European Commission

Monitoring industrial ecosystems

CONSTRUCTION

Analytical report – 2024 edition

This report was prepared by Daniela Kretz, Laura Lecluyse, and Els Van de Velde, IDEA Consult, Carmen Moreno, Technopolis Group for the European Commission Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs. However, it does not necessarily reflect the views of the European Commission.

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Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Directorate B – Simplification and networks
Unit GROW.B.4 – Industrial Forum, Alliances and Clusters

European Innovation Council and SMEs Executive Agency (EISMEA)
Unit I.02 - SMP/SME Pillar, Internal Market and Support to Standardisation
E-Mail: EISMEA-SMP-COSME-ECOSYSTEMS@ec.europa.eu

European Commission
B-1049 Brussels

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Executive Summary

This report has been prepared within the 'European Monitor of Industrial Ecosystems' (EMI) project with the objective to analysing the green and digital transformation of industrial ecosystems and progress made over time, in this specific case construction.

The second edition of the Industrial Ecosystems series has divided the analysis into two sections meaning, 'green transition' and 'digital transition' followed by three subsections each showing: a) industry efforts, b) framework conditions and c) the impact on the environment and on productivity.

The key findings of this year's analysis are being presented below:

Green Transition

What progress has the industry made in taking action for the environment?

- The share of patent applications within the construction industrial ecosystem related to the green transition ranged from **11% to 21% between 2010 and 2021** in the EU27. These patents are primarily concentrated in key technological areas, including **renewable energy, clean production methods, and advanced manufacturing technologies** such as robotics.

- In 2024, **18% of companies in the construction industrial ecosystem have adopted strategies for climate neutrality, showing a modest commitment**.

- Construction companies have been actively implementing environmental measures with 73% of companies aiming at **measures to minimise waste**, and 72% aiming to save energy in 2024. In addition, measures also aimed at saving materials and water, both being prioritised by 61% of respondents. Progress over time has been limited in recycling and in the use of renewable energy.

- A total of **296 construction industrial ecosystem startups** were created in support of the green transition between 2015 and 2022. In terms of underlying technologies, energy saving technologies report the highest number of construction startups with a total of 175 during the indicated period.

- **25% of construction companies** do not invest in resource efficiency, while 51% of companies invest less than 5% of annual revenue in resource efficiency. The majority of companies **invest less than 1% or between 1 and 5% of annual turnover** in environmental technologies.

- **Venture capital investments** lie predominantly in the area of **renewable energy technologies** over the period 2015-2023, totalling EUR 643 m in 2023.

To what extent do framework conditions such as public financing and skills support the green transition?

- The construction industrial ecosystem received **EUR 105 bn in support from the European Regional Development Fund** for the period 2014-2020. Projects that addressed specifically the **green transition of construction accounted for over EUR 33.7 bn.**

- **66.8% of ERDF related construction projects are directed towards the implementation of projects supporting energy efficiency** renovation of existing housing stock, public infrastructure, and private companies

- Under the **Horizon 2020 programme, EUR 102 million was allocated to projects within the construction industrial ecosystem**, while Horizon Europe has so far provided EUR 45 million, with **62.8% of this funding contributing to the green transition**.

- **Critical skills gaps in the construction industrial ecosystem relate to sustainability, circularity, and energy and resource efficiency.** The share of LinkedIn-registered professionals in the construction industrial ecosystem with green transition-related skills rose to nearly 9% in 2024, up from 6.6% in 2022.

How is the industrial ecosystem's impact on the environment changing?

- The **construction industrial ecosystem is addressing its emissions-related challenges** while continuing to face significant challenges in other environmental areas. 40% of energy consumed in the EU is used in buildings, with over 1/3 of the EU's greenhouse gas emissions stemming from buildings. The bulk of CO_2 emissions comes from consumption, rather than production for the construction industrial ecosystem.

- Construction represents the biggest source of Europe's waste. **The recovery rate for construction and demolition waste stands at 89% across the EU27 with significant differences across Member States.** The recovery rates have not increased significantly in recent years, hence the potential to improve recovery, reuse and recycling is not fully utilised.

- The construction industrial ecosystem accounts for about **50% of all extracted material.** Greater material efficiency could significantly reduce emissions underpinning the interplay between resource and energy efficiency potential related to the construction industrial ecosystem.

Digital Transition

What is the progress of industrial efforts towards digitalisation?

- The share of digital-related patenting activities in the construction industrial ecosystem ranged between **19% and 26%** from 2010 to 2021.

- **29% of companies had a concrete strategy in place for digital transformation** in the construction industrial ecosystem in 2024. The EMI Enterprise Survey revealed an **increase in the uptake of digital technologies** such as cloud technologies, Internet of Things, and artificial intelligence (AI).

- 70% of construction businesses that adopted AI did so within the past two years. **21% of companies use AI in the marketing and sales stage**. AI technology can offer innovative solutions ranging from support for design processes, to solutions related to building performance optimisation and management, energy efficiency and management, and recycling decision support, among others.

- **Startups active in the area of online platforms and AI and big data lead the startup creation** with a total of 413 startups formed between 2015 and 2023.

- **Most construction companies invest less than 5% of their annual turnover in digital technologies,** with AI and big data being the primary focus; however, 12.5% of companies report investing over 30% of their turnover in robotics.

To what extent do framework conditions such as public financing and skills support the digital transition?

- The European Regional Development Fund (ERDF) plays a vital role in the digital transition of the construction industrial ecosystem. Over the period 2014-2020, **about 8% (EUR 4.5 bn) of the funding to construction ERDF projects supported the digital transition.**

- **30.6% of the Horizon 2020 funding to construction projects contributed to the digital transition**. In Horizon Europe 61% of the EU funding to date contributes to construction projects related to the digital transition.

- In 2024, **nearly 8% of professionals registered on LinkedIn and employed within the construction industrial ecosystem possessed advanced digital skills compared to 5.75% in 2022**. This points towards an increased importance of having advanced digital skills in the construction industrial ecosystem.

- **Requirements for digital skills listed on online job advertisements within construction has been growing dynamically over the period from 2019-2023**. 19.2% of the job advertisements included a requirement of advanced digital skill such as **AI, big data, augmented and virtual reality, or cloud**, compared to 32% of the job advertisements requiring moderate digital skills.

What is the impact of digital technologies on competitiveness?

- The integration of **digital technologies** is viewed as a key element **to tackle some of the main challenges** the construction industrial ecosystem is faced with, such as labour shortage, resource and energy efficiency, and productivity. The construction ecosystem is making progress in the uptake of digital technologies, though with different levels of maturity and adoption across technologies and Member States.

- The construction industry puts pressure on the **development of digital technologies** to become more tuned to the industry specific needs. As such, digital technologies have the **potential to make the construction industry more competitive** in the EU in global comparison, while at the same time, those digital technologies can become more competitive through their uptake in the construction industry as well.

- The EMI Enterprise survey of construction companies reveals that the **adoption of advanced digital technologies has increased productivity by 10-15%.** Among the technologies driving this productivity boost, robotics and artificial intelligence were identified by respondents as having the greatest impact.

- Countries as **Spain and Italy** that promote knowledge valorisation of digital and green technologies through strong co-location patterns also **showcase a strong performance in the construction ecosystem** in terms of production, trade and patents.

1. Introduction

1.1. Objectives

This report has been prepared within the '**European Monitor of Industrial Ecosystems' (EMI)** project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA). The overall objective of the project is to **contribute to the analysis of the green and digital transformation of industrial ecosystems** and progress made over time.

The EU's updated industrial strategy[1] has identified 14 industrial ecosystems[2] – one of them being **'Construction'** - that is in the focus of this report. The industrial strategy defined industrial ecosystems as encompassing all players operating in a value chain: from the smallest startups to the largest companies, from academia to research, service providers to suppliers. The notion of ecosystems captures the complex set of interlinkages and interdependencies among sectors and firms across the EU. Industrial transition is driven by technological, economic, and social changes, and in particular by green and digital technologies and the shift to the circular economy. The process is however characterised by complex, multi-level, and dynamic development. To make transition sustainable, technological change needs to be coupled with new business models, the necessary investments, skills, regulatory framework conditions and behavioural change across the ecosystem.

Measuring performance and change is vital to allow policymakers and industry stakeholders to track progress over time and get feedback whether the system is moving in the desired direction. To measure performance, a dedicated **monitoring and indicator framework** has been set up for the purposes of this project with an aim to capture them in regular intervals (see the overview of the monitoring framework in Figure 1).

The indicator framework includes a **set of traditional and novel data sources that allow shedding new light on ongoing transformation patterns.** The novelty of the analysis lies in the exploratory and innovative data sources used across the different chapters. Due to its effort to analyse industrial ecosystems using a more or less standardised set of indicators, the study cannot address all aspects of the green and digital transition. Therefore, additional analysis and industry-specific data sources should be used to supplement a full assessment.

The **methodological report** that sets the conceptual basis and explains the technical details of each indicator is found in a separate document uploaded on the EMI website. Moreover, some of the specific industry codes used throughout this analysis have been also included in Appendix B. The green and digital technologies considered in this study are include the following:

- *Green transition technologies*: advanced materials, biotechnology, clean production technologies, recycling technologies, energy saving technologies
- *Advanced digital technologies*: artificial intelligence, cloud computing, augmented and virtual reality, blockchain, robotics, Internet of Things, digital security

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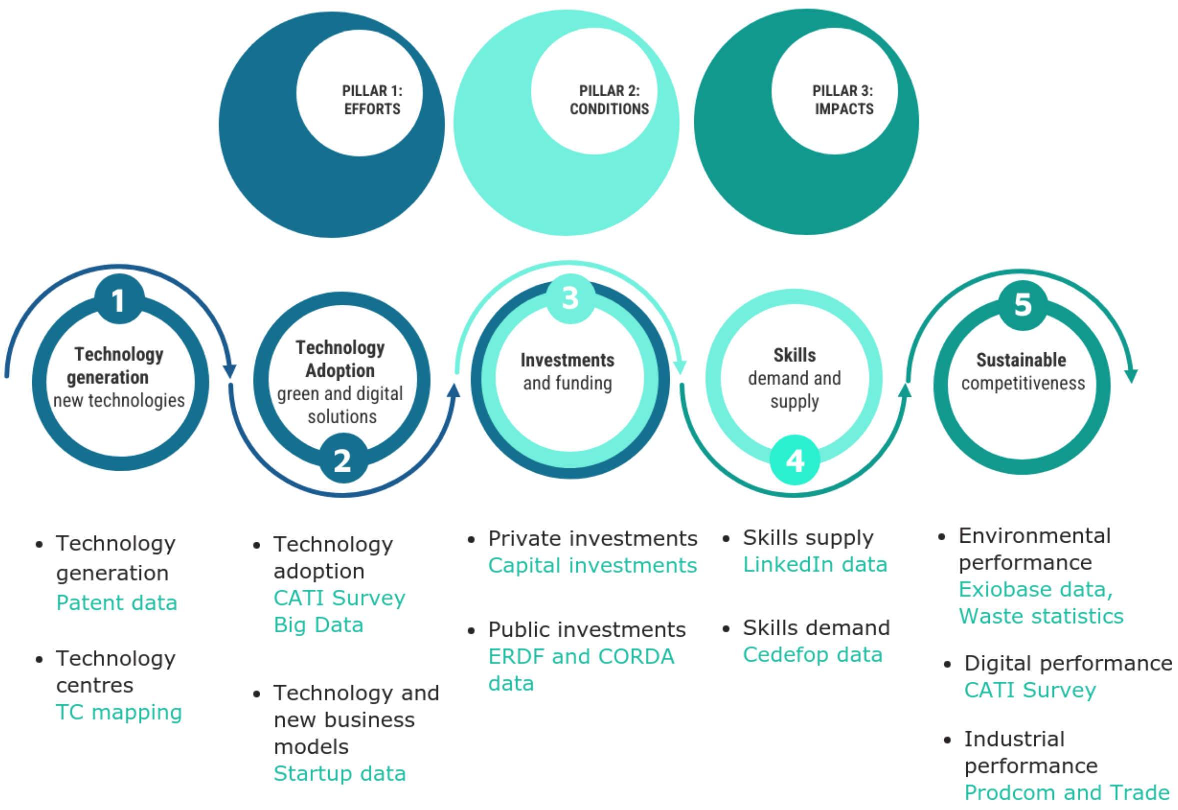
[1] European Commission (2020) A New Industrial Strategy for Europe, COM/2020/102 final and European Commission (2021). Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery, COM(2021) 350 final

[2] The 14 industrial ecosystems include: construction, digital industries, health, agri-food, renewables, energy intensive industries, transport and automotive, electronics, textile, aerospace and defence, cultural and creative culture industries, tourism, proximity and social economy, and retail

Figure 1: Overview of monitoring industrial ecosystems and relevant data sources



Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

This report contributes to the analysis of the **key pillars put forward in the 'Blueprint for the development of transition pathways'**[3] of the Industrial Forum developed in 2022.

The updated EU Industrial Strategy[4] underlines a swift green and digital transition of EU industry and its ecosystems. As a result, each industrial ecosystem must transform its business models and value chains in support of a green, digital, and resilient European economy. The concrete and actionable plans to enable this transition are outlined in the **Transition Pathway for Construction**[5]. The Transition Pathway is developed based on scenarios for the transition pathway (2021)[6], drafted in dialogue with the construction ecosystem and its stakeholders and outlining the main challenges and opportunities for the ecosystem.

Furthermore, this report considers and builds upon other European Commission communication and report with updates on the ecosystem and, in particular, on the European Construction Sector Observatory[7], the observatory that analyses and carries out comparative assessments on the construction sector in the EU and UK. Data and

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[3] European Commission (2020) Task Force 2 – Support to the development of transition pathways. Blueprint for the development of transition pathways for industrial ecosystems. Retrieved from: https://ec.europa.eu/docsroom/documents/49407/attachments/1/translations/en/renditions/native

[4] EUR-Lex (2021) Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions. Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0350

[5] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[6] European Commission (2021) Staff Working Document. Scenarios for a transition pathway for a resilient, greener and more digital construction ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/47996

[7] https://single-market-economy.ec.europa.eu/sectors/construction/observatory_en

information from other European and international agencies, such as the UN Environmental Programme, the European Environment Agency and the World Green Building Council, were also consulted.

1.2. Scoping of the industrial ecosystem

As described in the **Annual Single Market Report 2021**[8], the construction industrial ecosystem includes activities carried out during the whole lifecycle of buildings and infrastructures. As such, it covers the design, construction, maintenance, refurbishment and demolition of buildings and infrastructure (e.g., transport infrastructure). The industrial ecosystem hence covers *"contractors for building and infrastructure projects, some construction product manufacturers, engineering and architectural services as well as a range of other economic activities (e.g., rental and leasing of machinery and equipment, employment agencies)".*

In terms of NACE-classification, the following NACE-codes define the industrial ecosystem:

- Manufacture of furniture (C31)
- Construction (F)
- Architectural and engineering activities; technical testing and analysis (M71)
- Services to buildings and landscape activities (N81)

The data reported abide – to the extent possible - to this ecosystem delineation. Further details on the ecosystem delineation in terms of the NACE sectors as well as information on the coverage of each industrial ecosystems by data source are included in the methodological report. Nevertheless, the methods and industrial ecosystem coverage by data source are also briefly described in the related chapters below.

The construction industrial ecosystem is outlined by a series of key characteristics and traits which also showcase its positioning in the wider landscape. As indicated in the 2021 Staff Working Document on the scenarios for the transition pathway, the construction industrial ecosystem in the **EU employs around 24.9 million people** and contributes EUR 1.16 bn in value added, accounting for 9.6% of the EU's total[9]. This makes it the second most significant ecosystem in terms of employment and value added, surpassed only by the retail ecosystem. The industrial ecosystem is primarily composed of **micro and small enterprises** (SMEs). Out of a total of 5.3 million firms, 99.9% are SMEs, accounting for 90% of employment and 83% of the total value added. Moreover, approximately 90% of these companies are microenterprises[10].

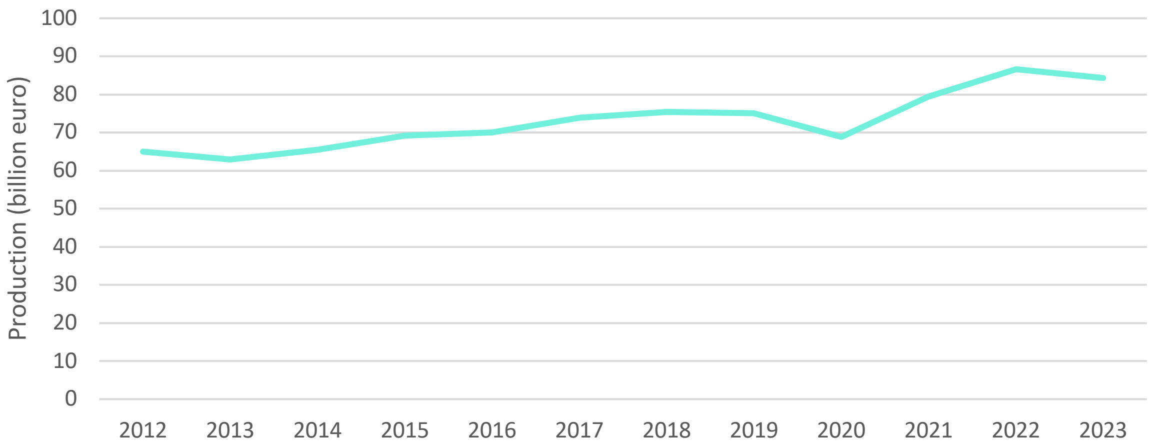
At the same time, the construction industrial ecosystem has a large environmental impact because it generates large amounts of waste while consuming natural resources and energy, as well as emitting large quantities of emissions, and affecting biodiversity and soil.

The total production value for the construction industrial ecosystem gives insight into the production performance of the overall ecosystem. Data on production were extracted from the PRODCOM dataset of Eurostat[11]. PRODCOM statistics reveal the total values of production of manufactured goods conducted by enterprises located in EU27. The construction industrial ecosystem is delineated by the NACE 2 classification based on

[8] European Commission (2021) Commission Staff Working Document. Annual Single Market Report 2021. Retrieved from: https://commission.europa.eu/system/files/2021-05/swd-annual-single-market-report-2021_en.pdf
[9] European Commission (2021) Commission Staff Working Document. Scenarios for a transition pathway for a resilient, greener and more digital construction ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/47996
[10] Idem
[11] Eurostat (2023) Industrial production statistics introduced – PRODCOM. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Industrial_production_statistics_introduced_-_PRODCOM

weights identified in the Annual Single Market Report[12]. Figure 2 presents the weighted sum of production related to the underlying NACE 2-digit level classification used to outline the construction industrial ecosystem (in bn EUR).

Figure 2: Evolution of the production value in the construction industrial ecosystem



Source: IDEA Consult based on Eurostat (prom)

Figure 2 shows an **overall growth in the production value** over the considered period of 2012-2023 with a couple of relapses. In 2020, the COVID-19 pandemic (and related disruptions in the supply chains and decreased demand) caused a drop in the production value. Nevertheless, in 2021 and 2022, the ecosystem showed a strong resurge. In 2023, the production value in the ecosystem is decreasing again, with many construction companies facing difficulties in keeping activities going, given challenges such as volatile costs of materials, increasing energy prices, and inflation. Experts consulted in the context of this study have indicated that these challenges will likely persist for several years, having longer term implications for the production value.

The main challenges facing construction as outlined by the European Commission are[13]:

- **Skills**: A central challenge for the construction industrial ecosystem is to ensure the sufficient availability of skilled labour, whereby securing enough workers with the right skills remains paramount. This related back to the need to foster training to ensure that workers are also sufficiently prepared in the area of emerging and new skills related to the green and digital transition.
- **Green transition and life cycle of construction works**: as an industrial ecosystem producing Europe's largest amounts of waste, enabling the circular economy for this industrial ecosystem is vital, and should include considerations related to recycling and reuse as well as resource efficiency to decrease the demand for virgin raw materials by taking a life cycle perspective on construction works. Buildings are a main source of EU energy consumption, and renovation rates remain low. Energy efficiency as such is also a central priority to future-proof Europe's existing building stock, while ensuring the uptake of latest technologies in new construction.
- **Digitalisation**: Uptake of digital technologies in construction is comparably slow due to the dominance by micro-enterprises, though the potential also linked to the green transition is evident.
- **Crises challenging ecosystem functioning**: The construction sector has been particularly hard hit by the COVID-19 pandemic as well as the subsequent financial and economic crises as a result of the war in Ukraine and energy crisis. The ecosystem may be further challenge by crises such as those related to increasing natural disasters, showcasing further vulnerability of the ecosystem needing attention.

[12] European Commission (2021) Commission Staff Working Document. Annual Single Market Report 2021. Retrieved from: https://commission.europa.eu/system/files/2021-05/swd-annual-single-market-report-2021_en.pdf

[13] European Commission (2021) Commission Staff Working Document. Scenarios for a transition pathway for a resilient, greener and more digital construction ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/47996

2. Green transition

2.1. Industry efforts to green the industrial value chain

What progress has the industry made in taking action for the environment?

- The share of patent applications related to the **green transition within the construction industrial ecosystem ranged from 11% to 21% of total patents** filed in this ecosystem between 2010 and 2021. Patents are concentrated in specific technological fields such as **renewable energy technologies, clean production technologies and advanced manufacturing technologies & robotics**.

- In 2024, **18% of companies in the construction industrial ecosystem have adopted strategies for climate neutrality**, showing a modest commitment.

- Construction companies have been actively implementing environmental measures with 73% of companies aiming at **measures to minimise waste**, and 72% aiming to **save energy** in 2024. In addition, measures also aimed at saving materials and water, both being prioritised by 61% of respondents. Progress over time has been limited in recycling and in the use of renewable energy.

- A total of **296 construction industrial ecosystem startups** were created in support of the green transition between 2015 and 2022. In terms of underlying technologies, **energy saving technologies** report the highest number of construction startups with a total of 175 during the indicated period.

- **25% of construction companies** do not invest in resource efficiency, while 51% of companies invest less than 5% of annual revenue in resource efficiency. The majority of companies **invest less than 1% or between 1 and 5% of annual turnover** in environmental technologies.

- **Venture capital investments** lie predominantly in the area of **renewable energy technologies** over the period 2015-2023, totalling EUR 643 m in 2023.

