Circular economy in the construction industry – BUS-GoCircular project

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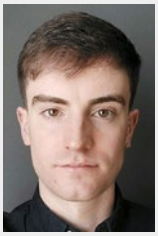

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The construction industry, notorious for waste and emissions, is shifting gears towards a circular economy. Even the new EPBD recast proposal emphasises the circular economy as a necessary approach. Explore BUS-GoCircular project, redefining construction practices. Discover how this initiative, driven by a groundbreaking qualification framework, revolutionizes skills and resources to reshape the industry's sustainable future.

Keywords: Circular economy, Construction industry, Sustainability, Qualification framework, EPBD recast proposal, Circular construction skills, Training programs

INTRODUCTION

The circular economy is an approach that is an essential part of sustainable development. It is obvious that the current linear approach (take-make-waste) is in direct conflict with sustainability [1]. In the current economy, we take materials from the earth, make products from them, and eventually throw them away as waste - the process is linear. In a circular economy, on the other hand, waste ceases to be generated [2]. The circular economy aims to maintain the value of products, materials and resources for as long as possible in the economic cycle and return them to the production cycle at the end of their life, while minimising waste generation [3].

The circular economy has the potential to tackle climate change and other global issues such as biodiversity loss, waste and pollution by decoupling economic activity from the consumption of scarce resources.

The circular economy is based on three principles:

- Eliminate waste and pollution
- To ensure the circulation of products and materials (with their highest value)
- To regenerate nature

By supporting the transition to renewable energy and materials, the circular economy is a resilient system that benefits business, people and the environment [2].

CIRCULAR ECONOMY IN THE CONSTRUCTION INDUSTRY

The construction sector consumes almost half of the world's extracted materials annually and contributes significantly to greenhouse gas emissions.

During their lifetime of operation, buildings are responsible for 40% of EU final energy consumption, and 36% of greenhouse gas emissions. The embodied emissions from the rest of the building life cycle are estimated to contribute at least a further 10% [4]. More than 50% of all extracted materials [5] are attributed to buildings, while construction is responsible [6] for around 2.3 billion tonnes of waste generated per year in the EU, or 36% of the total [7].

The way we design, build, and ultimately demolish is rooted in a linear "take-make-waste" economy. By applying circular economy principles to the design of buildings, infrastructure and other elements, we can reduce greenhouse gas emissions while creating urban areas that are more liveable, productive and comfortable. The circular economy has the potential to reduce global CO_2 emissions from building materials by reducing demand for steel, aluminium, cement and plastic. It could also make the sector more resilient to supply shortages and fluctuations in raw material prices.

By using new technologies and innovative business models, we can increase the value of our buildings if we rethink the way we design them. This will keep resources and building materials economical and prevent them from becoming waste.

Policy makers at all levels of government, investors and construction clients (developers, infrastructure operators and building owners) are key players in the transition of the construction sector to a circular economy. Policymakers can use policy levers such as public procurement to stimulate demand for circular solutions and facilitate the emergence of public-private partnerships. Investors can engage in public-private partnerships to develop circular projects, encouraging research into new techniques that eliminate structural waste and preserve or enhance value. Clients in the building industry can support public-private partnerships to develop circular projects and develop a fact base demonstrating the value of the circular economy in the built environment [8].

The circular economy is one of the recognised principles for ensuring a sustainable future and the question is how to bring it into the construction sector in the most effective way. A problem that may slow down or limit the successful application of this principle is the lack of a skilled workforce across all levels and professions in this sector. This issue is addressed in the European H2020 project BUS-GoCircular. The aim of the project was to map the situation in the European construction industry in terms of circular skills, to develop a task-based qualification framework and to produce learning materials that would be freely available to the general public.

CIRCULAR CONSTRUCTION SKILLS QUALIFICATION FRAMEWORK

Task-based qualification framework of circular construction skills is built on the idea of key elements of circular economy that defines most of the concepts associated with the circular economy.

