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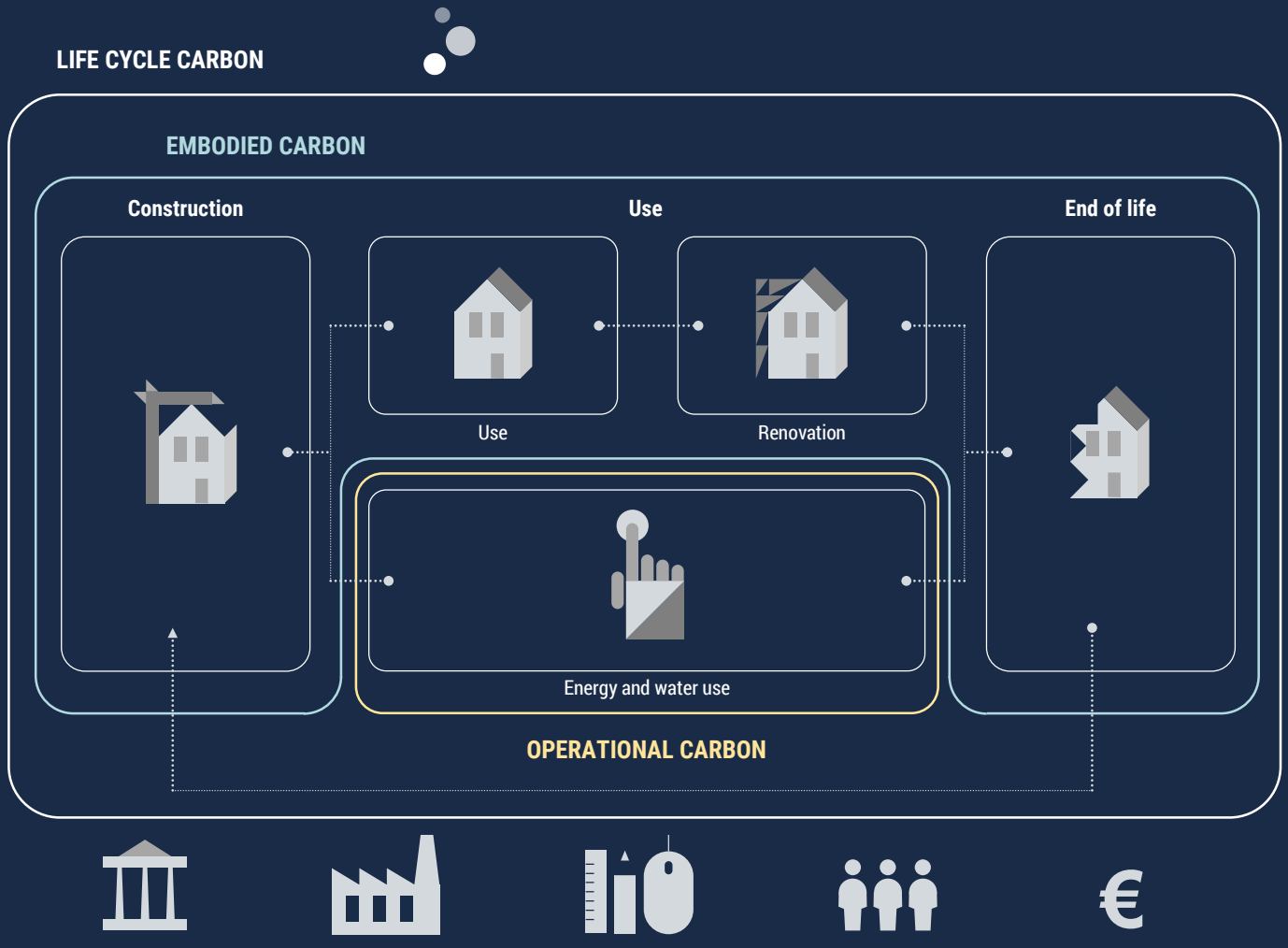
Whole Life Carbon Roadmap for a decarbonised built environment in Spain