This section reports first on the progress of firms within the industrial ecosystem towards the green transition, focusing on the adoption of environmental technologies and circular business models. It also analyses how startups and young companies that provide environmental solutions exclusively in construction contribute to the transformation of the industrial value chain. Moreover, it examines the level of investment by construction companies in the green transition including green technologies, renewable energy, and circular economy solutions.

2.1.1. Technology generation

Technology generation is defined both in terms of patenting activity and in terms of startup formation, based on the methodological framework. The following subsections detail the situation for patenting and company creation based on own and novel analyses executed.

Patents

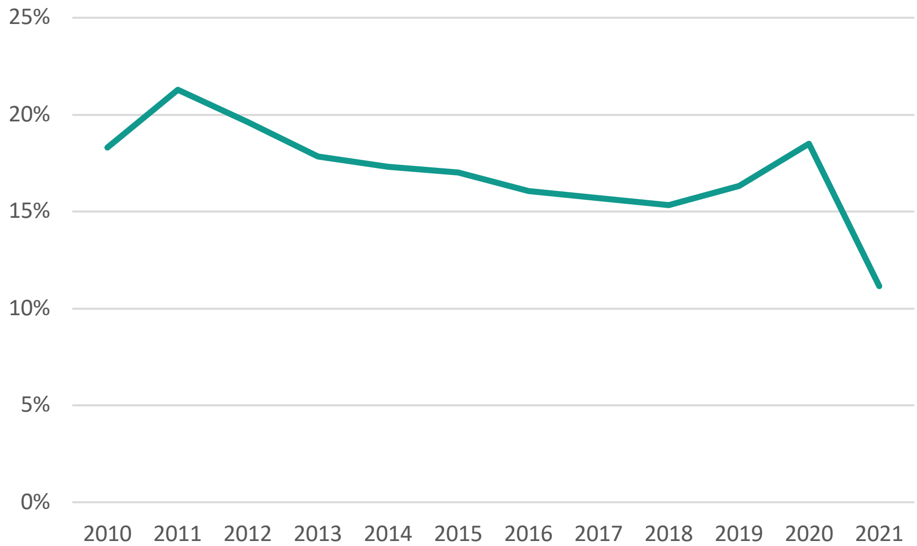
Patent applications in the construction industry are used in general to protect an innovative feature of a new building, structure or component for instance related to alternative construction methodologies or green building. In the construction industrial ecosystem, patenting is driven by major players that dominate the market globally.

In this report, technology developments through patents have been captured for the construction industrial ecosystem based on the patenting activities related to the specific sectoral activities as outlined in the NACE classification of the Annual Single Market Report

2021 and based on patent-based classifications. The analysis is based on 'transnational patents' (Frietsch/Schmoch, 2010) (i.e. PCT/WIPO filings or direct applications at the EPO, excluding double counts) and was conducted on an extended version of the EPO's Worldwide Patent Statistical Database that Fraunhofer ISI implemented locally. Technologies relevant to ecosystems, in this case the construction industrial ecosystem, are defined based on a search that refers to patent classifications (IPC) and/or use keywords to identify relevant applications across classes. The detailed methodology is presented in the EMI methodological report[14].

Looking at the technologies related to the green transition as presented in the methodological framework, Figure 3 presents the share of all greening patents in all patents filed for the construction industrial ecosystem among the EU27 industrial ecosystems overall. Figures of between roughly 11% and 21% over the period 2010 to 2021 are generally well aligned with the expected figures for the ecosystem. A steady decline is observed until 2018, after which an increase appears, culminating in 2020, which coincides with the COVID-19 pandemic. This can, in part, be attributed to an increase in the importance of green patents as a result of the European Green Deal, but also to a relatively higher share of patenting during the COVID-19 pandemic related to the construction industrial ecosystem overall. This trends generally aligns with figures reported for 2020 (as increasing trend) and the drop in 2021 (as a decreased trend) in terms of patents filed[15].

Figure 3: Share of greening patents in all patents filed for the construction industrial ecosystem among the EU27 industrial ecosystems overall

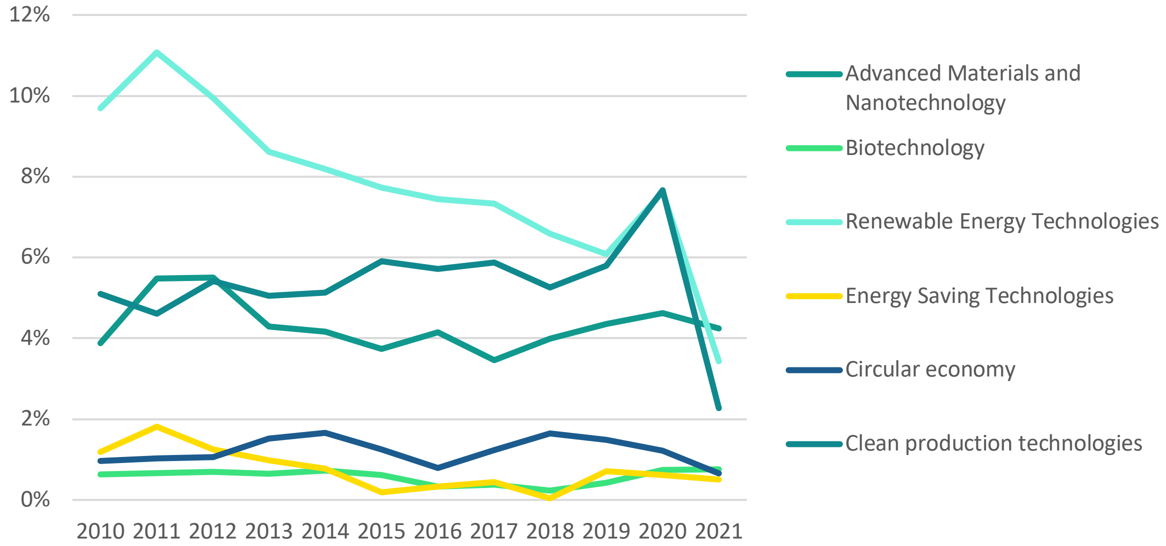


Source: Fraunhofer based on PATSTAT

In terms of which green technologies underpin these patenting activities, these are made up of renewable energy technologies, clean production technologies and advanced manufacturing technologies & robotics as the three leading technologies for the construction industrial ecosystem in terms of patenting activities (see Figure 4). A sharp decline as observed above for 2021 appears to be largely related to a decline in patenting related to renewable energy technologies and clean production technologies.

[14] https://monitor-industrial-ecosystems.ec.europa.eu/about/monitoring-framework
[15] World Construction Network (2024) Q2 2024 update: patent activity in the construction industry. Retrieved from: https://www.worldconstructionnetwork.com/data-insights/patent-activity-construction-industry/?cf-view

Figure 4: Share of respective green transition technologies in overall patents filed in the construction industrial ecosystem



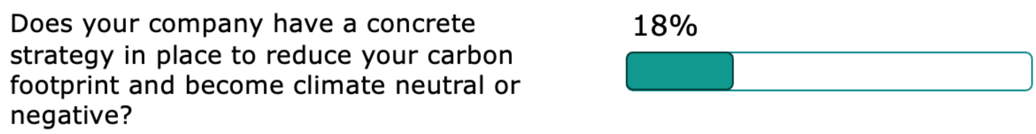
Source: Fraunhofer based on PATSTAT

2.1.2. Uptake of green technologies and solutions

The adoption of technologies and circular business models in the construction industrial ecosystem was analysed in detail by the 2024 Eurobarometer and further supported by a CATI survey from the EMI project, conducted between July and September 2024 with a sample of 630 construction firms.

According to the Eurobarometer 2024 survey results, 18% of companies have a concrete strategy to reduce carbon footprint or become climate neutral or negative.

Figure 5: Share of companies in construction industrial ecosystem that has adopted strategy to reduce carbon footprint



Source: Eurobarometer survey 2024

In terms of adoption of green measures, as depicted in Figure 6, **73% of companies aimed at measures aiming to minimise waste, with 72% aiming to save energy in 2024**. In addition, measures also aimed at saving materials and water, both being prioritised by 61% of respondents in 2024. Progress over time has been limited most relevant in recycling and in the use of renewable energy.

Figure 6: Share of firms indicating the adoption of environmental measures

Environmental measures	***Share of adoption (2021)***	***Share of adoption (2024)***
Minimising waste	71%	73%
Saving energy	71%	72%
Saving water	63%	61%
Saving materials	63%	61%
Recycling, by reusing material or waste within the company	49%	52%
Switching to greener suppliers of materials	43%	42%
Designing products that are easier to maintain, repair or reuse	30%	33%
Selling your residues and waste to another company	27%	25%
Using predominantly renewable energy	22%	28%

Source: Eurobarometer survey 2024

As a result of these actions, 29% of the companies observed decreased production costs, while for 38% of the companies, the production costs increased. This suggests that for over a third of the construction companies, the transition to greener practices may initially involve higher investments or operating costs, which could challenge their competitiveness, at least in the short term. However, the long term effects could still offer potential competitive advantages, as well as compliance with regulations, and alignment with consumer preferences for sustainability[16]. Consequently, within the next two years, saving energy, minimising waste, saving materials, saving water and recycling are areas where more than 40% of construction companies are planning to dedicate additional effort[17].

In addition to measures aimed at improving resource efficiency and supporting climate neutrality, construction enterprises have also directly implemented specific green technologies. The EMI survey indicates that **42% of construction companies invested in energy saving technologies**.

Figure 7: Adoption of green technologies by companies in construction

Green technologies	***Share of adoption***
Energy saving technologies	42.49%
Advanced materials	23.32%
Waste management technologies	20.73%
Clean production technologies	16.58%

Source: EMI Enterprise survey 2024, n=624

The efforts of companies in relation to the green transition of construction industrial ecosystem are focussed on the following technological areas, building upon the

[16] For example, Hermundsdottir, F., & Aspelund, A. (2021) Sustainability innovations and firm competitiveness: A review. Journal of Cleaner Production, 280, 124715. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0959652620347594

[17] Eurobarometer survey, 2024

technologies outlined in the methodological framework, while also allowing for ecosystem-specific interpretation. These include:

- Recycling technologies
- Energy saving technologies
- Renewable energy technologies

Although the green and digital transition of the construction industrial ecosystem are intertwined, this report sets out to explore the transition and technological developments thereunder independently.

Recycling technologies

The construction industrial ecosystem is responsible for generating a large amount of waste. Several novel technologies have emerged that support the recycling of construction materials. Due to the large variety in the materials that emerge from construction and demolition waste, varied recycling technologies are applied in order to extract the maximum value through recycling. These include both mechanical recycling (crushing, separation, melting, reforging, etc.) and chemical recycling (as is the case for plastics) depending on the underlying material. Examples include recycling of concrete and bricks for use as aggregates in further construction, as well as recycling of gypsum for use in plasterboard or further gypsum production, among others [18].

Energy saving technologies

Energy Saving technologies are a key technology for the green transition of the construction industrial ecosystem. They refer to innovations and practices aimed at reducing energy consumption and improving efficiency in building design, construction, and operation. The focal areas therein include the development of solutions for homes in residential settings but also for businesses[19].

These technologies encompass a wide range of practices, such as installing energy-efficient heating, ventilation (e.g., energy recovery ventilation), air conditioning systems, including heat pumps[20]. Nevertheless, heat pumps still only meet 10% of the global heating demand in buildings. Heat pumps are considered a crucial technology to reduce energy consumption and for heat decarbonisation, as the performance levels of domestic heat pumps can be up to 400% efficient.

Other energy saving technologies that are deployed include[21], amongst others, energy-efficient architecture (e.g., passive design); installing energy-efficient lighting technologies like LEDs, daylight harvesting systems, and smart lighting systems (by using sensors), (green) insulation, high-performance windows, water-efficient fixtures; developing and implementing smart building management systems for efficient energy management; and developing and implementing smart systems for monitoring, analysing and optimising building energy usage (e.g., smart thermostats).

Further technologies taken into consideration under the energy saving technologies also include green roofs[22] that offer a natural cooling effect by facilitating evapotranspiration, which helps mitigate the urban heat island effect as well as cool roofs that are engineered to reflect more sunlight and absorb less heat than traditional roofing materials, playing a

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[18] Joint Research Centre (2023) Techno-economic and environmental assessment of construction and demolition waste management in the European Union. Retrieved from: https://data.europa.eu/doi/10.2760/721895

[19] European Commission (2023) Monitoring the twin transition of industrial ecosystems – construction. Analytical report. Retrieved from: https://monitor-industrial-ecosystems.ec.europa.eu/sites/default/files/2023-12/EMIConstructionindustrialecosystemreport.pdf

[20] United Nations Environment Programme (2024) Global Status Report for Buildings and Construction: Beyond foundations: Mainstreaming sustainable solutions to cut emissions from the buildings sector. Nairobi. https://doi.org/10.59117/20.500.11822/45095

[21]Neurojcet (2023) Top 24 Sustainable Construction Technologies in 2024. Retrieved from: https://neuroject.com/sustainable-construction-technologies/

[22] Idem

crucial role in reducing building temperatures and conserving energy. In addition, construction machinery (e.g. diggers, drills etc.) in undergoing an important transition from diesel to electric machines, which enables both energy saving, but also encompasses the transition of manufacturing equipment, and the uptake of electrification in the aim of improving energy savings but also reducing carbon emissions from construction sites. The Big Buyers initiative has done work on zero emission construction sites in this regard[23].

Renewable energy technologies

Renewable energy technologies are also among the most dominant focal areas in the green transition for the construction sector. To a large extent, these technologies are covered under the renewable energy industrial ecosystem, however the focus in including them as a technology for the construction industrial ecosystem lies in their installation and interrelationship with the design and constructed works. Key technologies in this regard include:

- **Solar Photovoltaic (PV) Systems** have a wide range of applications, from small residential roof-top systems up to utility-scale power generation installations. Crystalline polysilicon remains the dominant technology for PV modules, with new (more) efficient designs expanding their market shares (e.g., Passivated Emitter and Rear Cell, TOPCon, and heterojunction)[24]. Another important advancement is the integration of solar cells directly into building materials. Roofing tiles, facades, and even windows can now be equipped with solar panels, offering an aesthetically pleasing and efficient sustainable energy solution.
- **Wind technologies and turbines** are increasingly used as a renewable energy source to power the construction industrial ecosystem. Wind energy accounted for over one-third (37.5%) of the total electricity generated from renewable sources in the EU in 2022[25]. Not only is wind power cleaner than traditional fossil fuels, but it can also lower operational costs of construction firms in the long run. As such, wind turbines can be installed one or nearby construction sites to generate electricity. Also, small-scale, **micro wind turbines** can be installed on rooftops to foresee a building of power or fed into the grid. These installations are becoming increasingly popular, both in residential and commercial settings. Another way to use wind power for buildings is to design the building itself as a wind turbine, or to incorporate wind turbines into the building envelope, i.e., **building-integrated wind turbines**. Power for buildings can also be purchased from off-site wind farms and excess electricity can be stored in batteries.

2.1.3. Environmental startups in construction

Entrepreneurial activity plays a critical role in accelerating the diffusion of technologies within industrial ecosystems. Startups offering green solutions serve as significant signs of how these ecosystems are evolving to meet environmental sustainability objectives. The emergence and growth of such enterprises reflect a broader transformation within the industrial landscape, as these innovative startups not only introduce new technologies but also drive the adoption of sustainable practices across the sector.

A total of **296 construction industrial ecosystem startups** were created in support of the green transition between 2015 and 2022[26]. However, as presented in Figure 11, a

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[23] European Commission (2023) Introducing EC's new Public Buyers Platform. Retrieved from: https://green-business.ec.europa.eu/news/introducing-dg-grows-new-public-buyers-platform-2023-05-19_en

[24] International Energy Agency (2023) Tracking Solar PV. Retrieved from: https://www.iea.org/energy-system/renewables/solar-pv

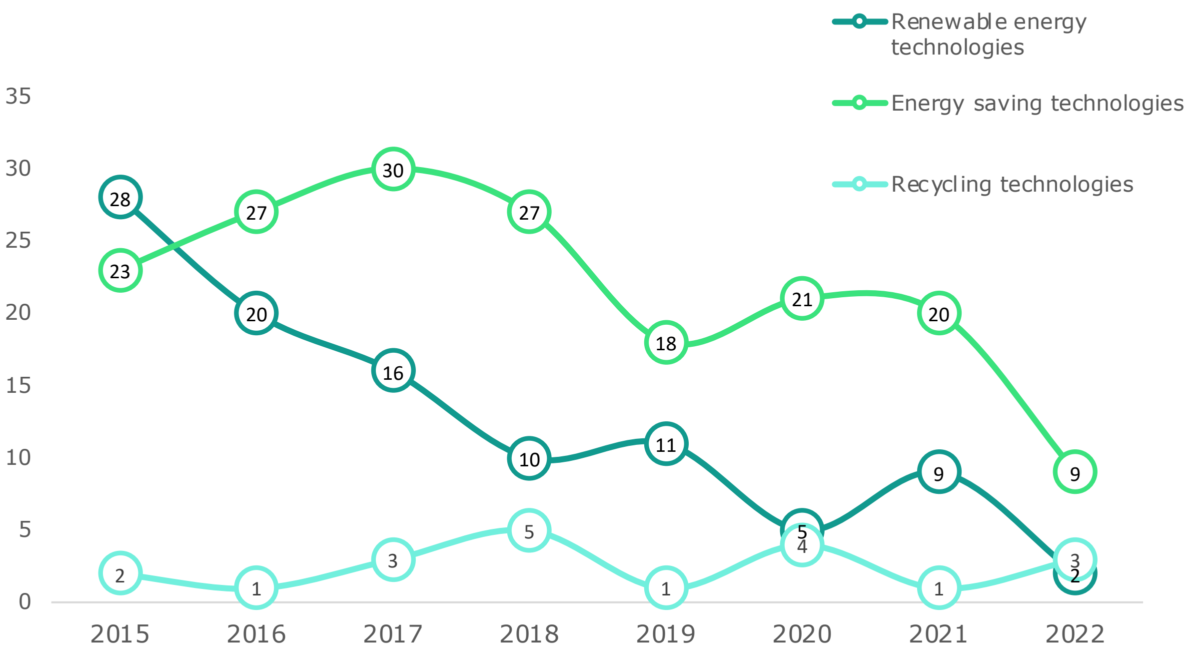
[25] Eurostat (2024) Electricity from renewable sources up to 41% in 2022. Retrieved from: https://ec.europa.eu/eurostat/en/web/products-eurostat-news/w/ddn-20240221-1

[26] The analysis of startup generation has been compiled through a database encompassing Crunchbase and Net Zero Insights data. For the precise delineation of the construction industrial ecosystem, please consult the methodological report related to the EMI project, where the precise tags are outlined. See www.crunchbase.com and https://netzeroinsights.com/

decline in numbers is evident from 2017/2018 onwards. A data lag has been identified and validated that showcase drawbacks in the data set and its ability to capture startups from that period, which at this time cannot be compensated. Explanations include a more limited presence of startups in the construction industrial ecosystem being present in the recent years, due to data protection and decreased emphasis on the formation of company websites which form the basis of the dataset.

In terms of underlying technologies, **energy saving technologies** report the highest number of construction startups with a total of **175** during the indicated period. This is followed by **101 startups related to the renewable energy technologies** and 20 related to recycling technologies.

Figure 8: Evolution of environmental tech startups in construction in the EU27 by year of founding



Source: Technopolis Group based on Crunchbase and NO

Examples of startups include:

- 1Komma5[27] (renewable energy technologies) founded in 2021 is a company that designs and installs rooftop photovoltaic panels, storage systems, EV charging facilities, and heat pumps for residential applications.
- Nolithe[28] (recycling technologies) founded in 2019 specialises in sustainable waste management using accelerated fossilization to transform non-recyclable waste into construction aggregates, offering an eco-friendly alternative to traditional disposal methods.
- Wind my roof[29] (renewable energy technologies) founded in 2018, develops modular roof wind turbines to support in the generation of wind energy through the exploitation of flat-roofed buildings.
- Thermosphr[30] (energy saving technologies) founded in 2020 develops software solutions to enhance thermal efficiency in buildings, utilizing thermal modelling technology and real-time building communication. Their services also encompass Software as a Service (SaaS) for real-time HVAC control, predictive maintenance, and

[27] https://1komma5.com/en/, see also https://www.crunchbase.com/organization/1komma5
[28] https://neolithe.fr/, see also https://www.crunchbase.com/organization/neolithe
[29] https://www.windmyroof.com/, see also https://www.crunchbase.com/organization/wind-my-roof
[30] https://www.thermosphr.com/, see also https://www.crunchbase.com/organization/thermosphr

equipment performance monitoring, relating back to the interplay between green and digital technologies in support of the twin transition.

Several programmes exist at European level to support and identify emerging startups, such as the **European Institute of Innovation and Technology Knowledge (EIT) and Innovation Community (KIC) EIT InnoEnergy**, which, through its Highway acceleration programme has supported, among others, Wind my roof mentioned above[31]. EIT InnoEnergy offers tailored support to foster innovation and innovators including supporting for gaining market intelligence, improving technology enhancement, identifying customer and growth opportunities, understanding the supply chain and industrialisation, designing a governance strategy, creating social acceptance and citizen engagement, understanding regulations, access to finance as well as human capital. Thematic focal fields include energy storage, sustainable buildings and cities, renewable energies, smart electric grid, energy for circular economy, and energy for transport and mobility[32].

2.1.4. Private investments

Private sector investments in green and sustainable buildings and construction materials and practices are indispensable for the green transition.

Global investments in energy efficiency of buildings rose by 14% from 2021 to over EUR 256 bn[33] in 2022[34,35]. However, these investments account for less than 5% of total global investment in the building sector[36]. Europe saw a nearly 23% increase from 2021 to 2022, making up EUR 137.2 bn. This increase in investment in energy efficiency within the building sector in 2022 was fuelled by direct public funding and Europe's response to energy insecurity during the cautious reopening of the global construction industry following the COVID-19 pandemic. This was followed by a slight downturn to EUR 122.8 bn in 2023[37].

Looking at the aspect of resource efficiency, the Eurobarometer survey results reveal that **25% of construction companies do not invest in resource efficiency, while 51% of companies invest less than 5% of annual revenue in resource efficiency.**

The findings from the EMI Enterprise survey complement the Eurobarometer survey results as indicated in the Figure below. The data indicates that the **majority of companies invest less than 1% or between 1 and 5% of annual turnover in environmental technologies and measures of those who are making investments (52%).** While certain categories of investments are increasing, e.g. the share of companies planning to invest 1-5% of annual turnover increased from 24% of current investments to 35% in planned investments, the number of companies making larger investments will likely decrease.