Key elements of circular economy

According to [9], 8 key elements need to be addressed for a successful application of the circular economy. The following three are the most basic and supporting elements:

I. Prioritizing renewable resources: striving to ensure the efficient use of renewable, reusable and non-toxic sources of materials and energy.
II. Preserving and extending what is already produced: While resources are in use, they are maintained, repaired and upgraded to maximise their lifetime and, where appropriate, give them a second life through take-back strategies.
III. Resource recovery: Using waste streams as a source of secondary raw materials and for re-use and recycling.

In addition to the three basic elements, five supporting elements can be defined:

i. Design for the future: the design needs to take a system perspective, use the right materials, design for durability and design for long-term future use.
ii. Collaboration to create shared value: Collaboration across the supply chain, internally with-in organisations and with the public sector to increase transparency and create shared value.
iii. Rethinking the business model: Consider opportunities to create more value and align incen-tives that build on the interaction between products and services.
iv. Incorporate digital technologies: Enable to monitor and optimise resource use and strengthen links between supply chain actors through

digital, online platforms and technologies that provide information.

v. Strengthening and developing knowledge: Developing research, structuring knowledge, fos-tering innovation networks and disseminating results fairly are essential.

The supporting elements support the application of circular economy by removing some of the barriers to the basic elements - for example, the use of waste as a resource is difficult to implement if products have not been designed with possible recycling in mind - so design for the future is a supporting element. Product life extension can be enabled through new business models such as rental and resale [9].

Built environment value chain

Task-based qualification framework also takes into account that in the built environment value chain where there are different roles within the different stages of the building. Based on [11] following stages are considered:

Table 1. *Example of key core element, its applications to circular construction and affected professions in different stages according to [10].*

Core key element	Strategy group	Approach to circular construction
Prioritise regenerative resources	Regenerative water	Use grey water for certain applications (e.g. washing)
		Use Plant-Based Biofilters to Purify Household Wastewater
		Sustainable water technology
		Collect and reuse water in humid interior areas, e.g. cellars
		Cascading of water

Plan	Procure	Construct	Operate	EoSL
architect, designer, plumber, electrical installer and technician	procurement officer, project developer	plumber, electrical installer and technician, roofer, gardener (roof and façade), interior planter, arboriculturalist horticulturist	building management, plumber, gardener (roof and façade), interior planter, arboriculturalist horticulturist	demolition/ deconstruction labourer, site analyst, deconstruction auditor, urban miner