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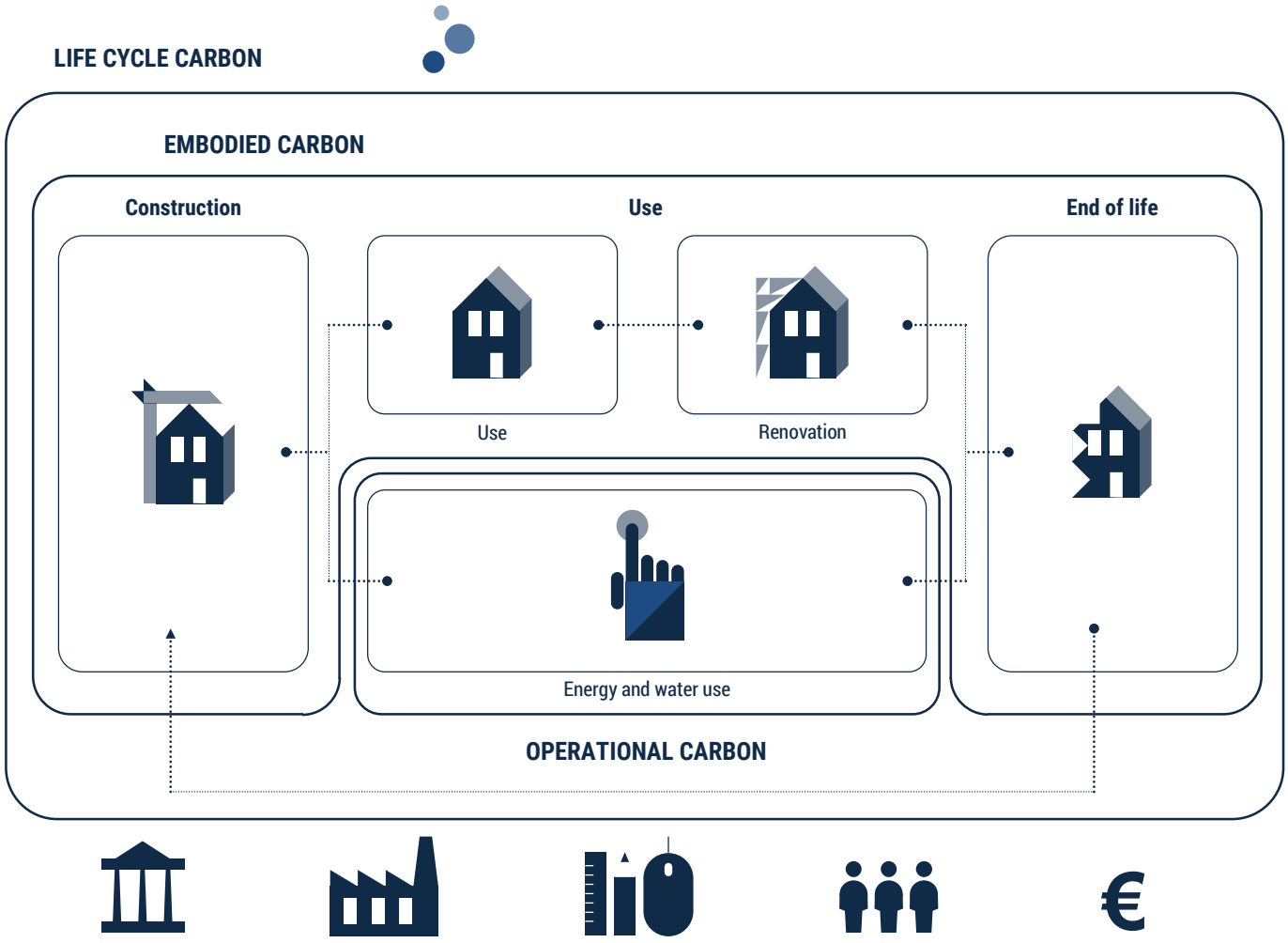

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EXECUTIVE SUMMARY

Why do we need a Whole Life Carbon Roadmap for the decarbonisation of the built environment?

In the **context of the climate emergency**, the building sector plays a crucial role. In Europe, it is responsible for 40% of energy consumption and 36% of energy-derived CO_2 emissions [1]. And nationwide, the sector accounts for a total of 30.1% of final energy consumption and 25.1% of emissions[2], 8.2% of which are direct emissions associated with fuel consumption in the residential, commercial and institutional sectors[3]. This is primarily due to the fact that Spain has an aged and inefficient building stock which does not meet the habitability needs of the 21st century.

The global and sectoral strategies implemented in Europe and nationwide to accelerate the transformation of our building stock (Renovation Wave, NECPs, LTRSs) and to increase the performance of new buildings (energy performance certificates, nearly zero-energy buildings) focus their efforts on decarbonising the operation of buildings, without mentioning other emissions from the lifespan of the building which can account for up to 50% of the building's overall emissions.

