different purposes in mind 'Legolise' the construction of multifunctional green roofs, façades, and interior elements	Material passports Modularity to enable easy disassembly
30	Design multifunctional green roofs, façades, and interior elements that make repair accessible	Design multifunctional green roofs, façades, and interior elements so that they are easy to repair by home owners or facility managers	Modularity to enable exchange of (parts of) products or materials Design strategies to allow for easy repair Material passports
31	Design multifunctional green roofs, façades, and interior elements that can serve a long and useful life, as well as stay relevant to residents and users	Select materials and technologies that resist damage and wear (e.g. natural slate) Design for flexible use to adapt to changing needs of occupants (e.g. partition walls and systems, change function of multifunctional roof after time)	Design strategies for flexible use of multifunctional green roofs, façades, and interior elements Materials that ensure longevity of buildings

32	Facilitate discussions and meetings between internal team members to identify circular opportunities multifunctional roofs and façades	Apply circular strategies within the firm to serve as an example Provide internal training about circularity topics (e.g. about circular procurement) Facilitate open discussions about circularity	Circular strategies Training strategies (Group) conversation strategies for circularity
33	Integrate circular economy thinking into employee evaluations that are linked to professional compensation	Integrate circular economy thinking into employee evaluations Link circular employee skills to professional compensation	Circular economy thinking for employee evaluations
34	Collaborate to apply and improve circular procurement processes of multifunctional green roofs, façades, and interior elements	Evaluate material suppliers on circular economy principles and guidelines Setting up purchasing guidelines for procurement departments Improve procurement further by acting regionally Include other lifecycle phases, such as renovation or dismantling works	Circular procurement/GPP Energy Performance Contracting and other performance-based servitization models
35	Collaborate with industry stakeholders to share best practices in circular multifunctional roofs and façades, and act together	Engage in discussions with industry stakeholders to share circular roofs and façades best practices Push stakeholders towards greater circularity Identify potential synergies Engage in activities or projects that advance circularity together Establish regional construction networks	Strategies for promoting greater circularity
36	Make choice of materials between different tender options for multifunctional green roofs, façades, and interior elements	Require Environmental Product Declarations (EPDs) Interpret EPDs	Tender options like bio-based (timber) versus secondary (recycled concrete or steel) Sustainable or circular tender options for roofs and façades
37	Work together with residents and users to jointly create multifunctional green roofs, façades, and interior elements fit for them	Organise feedback from consumers in order to improve roofs and façades in next applications	Co-creation strategies
38	Engage in discussions with construction customers to raise awareness of the circular economy and explore circular opportunities for multifunctional green roofs, façades, and interior elements together	Educate residents on circular multifunctional green roofs, façades, and interior elements as construction or renovation solution Provide consumers with reliable data on the environmental footprint of their choices Provide programmes for home owners and users to help people apply more circular principles	Ecolabelling Renovation options for roofs and façades Benefits of multifunctional roofs and façades (per function, plus increased benefits when functions are combined)