[31] EIT InnoEnergy (2020) EIT InnoEnergy is welcoming a new start-up: Wind my roof and their WindBox. Retrieved from: https://www.innoenergy.com/for-innovators/news-events/eit-innoenergy-is-welcoming-a-new-start-up-wind-my-roof-and-their-windbox/

[32] EIT InnoEnergy (n.d.). Fostering Innovation. Retrieved from: https://www.innoenergy.com/for-innovators/

[33] All currencies are based on current exchange rate of 1EUR = $US 1.09351, 14 October 2024

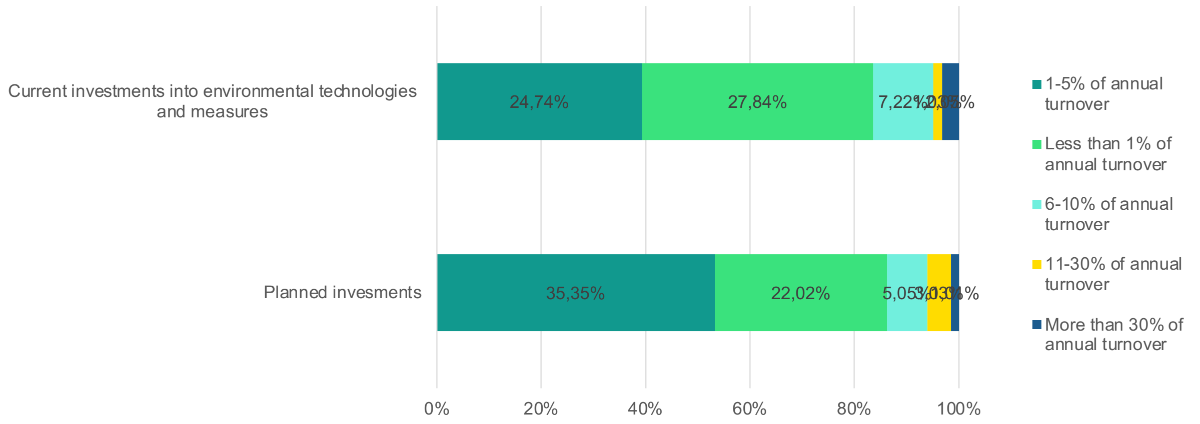
[34] IEA (2023) Annual investment in energy efficiency in the buildings sector in the Net Zero Scenario, 2017-2030. Retrieved from: https://www.iea.org/data-and-statistics/charts/annual-investment-in-energy-efficiency-in-the-buildings-sector-in-the-net-zero-scenario-2017-2030-2

[35] United Nations Environment Programme (2024) Global Status Report for Buildings and Construction: Beyond foundations: Mainstreaming sustainable solutions to cut emissions from the buildings sector. Nairobi. Retrieved from: https://doi.org/10.59117/20.500.11822/45095

[36] idem

[37] IEA (2023) Annual investment in energy efficiency in the buildings sector in the Net Zero Scenario, 2017-2030. Retrieved from: https://www.iea.org/data-and-statistics/charts/annual-investment-in-energy-efficiency-in-the-buildings-sector-in-the-net-zero-scenario-2017-2030-2

Figure 9: Level of investment of business in construction into green technologies



Source: EMI Enterprise survey 2024

Nevertheless, own financial resources are not enough to finance green transformation of the construction industrial ecosystem and external private investments are necessary. Following the results from the Eurobarometer, 22% of construction companies received private funding from bank, investment company or venture capital to produce green products or services. A higher percentage of companies (33%) received funding for enhancing resource efficiency.

The transition pathway for the construction ecosystem also indicates that private financial institutions offer various types of financing to developers, architects, construction companies, and property owners or investors. The loans range from large, long-term investments for land purchases to specific, small-scale loans for home renovations. Especially energy efficiency loans and mortgages, particularly those for improving building energy performance, are becoming increasingly popular. This trend is driven by high energy prices and incentives from Member States[38]. In some cases, large-scale, government-supported schemes promote efficient building renovations.

Despite this growth, investment in energy efficiency of buildings is expected to decline in 2023 due to higher borrowing costs, increased construction costs for labour and materials, economic uncertainty, and ongoing conflicts. Nevertheless, compared to other regions in the world, the total amount of investments in energy efficiency of buildings in Europe is particularly high[39]. Yet, in the European Union, to meet the 2030 climate target of a 55% reduction, an additional EUR 274 bn in building renovation investments is required annually[40].

In addition, a 2024 report from the European Investment Bank shows that investment cycles in the Europe are softening and are not as strong as compared to the US. Firms in the construction sector remain on the threshold between firms expecting to increase or decrease investment in 2024 (around 0%). Construction firms report that the largest percentage of investment goes towards replacement costs (60%) with only 10% dedicated to new products/services. Areas of investment for construction lie largely in machinery and equipment (56%) and training employees (14%)[41].

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[38] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[39] IEA (2023) Annual investment in energy efficiency in the buildings sector in the Net Zero Scenario, 2017-2030. Retrieved from: https://www.iea.org/data-and-statistics/charts/annual-investment-in-energy-efficiency-in-the-buildings-sector-in-the-net-zero-scenario-2017-2030-2

[40] United Nations Environment Programme (2024) Global Status Report for Buildings and Construction: Beyond foundations: Mainstreaming sustainable solutions to cut emissions from the buildings sector. Nairobi. Retrieved from: https://doi.org/10.59117/20.500.11822/45095

[41] European Investment Bank (2020) Going green: Who is investing in energy efficiency, and why it matters. Retrieved from: https://www.eib.org/attachments/efs/eibis_2019_report_on_energy_efficiency_investments_en.pdf

The transition pathway outlines that venture capital funding in construction startups increased globally in the past few years, going from EUR 43 m in 2012 to roughly EUR 1.2 m in 2018, yet with investments mainly being concentrated in the US and China[42].

In the context of this study, venture capital investment into construction young companies that support the green transition have been examined by means of the investment data in Crunchbase and the Net Zero Insights database[43]. Figure 13 shows that especially investments into construction startups related to the green transition dominate the construction scene, reaching a total of EUR 827.7 m raised in 2023. In terms of investment stage, the investments in 2023 related to green investments were mainly associated to the 'Late VC' funding stage (not depicted).

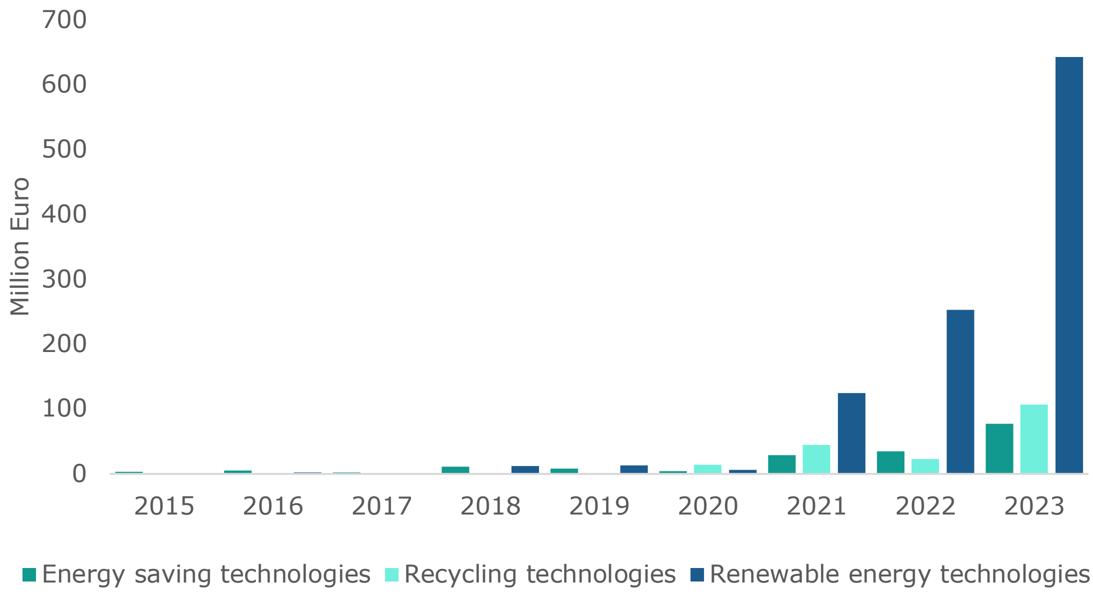
Figure 10: Venture capital investments into construction startups supporting the green transition

Source: Technopolis Group based on Crunchbase and Net Zero Insights

In terms of green technologies underpinning these investments, there were particularly a lot of investments in companies exploiting **renewable energy technologies**, **with EUR 643 m in 2023**. These investments were mainly raised by several highly successful startups, such as **1KOMMA5°** (see Box 1), **Sunroof** (Sweden), **Eranovum** (Spain), and **Klarx** (Germany). Young companies in recycling technologies raised EUR 107 m in 2023, while young companies related to energy saving technologies raised EUR 77 m in the same year.

[42] European Commission (2021) Commission Staff Working Document. Scenarios for a transition pathway for a resilient, greener and more digital construction ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/47996
[43] The precise delineation of the construction industrial ecosystem in this data set is described in the EMI methodological report.

Figure 11: Venture capital investment into the green transition by technology – construction industrial ecosystem



Source: Technopolis Group based on Crunchbase and Net Zero Insights

Box 1: 1KOMMA5° - Investments in renewable energy technologies

1KOMMA5°, founded in Germany in 2021, was one of the startups that raised a substantial amount of venture capital in 2023. The company is active in Germany, Sweden, Finland, Spain, Denmark, the Netherlands and Australia. Since its founding in 2021, it has raised a total of EUR 705 million during 4 founding rounds (cut-off date January 2024), of which EUR 430 m in Series B and EUR 200 m in Series A.

The company's 'Heartbeat AI' software platform optimizes the integration of solar panels, home batteries, and charging stations, connecting a customer's home directly to the energy trading market. It manages energy flows based on personal needs, automatically coordinating all devices. Additionally, Heartbeat AI can sell excess stored energy when prices are high, helping to lower energy bills and contributing to grid stability.

Details on the funding rounds of further select young companies based on the Crunchbase and Net Zero Insights dataset include:

- **Sunroof** (renewable energy technologies) founded in 2020, who manufactures and installs building-integrated photovoltaic panels for residential roofs. This young company raised EUR 35 m during 5 rounds since 2020.
- **Nolithe** (recycling technologies) founded in 2019 in France, has raised EUR 60 million in 2023 and a total of EUR 83 m since 2019.

2.2. Framework conditions – assessment of the broader ecosystem supporting the green transition

To what extent do framework conditions such as public financing and skills support the green transition?

- The construction industrial ecosystem received **EUR 105 bn in support from the European Regional Development Fund** for the period 2014-2020. Projects that addressed specifically the **green transition of construction accounted for over EUR 33.7 bn.**

- **66.8% of ERDF related construction projects are directed towards the implementation of projects supporting energy efficiency** renovation of existing housing stock, public infrastructure, and private companies

- While the **Horizon 2020 programme funded EUR 102 million** to projects classified under the construction industrial ecosystem, **Horizon Europe** has thus far provided **EUR 45 million** in funding. For **Horizon Europe, 62.8% of the EC funding** to construction projects contributes to the green transition until now.

- **Critical skills gaps in the construction industrial ecosystem relate to sustainability, circularity, and energy and resource efficiency.** The share of professionals registered on LinkedIn and employed in the construction industrial ecosystem with skills relevant to the green transition attained nearly 9% in 2024, up from 6.6% in 2022.

Framework conditions that support the green transition refer to various structural and institutional elements that create an enabling environment for businesses to transition towards more sustainable and environmentally friendly practices. These conditions are crucial for driving the adoption of green technologies and fostering circular economies. Key components of these framework conditions include the generation of underlying technologies, public policy, skills demand and supply and demand-side factors among others that are analysed in the sections below.

2.2.1. Public investments supporting the green transition

Public investments affect the attractiveness of the industrial ecosystem and advance the greening of the industrial ecosystem while also signalling a high-level commitment to sustainable development, making the ecosystem and the green transition therein more attractive to businesses, investors, and other stakeholders. In the context of this study, the **investments made in the green transition in the construction industrial ecosystem through the public policy programmes** – i.e., the European Regional Development Funds, Cohesion funds, and the Framework Programmes – are examined through the combination of the databases Cohesion Open Data and Kohesio, as well as the database Community Research and Development Information Service (Cordis). Exact details on the delineation of the construction industrial ecosystem related to this data set are outlined in the EMI methodological report.

Cohesion policy

A key source of public funding that enables the green transition is the **EU's regional development funds**[44]. ERDF projects[45] that are related to the construction industrial ecosystem could be identified in the data based on the codes of economic activity and additional keyword searches in the project descriptions. The total number of **ERDF projects in the construction industrial ecosystem** that could be identified in 2014-2020 was 88 701, good for a total funding of EUR 105 bn. The analysis shows that **about 32%** (or EUR 33.7 bn) **of the funding to ERDF projects related to construction supported the green transition**[46]. In terms of number of projects, 41% of the identified construction projects contribute to the green transition (or 36 641 projects). Some examples of construction projects supporting the green transition are described in Box 2.

66.8% of ERDF related construction projects are directed towards the implementation of projects supporting energy efficiency renovation of existing housing stock, public infrastructure, and private companies (see Figure 15).

Box 2: ERDF construction projects supporting the green transition

The ERDF funded Polish project "**Installation of photovoltaic installation in the Municipality of Offices**" ran between 2016 and 2019 and received EU funding of EUR 408.160,14. The project involved installing photovoltaic systems for electricity generation in 131 private facilities and 3 public utility buildings, with a total capacity of 0.392 MW. Additionally, 24 pellet/powder boilers were installed in private homes for water heating, contributing to a total capacity of 0.557 MW. In total, around 500 residents across 156 properties benefitted from the project. The project aimed to increase the use of renewable energy sources (RES) by installing 158 RES units with a total capacity of 0.949 MW.

The Polish project "**Deep thermal modernisation of school buildings in Krotoszyce Commune**" was carried out between 2020 and 2023 with an EU budget of EUR 585,466.98. The project involved the modernisation of the school in Kościelec and the gymnasium in Krotoszyce, including heat source upgrades to air/water heat pumps, the installation of thermostatic valves, improved ventilation, and replacement of existing joinery to meet thermal insulation standards. A 13.9 kWp photovoltaic system with 147 solar panels was installed at the school to integrate renewable energy.

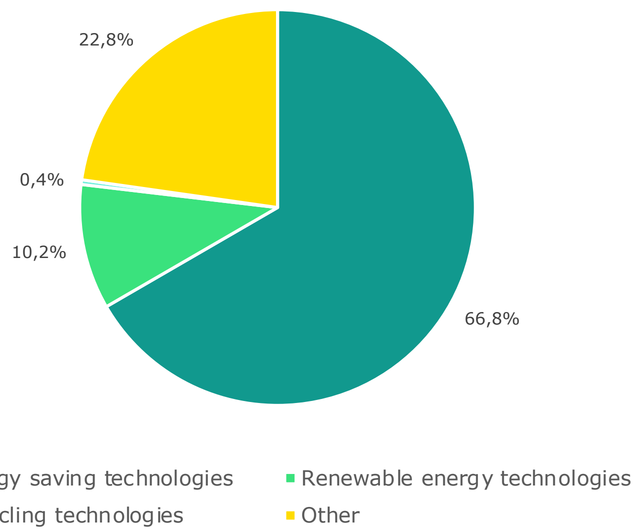
Source: Technopolis Group based on Kohesio

[44] For this analysis, two data sources have been used and merged, namely the Cohesion Open Data maintained by the European Commission and the Kohesio data. The latter contains more than 1.7 million projects and approximately 500 000 beneficiaries financed throughout the funding period 2014–2020 . For more information on the data sources and the approach, see the methodological report. See European Union (2022) Linking data: Kohesio platform. Retrieved from: https://data.europa.eu/en/publications/datastories/linking-data-kohesio-platform

[45] The European Regional Development Fund (ERDF) supports projects aimed to strengthen economic, social and territorial cohesion in the European Union. It aims to correct imbalances between regions enabling investments in a smarter, greener, more connected and more social Europe that is closer to its citizens. The ERDF finances programmes in shared responsibility between the European Commission and national and regional authorities in Member States.

[46] The projects related to the green transition were filtered in the same manner, using a selected list of green keywords that were also constructed for other parts of the data collection in this project.

Figure 12: ERDF construction projects that contribute to the green transition by green technology



Source: Technopolis Group based on Kohesio

Framework Programmes

While the Horizon 2020 programme funded EUR 102 m to projects classified under the construction industrial ecosystem[47], Horizon Europe has thus far[48] provided EUR 45 m in funding. These results differ from last year's findings given a different and more narrow methodology applied to the analysis of Horizon funding.

Under Horizon 2020, **68.5% of the EC funding to construction projects contributed to the green transition**, while in Horizon Europe, it concerns **62.8% of the EC funding.** These shares point towards the high importance of the green transition, as supported by the framework programmes.

Several calls in the Framework Programmes specifically target construction projects contributing to the green transition. For instance, the Horizon Europe call "Efficient, sustainable and inclusive energy use"[49], funded under Pillar II Cluster "climate, energy and mobility", supports activities targeting a more efficient use of energy as regards buildings and industry. The supported projects aim to, amongst others, demonstrate innovative integrated technology solutions for cost-effective buildings, overall performance enhancements, or investigate the viability of performance-based business models. Several of the construction projects that are funded through this call also contribute to the digital transition.

Examples of construction projects funded under Horizon 2020 and Horizon Europe supporting the green transition are described in Box 3.

[47] EC Framework Programmes for Research and Innovation cover both Horizon 2020 (2014-2020) and Horizon Europe (2021-2027) in the analysis of the construction industrial ecosystem. The methodological report provides detailed insights into the methodology. In particular, the CORDIS data have been merged with the relevant EuroSciVoc data. EuroSciVoc connects projects to relevant scientific concepts, providing a deeper understanding of the research focus.
[48] Cut-off date is March 2024
[49] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2021-d4-02-01

Box 3: Horizon 2020 and Horizon Europe construction projects supporting the green transition

RIBuild[50] (Robust Internal Thermal Insulation of Historic Buildings), funded through the Horizon 2020 programme with an EC contribution of EUR 4.96 m, focused on developing methods for installing internal thermal insulation in historic buildings without compromising their architectural and cultural integrity. The project created decision guidelines for implementing internal insulation in buildings with heavy external walls made of stone, brick or timber, commonly found in historic structures across the EU. Key activities led by the project involved assessing the suitability of historic buildings for thermal insulation through screening and material analysis, identifying reliable and cost-effective insulation solutions using probabilistic modelling, and developing a web-based assessment tool with decision guidelines. The aim of the project was to advance energy efficiency while minimizing the potential damage on historical buildings.

DRASTIC[51] (Demonstrating Real and Affordable Sustainable Building Solutions with Top-level whole life-cycle performance and Improved Circularity) is a Horizon Europe project launched in 2023, co-funded by the European Union (EU) via the Built4People partnership[52]. DRASTIC aims to reduce operational and embodied carbon by engaging its collection of five demonstrator projects, each based in distinct geographic zones with specific drivers that focus on reducing the embodied carbon impacts of construction materials. To reach this ambitious goal, 23 partners from 8 European countries collaborate, covering the entire value chain and supported by a co-creation strategy with relevant stakeholders.

The DRASTIC project will contribute to the objectives of the EU by demonstrating the feasibility of promising and affordable new technologies, processes and products combined with new business models for faster market uptake, leading towards more sustainable buildings with reduced life cycle carbon, high life cycle performance and reduced life cycle costs.

Source: authors based on Cordis

2.2.2. Skills supply and demand underpinning the green transition

The construction sector has significant untapped potential in sustainability, circularity, and energy and resource efficiency[53], with a **notable skill gap**, especially in **circular skills**[54]. Hence, up- and reskilling in energy efficiency and sustainability is crucial to create energy-efficient buildings, reduce environmental impact, and promote sustainable practices. However, meeting the demand for green skills will be challenging due to changing skill requirements, an aging workforce, and the high concentration of employment in hard-to-reach micro-enterprises[55].

In this light, several important EU policy initiatives, including the Renovation Wave and the Resilience and Recovery Facility (RRF), aim to support upskilling and reskilling of the construction workforce for the renovation of buildings. For example, the Commission introduced the **Blueprint for Sectoral Cooperation on Skills** initiative to enhance skills intelligence and address short- and medium-term skill needs. Within this framework, the Construction Blueprint project (2019-2023) concentrated on, amongst others, skills in

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[50] RIBuild. Cordis. https://cordis.europa.eu/project/id/637268/es
[51] DRASTIC. https://www.drasticproject.eu/about
[52] Built4People. https://built4people.eu/
[53] European Commission (2018) research eu. Results pack on construction skills. New skills for the construction sector to achieve European energy targets. Retrieved from: https://cinea.ec.europa.eu/system/files/2021-06/ZZAD18001ENN.en_.pdf
[54] Breen, M., et al. (2023) Developing a task-based qualification framework for circular skills in construction and its application in training plans (for trainers and SMEs). Retrieved from: https://build-up.ec.europa.eu/en/resources-and-tools/publications/task-based-qualification-framework-circular-skills-construction
[55] CEDEFOP (2023) The greening of the EU construction sector. Skills intelligence data insights. Retrieved from: https://build-up.ec.europa.eu/en/resources-and-tools/publications/task-based-qualification-framework-circular-skills-construction

energy efficiency and the circular economy. The EU also launched the **BUILD UP Skills initiative**[56] to support in training development with the aim to increase the number of qualified trade professionals. Activities included developing national qualification platforms and roadmaps and providing training in energy efficiency and renewable energy for buildings. Under Horizon 2020, the initiative expanded to include other building professionals, with projects creating multi-country qualification and training schemes. The **Pact for Skills** in construction is a large-scale partnership that plans to upskill and reskill overall at least 30% of the workforce of the construction industry by 2030, to reach a target of 3 million workers. The New European Bauhaus (NEB), an EU policy and funding initiative launched in 2021, has launched the **NEB Academy** in 2024. The NEB Academy, a flagship initiative of the **European Year of Skills**[57], is intended to give a push for new skills and education in the construction sector as it aims boosting skills in sustainable construction and accelerating the green transformation of the building sector. Practically, the NEB Academy will bring together educational and training professionals and connect local and regional hubs across Europe[58]. These hubs will provide tailored and high-quality co-created training services, curricula, and programmes on sustainable construction solutions via a digital platform.