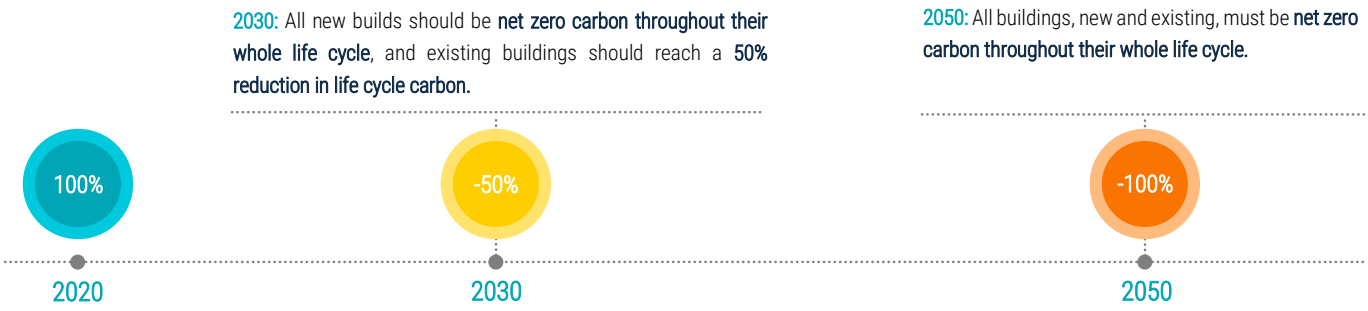
Taking into account both the trend of growth of new buildings, planned renovations and systems replacement, the global GHG emission scenarios (direct and indirect) for the residential sector in Spain for the coming years continue to grow, largely due to embodied carbon.

Spearheaded by 10 European countries through their GBCs (Green Building Councils), the Building Life initiative is a concerted effort that supports the ambition of the European Green Deal and seeks to accelerate change, mobilising the market as well as public administration bodies and citizens around shared decarbonisation targets.

To produce this roadmap in each participating country, a process of dialogue and joint participation was set in motion with all the stakeholders in the building value chain. In Spain, this forum will continue to run for at least another year, in order to improve and transform this initiative.

Which objectives can be reached by 2030 and 2050?

In line with Vision 2050 and the WorldGBC recommendations, the sector's gradual shift to **full decarbonisation of the building stock by 2050** is set as the Roadmap's primary goal.



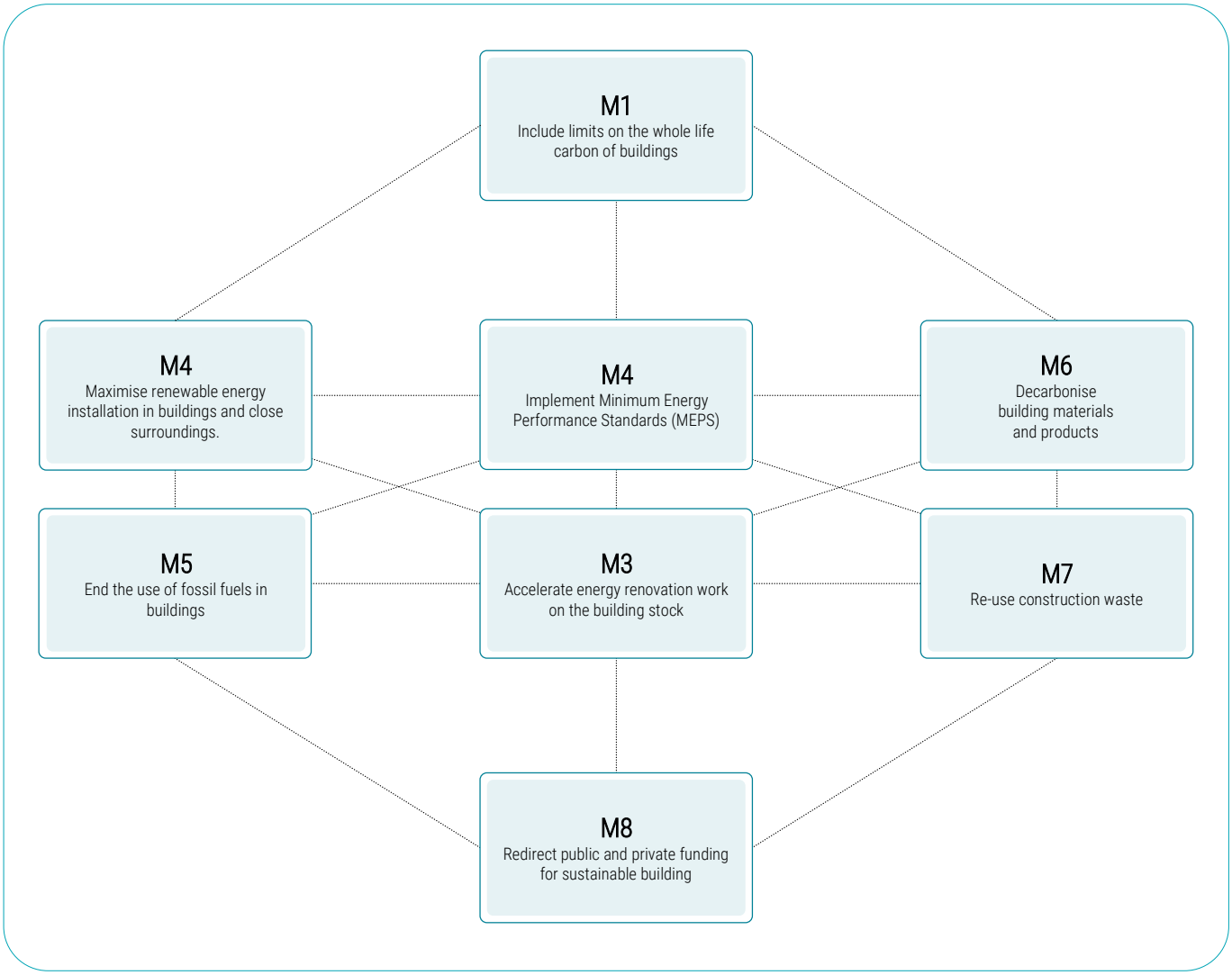
[1] Built4People, 2020. People-centric sustainable built environment
[2] Pontificia de Comillas University, 2020. Energy and Sustainability Development Observatory in Spain, pp. 20 and 21.
[3] Ministry for the Ecological Transition, 2021. National Inventory Report on Greenhouse Gases.