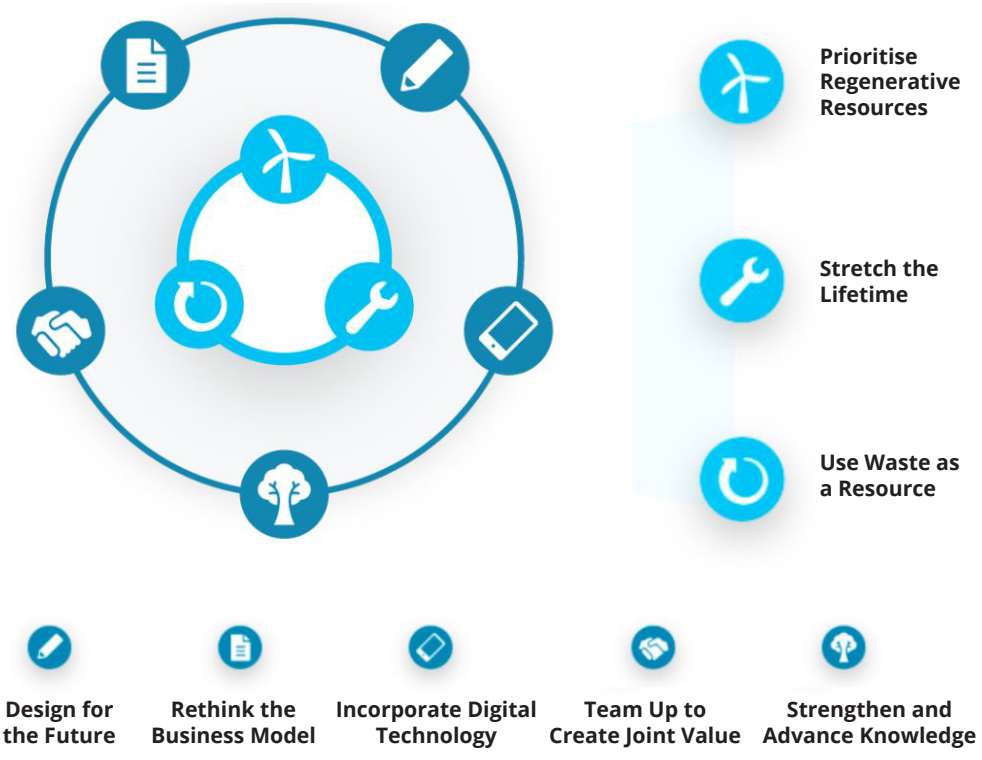

Figure 1. The key elements of the circular economy. [10]

1. Plan: design and commission (new and existing buildings);
2. Procure / source: materials, products and services (new and existing buildings);
3. Construct: build and fit-out (new buildings);
4. Operate: maintain, renovate and manage (existing buildings);
5. End of service life (EoSL): Deconstruct, dismantle, repurpose, sort and process
6. Governance: ambition setting through policy and standards, and compliance

The sixth point doesn't represent stage, but greatly influences attitudes to building projects.

BUS-GoCircular Qualification framework

The qualification framework for the application of circular economy principles consists of 9 main tasks and each task is further divided into 8-10 sub-tasks. For each sub-task, the profession that can implement the principle in its activities is also indicated (e.g. architect, civil engineer, plumber, roofer) by its abbreviation (e.g. AR, CE, P, R). For each sub-task, 'Units of Learning Outcomes' (ULOs) are further defined, where each unit is described by competence, skills and knowledge. Information on which professionals are needed for each subtask is added. By linking the sub-tasks to the corresponding professions, it can be decided which learning objectives the members of the profession should have and therefore which learning outcomes should be obtained.

The Qualification Framework is one of the significant outputs of the project in its comprehensiveness and scope and is freely available on the project website. In addition to providing an orientation on the issues, it can help to define the necessary competences/knowledge for almost any area of the construction industry, and thus tell in which direction to focus further training of relevant professions.

#	Task	Subtask	ULO Nr.	Profession(s)
1	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, El
1.6		Enact water efficiency measures	7, 15	P, Gd, R, El
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

Figure 2. Example of Task 1 and its subtasks, including corresponding ULO numbers and relevant professions from the Qualification Framework. [12]

ULO Nr.	Competence	Skills	Knowledge
1	Design with bio-based materials as an alternative for conventional construction materials	• Select bio-based materials for the construction project at hand • 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 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 compound (VOC) emissions	• Types of bio-based materials in construction such as hemp, seaweed, cork, bamboo, sustainably sourced wood, agricultural residues • Advantages and disadvantages of biobased materials • Seven functional requirements of building walls • Alternative forms of concrete

Figure 3. Example of Unit of Learning Outcomes, consisting of competences, skills, and knowledge components from the Qualification Framework. [12]

Skills mapping

At the same time, the project mapped and analysed the current level of knowledge of circular economy principles among construction workers. To this end, an extensive questionnaire survey was carried out in seven European countries. The questionnaire was based on the areas of the qualification framework and looked at the level of knowledge the respondent feels he/she has in the area and also what the level of knowledge should be for the successful application of circular economy principles in his/her profession. The results of the survey were further discussed and corrected in each country with the help of external advisory boards composed of experts working in the construction sector. The survey shows that there are differences between countries and therefore there is a great potential for the development of training programmes for the whole construction sector within Europe.

OUTPUTS OF THE BUS-GOCIRCULAR PROJECT

Eleven learning modules for trainers

Based on the results of a survey of current and necessary skills and the structure of the qualification framework, the project developed a bank of freely available materials for the development of training programmes. In order to better navigate the available materials, 11 learning modules were created covering 52 skills and 38 occupations in the construction industry.