39	Engage in discussions with government bodies and policy makers to push for regulations that support the application of circular multifunctional green roofs, façades, and interior elements	Establish circular construction and demolition criteria for multifunctional green roofs, façades, and interior elements Open and engage in discussions with government bodies and policy makers Connect public (regional innovation bodies) and private parties to deepen knowledge and incentivise practical collaboration on circular applications on multifunctional green roofs, façades, and interior elements	Public private partnerships Which government bodies and policy makers are relevant to interact with
40	Participate in government programmes that support and advance circular multifunctional green roofs, façades, and interior elements	Select relevant government programmes Contribute to government programmes for circularity or for multifunctional green roofs, façades, and interior elements	Government programmes that support and advance circular economy
41	Work together with the (local) community and engaging them in the company operations	Develop high-value, circular applications of multifunctional green roofs, façades, and interior elements through community collaboration Engage with environmentally conscious inhabitants of buildings to find solutions for installing a multifunctional green roof or façade	Strategies to engage people in local communities with company projects
42	Provide building components (e.g. façades, technical installations on roof, partition walls) as a service instead of as a product	Set up a product business model for building components Provide building components as a service Provide services through a subscription plan with regular payment schemes Employ take-back schemes	Strategies for providing building components as a service (e.g. installation company ensures good indoor climate and remains owner of installations) Subscription plans
43	Offer maintenance and repair services for multifunctional green roofs, façades, and interior elements with help of service business models	Provide maintenance and repair services to buildings as a service Emphasise a locally skilled workforce to provide services	Service business models
44	Offer different leasing and rental models to provide access rather than ownership	Provide leasing or rental models for multifunctional green roofs, façades, and interior elements Recognise and prevent under-use of existing built space Organise multi-use or sharing of spaces (e.g. use office social roof for events during evenings and weekends)	Leasing models Rental models Options for multi-use, sharing of spaces
45	Incentivise the renovation of roofs with a potential of applying multifunctionality	Provide reasonable incentives to firms or individuals who choose to renovate an unused roof Set up projects for incentivisation	What incentives are suitable Models for incentivisation
46	Apply digital tracking of materials to optimise maintenance, demolition, and recovery of multifunctional	Apply digital tracking of materials used in the construction project Provide and gain insights into the materials used	Digital material tracking software Methods to track materials Use of BIM

	green roofs, façades, and interior elements		On site tracking ID's / RFID identification
47	Develop and apply material and building passports	Develop and apply material and building passports Ensure availability of material and building passports to everyone	Material passports Buildings passports Use of BIM Software options (e.g. Cirlinq platform)
48	Employ a regional construction digital marketplace for construction resources	Set up a regional construction digital marketplace Utilise existing online platforms to enable digital marketplace Persuade and incentivise use of digital construction marketplace by stakeholders	Digital marketplaces Methods for setting up a digital marketplace Peer-to-peer exchange of materials and products Use of BIM
49	Incorporate circular strategies, archetypal circular interventions and case studies into educational programmes (in the construction value chain)	Incorporate circular strategies into educational programmes Incorporate archetypal circular interventions into educational programmes Incorporate case studies into educational programmes	Suitable approaches for primary, secondary and tertiary education curricula Suitable approaches for lifelong learning and workplace training Distinguish between types of professions in training
50	Provide internal training about navigating in the value chain for circular multifunctional green roofs, façades, and interior elements	Set up circularity training Provide circular workplace training Provide guidance to trainees Set up a training agreement	Strategies and methods for circularity How to engage trainees with regards to procurement
51	Solidify definitions of circular construction by being consistent and using circularity frameworks	Explain what circularity means in construction	Key Elements of the circular economy Circularity definitions and which to maintain
52	Conduct research about circular construction strategies applied to multifunctional green roofs, façades, and interior elements	Generate knowledge on applied circular strategies by case studies and meta studies Analyse effectivity, barriers and successes of applied circular strategies Give informed advice for future applied strategies	Case studies and meta studies Suitable applied strategies for research
53	Follow developments in the field of environmental costing models and CO2 taxes	Distinguish and interpret environmental costing models and CO2 taxes by following the right sources to remain familiar	Environmental costing models CO2 taxes
54	Integrate multi-functionality into buildings by making use of roofs and façades	Apply functions of multifunctional roofs (e.g. social roofs, green roofs, energy roofs, water roofs) Create vertical gardens as part of façades or interior walls Connect green roofs to sewage systems to avoid flooding them	Types of multifunctional roofs and how to combine functions in design