In line with this global target, 8 main milestones have been proposed to help the sector, investors and citizens in general to focus their efforts and make them more efficient. The main milestone (M1) is to include carbon limits for the whole life cycle of buildings. Three groups of milestones are defined around it:

- On the transformation of the building stock: M2 and M3 introduce the Minimum Energy Performance Standards (MEPS) for existing buildings and dwellings and accelerate the pace of the comprehensive renovation of buildings, taking advantage of the Next Generation EU Fund opportunity.

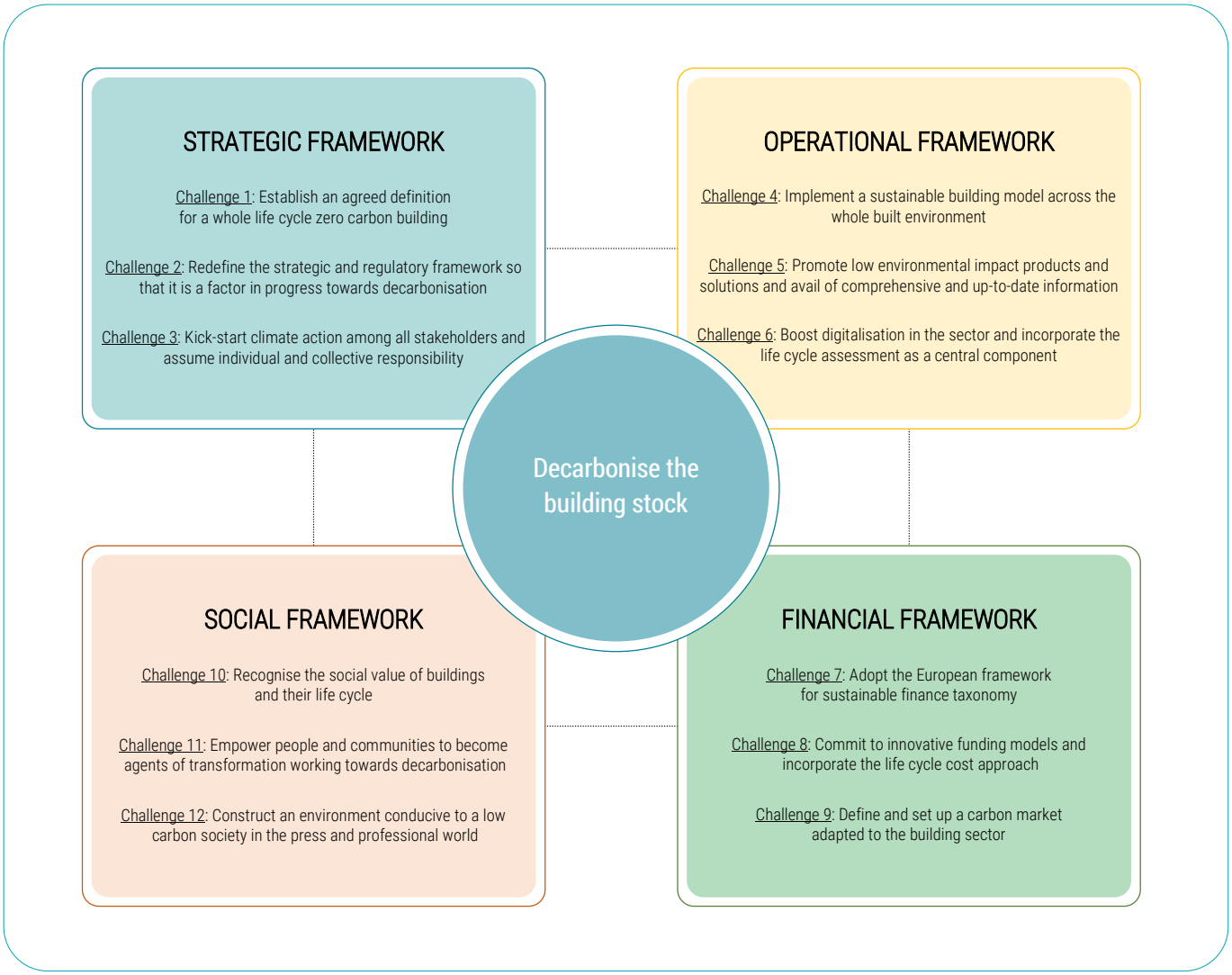
- On energy in buildings: M4 and M5 accelerate the implementation of renewables in buildings or their close surroundings. Furthermore, they mark the end of use of fossil fuels in buildings.