Recently, CEDEFOP has identified essential managerial and technical skills needed for the green transition in the construction industry. These are displayed in Table 1. Most of the emerging green skills relate to waste management and energy efficiency. The skill mismatch may have contributed to the fact that the anticipated significant growth in green employment has not yet materialised[59].

Table 1: Skills required for the green transition (CEDEFOP)

Skills required to manage the green transition and implement changes (managerial positions)	Needs detected regarding skills for technical positions
• Knowledge of waste management and circular economy principles; • Understanding of the concept of sustainability and its application in construction; • Skills related to demolition waste management; • On-site recycling; • Energy conservation and processes for bringing about energy efficiency; • Knowledge of green materials' use and properties, especially for architects and designers	• For traditional craftworkers (plumbers, electricians, carpenters and joiners, plasterers, bricklayers, thermal insulators, and window installers) upskilling is needed in energy efficiency, in following waste management guidelines, in the application of circularity principles when handling materials (avoiding waste as much as possible), and making more efficient use of energy; • Knowledge of safe and correct use of specific materials, like skills related to wood used in construction; • Installation of renewable energy equipment, like solar panels; • Knowledge of material structures and their interaction with the environment.

Source: CEDEFOP

[56] https://build-up.ec.europa.eu/en/home
[57] More information is available at: https://year-of-skills.europa.eu/index_en
[58] European Commission (2024) News Announcement: Commissioner Ivanova launches New European Bauhaus Academy to boost sustainability skills in the construction sector. Retrieved from: https://new-european-bauhaus.europa.eu/get-inspired/selection-your-contributions/commissioner-ivanova-launches-new-european-bauhaus-academy-boost-sustainability-skills-construction-2024-04-11_en
[59] CEDEFOP (2023) The greening of the EU construction sector. Skills intelligence data insights. Retrieved from: https://build-up.ec.europa.eu/en/resources-and-tools/publications/task-based-qualification-framework-circular-skills-construction

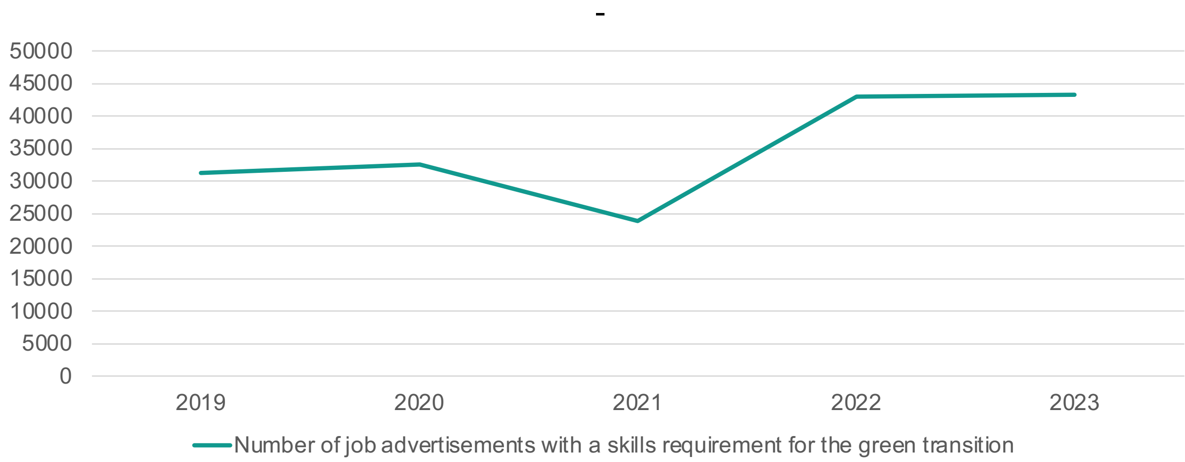
Skills demand

Skills demand in the construction industrial ecosystem has been analysed following the skills intelligence insights of Cedefop, the European Centre for the Development of Vocational Training[60]. This dataset covers the EU27 Member States (plus UK) and is based on the collection and analysis of more than 530 online job advertisement sources (424 distinct websites) which are open-access sites. The dataset provides information on most requested occupations and skills across European countries based on established international classifications, e.g., ISCO-08 for occupations, ESCO for skills, and NACE rev. 2 for sectors. These websites reflect the characteristics of the local labour markets in terms of geographical distribution, ranging from 50 sites in Belgium and the Netherlands, to three in Luxembourg. For each job advertisement, there is data on the characteristics of the job, the employer, and job requirements[61].

Specific to the construction industrial ecosystem, there were **7 702 824 unique job advertisements** from companies between 2019-2023 in the EU27. These job advertisements have been text-mined and the required skills analysed from the perspective of the green transition. Green skills have been identified as skills related to environmental protection, environmental services, environmental policy, environmental sustainability, environmental standards, low carbon technologies, renewable energy, the circular economy including circular design and recycling, and clean production technologies and business models related skills.

In 2023, the share of online job advertisements requiring skills related to the green transition was between 2% and 3%. The total number of such job ads increased notably from 2021 to 2022, indicating a growing interest in green skills. However, this trend has recently stabilised, with only slight fluctuations. As a result, the share of green-related job ads within the overall pool has seen a modest decline from 2022 to 2023, suggesting that while green skills remain in demand, other types of skills are also being prioritised in recent hiring.

Figure 13: Share of online job advertisements with a requirement for environmental skills in construction



Source: Technopolis Group based on analysis of Cedefop data

These findings corroborate with other recent findings from the OECD. OECD insights on vacancies show that the construction sector made up less than 5% of total green vacancies, behind manufacturing (20%), professorial & scientific (17.5%), administrative and support

[60] https://www.cedefop.europa.eu/en/tools/skills-online-vacancies

[61] This methodology has its limitations, as described in the methodological report. Some limitations are, for instance, that only online job advertisements are represented and that the volume and quantity of the data depend on the selection of portals and sources.

service activities (17%), wholesale retail and trade (7%), information and communications (6.5%) and finance (5%)[62].

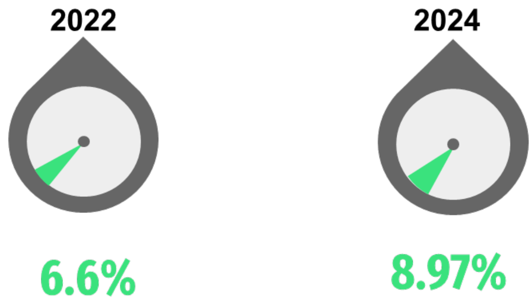
Skills supply

To gain insights into the supply of skilled professionals, the **LinkedIn database** has been consulted. LinkedIn is the largest professional network platform with rich information like profile summary, job title, job description and field of study, which can be used for the identification of skilled professionals with skills relevant to the green transition. In particular, green skills have been identified as skills related to biotechnology, renewable energy technologies, circular business models, and clean production technologies.

A total of **3.9 million professionals worked in the construction industrial ecosystem with a profile on LinkedIn in April 2024** (including construction, civil engineering and architecture). While this means that an estimated 30% of the persons employed in construction are active on the platform, it is to be noted that some jobs, functions and countries are better represented than others, such as architects, engineers, and managers[63]. The data shows that about 55% of the professionals active on LinkedIn have a master's degree, and 33% a bachelor's degree and has a bias towards more educated professionals in the industry.

Within the registered professionals on LinkedIn employed in the construction industrial ecosystem, **8.97% indicated to have one type of green skill in 2024**, which is an increase compared to 2022 where 6.6% were found to have at least one green skill (see Figure 17). Professionals on LinkedIn working in the field of architecture have the highest share, with 29% of these professionals reporting a green skill.

Figure 14: Share of professionals in construction with skills relevant for the green transition



Source: Technopolis Group based on LinkedIn

2.2.3. Demand for green products

This section explores the demand for energy efficient and green buildings by EU citizens and the demand for clean, renewable and energy efficient heating, ventilation, and insulation.

Demand for energy efficient and green buildings

Recent reports highlight that the construction industrial ecosystem has observed that many customers are becoming more sustainability-conscious and place greater pressure on developers to lower the carbon footprint of new builds[64]. Homeowners are increasingly

[62] Institute for Human Rights and Business (2024) Future green construction jobs: skills and decent working conditions. Retrieved from: https://ihrb-org.files.svdcdn.com/production/assets/uploads/reports/Future_Green_Contruction_Jobs_June2024.pdf
[63] The methodological report outlines how the report corrects this representativeness bias, i.e., by comparing LinkedIn population to the active population and derive a corrective weighting.
[64] Deloitte (2023) Customers' green focus is read loud and clear by construction industry. Retrieved from: https://action.deloitte.com/insight/3224/customers-green-focus-is-read-loud-and-clear-by-construction-industry

seeking greener and energy-efficient buildings due to significant energy consumption and high related costs, environmental concerns, and environmental regulations.

The European Climate Foundation[65] conducted a survey in four European countries (Czech Republic, Germany, Italy, and Spain) and found that **89% of the respondents said that it is important** for them to buy or rent energy-efficient properties, mainly because of energy bills (50%) and for environmental reasons (40%).

Currently, **75% of the EU's building stock has a poor energy performance**. Yet, in many cases, individual measures like installing new windows, insulating the roof or walls or changing the boiler, have the potential to deliver substantial energy performance improvements – without the need for more extensive renovation works[66]. An obstacle, however, in energy efficiency investments in landlord-tenant relationship is the issue of diverging incentives between the tenant and the owner of the building[67]. The landlord lacks the incentive to invest in improving the energy performance of a property unless the investment costs can be recovered through premium rents. The tenant's incentive to invest in energy performance improvements to the property is often dependent on the foreseen longevity of the tenancy in relation to the payback time involved in the investment. Regulatory rights and obligations should be in place to facilitate investments.

Demand for clean, renewable and energy efficient heating, ventilation, and insulation

Traditionally, many households use natural gas to warm their homes, provide hot water, and cook. Yet, the energy crisis made electrification of heat more attractive to consumers, which is reflected in a sharp increase of **residential heat pump sales** in 2022[68]. In fact, global sales of heat pumps grew by 11% in 2022, according to IEA. Especially in Europe, heat pumps enjoyed a record year in 2022, with sales growing by nearly 40%[69], reaching around 3 million installations and supporting the steep reduction in natural gas demand in that year[70]. In 2023, global sales of heat pumps decreased by 3% due to the growing consumers' aversion to large-ticket purchases amid higher interest rates and inflation, and the fact that natural gas prices declined after their peaks in 2022. The IEA indicate that particularly in Italy, Poland, and Finland, major downturns in sales were noticeable.

Despite their overall increasing popularity, heat pumps still only meet around 10% of the global heating need in buildings. Several home heating technologies include air-to-water heat pumps, ground source heat pumps, and air-to-air heat pumps.

Globally, there is an increased demand for **thermal insulation** noticeable. In Europe, the thermal insulation market in 2022 is valued at EUR 5.23 m and is projected to expand at 5.5% Compound Annual Growth Rate (CAGR) during 2022-2028, until EUR 7.23 m[71].

Furthermore, according to SolarPower Europe[72], 2023 was a record year for **solar PV** in the EU, with 55.9 GW new solar PV installed across the 27 Member States. This represents a 40% growth from 2022 and a doubling of the market in just two years. These numbers imply that 306.000 PV modules per day were installed in 2023. Germany is the largest solar market (with 14.1 GW newly installed capacity in 2023), followed by Spain and Italy.

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[65] European Climate Foundation (2022) New survey shows high support in Europe for energy efficient homes. Retrieved from: https://europeanclimate.org/resources/new-survey-shows-high-support-in-europe-for-energy-efficient-homes/

[66] European Commission (2024). In focus: Energy efficient buildings. Retrieved from: https://energy.ec.europa.eu/news/focus-energy-efficient-buildings-2024-04-16_en

[67] ESCO (2018) Improving energy and resource efficiency. Analytical report. Retrieved from: https://ec.europa.eu/docsroom/documents/33121/attachments/1/translations/en/renditions/native

[68] IEA (2023) Has the energy crisis accelerated the shift away from gas in residential space heating? Retrieved from: https://www.iea.org/reports/energy-efficiency-2023/has-the-energy-crisis-accelerated-the-shift-away-from-gas-in-residential-space-heating

[69] IEA (2023) Global heat pump sales continue double-digit growth. Retrieved from: https://www.iea.org/commentaries/global-heat-pump-sales-continue-double-digit-growth

[70] IEA (2024) Heat pumps. Retrieved from: https://www.iea.org/energy-system/buildings/heat-pumps

[71] Business Market Insights (2023) Europe Thermal Insulation Market. Retrieved from: https://www.businessmarketinsights.com/pr/europe-thermal-insulation-market

[72] SolarPower Europe (2023) European Market Outlook for Solar Power 2023-2027. Retrieved from: https://www.solarpowereurope.org/insights/outlooks/eu-market-outlook-for-solar-power-2023-2027#download

The cumulative installed solar capacity in the EU27 reached 263 GW in 2023, a 27% growth compared to 2022 (207 GW).

2.3. The impact of the industrial ecosystem on the environment

How is the industrial ecosystem's impact on the environment changing?

- The **construction industrial ecosystem is addressing its emissions-related challenges** while continuing to face significant challenges in other environmental areas. 40% of energy consumed in the EU is used in buildings, with over 1/3 of the EU's greenhouse gas emissions stemming from buildings. The bulk of CO2 emissions comes from consumption, rather than production for the construction industrial ecosystem.

- Construction represents the biggest source of Europe's waste. The **recovery rate for construction and demolition waste stands at 89% across the EU27** with significant differences across Member States. The r**ecovery rates have not increased significantly** in recent years, hence the potential to improve recovery, reuse and recycling is not fully utilised.

- The construction industrial ecosystem accounts for about **50% of all extracted material**. Greater material efficiency could significantly reduce emissions underpinning the interplay between resource and energy efficiency potential related to the construction industrial ecosystem.

This section explores the environmental impact and performance of the construction industrial ecosystem and provides (long-term) trends in terms of several indicators, such as the waste, greenhouse gas emissions and energy consumption, material extraction and resource utilisation, and pollution. In doing so, it builds on secondary data sources such as Eurostat, which often represent the construction industry (NACE F) or aspects thereof, and not per se the industrial ecosystem as a whole. Furthermore, this study reports on indicators developed through the Exiobase[73] dataset. This dataset allows to measure the environmental impact of industrial ecosystems both in terms of production and consumption footprints of an industrial ecosystem. More information on this dataset and the constructed indicators is provided in the EMI methodological report.

Emissions and energy consumption

When looking at the buildings and construction sector, it is apparent that these significantly impact global climate change by contributing to greenhouse gas emissions and consuming significant shares of energy, especially in the buildings themselves. In terms of global trends, the following observations stem from the 2024 UN Environmental Programme report on emissions in the buildings and construction sector[74]:

- The buildings and construction sector contributes to about **21% of all global greenhouse gas emissions**.
- In 2022, buildings accounted for **34% of global energy demand** (mainly for operational needs like heating and cooling). However, while global energy demand in buildings has grown by 13% since 2010, there are large regional differences, with **Europe having experienced a 15% decline** over this period.
- In 2022, buildings accounted for 37% of global energy and process-related CO_2 emissions.

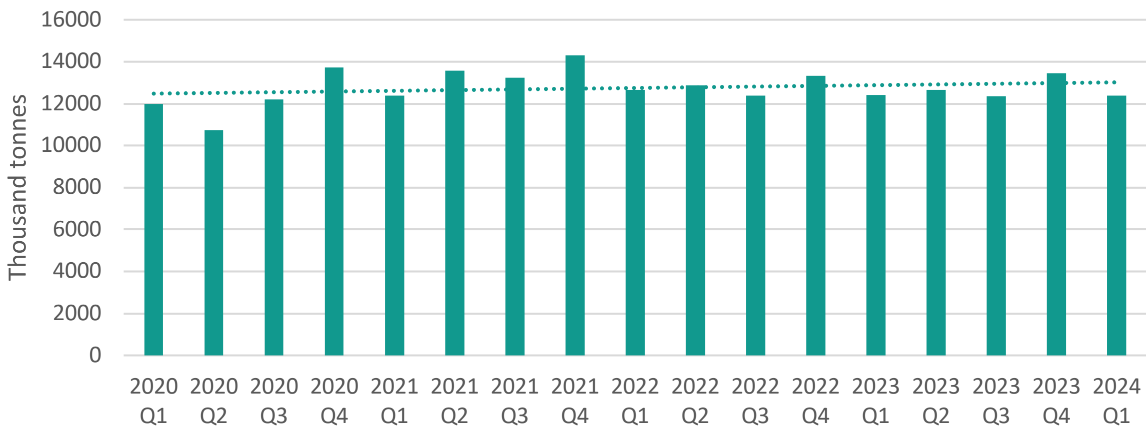
[73] About Exiobase. Retrieved from: https://www.exiobase.eu/index.php/about-exiobase

[74] United Nations Environment Programme (2024) Global Status Report for Buildings and Construction: Beyond foundations: Mainstreaming sustainable solutions to cut emissions from the buildings sector. Nairobi. Retrieved from: https://doi.org/10.59117/20.500.11822/45095

Focussing on the EU27, **40% of energy consumed in the EU is used in buildings**, with over **1/3 of the EU's greenhouse gas emissions stemming from buildings**[75]. At present, about 35% of the EU's buildings are over 50 years old and almost **75% of the building stock is energy inefficient**. About 80% of the energy used in EU homes is for heating, cooling and hot water. At the same time, the **average annual energy renovation rate is only about 1%**[76]. Recent numbers in the 2024 State of the Energy Union Report indicate that in 2022, final energy consumption in the EU residential building sector decreased by 7.5% compared to the levels of 2021. Yet, the decrease would be largely related to the milder winter and a reduction in consumption, rather than by an improvement of the building performance itself[77].

In addition, Eurostat data provide insight into the total greenhouse gas emissions generated by the Construction sector (as captured by NACE F). Figure 18 shows that the generation of greenhouse gas emissions in the EU27 by the construction sector is rather stable over the last years, with a decrease in 2020 attributable to the COVID-19 pandemic, and subsequent increase observed since as a result (see dotted line increasing since 2020).

Figure 15: Greenhouse gas emissions in the Construction sector (NACE F) (EU27)



Source: IDEA Consult based on Eurostat (env_ac_aigg_q)

Exiobase provides additional insights into the greenhouse gas emissions of the construction industrial ecosystem in terms of its consumption and production account. Figure 19 shows that from 2019 onwards, the CO_2 emissions in terms of production seem rather stable. There is, however, a small increase in CO_2 emissions when focusing on the consumption account – i.e., the CO_2 emissions produced by all inputs needed for construction purchased by EU consumers. In general, the figures show that the bulk of CO_2 emissions comes from consumption, rather than production for the construction industrial ecosystem. This can be attributed to the fact that the construction industrial ecosystem as it is outlined does not include the materials aspect, as such the production is limited as compared to the consumption, focussed on the construction and demand for buildings.

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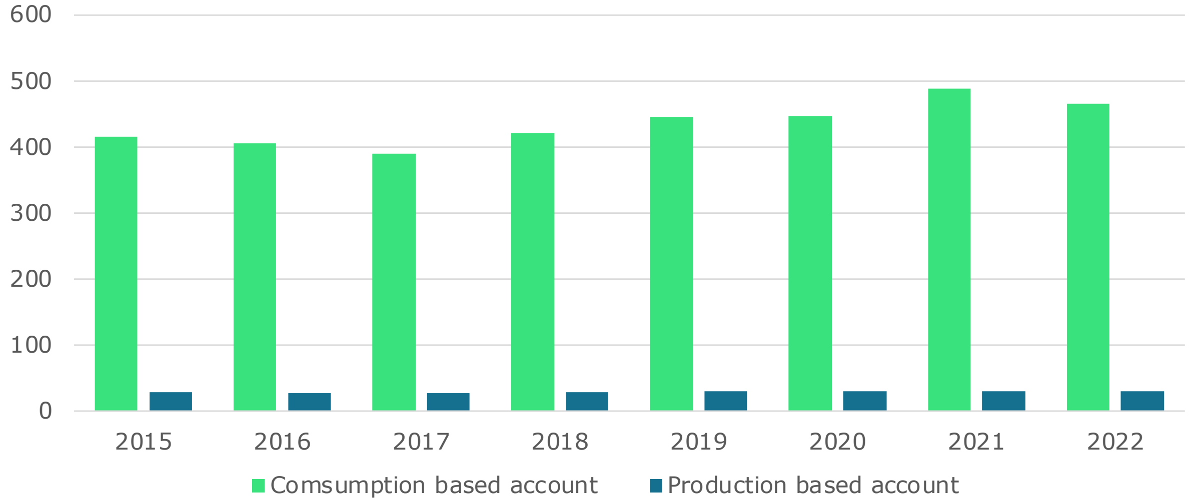
[75] European Commission (n.d.) Energy Performance of Buildings Directive. Retrieved from: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en#:~:text=The%20directive%20contributes%20to%20the,emission%20building%20stock%20by%202050.

[76] European Commission (2024) Commission welcomes political agreement on new rules to boost energy performance of buildings across the EU. Retrieved from: https://ec.europa.eu/newsroom/neb/items/814531/

[77] European Commission (2024) Report from The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. State of the Energy Union Report 2024. (pursuant to Regulation (EU)2018/1999 on the Governance of the Energy Union and Climate Action). Retrieved from: https://energy.ec.europa.eu/document/download/bd3e3460-2406-47a1-aa2e-c0a0ba52a75a_en?filename=State%20of%20the%20Energy%20Union%20Report%202024.pdf

Figure 16: Greenhouse gas emissions of the construction industrial ecosystem (CO_2 emissions in megatons) - consumption and production based account



Source: Technopolis Group based on Exiobase

Acting on the energy efficiency of buildings and increasing renovation rates and electrification of heating equipment are hence key to saving energy, reducing bills for citizens and small enterprises and achieving a zero-emission and fully decarbonised building stock by 2050[78] [79].