Training material for public procurers

Another training material aims to help public procurers and policymakers better understand how they can stimulate demand for circular construction skills through public procurement. It is in the form of a presentation and can be used as a self-study tool with links to other resources to learn more about the topic.

BUILD UP Skills Advisor app

Learning outcomes from the framework will also be added to the BUILD UP Skills Advisor app, to further increase skills recognition for professionals and craftsmen. The BUILD UP Skills Advisor app is a free tool for practitioners and craftsmen to look for opportunities for trainings in Europe and some specific EU countries. It also contains a community-managed content repository and can facilitate the use of micro-credentials for personal recognition and lifelong learning.

Training plans and training packages for SMEs

Other outputs of the project are training packages for SMEs. These packages consist of attractive training materials, including different formats, and will be freely available after the project to all organisations wishing to upskill their employees in the circular economy. Four different training plans were drawn up depending on the target groups of different SMEs (**Table 2**).

Table 2. *Designed Training plans overview with target SMEs.*

TRAINING PLAN (TP)		SMEs TYPES
TP1	INITIAL CIRCULARITY	ALL
TP2	CONSTRUCTION WORKS IN CIRCULARITY	• Company specialised in specific material systems – installers • Masonry company • Carpenter (wood) company • Another specific profession (welder, plasterer, plumbers) company • Maintenance company • Building company
TP3	CIRCULARITY IN INSTALLATIONS	• Electrical installation company • Water systems installation company • HVAC installation company • RE installations company
TP4	ADVANCE CIRCULARITY	• Sustainable consulting or engineering, architecture´s office • Public management/governance • Demolition company (or building companies) • Waste management company • Material producer • Waste treatment and recycling company

Each training plan consists of several modules, where the topics, format and possible timing is designed. These materials will be available in English and some of them also in 6 more European languages of the project partners (Spanish, Dutch, Czech, Bulgarian, Hungarian and Croatian). Examples of the designed parts of the training plans can be seen in **Figure 4** and **Figure 5**.

	STARTING CIRCULARITY	TP1		21 hours
Essential profiles	Contents	Format for contents	Training methodology *(from report)*	Minimum Time
	COMMON MODULE			
	Module 1. INTRODUCTION TO CIRCULAR ECONOMY IN CONSTRUCTION			6:10 h
Mandatory	**Key principles of circular economy**			
Mandatory	Prioritise regenerative and efficient use of resources	Interactive reading material + quiz	Microlearning courses	
Mandatory	Design for the future	Interactive reading material + quiz	Microlearning courses	
Mandatory	Assemble/construct for the future	Interactive reading material + quiz	Microlearning courses	
Mandatory	Rethink the business model	Interactive reading material + quiz	Microlearning courses	
Mandatory	Stretch the lifetime	Interactive reading material + quiz	Microlearning courses	
Mandatory	Use secondary resources	Interactive reading material + quiz	Microlearning courses	
Mandatory	Incorporate digital technology	Interactive reading material + quiz	Microlearning courses	
Mandatory	Collaborate to create joint value	Interactive reading material + quiz	Microlearning courses	
Mandatory	Strengthen and advance knowledge	Interactive reading material + quiz	Microlearning courses	
	Circularity definition and different vectors			10 min
	Circularity definition. Materials, energy, waste and water	Videos /schemes	Information pills	

Figure 4. Example of part of the "Initial Circularity" Training plan.