- On building products and systems (materials): M6 and M7 seek to decarbonise building products and bring about circular solutions. Lastly, they aim to secure the investments necessary for the sector's transformation.



What will make the transformation possible?

To reach these milestones, the roadmap proposes measures across 4 frameworks of intervention, addressing the need to promote comprehensive action on all fronts involved in the decarbonisation of the building sector: the strategic framework, the operational framework, the financial framework and the social framework.



Each of these frameworks is related to reaching the decarbonisation milestones in the building sector. And to make it possible, **14 specific courses of action** address a series of specific challenges.

Conclusions

- **We must tackle the whole life-cycle carbon emissions.**

  According to the scenarios in this roadmap, embodied carbon accounts for more than 50% of the sector's cumulative emissions over the next 30 years. Limiting it is as urgent as reducing operational carbon. We will only be able to do so if we take action across the whole life cycle of buildings.

- **We must take urgent action.**

  We are in the midst of a climate emergency, to which the building sector is a major contributor. It is our responsibility to maximise the scope of the measures already available, particularly by building on the momentum of the Recovery, Transformation and Resilience Funds. Postponing key measures for complete decarbonisation of buildings would be a missed opportunity, thus delaying the path to net zero emissions.

- **We must leverage the carbon investment that has already been made in the existing building stock**

  We have a building stock of more than 40 million buildings. It accounts for a huge investment in carbon which we must leverage through renovation. 11% of the 21 million main dwellings planned for 2050 are newly built, however, they will be responsible for a third of the carbon emitted up to that point. Renovation must be the sector's main activity so that it meets at least the target of 9 million dwellings renovated by 2050.

- **Decarbonisation is, above all, an opportunity**

  The transition towards a decarbonised sector implies multiple systemic changes to the way we work and organise ourselves. Changes that help to improve the sector and meet social and environmental needs, thereby generating wealth. New markets and business models around decarbonising the building sector will emerge from this transition.

- **All stakeholders need to get on board**

  The whole life carbon roadmap for a decarbonised built environment is an instrument for steering the efforts of all the stakeholders in the value chain. Working together is essential if we want to make more rapid progress towards hitting our goals. Each organisation has its own responsibility and as a sector we have a responsibility, too. We must now take it on and act decisively.

CONTENTS

TERMINOLOGY

Life cycle carbon (or whole life carbon)

Greenhouse gas emission (GHG) emissions associated with the energy consumed during all the phases of the life cycle, encompassing both embodied and operational carbon. In relation to EN 15978, the life cycle carbon corresponds to all the modules. It is also referred to as total carbon.

Embodied carbon

Greenhouse gas emissions (GHG) associated with the phases of production, construction, renovation, use and end of life of the building. Concerning renovations, it encompasses both the upfront carbon as well as the incorporated embodied carbon. Embodied carbon is therefore generated throughout the whole life cycle of the building and refers to both the materials and the construction processes used in the building. In relation to EN 15978, embodied carbon corresponds to modules A1-3 of the production phase, A4-5 of the construction and renovation phase, B1-5 of the use phase and C1-4 of the end of life phase.

Upfront (embodied) carbon

Greenhouse gas emissions (GHG) associated with the phases of production and construction of new builds. Upfront carbon is therefore generated before the building is used and refers to both the materials and the construction processes used. In relation to EN 15978, upfront carbon corresponds to modules A1-3 of the production phase and A4-5 of the construction phase.

Incorporated embodied carbon

Greenhouse gas emissions (GHG) associated with the phases of renovation, use and end of life of the building. Incorporated embodied carbon is therefore generated after the building starts to be used and refers to both the materials and the construction processes used. In relation to EN 15978, incorporated embodied carbon corresponds to modules B1-4 of the use phase and B5 of the renovation phase, as well as C1-4 of the end of life phase.