More recently, the European Union has more legislative initiatives that are increasingly impacting the construction and real estate sector. Some examples are provided below:

- In 2023, the EU has revised the **Energy Efficiency Directive** (EU/2023/1791)[80] to ensure that the EU's 2030 target of reducing greenhouse gas emissions by at least 55% (compared to 1990) can be met. The Directive establishes 'energy efficiency first' as a fundamental principle of EU energy policy, meaning that EU countries must consider energy efficiency in all important policy and investment decisions in both energy and non-energy sectors. The 2023 revised directive raises the EU energy efficiency target, making it binding for EU countries to collectively ensure an additional 11.7% reduction in energy consumption by 2030, compared to the projections of the EU reference scenario 2020[81].
- In 2024, the EU has revised its **Energy Performance of Buildings Directive** (EPBD, EU/2024/1275)[82]. The Directive contributes to the objective of reducing GHG emissions by at least 60% in the building sector by 2030 compared to 2015, and achieving a decarbonised, zero-emission building stock by 2050. The EPDB aims to decarbonize Europe's building stock by 2050 through increased renovations, especially of the worst-performing buildings, while providing flexibility for Member

[78] European Commission (2024) Commission welcomes political agreement on new rules to boost energy performance of buildings across the EU. Retrieved from: https://ec.europa.eu/newsroom/neb/items/814531/

[79] European Commission (2024) Report From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. State of the Energy Union Report 2024. (pursuant to Regulation (EU)2018/1999 on the Governance of the Energy Union and Climate Action). Retrieved from: https://energy.ec.europa.eu/document/download/bd3e3460-2406-47a1-aa2e-c0a0ba52a75a_en?filename=State%20of%20the%20Energy%20Union%20Report%202024.pdf

[80] EUR-Lex (2023) Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). Retrieved from: http://data.europa.eu/eli/dir/2023/1791/oj

[81] European Commission (n.d.) Energy Efficiency Directive. Retrieved from: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

[82] EUR-Lex (2024) Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast). Retrieved from: http://data.europa.eu/eli/dir/2024/1275/oj

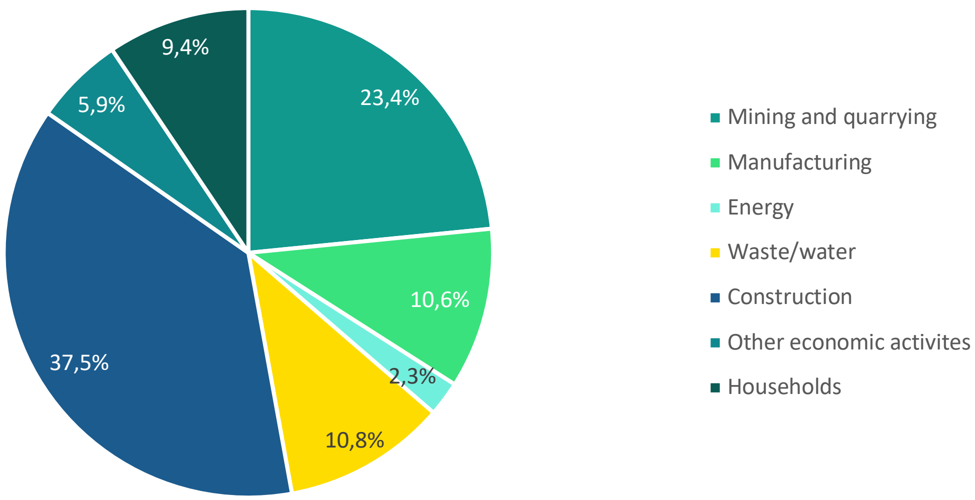
States[83]. New buildings must have zero on-site emissions from fossil fuels by 2028 for public buildings and by 2030 for others. The directive also strengthens the framework for renovations, introduces 'Building Renovation Passport' schemes, safeguards against 'renovictions,' and improves data provision for renovations. The revised EPBD supports the phase-out of fossil fuels for heating by 2040, with boilers powered by fossil fuels becoming ineligible for public support from 2025.

- In 2024, a new Construction Products Regulation (EU/ 2024/3110)[84] was adopted repealing the previous regulation. The new regulation lays down harmonised rules for the marketing of construction products and was part of a package of proposals aiming to support circular business models and empower consumers in relation to the green transition[85]. It sets out methods and criteria for assessing and expressing the performance of construction products and the conditions for the use of CE marking.

Waste

Construction represents the biggest source of Europe's waste. In 2020, according to Eurostat data (see Figure 20), construction (NACE F) contributed **37.5%** of the total waste generated by economic activities and households[86].

Figure 17: Waste generation by economic activities and households (EU27, 2020) (% of total waste)



Source: IDEA Consult based on Eurostat (env_wasgen)

In absolute numbers, the total waste generated by the construction sector in the EU27 increased from 2004 onwards from 667 million tonnes to 839 million tonnes in 2018, and then decreased slightly in 2020 to 807 million tonnes due to a slowdown in the construction industry as a result of the COVID-19 pandemic[87].

[83] e.g., Each Member State will adopt its own national trajectory to reduce the average primary energy use of residential buildings by 16% by 2030 and 20-22% by 2035, allowing for sufficient flexibility to take into account national circumstances. Member States are free to choose which buildings to target and which measures to take.

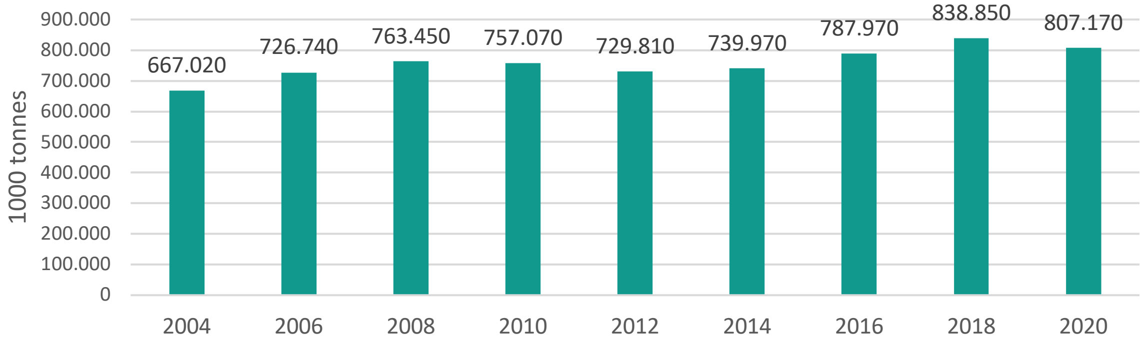
[84] European Union (2024) REGULATION (EU) 2024/3110 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 November 2024 laying down harmonised rules for the marketing of construction products and repealing Regulation (EU) No 305/2011. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L_202403110

[85] European Parliament (2025) Revision of the Construction Products Regulation (REFIT) In "A European Green Deal". Retrieved from: https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-construction-products-regulation

[86] Eurostat (2020) Waste statistics. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Total_waste_generation

[87] Eurostat (2024) Generation of waste by waste category, hazardousness and NACE Rev.2 activity. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/ENV_WASGEN/default/table

Figure 18: Waste generation by Construction (NACE F) (EU27, 2004-2020)



Source: IDEA Consult based on Eurostat (env_wasgen)

The Waste Framework Directive (Directive 2008/98/EC)[88] sets the objective for the preparation for re-use, recycling and other material recovery of construction and demolition waste. Nevertheless, it is often challenging to recycle construction and demolition waste because of many reasons including contamination, lack of on-site waste separation, logistics and costs.

The **recovery rate for construction and demolition waste stands at 89% across the EU27** with significant differences across Member States[89]. This means that the recovery target for construction waste in the EU of 70% was met, as stipulated by the Waste Framework Directive. Nevertheless, it was argued that, over the most recent years, the **recovery rate has not increased significantly**, and the bulk of the recovery consists of backfilling[90] or low-grade recovery, for instance using recycled aggregates from the mineral part of construction and demolition waste on applications such as road sub-bases[91]. This approach diminishes the value of the materials, overlooks qualitative recycling aspects, and does not support closed-loop recycling, which would help preserve the value of recycled materials.

Studies such as the 2022 JRC Report on the Background data collection and life cycle assessment for construction and demolition waste management highlight the potential to improve recovery, reuse and recycling quality by targeting fractions of construction and demolition waste with the greatest potential to reduce environmental impacts. These include notably reuse of concrete waste, followed by PVC, EPS-insulation and wood[92]. Furthermore, the Background data collection for future EU end-of-waste criteria of construction and demolition waste highlights the greatest potential for future end of waste criteria lies in concrete, fired clay bricks and gypsum[93]. The highest impacts can be achieved by first targeting those with the greatest potential in order to reduce the overall waste footprint of construction and demolition waste as a result.

[88] European Environment Agency (2020) Construction and demolition waste: challenges and opportunities in a circular economy. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[89] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[90] Backfilling is a recovery operation where suitable waste is used for reclamation purposes in excavated areas or for engineering purposes in landscaping and where the waste is a substitute for non-waste materials. Backfilling can be considered low-quality recovery, as it replaces a natural resource (soil) that is abundant without high environmental impacts from its production.

[91] Joint Research Centre (2023) Techno-economic and environmental assessment of construction and demolition waste management in the European Union. Retrieved from: https://circulareconomy.europa.eu/platform/sites/default/files/2024-01/JRC135470_01_1.pdf

[92] European Commission (2022) Background data collection and life cycle assessment for construction and demolition waste (CDW) management. Retrieved from: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC130992/JRC130992_01.pdf

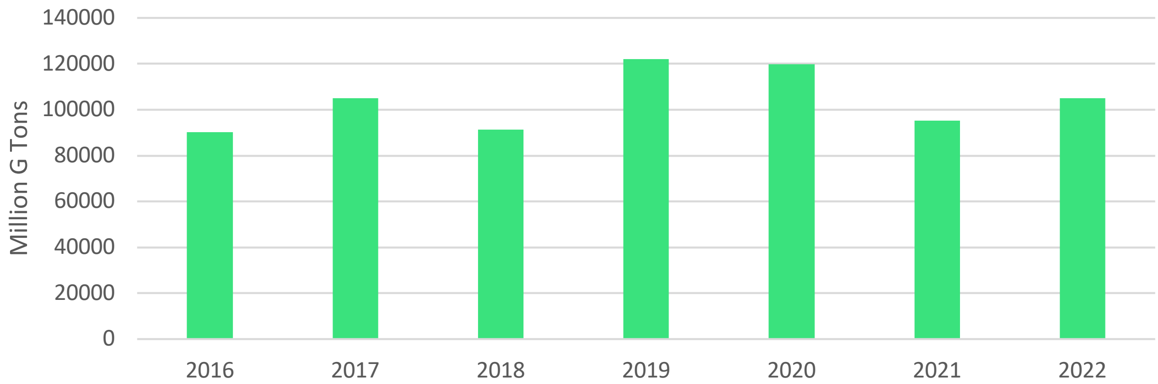
[93] European Commission (2024) Background data collection for future EU end-of-waste criteria of construction and demolition waste. Retrieved from: https://op.europa.eu/en/publication-detail/-/publication/89a1cfe5-60fd-11ef-a8ba-01aa75ed71a1/language-en

Material extraction and resource utilisation

The European Commission indicates that the **construction sector accounts for about 50% of all extracted material**[94]. They also indicate that greater material efficiency could significantly reduce emissions. More specifically, material use for buildings could potentially decrease by 30% if used more efficiently[95].

In addition, the Exiobase indicators provide insights into the amounts of used and unused materials[96] (**material extraction**) for the consumption and production related to the construction industrial ecosystem. The trends in both consumption and production within the EU exhibit fluctuations, yet overall, they tend to stabilise around consistent levels.

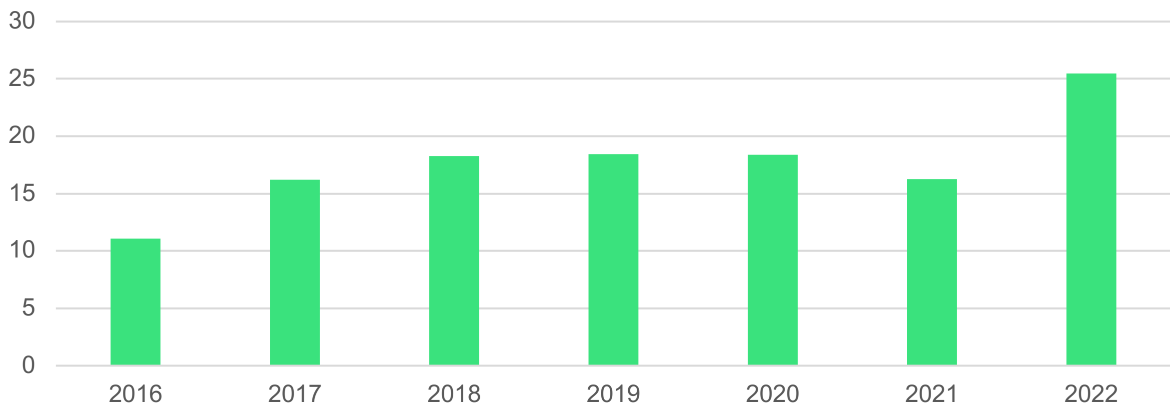
Figure 19: Material extraction of the construction industrial ecosystem (in million G tons) – production account



Source: Technopolis Group based on Exiobase

In addition, the Exiobase indicators provide more insights into resource utilisation and the implications thereof. For instance, **water** is a key input for construction. The total water consumption of the construction industrial ecosystem is generally increasing, both when considering consumption and production in the EU (for production account see Figure 23). The use of land for construction production (not depicted) in the EU is substantially lower than the land for construction consumption (see Figure 24), yet the production account grew in 2022 compared to 2021, likely attributed to an increase in construction activities following the slight decline in the COVID-19 pandemic year.

Figure 20: Water consumption of the construction industrial ecosystem (Mm³) – production account



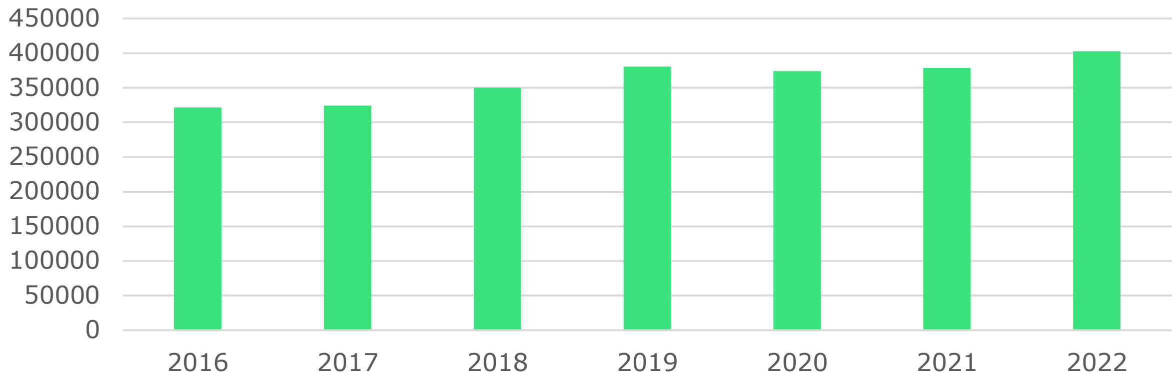
Source: Technopolis Group based on Exiobase

[94] European Commission (n.d.) Buildings and construction. Retrieved from: https://single-market-economy.ec.europa.eu/industry/sustainability/buildings-and-construction_en

[95] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[96] The methodological report outlines that these materials include used and unused crops and crops residue, grazing and fodder, forestry and timber, fisheries, non-metallic minerals, iron ore, non-ferrous metal ores, coal and peat, and oil and gas.

Figure 21: Land use (km²) of the construction industrial ecosystem - consumption account



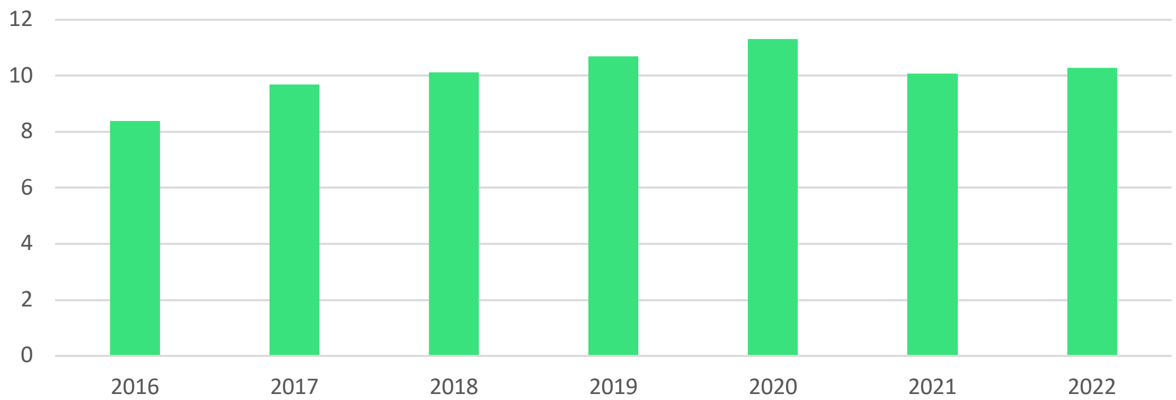
Source: Technopolis Group based on Exiobase

Pollution

The construction industry is known to contribute significantly to pollution, impacting air and water quality, as well as generating noise disturbances.

Key sources of air pollution in construction include land clearing, diesel engine operation, demolition processes, and handling toxic materials, among others. Dust is a pervasive issue across all construction sites, capable of spreading over large distances and persisting for extended periods. Exiobase indicators provide insights into the emissions of particulate matter stemming from the production accounts (environmental impact of producing in the EU, see Figure 25). The data results indicates that there is a decline noticeable in 2022 in both consumption and production particulate matter emissions. Moreover, construction activities can result in the contamination of water sources as substances like oil, diesel, solvents, and chemicals may seep into surface water or groundwater.

Figure 22: Particulate matter emissions of the construction industrial ecosystem (PM10, PM2.5[97]) (in G Tons) - production account



Source: Technopolis Group based on Exiobase

[97] Particles with a diameter of 10 microns (μm) or less (PM10) and particles with a diameter of 2.5 microns (μm) or less.

3. Digital transition

3.1. Industrial efforts into the digital transition

What is the progress of industrial efforts towards digitalisation?

- The share of digital related patenting activities in the industrial ecosystem lies **between 19 and 26% over the period of 2010 to 2021.**

- **29% of companies had a concrete strategy in place for digital transformation** in the construction industrial ecosystem in 2024.

- **The EMI Enterprise Survey revealed an increase in the uptake of digital technologies like** Cloud, Internet of Things and Artificial Intelligence. - 70% of businesses that adopted AI did so within the past two years. **21% of companies use AI in the marketing and sales stage.** AI technology can offer innovative solutions ranging from support for design processes, to solutions related to building performance optimisation and management, energy efficiency and management, and recycling decision support, among others.

- The construction industrial ecosystem is supported by **several technology centres that are active in advanced manufacturing technology & robotics, micro-and nano-electronics & photonics, as well as AI & Big data**. A co-location of cluster organisations and technology centres exists in the north-east and south of Spain, the centre of Portugal, Denmark, Sweden and Latvia, among others.

- **Startups active in the area of online platforms and AI and big data lead the startup creation** with a total of 413 startups formed between 2015 and 2023.

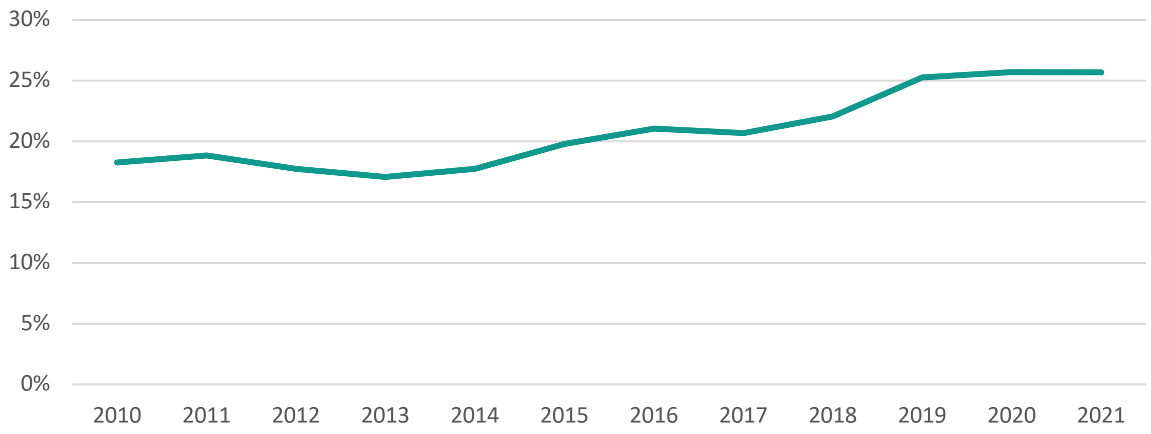
- **The vast majority of construction companies invest less than 5% of their annual turnover into digital technologies, with AI and big data leading these investments**. Robotics is a technology however, in which 12.5% of companies report investing more than 30% of their annual turnover.

3.1.1. Technology generation

Technology generation in terms of patents for the digital transition in the construction industrial ecosystem represent a complementary picture to those patenting activities highlighted in the green transition chapter above.

The share of digital transition-related patent activities of the construction industrial ecosystem relative to the other industrial ecosystems in the EU27 is presented in Figure 26. A steady increase in patents related to the digital transition can be observed over the period of 2010 to 2021. Overall, the share of digital related patenting activities lies between 19 and 26%. The steady increase can be attributed to the increasing importance of digitising the construction industrial ecosystem, also in support of overall green transition, where digital technologies are needed in order to enable the green transition.