	CIRCULARITY IN INSTALLATIONS	TP3	
Essential profiles	Contents	Format for contents	Training methodology *(from report)*
	CONSTRUCT		
	ENERGY		
	Module 2. INSTALL ENERGY EFFICIENCY MEASURES IN BUILDINGS: PASSIVE		15 min
Mandatory	1 case study with Main passive design strategies for four season climates: crossed ventilation, solar protection, isolation, solar energy-inertia, solar captors to store passive energy, airtightness	Video /schemes	Information pills
	Conduct airtightness test	Video	Information pills
	Module 3. INSTALL ENERGY EFFICIENCY MEASURES IN BUILDINGS: ACTIVE		2:15 h (*6:30h)
Mandatory	Apply smart solutions to installations and manage correctly (termostates, timetibles)	Video	Information pills
	Systems and solutions that make intallations accesible to repair	Reading material/guides	Information pills
	Sectorize installation to be adaptable to changes and reparations	Video/ Reading material	Information pills
Mandatory	Energetic efficient systems that generates heat/cold (heat water pumps, underfloor heating, centralized systems versus individual, waste heat/district heating, etc.)	Video/ Reading material	Information pills
	Efficient lighting systems	Video	Information pills
Mandatory	Regulations related to energy limitations and with regards to energy source	Reading material	Information pills
	Install underfloor heating	Video / Guide	Information pills
	Connection to district heating	Video / Scheme	Information pills
	2 cases studies of underfloor heating + connection to district heating	Video	Information pills
	Optional: 1 workshop of underfloor heating	Visual demonstration + exercise	Workshop practical

Figure 5. Example of part of the "Circularity in Installations" Training plan.

Train the Trainers program

The project also provided a train the trainer programme for people from a wide range of professions working in the education sector. The first training of trainers took place in January 2023 in Prague and was a face-to-face event. Further trainings took place online in June and November 2023. During the course, participants were introduced to the project outputs to date, all available materials and teaching methods. The course also has its interactive part, where future training programmes were created in groups divided by professions. During these three courses, a total of 57 trainers of various professions from 16 countries were trained, who can further disseminate the idea of the circular economy in the construction industry in the form of training targeted at various groups of professionals.

Conclusion

According to the current state of knowledge, the circular economy is one of the strategies leading to a sustainable construction industry. Greater application of circular economy means that less waste will be produced, making it easier to greater reuse and recycling of products and materials at the end of their useful life; and helping to reduce environmental impacts and life cycle costs. However, a properly trained workforce across the construction sector is essential for its implementation.

The results of the BUS-GoCircular project can be found at: https://busgocircular.eu/. ■

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References

[1] Circular Economy & SDGs, How circular economy practices help to achieve the Sustainable Development Goals: https://circulareconomy.europa.eu/platform/sites/default/files/3228_brochure_sdg_-_hch_cmyk_a4_portrait_-_0520-012.pdf.

[2] What is a circular economy? | Ellen MacArthur Foundation, dostupné z: https://ellenmacarthurfoundation.org, cit. 30.11.2023.

[3] Cirkulární Česko - Ministerstvo životního prostředí (mzp.cz), dostupné z: https://www.mzp.cz/cz/cirkularni_cesko.

[4] Impact Assessment for the amendment of the Energy Performance of Buildings Directive, SWD(2016) 414.

[5] IEA, 2019. Material Efficiency in Clean Energy Transitions reports estimates that 10-20% of EU buildings' CO2 footprint represents the embodied carbon.

[6] DG GROW, 2021. https://ec.europa.eu/growth/industry/sustainability/buildings-and-construction_en.

[7] Eurostat, 2018. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics.

[8] Reimagining our buildings and spaces for a circular economy, Ellen MacArthur foundation. https://ellenmacarthurfoundation.org/topics/built-environment/overview.

[9] The key elements of the circular economy - Circle Economy (circle-economy.com), https://www.circle-economy.com/circular-economy/key-elements.

[10] Framework for circular interventions in the construction value chain, https://busgocircular.eu/wp-content/uploads/D2_1_Framework_for_Circular_Economy_interventions.pdf.

[11] Schober, K-S (2021). It's time for construction to embrace the circular economy. Roland Berger. https://www.rolandberger.com/en/Insights/Publications/It%E2%80%99s-time-for-construction-to-embrace-the-circular-economy.html.

[12] Circular construction skills qualification framework, https://busgocircular.eu/wp-content/uploads/D2_3_Circular_construction_skills_qualification_framework.pdf.

[13] Content and methodology proposal "BUS-GoCircular Fundamentals Training Packs", https://busgocircular.eu/wp-content/uploads/D3_4_BGC_Fundamentals_Training_Packs.pdf.