Operational carbon

Greenhouse gas emissions (GHG) associated with the energy consumed during the building's use phase in order to maintain habitable conditions inside it, referring to both air conditioning (heating and cooling) and other uses (domestic hot water, appliances, cooking appliances and lighting). In relation to EN 15978, operational carbon corresponds to module B6.

Environmental Product Declaration (EPD)

The Environmental Product Declaration or EPD is a standardised report or document that provides environmental information about a product, material or service, which is quantified and verified by a third party. This tool is used to assess the environmental impact and the use of resources throughout the life cycle of products in accordance with EN 15804 and its Product Category Rules (PCRs).

Ecolabels

Ecolabels or environmental labels are a form of labelling referring to a product's environmental performance. There are 3 types of Ecolabels: Ecolabels (Type I) in accordance with ISO 14024, self-declared claims (Type II) in accordance with ISO 14021 and environmental product declarations (Type III) in accordance with ISO 14025 and UNE EN 15084. The latter provides data from a product's life cycle assessment (LCA) by undertaking an overall, multi-criteria evaluation of the environmental impacts from the product's source right the way through to the end of its lifespan.

Circular Economy

The circular economy is an economic model that uses the minimum amount of natural resources necessary (and in a broader sense, water and energy) to meet the needs required at any given time. It selects resources in an intelligent way, avoiding non-renewable energy and critical raw materials. It favours the use of recycled material if possible and they are fit for the purpose in question. It efficiently manages the resources used, maintaining and recirculating them in the economic system for as long as possible thereby creating added value. It generates less waste and avoids the use of unnecessary resources. It reduces environmental impacts, restoring natural capital and encouraging their regeneration.

Nearly zero energy buildings (NZEBs)

Nearly zero energy buildings (NZEBs) are buildings with a very high level of energy performance whose energy demand is covered by renewable sources of energy generated in the building itself or its surroundings. This first definition has been transposed to the national context in the Spanish Technical Building Code, which defines a nearly zero energy building as a new or existing building that meets the regulatory requirements established in the basic document "DB HE Ahorro de Energía" (energy savings) regarding the limitation of energy consumption for new builds. It became effective on 31 December 2020 for newly constructed buildings and on 31 December 2018 for public buildings.

Zero operational carbon buildings (or net zero operational carbon buildings)

Although still awaiting an official definition, a zero operational carbon building is a building with zero greenhouse gas emissions (GHG) during the operational use of the building. In relation to EN 15978, these emissions correspond to module B6.

Zero whole life carbon building (or net zero whole life carbon building)

Although still awaiting an official definition, a zero whole life carbon building is a building with zero greenhouse gas emissions (GHG) during the whole life cycle of the building. It therefore requires detailed accounting of the GHG emissions associated with all building processes, from design to demolition, and it encompasses both the embodied carbon (associated with the external appearance of the building) as well the operational carbon (associated with the running of the building during its lifespan). In relation to EN 15978, these emissions correspond to all the modules.

The official definition should clarify both the carbon thresholds of a net zero building over the whole life cycle and the strategies to achieve this net zero emissions balance, such as carbon offsetting or sequestration.

Greenhouse gas emissions (GHG)

Greenhouse gas emissions or GHG emissions refer to the amount of gases released into the atmosphere (in addition to CO_2) that absorb and emit radiation and cause the greenhouse effect. These emissions are quantified in the form of CO_2 equivalent (CO_2eq) on the basis of their global warming potential (GWP), taking into account a time period of 100 years. The measurement of CO_2 equivalent is a common scale for comparing emissions of different GHGs to determine the carbon footprint of each product, process or service.

Direct greenhouse gas emissions (GHG)

Direct GHG emissions refer to the amount of greenhouse gases released into the atmosphere from the consumption of fuels in the building itself. In relation to EN 15978, these emissions correspond to the part of module B6 that uses fossil fuels on the building site itself.

Indirect greenhouse gas emissions (GHG)

Indirect GHG emissions refer to the amount of greenhouse gases released into the atmosphere outside the building itself, such as emissions derived from electricity generation or from the manufacture of materials. In relation to EN 15978, these emissions correspond to all the A and C modules, and to the part of module B6 that generates emissions outside the building site.

Minimum Energy Performance Standards (MEPS)

Minimum Energy Performance Standards (MEPS) are rules that compel buildings to meet minimum energy performance requirements by a specific compliance deadline or at a certain key point in the life of the building, e.g., sale or lease of the building. MEPS can be based on a building's energy or carbon rating as well as improvement measures. MEPS can be applied to the whole building stock or even to specific sectors according to, for example, type (offices, dwellings, etc.), size, occupancy, public or private ownership.