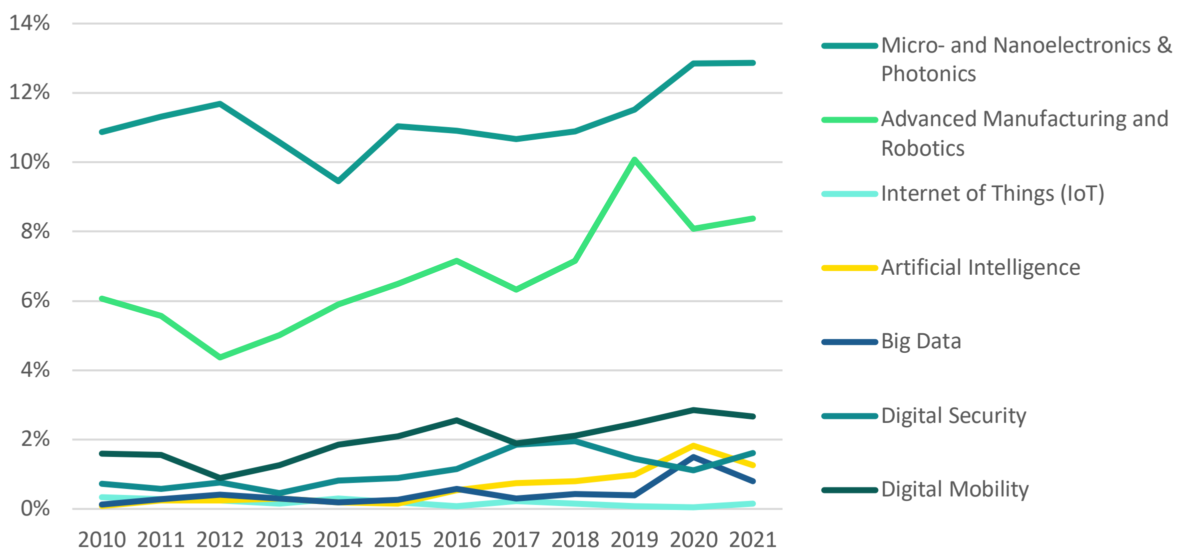
Figure 23: Share of digitalisation-related patents in the construction industrial ecosystem in all patents filed in EU27 industrial ecosystems



Source: Fraunhofer based on PATSTAT

For the digital technologies, micro- and nano electronics and photonics as well as advanced manufacturing technologies and robotics are the two leading technologies according to patenting activities for the construction industrial ecosystems in terms of patenting activities over the period of 2010 to 2021 and are significantly leading all other technologies. Recent years show the increasing trend for micro- and nanoelectronics and photonics reaching 12.9% in 2021, while advanced manufacturing technologies and robotics decline from 10.1% in 2019 to 8.1% in the pandemic year 2020 and recover to 8.4% in 2021.

Figure 24: Share of respective digital transition technologies in overall patents filed in construction industrial ecosystem



Source: Fraunhofer based on PATSTAT

3.1.2. Uptake of digital technologies

The targets of the Digital Compass set in relation to the digital transformation of businesses are dedicated to help **late digital technology adopters,** more than 90% of SMEs, to reach at least a basic level of digital intensity[98]. Despite these ambitious targets, according to the EMI survey 2024 results, **only 29% of companies have a concrete strategy in place for digital transformation in the construction industrial ecosystem**.

Figure 25: Share of companies in the construction industrial ecosystem that has adopted a strategy for the digital transformation

Does your company have a concrete strategy in place for digital transformation?

Source: EMI Enterprise Survey 2024, n=624

In 2023, cloud and big data were the leading technologies, however in 2024 the landscape of digital technology adoption for the construction industrial ecosystem has shifted towards **Cloud, Internet of Things, Artificial Intelligence, Big data and Augmented and virtual reality**, as depicted in the Figure below.

Figure 26: Share of businesses in the construction industrial ecosystem that have adopted digital technologies

Digital Technologies	***Share of adoption (2023)***	***Share of adoption (2024)***
Cloud	**27%**	**37%**
Internet of Things	12%	**23%**
Artificial Intelligence	10%	16%
Big Data	14%	15%
Augmented and Virtual Reality	11%	14%
Robotics	5%	9%
Blockchain	4%	4%
Edge Computing		3%

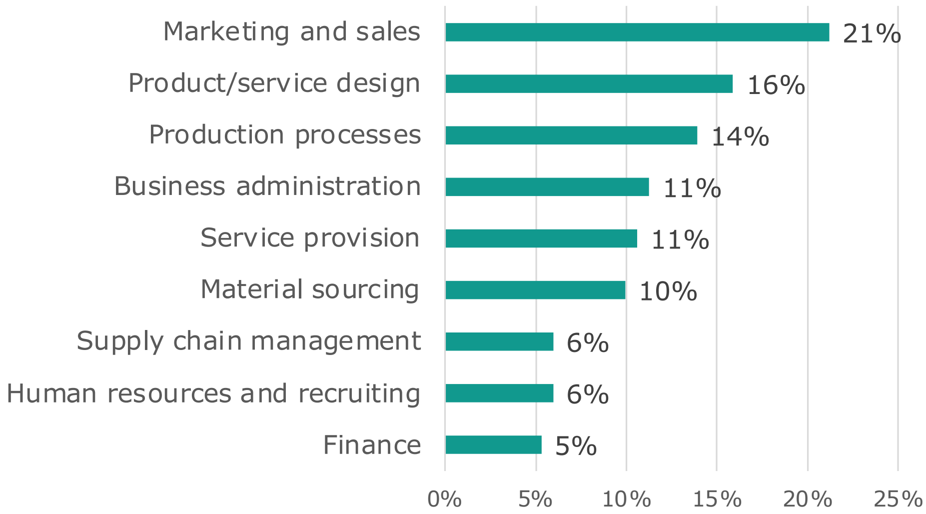
Source: EMI Enterprise Survey 2024, n=624

Adoption of Artificial Intelligence

In particular, the growing volume of accessible data has the potential to significantly enhance the capability of AI algorithms. AI technology can offer innovative solutions ranging from support for design processes, to solutions related to building performance optimisation and management, energy efficiency and management, and recycling decision support, among others. The survey of companies in the construction industrial ecosystem indicates that **70% of businesses that have adopted AI have done so within the last two years**. In terms of business operation stage, 21% of companies use AI in the marketing and sales stage. Only 30% of construction businesses develop AI systems in house (with 23% of companies relying on own employees and externals for the programming). Of the companies that report using AI, 33% rely on US service providers.

[98]European Commission (n.d.) Europe's Digital Decade: digital targets for 2030. Retrieved from: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

Figure 27: Share of construction companies using AI according to the business operation stage



Source: EMI Enterprise Survey 2024

In terms of the overall impact of the uptake of AI on construction company activities **70% of businesses that adopted AI indicated that the technology increased productivity** by an estimated 2%. The majority of respondents (83%) said that they have not laid off any employees as a result of the use of AI systems. Given the nature of AI, roles that are threatened include project managers and project consultants on construction sites. According to 22% of respondents, AI has the greatest impact on content creation, notably through generative design, which is followed by data analytics within the construction businesses.

Digital technologies contributing to the digital transition and industrial transformation are the following:

- Advanced manufacturing technology & robotics
- Online platforms
- Artificial intelligence & big data
- Augmented and virtual reality
- Internet of Things

These technologies that are applied in the construction industry are heavily interconnected and can be applied in all phases of the construction process and at any point in the building's lifecycle.

AI has the potential to help actors realise value throughout construction project lifecycles, including design, bidding, and financing; procurement and construction; operations and asset management; and business model transformation[99]. In this context, the Commission's AI Act aims at setting up a balanced approach towards AI systems, among others, for the construction professionals, as users of AI systems located within the Union. In particular, the aspects of major concern for the construction ecosystem are the harmonised rules for 'AI systems' in the Union, the specific requirements for high-risk AI systems and obligations for operators of such systems, AI resilience, and the introduction of measures in support of innovation.

In 2021 **AI adoption was reportedly still very limited** and mainly confined to pilot projects[100]. However, recent developments in the technology see an increasing exploration

[99] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[100] European Construction Sector Observatory (2021) Digitalisation in the construction sector. Analytical Report. Retrieved from: https://ec.europa.eu/docsroom/documents/45547

in the application possibilities across industries, including construction[101]. Many contractors are embracing AI innovations for their potential to transform end-to-end workflows. AI is enhancing efficiencies in design, construction, operations, and maintenance by automating repetitive tasks and addressing labour shortages. It optimises projects for sustainability and streamlines the supply chain, improving relationships between contractors and project owners through better predictability.

Advanced manufacturing technology & robotics

In advanced manufacturing technology, prefabricated construction is gaining popularity. **Prefabricated construction** or generating components or units in a factory and assembling them on-site, can reduce waste generation, transportation costs and construction time, and improve quality control, safety and flexibility. **3D printing**, also referred to as additive manufacturing, poses a game-changing advanced manufacturing technology in the construction ecosystem allowing for the development of construction components (or even whole houses) and structures through layer-by-layer manufacturing. Through this technology, custom-made building elements can be developed with minimal material waste, energy consumption can be reduced, and design flexibility and rapid prototyping is enabled. Although Europe is not always the frontrunner in digital transformations in the construction industry, **Europe is leading is construction-related 3D printing and prefabrication**[102], though the application of 3D printing is mainly limited to relatively small-scale applications[103].

Construction robots employing cutting-edge technologies significantly reduce construction time, enhance safety by replacing workers in dangerous operations, while allowing for tasks to be performed more accurately, potentially producing higher-quality results and, at the same time, reducing waste. By means of sensors, cameras, GPS, drones, etc., robots can be utilised for tasks such as conducting site inspections, excavation, concrete placement, and welding, as well as gathering data and monitoring progress, safety, and quality[104]. **Demolition robots** make up an important part of those robots used in construction as they can dismantle structures and materials with precision and speed, while minimising noise and dust. Another application of robots is in the use of **exoskeletons**, where metal frameworks are equipped with motorised parts that on-site workers wear to help with repetitive or dangerous tasks[105].

The use of robots on construction sites is still very limited in the EU according to a 2021 ESCO report[106], and the market adoption is at the infancy stage. Yet, robotics production market is predicted to grow steadily over the next years. Indeed, Mordor Intelligence estimated the construction robot market at EUR 350.3 m in 2024 and expect it to reach EUR 720 m by 2029, growing at a CAGR of 15.5%[107]. It also indicates that Asia Pacific is the largest growing market and North America is the largest market in total. Yet, several major players in this fragmented market are European, like Brokk AB in Sweden.

Online platforms

Online platforms within the construction industrial ecosystem refer to technologies that rely on Software as a Solution, providing support in various application areas. Notably among those are online platforms related to **Life Cycle Assessment (LCA)** techniques, **Building Information Modelling (BIM)** as well as **Computer Aided Design (CAD)** solutions. LCA techniques are contributing to the green transition, as LCA looks at the

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[101] Forbes (2024) AI's Current And Future Impacts On Construction. Retrieved from: https://www.forbes.com/councils/forbestechcouncil/2024/02/21/ais-current-and-future-impacts-on-construction/

[102] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[103] European Construction Sector Observatory (2021) Digitalisation in the construction sector. Analytical Report.

[104] Liu, Y., A.H., A., Haron, N.A. et al. (2024) Robotics in the Construction Sector: Trends, Advances, and Challenges. J Intell Robot Syst 110, 72 Retrieved from: https://doi.org/10.1007/s10846-024-02104-4

[105] European Construction Sector Observatory (2021) Digitalisation in the construction sector. Analytical Report.

[106] Idem

[107] Mordor Intelligence (2024) Construction Robots Market Size & Share Analysis - Growth Trends & Forecasts (2024 - 2029). Retrieved from: https://www.mordorintelligence.com/industry-reports/construction-robots-market

environmental impact of an entire product life cycle (in this case a building or construction project), including up and downstream aspects, related to materials and emissions[108].

BIM represents a solution that can help optimise energy usage by presenting and visualising system components and consumption, by predictive maintenance and by enabling real-time facility management[109]. BIM is arguably the most developed and used digital technology in the construction sector, while its **market adoption in the EU is still moderate**[110]. In Europe, 29% of construction companies use BIM 3D (including information sharing and the creation of graphical and non-graphical information), while 61% have never used it. Future BIM developments are anticipated to incorporate real-time sensor data integration in smart buildings, creating a comprehensive virtual living model of the construction project that includes status updates on potential damage and malfunctions[111].

CAD, on the other hand, presents those tools that are used in the design phase relying on specialised software. Where CAD is unanimously applied in the design process, BIM is rather a methodology looking at the full lifecycle[112].

Augmented and virtual reality

Virtual and Augmented Reality (VR/AR) integrate virtual elements into real surroundings or create entirely simulated environments. VR offers a fully digital, interactive space, while AR overlays digital elements onto the real world through computer-generated sensory inputs. In construction, VR/AR allows combining digital architectural models with physical sites and visualising project outcomes before construction begins.

The 2021 ESCO report indicates that the European VR/AR market was projected to grow significantly, with an annual growth rate exceeding 36% from 2019 to 2025. However, **market adoption in the EU remained limited**. The report finds that only 12% of construction companies report using virtual or augmented reality in their activities, with larger companies leading in adoption.

In the construction sector, VR/AR can simulate real-world situations and scenarios, offering a wide range of applications across various phases of a building's lifecycle, particularly in design, planning, construction, and management.

Internet of Things

Internet of Things (IoT) technologies allow to provide real time insights into construction activities, through the use of sensors and related software to support monitoring and decision making, while at the same time enabling worker safety and reducing costs. However, **IoT has a low adoption rate in the EU** when compared to, for example, the USA, with only around one fourth (26%) of European companies starting to use this technology, against a 40% average in the USA[113]. The low adoption rate is attributed to the fact that IoT is not yet perceived as a fully mature technology with its implementation is often limited to pilot projects. Opportunities for the adoption of IoT also lie in supporting building management, where solutions can support in optimising energy use, as well as supporting efficient waste management with real-time monitoring and automated recycling protocols[114]. There are, however, several challenges related to the uptake including high

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[108] ISO (n.d.) Environmental management — Life cycle assessment — Principles and framework. Retrieved from: https://www.iso.org/obp/ui/#iso:std:iso:14040:ed-2:v1:en

[109] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[110] European Construction Sector Observatory (2021) Digitalisation in the construction sector. Analytical Report. Retrieved from: https://ec.europa.eu/docsroom/documents/45547

[111] Idem

[112] Eng (2024). What is the difference between CAD and BIM? Retrieved from: https://engbim.com/what-is-the-difference-between-cad-and-bim/#:~:text=CAD%20deals%20almost%20exclusively%20with,across%20the%20entire%20construction%20lifecycle

[113] Idem

[114] European Construction Sector Observatory (2021) Digitalisation in the construction sector. Analytical Report. Retrieved from: https://ec.europa.eu/docsroom/documents/45547

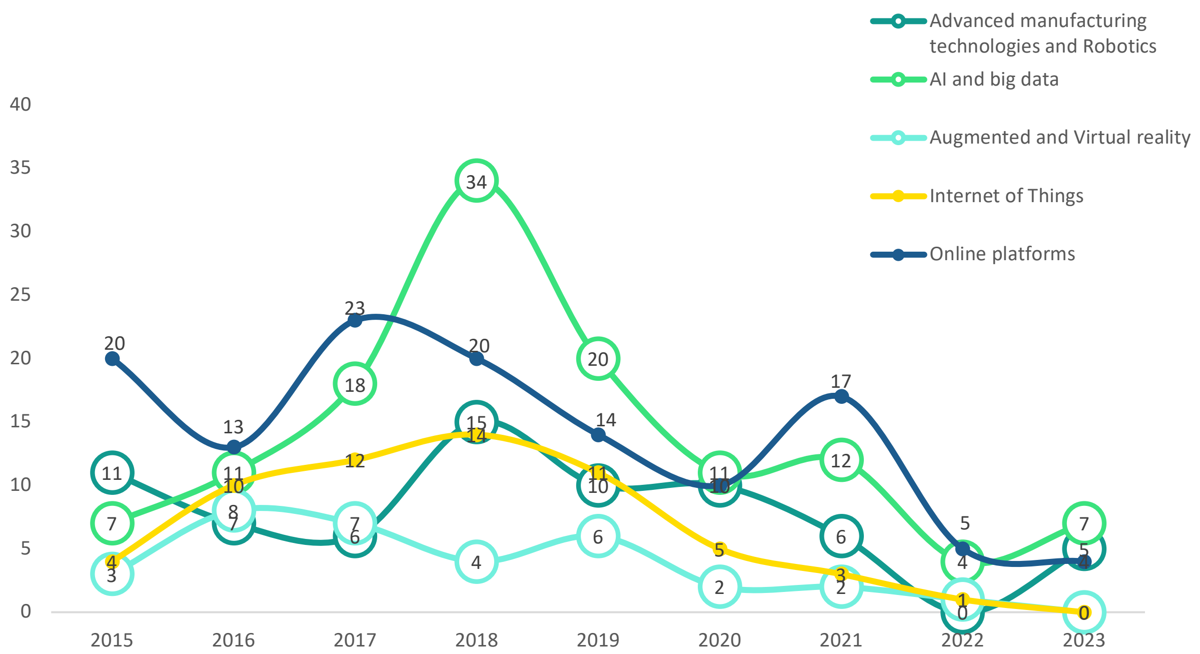
implementation costs, connectivity issues (e.g., in remote areas), maintenance and updates, and concerns about cybersecurity and privacy[115].

3.1.3. Construction tech startups

A total of **413 digital transition related startups were created in relation to the construction industrial ecosystem** between 2014 and 2023[116].

The technologies underpinning the development of digital startups in the construction industrial ecosystem include online platforms with 126 startups created over the indicated period, closely followed by startups active in artificial intelligence and big data (N=124; see Figure 34[117]).

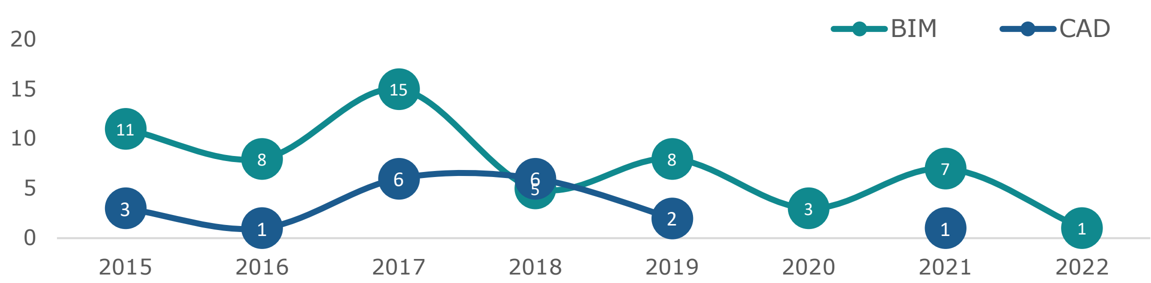
Figure 28: Digital technology startups in the construction industrial ecosystem



Source: Technopolis Group based on Crunchbase and Net Zero Insights

Zooming in on the specific topic of CAD and BIM, the startup data captures the specific developments with a total of **58 startups created in the area of BIM** in the period of 2015 to 2022, as well as **19 startups created in the area of CAD** over the same period. The declining trend observed can largely be attributed to the aforementioned data lag.

Figure 29: Construction startups specialised in CAD and BIM



Source: Technopolis Group based on Crunchbase and Net Zero Insights

[115] Neuroject (2023) What is IoT in Construction? Definition, Applications and Steps. Retrieved from: https://neuroject.com/iot-in-construction/
[116] According to the Crunchbase and NetZero Insights dataset compiled for this study
[117] A data lag has been identified due to under representativeness of the data from 2018 onwards.

Examples of startups include:

- **Aedifion**[118] (artificial intelligence and big data), founded in 2017, is a cloud platform for building and portfolio management that aims to make buildings more sustainable. The platform uses artificial intelligence for self-learning and on-demand regulation and provides a smart plug-and-play approach for easy implementation in new and existing buildings.
- **Tector**[119] (artificial intelligence) is a Danish startup founded in 2019 that focuses on eliminating damages in buildings using sensors and an AI based anomaly detection system, specifically targeting moisture.
- **SustainEcho**[120] (online platforms) is a company that has developed the first platform to use artificial intelligence (AI) for conducting Life Cycle Assessments (LCA). Their platform combines digital technology and environmental impact assessment to automate the carbon assessment of structures directly from measurements.

3.1.4. Private investments

Investments play a central role in the digital transition of the construction industrial ecosystem. EU companies tend to structurally invest limited volumes into digital technologies. In support of the digital transition, according to the EIB survey from 2024, construction firms report dedicating 12% of their annual investments towards software, data, IT and website activities[121].

Table 3 indicates the **average current and planned investments in advanced digital technologies for the construction industrial ecosystem** based on the EMI survey 2024. The survey data indicates that construction companies are planning to invest in varying digital technologies depending on the size of the planned investment. Investments in artificial intelligence and big data will be important, but comparatively small (less than 1% of annual turnover), whereas investments requiring 1 to 5% of turnover will lie rather in Cloud, Blockchain and Internet of Things. Comparatively, investments requiring more than 30% of annual turnover are led by the application of robotics technologies, indicated by 12.5% of respondents.

Table 2: Level of investment of businesses in construction into digital technologies

	Cloud	Robotics	IoT	Big Data	Artificial Intelligence	AVR	Blockchain
Less than 1% of annual turnover	45,76%	20%	48,65%	59,09%	83,87%	50,00%	28,57%
1-5% of annual turnover	44,07%	18,75%	21,62%	18,18%	3,23%	16,67%	28,57%
6-10% of annual turnover	6,78%	6,25%	5,41%			4,17%	
11-30% of annual turnover	3,39%		6,67%	4,55%			14,29%
More than 30% of annual turnover		12,50%	5,41%		3,23%		

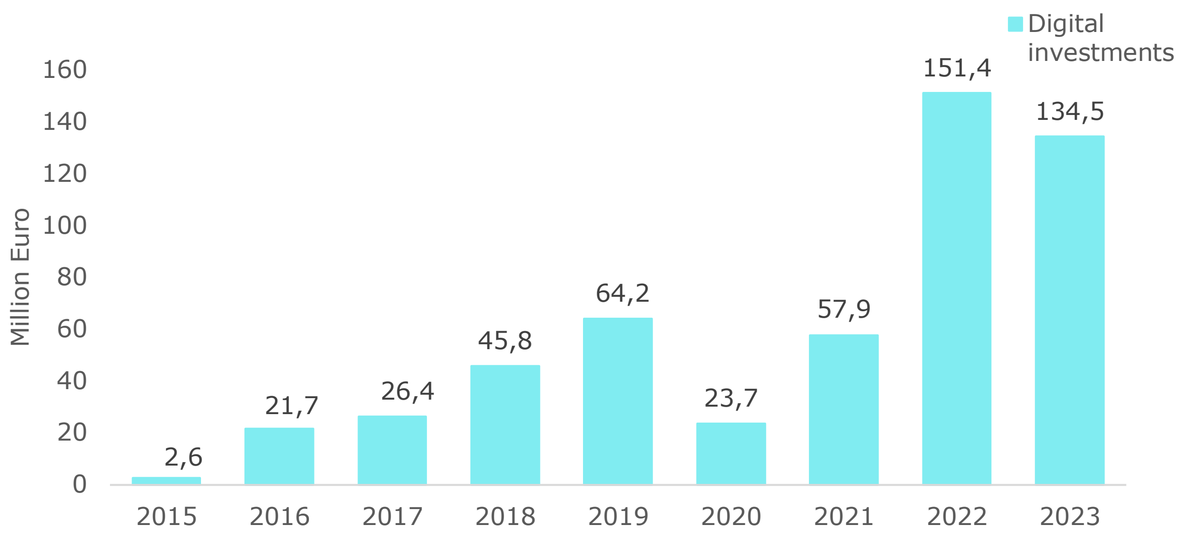
Source: EMI Enterprise survey 2024, n=630

[118] https://www.aedifion.com/en/home
[119] Formerly Woodsense, retrieved from: https://www.tector.com/
[120] https://www.emersus.io/
[121] European Investment Bank (2020) Going green: Who is investing in energy efficiency, and why it matters. Retrieved from: https://www.eib.org/attachments/efs/eibis_2019_report_on_energy_efficiency_investments_en.pdf

The transition pathway outlines that **venture capital (VC)** funding in construction startups increased globally in the past years, going from EUR 43 m in 2012 to EUR 1.2 m in 2018. However, VC investments are largely concentrated in the US and China, with the European digital startups accounting for only 4% of global VC funding in digital construction startups in 2017. France, Germany, and Sweden attracted most of these investments[122].