55	Raise awareness about recycled construction materials and reconstructed buildings	Raise the awareness of stakeholders about reconstruction of buildings and recycled construction materials Explain the value of reconstruction of buildings and recycled construction materials Motivate stakeholders and break unwillingness to use new construction materials or build new	Recycled construction materials Reconstruction of buildings
56	Install energy efficiency measures on roofs, façades, and interior elements	Apply smart solutions to installations Conduct draught-proofing in buildings Conduct airtightness testing Apply suitable method for creating airtightness Build with passive design techniques	Energy efficiency solutions, e.g. ventilated roofs, air quality, insulation, airtightness. Draught-proofing for efficient use of thermal energy Passive design techniques (e.g. passive solar heating, solar collectors like atriums, crossed ventilation, inertia)
57	Employ BIM modelling to get insight into the effects and changes affiliated with upkeep, repair, or improvement of buildings	Make use of BIM modelling for upkeep and repair purposes	BIM modelling for repair information
58	Reduce waste as much as possible during production of multifunctional green roofs, façades, and interior elements	Reduce waste as much as possible during construction Incentivise building crew to avoid waste (=don't reward haste) Collect multiple separated waste streams on site	Strategies to reduce waste
59	Compile demolition specifications for multifunctional green roofs, façades, and interior elements and provide them at final commissioning of the building	Compile clear demolition specifications of the roof, façade, or inner wall at hand	Demolition specifications / detachable construction details
60	Assemble modular structures for multifunctional green roofs, façades, and interior elements	Modular construction systems and their procedures for assembly Apply removable joints Apply sealants that allow for disassembly (e.g. not glueing them or using PUR or KIT for mounting) Ensure that connections made are accessible	Modular construction systems and their procedures for assembly (incl. prefabricated modules) Removable joints (incl. those made from non-conventional materials, whilst maintaining quality of joints) Wall panels, dowels, slot systems etc.
61	Conduct a feasibility study to, if applicable, prioritise renovation, minimise used surface, and minimise the total mass of materials to be used	Conduct a feasibility study to explore possibilities of renovation in order to avoid building new when buildings can be reused Conduct a feasibility study to scan possibilities to minimise the amount of surface used for new built/renovation project Conduct a feasibility study to scan possibilities to minimise total mass of materials used in the project	Feasibility studies in construction projects Statutory requirements for feasibility study Multifunctional green roofs as a possibility to reduce surface use of buildings

		Ensure that results of feasibility study comply with statutory requirements	
62	Construct multifunctional green roofs, façades, and interior elements according to service business model	Assemble multifunctional green roofs, façades, and interior elements properly Ensure that building components are properly assembled as components (e.g. not glueing them or using PUR or KIT for mounting)	Roofs and façades as a service not as a property Modular construction systems and prefabricated modules
63	Install renewable energy technologies in buildings to generate power or heat/cold	Install solar PV panels Install heat pumps	Renewable energy technologies, such as solar panels, heat pumps, waste water heat recovery
64	Maintain and repair multifunctional green roofs, façades, and interior elements in order to maximise lifetime	Maintain and repair multifunctional green roofs, façades, and interior elements (incl. installations and technologies) Renovate multifunctional green roofs, façades, and interior elements to maximise their lifetime	Repair techniques for buildings and installations Renovation techniques Renovation of bio-based materials and greenery
65	Disassemble modular structures from multifunctional green roofs, façades, and interior elements for reuse	Disassemble modular construction systems Write and interpret detachable construction details	Modular construction systems Detachable construction details
66	Rebuild existing (parts of) multifunctional green roofs, façades, and interior elements for a new purpose	Rebuild disassembled buildings Adaptive reuse of existing buildings for a new purpose	Modular construction systems
67	Install measures to use and store energy more efficiently in buildings	Connect elements of systems where heat/electricity is harvested on the roof and stored elsewhere in the building Ensure continuity of insulation in building envelope and pipes.	Types of connected elements in systems for energy storage
68	Apply bio-based, non-critical, non-toxic, and/or reusable products on site whilst maintaining material efficacy	Apply bio-based, reusable, non-critical and/or non-toxic materials at the construction site Enact measures that optimise material use to strive for material efficacy Collect leftover materials	Applications and characteristics of different bio-based materials, what to consider while applying them Alternative forms of concrete Applications of reusable and/or recyclable materials