Digital Building Logbook

The Digital Building Logbook is a shared telematic repository for all the data relevant to the building. It provides transparency, trust, informed decision-making and the exchange of information within the construction sector, among owners and occupants of buildings, financial institutions and public authorities.

Level(s) framework

Level(s) is an informative and voluntary framework driven by the European Commission which provides a common language for sustainability in the construction sector, i.e., a set of simple indicators that allow us to measure building performance from a sustainability point of view throughout its life cycle. Level(s) encourages the application of the life cycle concept to the whole building. It is, in effect, an exhaustive set of instruments for the development, supervision and operation of the building, which contributes to improving performance from the design phase right through to the end of the life cycle.

Climate neutrality

The concept of climate neutrality is defined in the Paris Climate Agreement 2015. It states that greenhouse gas (GHG) emissions, not just CO_2, should be balanced and equal to (or less than) those removed through the planet's natural absorption.

Building Renovation Passport

The Building Renovation Passport is an instrument proposed by the European Union as a complementary measure to long-term renovation strategies, which supports the owner or community of owners throughout the intense renovation process in steps to increase the quality of all the aspects of the building, with the aim of improving living conditions, enhancing its energy efficiency and reducing its GHG emissions.

European Taxonomy

The EU Taxonomy is a classification system which establishes a list of environmentally sustainable economic activities. The EU Taxonomy is important to sustainable investments and the application of the European Green Deal. In particular, by providing companies, investors and policy-makers with appropriate definitions for the economic activities that can be considered environmentally sustainable. It is expected to create security for investors, protect private investors from greenwashing, help companies to plan for the transition, mitigate market fragmentation and finally help shift investments to where they are most needed.

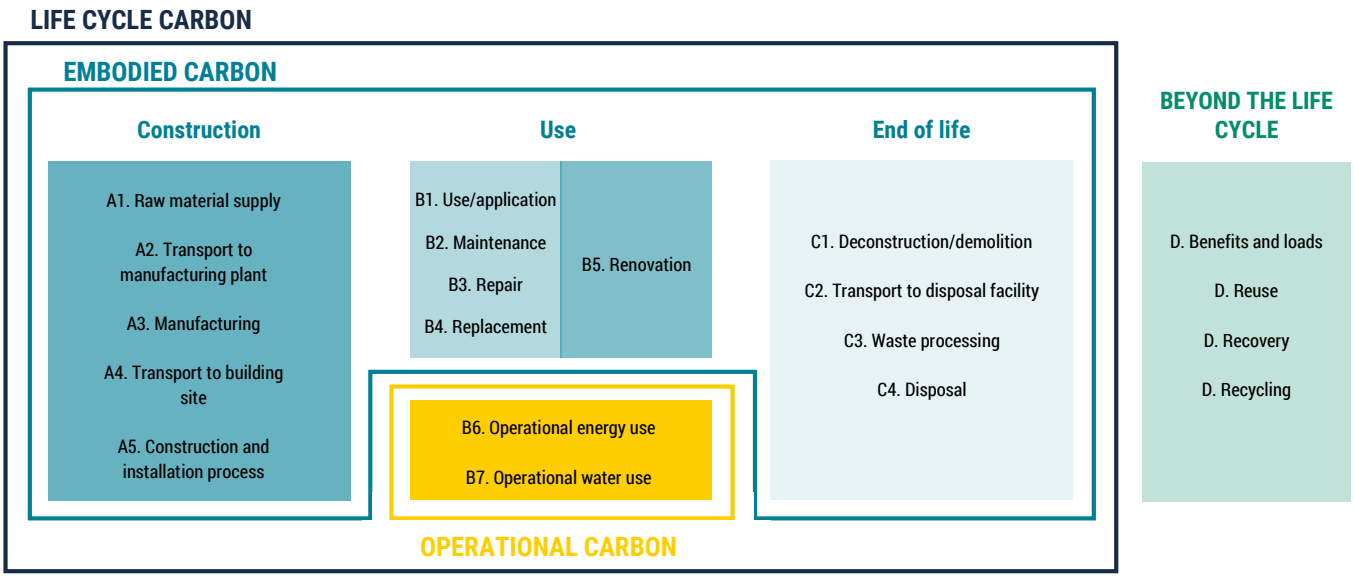


Figure 1. Terminology used in the document relating to the life cycle carbon. Source: Own publication based on EN 15978

INTRODUCTION

CARBON IN THE BUILDING SECTOR

Global, European and national context

On 28 November 2019, the European Parliament declared a climate emergency, so the EU committed to neutralising its total greenhouse gas emissions by 2050[4], with the ultimate aim of curbing global warming to 1.5 °C.