Venture capital investments related to the digital transition in the construction industrial ecosystem over the period 2015 to 2023 are depicted in the Figure below[123]. A global increase can be observed over the indicated period, underlying the importance of the digital transition for the construction industrial ecosystem. A peak is observed in 2022 at EUR 151 m, with a slight downturn in 2023, however this can also be related to data lags in the most recent year.

Figure 30: Venture capital investments into the construction young companies supporting the digital transition



Source: Technopolis Group based on Crunchbase and Net Zero Insights

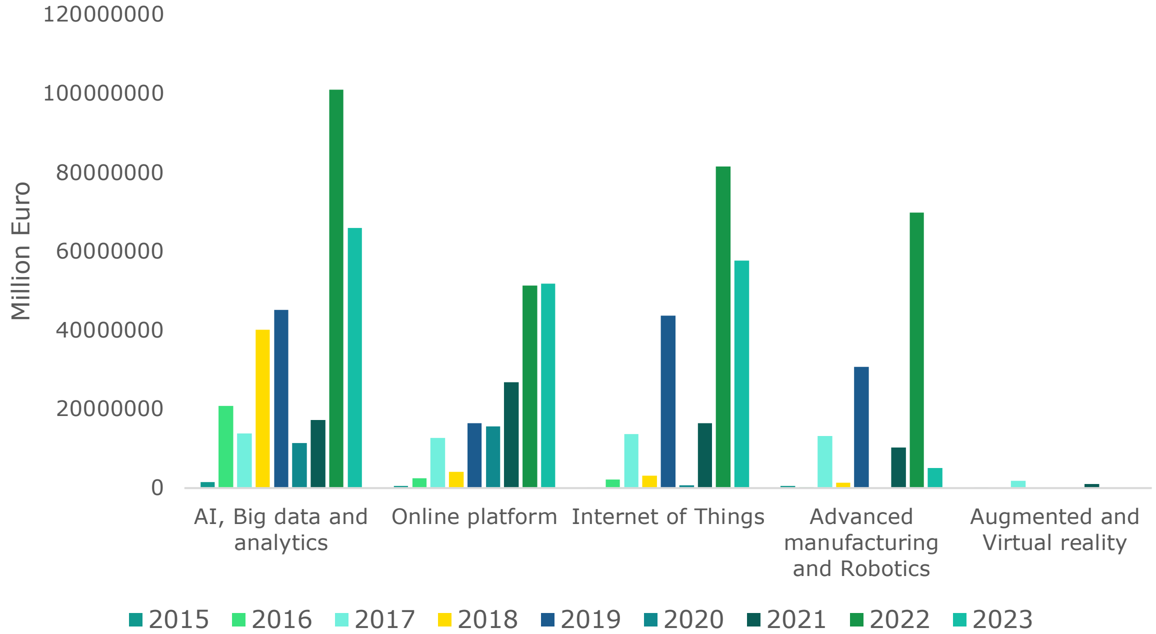
In terms of technologies, **artificial intelligence and big data have attracted a total of over EUR 317 bn in the period of 2015 to 2023**. Internet of Things follows closely with EUR 219 bn over the same period (see Figure 37). Zooming in on the venture capital investments related specifically to the case of BIM and CAD technologies, the Figure below highlights the global amounts of investments related to these specific subtopics, including information on the investment stage.

VC investments supporting BIM are largely related to seed funding, making up EUR 8.5 m of the EUR 10.6 m that went to BIM related investments in the period of 2016 to 2023. 95% of the funding that went to BIM companies, went to those combining BIM with AI or augmented and virtual reality technologies.

Funding related to CAD has largely been related to late VC funding, totalling EUR 52 m of the EUR 66 m that have gone to CAD solutions over the indicated period.

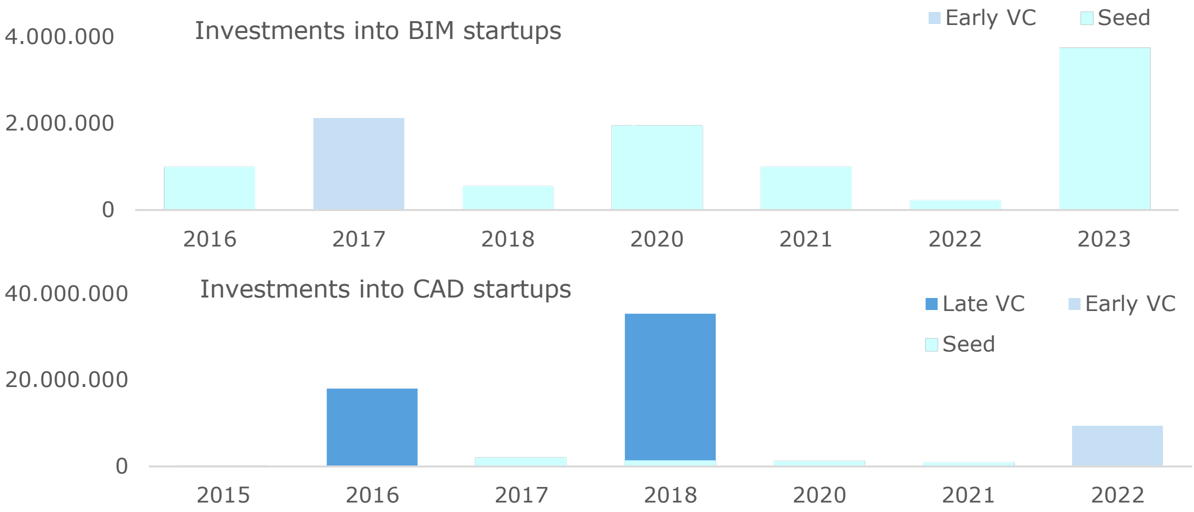
[122] European Commission (2021) Commission Staff Working Document. Scenarios for a transition pathway for a resilient, greener and more digital construction ecosystem. Retrieved from: https://ec.europa.eu/docsroom/documents/47996
[123] In the context of this study, venture capital investment into construction companies that support the digital transition have been examined by means of the investment data in Crunchbase and the Net Zero Insights database.

Figure 31: Venture Capital investments into the construction startups supporting the digital transition by category of technology



Source: Technopolis Group based on Crunchbase and NO

Figure 32: Venture capital investments in the construction industrial ecosystem related to CAD and BIM



Source: Technopolis Group based on Crunchbase and Net Zero Insights

Details on the funding rounds of further select young companies based on the Crunchbase and Net Zero Insights dataset include:

- **Agade**[124] (advanced manufacturing technology and robotics) is a company founded in 2020 that develops exoskeletons to relieve workers in pick and place operations. The company has raised nearly EUR 14.5 m over two funding rounds and received one grant.
- **Aedifion**[125] (artificial intelligence and big data) is a company founded in 2017 that has developed an automation platform to process operating data in view of increasing building operation efficiency. It raised a total of EUR 12 m in funding over 4 rounds. Their latest funding was raised in 2023 from a Series A round.

[124] https://agade-exoskeletons.com/
[125] https://www.aedifion.com/en/home

- **Oporto** (Internet of Things) is a young company, founded in 2015 that has raised just under EUR 20 m over five rounds since its founding, and focusses on the development of an intelligent maintenance management platform in support of facility management.

3.2. Framework conditions relevant for the digital transition

To what extent do framework conditions such as public financing and skills support the digital transition?

- The European Regional Development Fund (ERDF) plays a vital role in the digital transition of the construction industrial ecosystem. Over the period 2014-2020, **about 8% (or EUR 4.5 bn) of the funding to construction ERDF projects supported the digital transition.**

- **30.6% of the EC H2020 funding to construction projects contributed to the digital transition**. In Horizon Europe 61% of the EC funding to date contributes to construction projects related to the digital transition.

- In 2024, **nearly 8% of professionals registered on LinkedIn and employed within the construction industrial ecosystem possessed advanced digital skills compared to 5.75% in 2022**. This points towards an increased importance of having advanced digital skills in the construction industrial ecosystem.

- **Requirements for digital skills listed on online job advertisements within construction has been growing dynamically over the period from 2019-2023**. 19.2% of the job advertisements included a requirement of advanced digital skill such as **AI, big data, augmented and virtual reality, or cloud**, compared to 32% of the job advertisements requiring moderate digital skills.

As in the case of the green transition, framework conditions refer to various structural and institutional elements that create an enabling environment for businesses to progress in the digital economy. These conditions are crucial for driving the adoption of digital technologies. Key components of these framework conditions include the generation of underlying technologies, public policy, skills demand and supply and demand-side factors among others that are analysed in the sections below.

3.2.1. Public investments supporting the digital transition

Public investments in the digital transition serve as an important framework condition. Not only do private investments stimulate innovations and technological developments, but they also signal a commitment to sustainable development, making the ecosystem more attractive to businesses, investors, and other stakeholders. This study examines the **public investments supporting the digital transition in the construction industrial ecosystem.**

Cohesion policy

A key source of public funding that enables the digital transition is the **EU's regional development funds**. For this analysis, two data sources have been used and merged, namely the Cohesion Open Data maintained by the European Commission and the Kohesio data[126].

[126] For more information on the data sources and the approach, see the methodological report.

The total number of **ERDF projects in the construction industrial ecosystem** that could be identified in 2014-2020 was 88 701, representing a total funding of EUR 105 bn. The analysis shows that **about 8%** (or EUR 4.5 bn) **of the funding to construction ERDF projects supported the digital transition**. Some examples of construction projects supporting the digital transition are described in Box 4.

Box 4: ERDF construction projects supporting the digital transition

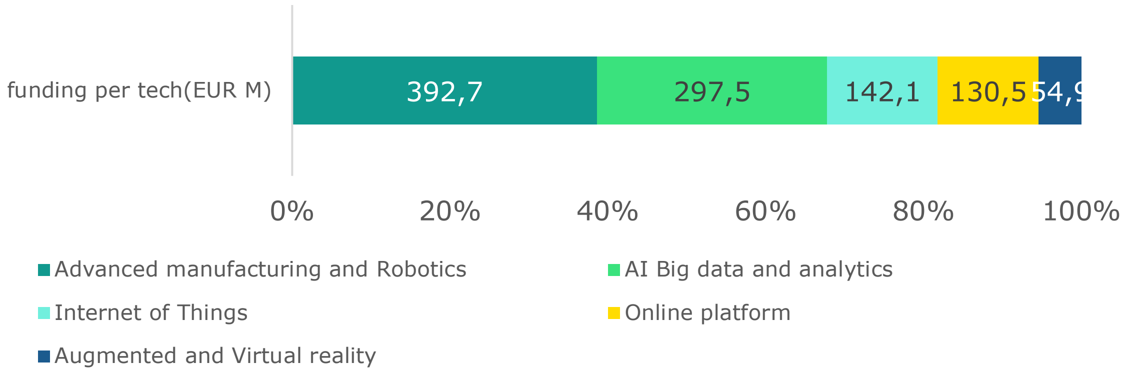
The ERDF project "**Intelligent system for analysis and diagnosis in building automation, enhanced with semantic technologies and based on the internet of things**" was carried out in Cyprus from 2018 to 2021. Domognostics+ aimed to harness the flexibility of the Internet of Things by providing seamless monitoring and control capabilities for buildings with the goal of improving aspects such as occupant comfort, energy efficiency, air quality, and system reliability. The project focused on developing and evaluating an innovative smart solution that combined software and low-cost hardware, designed to improve the monitoring of essential building systems. Domognostics+ includes a platform, an Internet of Things gateway, a semantic enhancement system, and a suite of smart building applications. The project received EUR 150,888 in EU funding.

The Czech project '**Artificial intelligence for automatic visualization of new roofs and facades"'** was implemented in 2022. The project focused on developing software powered by neural networks, which allows customers to automatically visualize new roofs or facades criteria using a smartphone application. By uploading a photo of the house, the neural network—pre-trained on the applicant's existing data—automatically identifies and marks the roof or facade areas where new coverings or paint can be applied, providing customers with an immediate preview of the result. The project received EUR 14,667.75 in EU funding.

Source: Technopolis Group based on Kohesio

When examining the ERDF construction projects that contribute to the digital transition, 19.2% of the funding is going towards projects related to advanced digital technologies[127]. Figure 39 shows the distribution of funding in these projects. Most funding is attributed to advanced manufacturing technology and robotics, followed by AI and big data.

Figure 33: Share of funding into advanced digital tech funded within ERDF construction projects that contribute to the digital transition



Source: Technopolis Group based on Kohesio

Framework Programmes

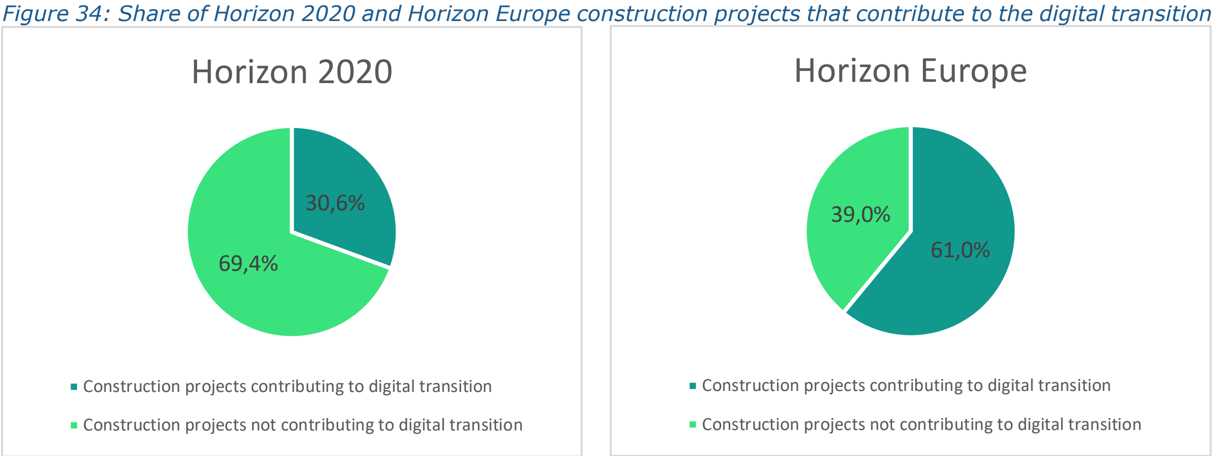
Funding data from the EU Framework Programmes for Research and Innovation, in particular from Horizon 2020 (2014-2020) and Horizon Europe (2021-2027) has been analysed. The analysis of the CORDIS data demonstrates that the Horizon 2020 programme provided EUR 102 m to projects classified under the construction industrial

[127] As identified for the purpose of this project, e.g., projects related to IoT, AI, Cloud, Blockchain, advanced manufacturing etc.

ecosystem[128]. Horizon Europe has thus far[129] provided EUR 45 m in funding to those projects.

In Horizon 2020, **30.6% of the EC funding to construction projects contributed to the digital transition**. In Horizon Europe, **61% of the EC funding** contributes to construction projects related to the digital transition (see Figure 40). This is a significant increase and underscores the importance of the digital transition in the construction industrial ecosystem. It is to be noted that there are Framework Programme projects that contribute both to the green and digital transition.

Figure 34: Share of Horizon 2020 and Horizon Europe construction projects that contribute to the digital transition



Source: Technopolis Group based on CORDIS

Several examples of construction projects funded under Horizon 2020 and Horizon Europe supporting the digital transition are described in Box 5.

Box 5: Horizon 2020 and Horizon Europe construction projects supporting the green transition

Horizon 2020 funded the **BIM4REN** (Building Information Modelling based tools & technologies for fast and efficient RENovation of residential buildings) project[130] that started in 2018. BIM4REN is designed around three workflows tailored to the needs of the construction sector, particularly focusing on SMEs. The project adapts its consortium, processes, methodologies, and tools to offer innovative solutions for each segment, using advanced BIM technologies like the open-source BIM Server and TNO's BIM Bots. Partners include the European Builders Confederation, the Green Building Council Italy, and the French social housing organisation Logirep, ensuring representation across the entire residential renovation value chain. The project received EUR 6.997.515 in EU funding.

Horizon Europe funds the project **REHOUSE** (Renovation packagEs for HOlistic improvement of EU's bUildingS Efficiency, maximising RES generation and cost-effectiveness). The REHOUSE project, started in 2022, aims to develop and demonstrate eight renovation packages with innovative technologies up to TRL7, designed for various building renovation actions, including deep renovations. These packages follow circularity principles, integrating multifunctional elements, prefabrication, and off-site construction while respecting architectural and historical values. The project includes a people-centric approach to ensure affordable and attractive renovations for residents and owners. The packages will be tested in demonstration sites across Greece, Italy, France, and Hungary. REHOUSE offers flexible, affordable solutions that address nearly all EU renovation challenges and aims to boost market uptake, scalability, and replicability by addressing economic, technical, social, and regulatory barriers. The project receives an EU contribution of EUR 10.016.536.

Source: authors based on Cordis

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[128] The methodological report provides detailed insights into the methodology. In particular, the CORDIS data have been merged with the relevant EuroSciVoc data. EuroSciVoc connects projects to relevant scientific concepts, providing a deeper understanding of the research focus.
[129] Cut-off date is March 2024
[130] BIM4REN. Cordis. https://cordis.europa.eu/project/id/820773

3.2.2. Digital skills

Construction is labour intensive, hence **technological changes** and **digitalisation** of working processes can improve working conditions, prolong working life and enhance employee well-being and morale, while also attracting young talent to the sector.[131].

The greater adoption of digital technologies and the recognition that these technologies are needed to enhance competitiveness, productivity, and energy efficiency, also imply **changing skills needs** in the construction sector[132]. Yet, the Construction Blueprint discloses a key skill gap in, amongst others, the area of digitalisation. Cedefop identifies key emerging skills in digitalisation and reskilling needs (see Table 3). Cedefop also outlines that new production techniques, especially the use of off-site fabrication, change the organisation of work on a construction site and have a significant impact on skills demand.

Table 3: Skills in digitalisation

Emerging skills in digitalisation	Reskilling needs in construction sites due to the adoption of digital technologies
• Data analysis; • Robot programming; • Robot managing: operation of robotic systems used in a manufacturing environment, but also on site, such as demolition, welding, and bricklaying robots; • Construction drone piloting; • Sensor installation and operation; • Knowledge of AI-assisted tools in architecture; • Design automation expertise (using key tools such as 3D modelling); • Cybersecurity expertise; • GIS skills; • Innovation and integration expertise.	• Increased familiarity with the use of digital devices on site, such as computers, tablets and other smart devices for monitoring processes and operations; • Usage of cloud technologies; • Basic programming knowledge; • Familiarity with common data standards and KPIs; • Knowledge of construction-specific application programmes, like CAD or 3D modelling; • Knowledge of BIM and related digital tools; • Knowledge of digital workflow and project management platforms and advanced scheduling optimisation programmes.

Source: Cedefop

3.2.2.1. Skills demand

Skills demand in the construction industrial ecosystem has been analysed following the skills intelligence insights of Cedefop, as outlined in Chapter 2. These data provide insights into the job advertisements in the construction industrial ecosystem and about the advanced and moderate digital skills that are in demand.

The results indicate that the requirements for digital skills listed on online job advertisements within construction has been growing dynamically over the period from 2019-2023. The results of the data analysis show that 19.2% of the job ads included a requirement of advanced digital skill such as AI, big data, augmented and virtual reality, cloud. A higher share notably 32% of the job ads required moderate digital skills (more than simple Microsoft or web skills but not necessarily artificial intelligence).

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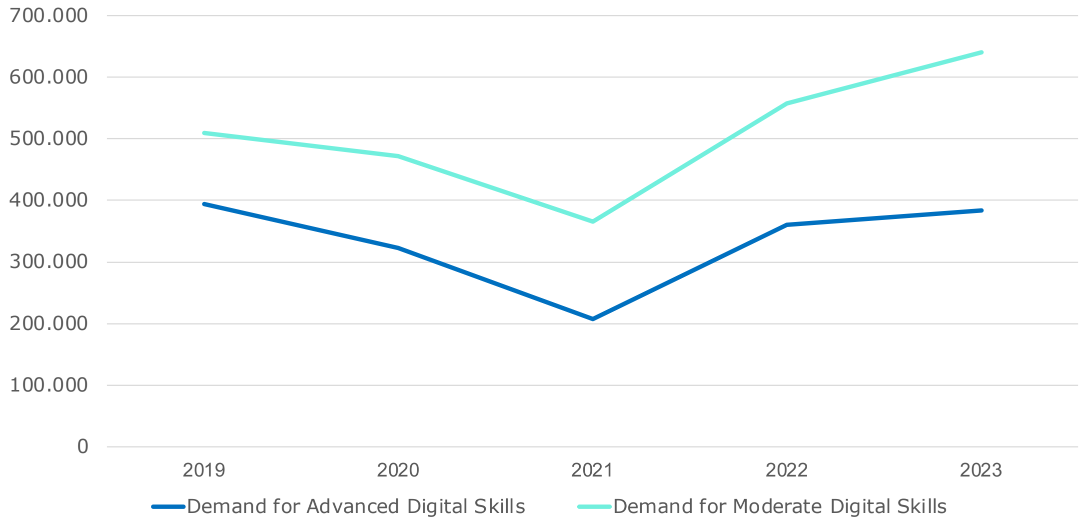
131 European Commission (2023). Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

132 Cedefop (2023). The greening of the EU construction sector. Skills intelligence data insights. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

Figure 35: Total number of online job advertisements with a requirement for digital skills in construction in the EU27



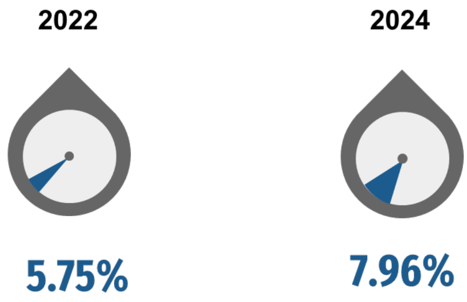
Source: Technopolis Group based on analysis of Cedefop data

3.2.2.2. Skills supply

The **LinkedIn database** has been consulted to gain insights into professionals working in the construction industrial ecosystem. Keywords have been defined to capture the **advanced digital transition skills** that professionals have. In particular, advanced digital skills have been defined in the context of the main digital technologies captured in this project notably in artificial intelligence, cloud computing, connectivity, robotics, Internet of Things, augmented and virtual reality and blockchain, but in additional advanced software technologies have been also included that are relevant for the industrial ecosystem.