			General knowledge about measures that optimise material use in construction, such as 3D printing
69	Construct multifunctional green roofs, façades, or interior elements on site	Apply techniques for constructing green roofs, facades, or interior elements	Soil-bound vs. non-soil bound facades Types of planting (e.g. sedum)
70	Apply sensor technology to green roofs and façades (e.g. for predicting maintenance, to facilitate water flow from roof when needed)	Apply sensor technology to green roofs and façades design Capture the right information with technology (e.g. local weather patterns, moisture levels)	Sensor technology for buildings Green roof monitoring
71	Explain the benefits of green and/or multifunctional green roofs, façades, and interior elements in different contexts and situations (e.g. public/private, to building users, industry, or local community)	Explain the benefits of green and/or multifunctional green roofs, façades, and interior elements	Benefits of multifunctional roofs and façades (per function, plus increased benefits when functions are combined)
72	Renovate buildings with the use of multifunctional green roofs, façades, or interior elements to extend lifetime of current building stock	Examine opportunities for applying multifunctional green roofs, façades, or interior elements Apply design of multifunctional green roofs, façades, or interior elements to renovation projects	Types of multifunctional roofs and how to combine functions in design
73	Organise logistics and storage of secondary materials, whilst aiming to reduce waste	Collaborate with resource hub(s) Include data and knowledge about materials in passports Prioritise local storage and distribution Prepare detailed planning of materials Order materials just in time Avoid overlong on site storage of materials	Resource hubs/ material banks
74	Source local and lightweight materials for multifunctional green roofs, façades, and interior elements if possible	Source local and lightweight materials	How to work with resource hubs or materials banks
75	Provide documentation as guideline to use the multifunctional green roofs, façades, and interior elements properly in order to stretch its lifetime	Provide information about how and when to maintain the roof, facade, or inner wall Create guide for building users Explain the importance of maintenance of greenery	When and how built structure at hand needs regular checks and repair Any kind of documentation as guideline for users
76	Operate multifunctional roofs in a clever manner that suits the current situation best, looking further than solely the original design to optimise sustainability and circularity	Operate multifunctional roofs while considering post occupancy evaluation, changes in use, and the search for energy and material savings during operation Adapt operation of roof to changes in use and context	Post Occupancy evaluation (incl. evaluation during use phase of building) Options for energy and material savings during operation

77	Conduct post occupancy survey and analysis for building with multifunctional green roof, façades, or interior element	Conduct post occupancy survey and analysis - To be specified	The importance of post occupancy survey and analysis (also during operation) The purpose of post occupancy survey and analysis (to provide feedback to design practices of design professions)
78	Assess quality of materials to be reused from multifunctional green roofs, façades, and interior elements (audit of waste)	Conduct effective end-of-life assessment about used materials Make decision about reuse of materials Share feedback about quality to constructor and architect Distinguish between high-quality and lower-quality reuse	If applicable, connect end-of-life assessment to purpose of the building the materials are to be used for
79	Trade secondary materials and products on digital marketplaces	Employ (regional) digital marketplace to trade used construction materials that have been selected for reuse Use and apply the data and insights from multifunctional green roofs, façades, and interior elements material passports	How to use digital marketplaces to sell (transformed) used materials
80	Redefine building regulations to incentivise circular approaches to multifunctional green roofs, façades, and interior elements	Redefine building regulations to incentivise circular approaches to multifunctional green roofs, façades, and interior elements	How existing building regulations interact with circular approaches
81	Comply design of multifunctional green roofs, façades, and interior elements with applicable (national/local/EU) legal requirements	Comply with applicable legal requirements	What are the relevant legal requirements (e.g. CPR, functional requirements of building walls) National and regional legal requirements
82	Organise and provide insurance and guarantees for reused materials to buyers	Organise insurance and guarantees for reused materials Provide insurance and guarantees for reused materials	Material passports and digital marketplaces
83	Increase (access to) understanding of biobased construction materials for applications to multifunctional green roofs, façades, and interior elements	Conduct research about quality and characteristics of biobased materials Feedback material research results to established construction requirements Experiment with materials to innovate and discover new sustainable methods of construction Develop new prototypes of multifunctional roofs and facades Improve tailored solutions for multifunctional roofs and facades with the focus on effectivity, multifunctionality and circularity	Construction requirements
84	Use drones and imaging technologies to collect data about roofs or facades for renovation purposes	Use drones and imaging technologies to collect data about building and analyse roofs and facades for required renovation	Drones and imaging technologies for collecting data in construction projects