As outlined in Section 2.3, there were 3.9 million professionals registered in construction on LinkedIn in April 2024. Notably, within the registered professionals on LinkedIn employed in the construction industrial ecosystem, the shares of professionals with advanced digital skills have increased from 2022 to 2024 from about 5.8% to 8% (see Figure 42), pointing towards an increased importance of having advanced digital skills in the construction industrial ecosystem.

Figure 36: Share of professionals in construction with advanced digital skills



Source: Technopolis Group based on LinkedIn

3.2.3. Demand for digital services by consumers

This section explores the demand of consumers for digital services, hereby focussing on two concrete applications, namely the demand for smart homes and buildings, and the demand for prefabricated construction.

Demand for smart homes and buildings

Digitalisation of buildings is a key component of the EU clean energy transition. Integrating smart technologies in buildings can enhance energy efficiency, allow buildings to be more responsive to the needs of occupants, and improve the flexibility of energy systems. According to the European Commission, a smart building can sense, interpret, communicate, and actively respond efficiently to changing conditions like the operation of technical building systems, the external environment, and demands from the grid.

Current concerns when turning a household into a smart home are security, the interoperability of different devices, aftermarket support requirements, and increased prices of these devices. Also hindering the uptake of smart appliance technologies is the fact that it presents solutions to problems not really needing a solution (e.g., most people do not really need a wi-fi refrigerator, smart lock, new thermostat etc.)[133].

In addition, for a successful deployment of technologies like smart appliances and home energy management systems within smart homes, some conditions need to be in place, such as the roll-out of smart meters, smart grids, and fast internet access to name a few[134]. Recently, the European Commission developed the **Smart Readiness Indicator** (SRI), an initiative that measures buildings' abilities to use smart technologies. Currently, the SRI is being tested by EU countries, preparing its large-scale implementation. An earlier BPIE report[135] concluded that, in 2017, some Member States were on track for a smart buildings reality (namely Sweden, Finland, Denmark and Netherlands), while other Member States still had a long way to go concerning the development of a smartness environment in the building sector.

BUILD UP, the European Commission's portal for energy efficiency and renewable energy in buildings, estimates that in 2022, **45 million buildings are smart**[136], and it predicts more than 115 million smart buildings by 2026. Moreover, Statista Market Insights shows that customers in the EU27 are increasingly seeking smart home solutions that offer convenience and efficiency. One prominent trend in the smart home market is smart lighting systems. Revenues in the smart home market are projected to reach EUR 21.9 bn in 2024[137].

Demand for prefabricated construction

As indicated above, prefabricated construction is gaining popularity. The technologies involved fulfil the changing demands of modern architecture for sustainability and customisation while increasing productivity, decreasing waste, and providing greater design flexibility, also allowing for faster completion of projects[138]. In the past, many research and innovation projects (such as Framework Programme funded projects) have exploited the modular and industrialised approach, with advanced digital technologies like AI, IoT, 3D printing, and BIM driving advancements[139]. To date, the challenges mainly

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[133] Joint Research Centre (2019). Smart home and appliances – State of the art – Energy, communications, protocols, standards. Retrieved from: https://data.europa.eu/doi/10.2760/453301

[134] Joint Research Centre (2019). Smart home and appliances – State of the art – Energy, communications, protocols, standards. Retrieved from: https://data.europa.eu/doi/10.2760/453301

[135] BPIE (2017) Is Europe ready for the smart buildings revolution? Retrieved from: https://www.bpie.eu/publication/is-europe-ready-for-the-smart-buildings-revolution/

[136] European Commission (2022) More than 115 million smart buildings predicted by 2026. Retrieved from: https://build-up.ec.europa.eu/en/news-and-events/news/more-115-million-smart-buildings-predicted-2026

[137] STATISTA (2024) Smart Home – EU27. Retrieved from: https://www.statista.com/outlook/cmo/smart-home/eu-27?currency=EUR

[138] Ferdous, W., et al. (2022). Construction industry transformation through modular methods. In *Innovation in Construction: A Practical Guide to Transforming the Construction Industry.* Retrieved from: https://link.springer.com/chapter/10.1007/978-3-030-95798-8_11

[139] European Commission (2024) Build Up. Modular construction in the commercial sector. Retrieved from: https://build-up.ec.europa.eu/en/news-and-events/news/modular-construction-commercial-sector

relate to boosting market uptake, stakeholder acceptance and exploiting the benefits of the modular approach[140].

The European market for prefabricated buildings is estimated to reach a value of EUR 52.82 bn by the end of 2024, with expectations to grow to EUR 68.83 bn by 2029, representing a CAGR of 5.4% throughout the period from 2024 to 2029. The European market for prefabricated buildings is particularly strong for commercial buildings with a projected CAGR growth of 5.7% between 2022 and 2027. The residential prefabricated buildings market is expected to grow at a slightly lower rate of 4.5%[141].

3.3. Impact of digital technologies on industrial competitiveness

What is the progress of industrial efforts towards digitalisation?

- The integration of **digital technologies** is viewed as a key element **to tackle some of the main challenges** the construction industrial ecosystem is faced with, such as labour shortage, resource and energy efficiency, and productivity. The construction ecosystem is making progress in the uptake of digital technologies, though with different levels of maturity and adoption across technologies and Member States.

- The construction industry puts pressure on the **development of digital technologies** to become more tuned to the industry specific needs. As such, digital technologies have the **potential to make the construction industry more competitive** in the EU in global comparison, while at the same time, those digital technologies can become more competitive through their uptake in the construction industry as well.

- The EMI survey of construction companies reveals that the **adoption of advanced digital technologies has increased productivity by 10-15%**. Among the technologies driving this productivity boost, robotics and artificial intelligence were identified by respondents as having the greatest impact.

-Countries as **Spain and Italy** that promote knowledge valorisation of digital and green technologies through strong co-location patterns also **showcase a strong performance** in the construction ecosystem in terms of production, trade and patents.

This section analyses the extent to which companies perceive digital technologies as enhancing their competitiveness, both for their business and the industry. It also explores the reasons why investing in digital technologies is worthwhile and identifies which ones are particularly advantageous for the construction industrial ecosystem. Next, it analyses whether countries with strong co-location patterns of technology centres and cluster organisations also exhibit higher levels of production, trade and patent activity.

Advanced digital technologies have been adopted by several companies in the EU and the construction ecosystem is rapidly digitalising in various areas[142]. **Construction is however recognised as one of the least digitised industrial ecosystems**, although still more advanced than some others[143]. While different levels of maturity and adoption

[140] European Commission (2022) Build Up. OVERVIEW| Modular and industrialised solutions for building renovation. Retrieved from: https://build-up.ec.europa.eu/en/resources-and-tools/articles/overview-modular-and-industrialised-solutions-building-renovation

[141] Mordor Intelligence (n.d.) Europe prefabricated buildings market size & share analysis-growth trends and forecast (2024-2029). Retrieved from: https://www.mordorintelligence.com/industry-reports/european-prefabricated-buildings-industry-study

[142] European Commission (2023) Transition pathway for Construction. Retrieved from: https://ec.europa.eu/docsroom/documents/53854

[143] CEDEFOP (2023) The greening of the EU construction sector. Skills intelligence data insights. Retrieved from: https://www.cedefop.europa.eu/en/data-insights/greening-eu-construction-sector

were identified among various technologies and EU Member States, it is clear that the EU construction ecosystem is making progress in the uptake of digital technologies[144]. The integration of digital technologies is viewed as a key element to tackle some of the main challenges it is faced with, such as labour shortage, competitiveness, resource and energy efficiency, and productivity[145].

The construction industry puts pressure on the development of digital technologies to become more tuned to the industry specific needs. Efficiency gains in construction have sufficient potential in terms of actual energy and materials savings, also in view of overall scarcity and in times of crisis. At the same time, the construction industrial ecosystem is important in terms of reaching political targets especially in the decarbonisation of buildings, such as those put forward in the revised Energy Performance of Buildings Directive[146], but also related to initiatives such as the New European Bauhaus[147]. As such the industry itself also dictates the needs for future digital technologies. Materials scarcity drives the need to look for solutions such as 3D printing in construction to not only customise but maximise the materials available during a building project. Drones find considerable application in the construction industrial ecosystem in order to remotely monitor parts of the construction, gaining insights that were not possible before. The need to ensure safety also pushes for the creation of exoskeletons to protect workers.

As such, **digital technologies have the potential to make the construction industry more competitive** in the EU in global comparison, while at the same time, those **digital technologies can become more competitive through their uptake in the construction industry** as well. In global comparison, the EU lags behind especially China and the US in many aspects related to the development and uptake of digital technologies related to the construction industrial ecosystem, which is in part due to the larger market size[148]. Through combining the digital and green transition, building on the ambitious targets put forward at European level, European construction industrial ecosystem players can boost their competitive positioning while reinforcing the European industry.

The survey of construction companies indicates that the adoption of advanced digital technologies increased productivity between 10-15%. The largest share of respondents witnessed an increase in productivity as a result of robotics followed by AI (see Table below).

[144] European Construction Sector Observatory (2021) Digitalisation in the construction sector. Analytical Report. Retrieved from: https://ec.europa.eu/docsroom/documents/45547
[145] European Commission (n.d.) State of play. Digitalisation in construction. Retrieved from: https://single-market-economy.ec.europa.eu/document/download/19b956ba-7c22-4cfb-bb4f-9b85d5f4c212_en
[146] European Union (2024) DIRECTIVE (EU) 2024/1275 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L_202401275
[147] European Union (n.d.) New European Bauhaus. Retrieved from: https://new-european-bauhaus.europa.eu/about/about-initiative_en
[148] Future Market Insights Inc. (2023). Construction Tech Market Outlook (2023 to 2033). Retrieved from: https://www.futuremarketinsights.com/reports/construction-tech-market

Table 4: The impact on productivity of advanced digital technologies as expressed by the share of respondents in construction

	Increased	No change	Decreased
Robotics	80%	20%	
Artificial Intelligence	67%	32%	6.12%
Cloud computing	65%	34%	
Big Data	59%	40%	
AVR	16%	75%	8%
IoT	27%	69%	
Edge computing	37%		
Blockchain	50%	50%	

Source: EMI Enterprise survey 2024, n=630

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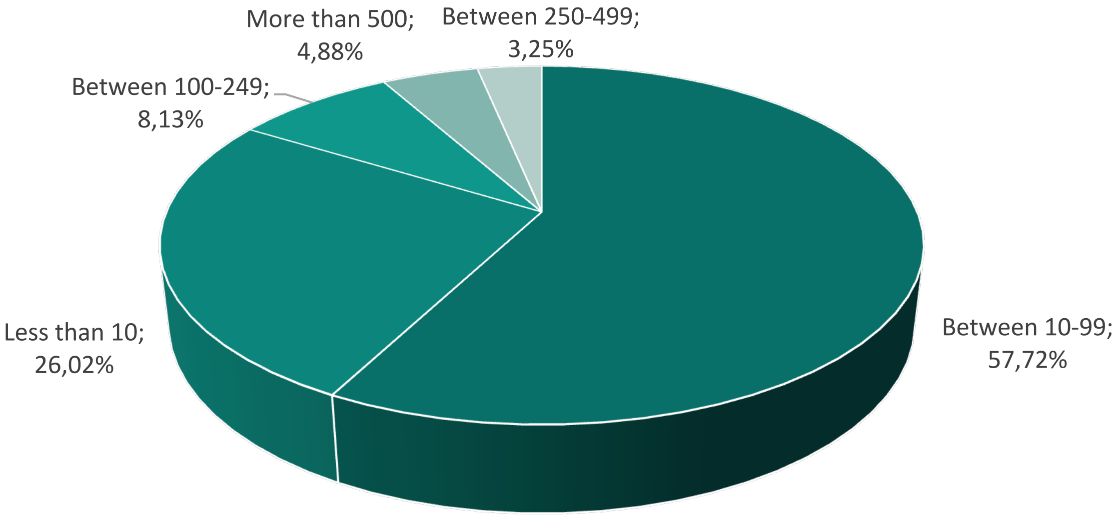
Appendix B: Methodological notes

EMI Survey 2024 – Sample of construction companies

The EMI Survey 2024 included a total of 624 companies were included and the following sample distribution of companies from the construction industrial ecosystem.

Figure 37: Survey sample distribution according to company size – construction



Source: EMI Enterprise survey 2024

Startup data and venture capital data analysis

Selected fields from Crunchbase and Net Zero Insights: Architecture, Construction, Smart Home, Smart Building, Real Estate, Green Building

LinkedIn data analysis

Selected fields from LinkedIn included:

- Construction
- Architecture & Planning

Green skills – keywords used: Cleantech, Sustainability, Sustainable Development, Sustainable Business, Energy Efficiency, Clean Energy Technologies, Renewable Energy, Wind Energy, Biomass, Biomass Conversion, Solar Energy, Solar Power, Urban Forestry, Forest Ecology, Sustainable Communities, Waste Management, Waste Reduction, Recycling, Water Treatment, Water Resource Management, Water Purification, Green Marketing, Green Printing, Environmental Biotechnology, Environmental Science, Environmental Engineering, Environmental Management Systems, Environmental Protection, Wastewater Treatment, Ecology, Circular Economy, Zero Waste, Waste to Energy, Plastics Recycling, E-Waste, Carbon Reduction Strategies, Carbon Footprinting, Carbon Neutral, Energy Retrofits, Biodiversity, Biodiversity Conservation, Nature Conservation, Advanced Materials, Nanomaterials, Biomaterials, Reuse, Separation Process, Sorting, Equipment Repair, Natural Resource Management, Sustainability Reporting, Green Development, Sustainable Cities, Energy Conservation, Energy Management, Environmental Awareness, Environmental Impact Assessment, Environmental Compliance, Leadership in Energy and Environmental Design (LEED), Environmental Policy, Green Technology, Sustainable Design, Sustainable Architecture, Environmental Consulting, Maintenance and Repair, Solar PV, Solar Cells, Wind Turbines, Wind Turbine Design, Carbon Capture, Low Carbon Technologies, Low Carbon, Renewable Fuels, Renewable Energy Systems, Renewable Resources, Integrated Water Resources Management, Natural Resources, Biodiesel, Bioplastics, Waste Treatment, Waste Water Treatment Plants, Electric

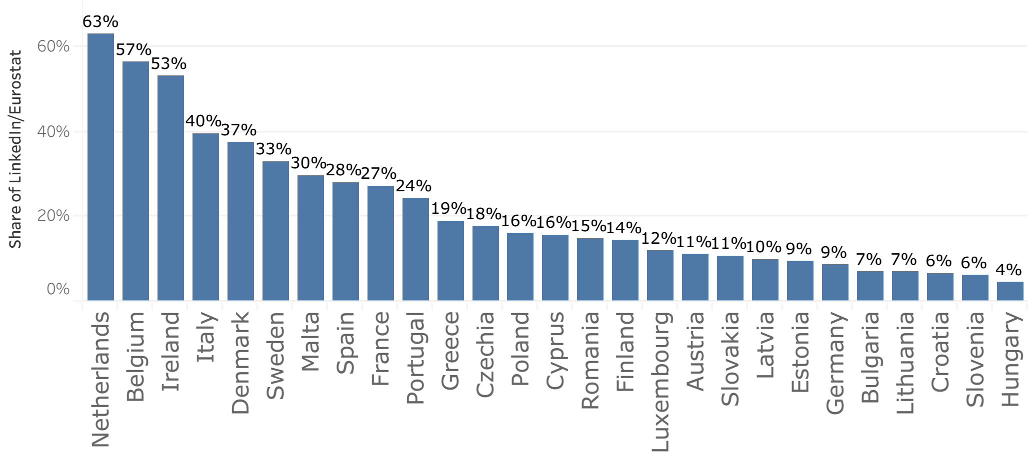
Vehicles, Hybrid Electric Vehicles, Multi-modal Transportation, Energy Efficiency Consulting, Recycled Water, Adaptive Reuse, Ecodesign, Life Cycle Assessment, Energy Optimisation, Alternative Fuels, Green Building, Green Infrastructure, Green Purchasing, Biodegradable Products, ISO 14001, EMAS, Environmental Standards

Digital skills – keywords used: data analytics, tourism flow management, online platforms, digital payment, online ticketing, Cybersecurity, Intrusion Detection, Malware Detection, Cloud Security, Cybercrime Investigation, Cyber Threat Intelligence (CTI), Cryptography, DLP, Malware Analysis, IDP; Vulnerability Assessment, Certified Information Security Manager (CISM), Computer Forensics, Cloud Infrastructure, Cloud Services, Google Cloud Platform (GCP), SAP Cloud Platform, SAP HANA, Everything as a Service (XaaS), Software as a Service (SaaS), Platform as a Service (PAAS), Infrastructure as a Service (IaaS), Private Clouds, Hybrid Cloud, Cloud Computing, Edge Computing, High Performance Computing (HPC), Serverless Computing, Robotics, Robot, Robotic Surgery, Human-robot Interaction, Drones, Connected Devices, Internet of Things (IoT), Robotic Process Automation (RPA), Wireless Sensor Networks, Embedded Systems, Cyber-Physical Systems, Smart Cities, Artificial Intelligence (AI), Biometrics, Cognitive Computing, Computer Vision, Deep Learning, Machine Learning, Natural Language Processing (NLP), Natural Language Understanding, Natural Language Generation, Reinforcement Learning, Speech Recognition, Supervised Learning, Unsupervised Learning, Big Data Analytics, Hadoop, Real-time Data, Yarn, Teradata Data Warehouse, Blockchain, Ethereum, Bitcoin, Cryptocurrency, Crypto, Distributed Ledger Technology (DLT), Hyperledger, Augmented Reality (AR), Virtual Reality (VR), Mixed Reality, Computer-Generated Imagery (CGI), Connectivity, M2M, 5G, SD-WAN, Home Automation, Flexible Manufacturing Systems (FMS), Smart Manufacturing, Smart Materials, Quantum Computing, Smart Devices, Intelligent Systems, Big Data, Computer-Aided Design (CAD), Computer Science, MATLAB, C (Programming Language), Python (Programming Language), Digital Strategy, Digital Printing, Digital Marketing, Online Journalism, Revit, Building Information Modeling (BIM), JavaCard, R (Programming Language), Digital Imaging, Digital Media, C++, Collaborative Robotics, Industrial Robotics, Medical Robotics, Mobile Robotics, AutoCAD, Automation, Autodesk 3ds Max, Lumion, Data Analysis, Data Mining, 5G Core, Integrated Security Systems, Cloud Applications, Cloud Computing IaaS, Cryptocurrency Mining, CryptoAPI, Automated Machine Learning (AutoML), Machine Learning Algorithms, Virtual Reality Development, Virtual Data Rooms, Intelligence Systems, Robot Programming, Predictive Analytics, Data Lakes, Blockchain Analysis, Digital Publishing, Enterprise Software, Software Development, SAS (Software), SAP Products, SAP ERP, Online Payment, Online Payment Solutions; Online Travel, Online Marketing, Online Business Management, Online Advertising, Online Gaming, Web Services, Mobile Applications, Mobile Marketing, Java Database Connectivity (JDBC), Data Warehousing, Statistical Data Analysis, Data Modeling, Databases; Electronic Data Capture (EDC), Data Centers, Oracle Database, SAP Solution Architecture Data Entry, Data Management, Data Mapping, Web Applications, GIS Applications, Oracle Applications, Visual Basic for Applications (VBA), Computer Hardware, Computer Maintenance, Computer Network Operations, Computer Networking, Computer Graphics, Online Communications, Social Media Marketing, Digital Direct Marketing, Digital Illustration, Digital Video, Digital Photography, Xero, GPS Applications, GPS Devices, GPS Tracking, GPS Navigation, Microsoft Power Apps, Social Networking Apps, Google Apps Script, Social Media, E-Commerce, Data Intelligence, Online Platforms, Mobile Payments

Representativeness of LinkedIn data. In November 2022, there were 3 659 017 professionals employed in the Construction industrial ecosystem including construction (2 380 902), architecture (742 067) and civil engineering (536 048), located in the EU27 and registered on LinkedIn.

When we compare the number of the Construction sector profiles on LinkedIn with the Eurostat Structural Business Statistics Annual detailed enterprise statistics for construction (last data available from 2018), we get some impressions about the representativeness of the LinkedIn sample). The comparison shows that some countries as the Netherlands, Belgium or Ireland included a larger share of the estimated total workers while other countries are not at all representative in this sector.

Figure 38: Share of the number of LinkedIn users with a profile registered in the industry 'Construction' and the number of Employees in Construction as captured by Eurostat



Source: Technopolis Group based on LinkedIn and Eurostat, SBS Annual detailed enterprise statistics for construction (NACE Rev. 2, F) (online data code: SBS_NA_CON_R2)

There is however a need for a lot of caution when interpreting the above figures. First, there is a difference between the official statistical information available about the persons employed in the Construction sector and the taxonomy of LinkedIn regarding Construction. In LinkedIn profiles of registered professionals and companies are attributed to a certain sector such as 'Construction' based on the self-selection of core industry by the registered members themselves on the one hand and there is also an algorithm cleaning up the missing information on the other hand. Our assessment after checking some of the profiling is that people who claim to work in the Construction sector, do so and the overall attribution is correct. Differences also come from the fact that LinkedIn in general is more of a target for professionals with higher educational attainment. In the Construction sector, this means that managers and engineers with a profile on LinkedIn are better represented on this platform compared to professionals with lower level of education.

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