Appendix C

Table 13: Training Plan 1, Starting Circularity

STARTING CIRCULARITY	TP1			24 hours		
Contents	ULO's	Format for contents	Training methodology	Minimum Time	Cost qual.	Evaluation
COMMON MODULE						
Module 1. INTRODUCTION TO CIRCULAR ECONOMY IN CONSTRUCTION				6 h	€	
8 Key principles of circular economy	All	Reading material + quizzes	8 Microlearning courses			
Circularity definition and different flows: Materials, energy, waste and water	51	Videos /schemes	Information pills	5 min		
PLAN						
MATERIALS & WASTE				6:20 h	€€	
Module 2. STRATEGIES OF CIRCULAR DESIGN IN MATERIALS				5:40 h	€€	
Main strategies related with materials in circular construction	51	Reading material	Information pills			
DESIGN TO CLOSE THE LOOP OF MATERIALS: 1 Case study to choose from renewable materials (bio-based): wood structure, cork exterior isolation, straw bricks, rammed earth or bio "concrete"(hemp)	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO CLOSE THE LOOP OF MATERIALS: 1 Case study : recycled aggregates in concrete, recycled cotton isolation, steel, aluminium windows, etc.	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO CLOSE THE LOOP OF MATERIALS: 1 Case of study in reuse of materials in national level if possible: close loop, high quality reuse	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO REDUCE IMPACT: LOCAL, LOW IMPACT AND/OR NON-CRITICAL MATERIALS: 1 Case study of low impact materials: at least one material not repeated and preferably biobased and/or local	1, 2, 3, 4, 36	Video	Information pills	5 min		
DESIGN TO REDUCE IMPACT: NON-TOXIC MATERIALS: Types of non-toxic construction materials (alternatives to anti-flame retardants used on wood, low formaldehyde panels, COV's free paints, etc)	4	Video	Information pills	5 min		
DESIGN TO REDUCE WASTE IN SITE AND IN EOSL: 1 Case of products demonstrations of modular and/or prefabricated (dry solutions) to deconstruct	26	Video	Information pills	5 min		
DESIGN TO REDUCE WASTE IN SITE AND IN EOSL: 1 Case study of renovation (showing savings versus NB) + Subsides or incentives EU or national.	45	Video	Information pills	5 min		
2 Products demonstration	1, 2, 3, 4, 26, 36	Visual presentation	Demonstration of circular products	3 h		

Maintenance plan example	11, 17,42, 64, 68	Reading material	Information pills	extra material		
1 Visit with detective game to a different case study (from list)	1, 2, 3, 4, 26, 36, 45, 64, 68	Visit + quiz	Visit + "detective games"	2 h		
Module 3. TOOLS TO SUPPORT CIRCULAR DESIGN IN MATERIALS				40 min	€	
How to read an EPDs	36	Video	Information pills	5 min		
2 Cases study: two EPD's to compare (one high impact like plastic element and other low impact)	36	Reading material	Information pills	10 min		
Material Circularity Indicator	1	Reading material	Information pills	5 min		
How to read material passports and its use	47	Example	Digital / self-led	5 min		
2 Cases study: examples of LCA assessment (one new building, other renovation)	25	Videos	Information pills	10 min		
BIM modelling applications to building to aid circular applications	57	Video	Information pills	5 min		
ENERGY				3:30 h	€€	
Module 4. DESIGN TO REDUCE ENERGY DEMAND				3:00 h	€€	
1 example with climate consultant analysis of 2 different climates and main strategies of psychometric chart	9,1	Video	Information pills	10 min		
1 case study with design strategies for hot climates or hot season (can be historical examples)	9,10, 56	Video	Information pills	10 min		
1 case study with design strategies for cold climates or cold season (can be historical examples)	9,10, 56	Video	Information pills	10 min		
1 Visit with detective game to a case study with cool and hot bioclimatique strategies and PV panels	56, 63	Visit + quiz	Visit + "detective games"	2 h		
Module 5. TOOLS TO SUPPORT ENERGY EFFICIENT DESIGN / DIGITIZATION				30 min	€	
Software for energy simplify models (National energy certifications, CE3x, etc)	26	Video	Information pills	15 min		
1 practice with Tools such as R10 from IVE for renovation, triplea-reno to get some initial advice	54	Exercise	Digital tool self-led	15 min		
WATER				30 min	€	
Module 6. DESIGN TO REDUCE WATER CONSUMPTION				10 min	€	
1 Case study (national level) of Harvesting greywater and rainwater	6,7	Video	Information pills	3 min		
1 Case study (national level) of purify water with Plant-based biofilters	7	Video	Information pills	2 min		
1 Case study (national level) of draining pavements for public spaces or green roofs/facades	6, 27	Video	Information pills	5 min		

Module 7. TOOLS TO SUPPORT WATER EFFICIENT DESIGN / DIGITIZATION				20 min	€	
1 practice with tool with tips for reducing water consumption (Drive 0)	6,7, 27	Exercise	Digital tool self-led	20 min		
PROCURE						
MATERIALS & WASTE				5 h	€	
Module 8. BANKS AND CERTIFICATION FOR MATERIALS				40 min		
Green building certification systems (LEED, BREAM, DGNB, VERDE, even Level(s)): materials credits/objectives focus	80	Video /simplify guide	Information pills	10 min		
List of materials with Ecolabels	38	List /web	Digital / self-led	5 min		
How to read material passports	47	Reading material	Information pills	10 min		
How to use digital marketplaces to find or to sell (transformed) used materials	79	Reading material	Information pills	10 min		
Examples of marketplaces (existing online platforms or physical local stores) of reuse materials in national level	48	List /web	Digital / self-led	5 min		
Module 9. BUSINESS MODELS				4:20 h		
Strategies for providing building components as a service (e.g., installation company ensures good indoor climate and remains owner of installations)	42	Reading material	Information pills	5 min		
Leasing models and Rental models	44	Video /manual	Information pills	10 min		
Options for multi-use, sharing of spaces rather than ownership	44	Video	Information pills	10 min		
1 case study of co-housing or multi-use	44	Optional visit + quiz	Visit + "detective games"	2 h		
Buildings and product as a service not as a property	42, 43, 44	Video	Information pills	5 min		
Strategies for promoting greater circularity in your company	35	Presentation + contest	Workshop contest	1:30 h		
Examples of European regulations requiring it (new circular economy legislation, embodied carbon for GP) and limit values	25	Reading material	Information pills	20 min		
EoSL						
MATERIALS & WASTE						
Module 10. USE SECONDARY RESOURCES				2 h		
2 case study: recycled secondary materials/components from other industry (1) and from the same (1)		Video	Information pills	10 min		
Collaborate with industry peers to create joint value and identify synergies - Industry Symbiosis (best practices or tool from SYMBIOSI)	34, 35	Video, tool	Information pills, Digital tool self-led	20 min		
1 visit to plant of best practices in transforming recycling materials (recycling aggregates for concrete)		Visit	Visit case study	1:30h		

€ Range of expected module cost, with range from €, very low to €€€, higher cost

Individual insignia / rewards when the module is finished (individual)

Conducted visit to a case study (groupal)

Visit a case study with "detective game"(groupal)

Serious game - trivial quiz (groupal)

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