The building sector plays a crucial role in this climate emergency context, as it is responsible for 36% of final energy consumption and 39% of the CO_2 emissions derived from energy worldwide[5]. In addition, it is estimated than by 2050 the current size of the building stock will have doubled to meet the ever-increasing world population, which could reach 10 billion inhabitants, a particularly significant fact for developing countries. Given current trends, the global building sector would, over this time horizon, generate the entire greenhouse gas budget, which the IPCC believes would lead to the 2 °C increase limit being met[6].

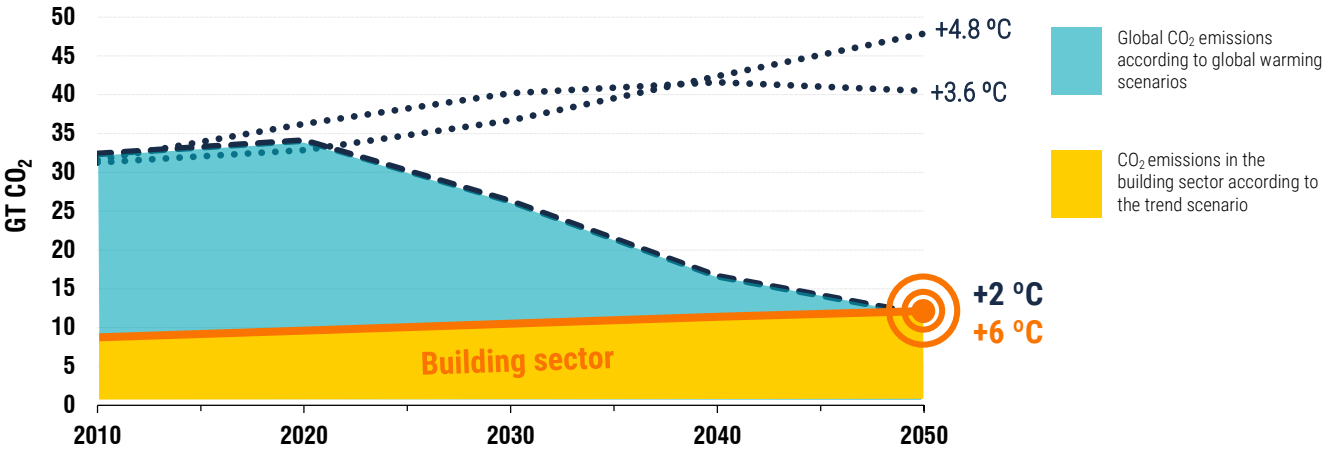


Figure 2. Annual global and building sector CO_2 emissions evolution ($GtCO_2$/year). Source: Own publication based on data from the IEA 2013 and IPCC 2014.

In Europe, the building sector is responsible for 40% of energy consumption and 36% of energy-derived CO_2 emissions [7]. And nationwide, the sector accounts for a total of 30.1% of final energy consumption and 25.1% of emissions[8], 8.2% of which are direct emissions associated with fuel consumption in the residential, commercial and institutional sectors[9]. This is due, in large part, to the fact that we have an aged building stock. In the case of residential buildings, in the EU more than half was built without any insulation standards[10], and in Spain 60% were built prior to the first standard that introduces minimum energy efficiency criteria (NBE-CT-79)[11].

[4]European Parliament, 2019. European Parliament Resolution of 28 November 2019 on the Climate and Environmental Emergency

[5] International Energy Agency & United Nations Environmental Program, 2019. Global Status Report for Buildings and Construction

[6] Intergovernmental Panel on Climate Change, 2014. Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the IPCC 5th Assessment Report

[7] Built4People, 2020. People-centric sustainable built environment

[8]Pontificia de Comillas University, 2020. Energy and Sustainability Development Observatory in Spain, pp. 20 and 21.

[9]Ministry for the Ecological Transition, 2021. National Inventory Report on Greenhouse Gases.

[10] European Commission. EU Buildings Factsheets. https://ec.europa.eu/energy/eu-buildings-factsheets_en

Ministry of Transport, Mobility and Urban Agenda, 2020. LTRS 2020.
https://www.mitma.gob.es/recursos_mfom/paginabasica/recursos/es_ltrs_2020.pdf

Both in Europe and nationally, the majority of these energy inefficient buildings in the current building stock will still be operating in 2050, which means there is a need for energy renovation.

Recent advances

The European Union has adopted a leadership role in the international fight against global warming and the promotion of energy efficient buildings through multiple initiatives, the majority of which were introduced in the successive updates to the Energy Performance of Buildings Directive (EPBD), with the aim of reducing energy demand and upping the number of renewable energies integrated into the network. Some of these initiatives are widely known, such as the Long-Term Renovation Strategies (LTRS), the Nearly Zero Energy Buildings (NZEB) and the Building Renovation Passport.

Despite the progress that implementing these measures entails, they only focus on one part of the building problem: operational carbon, which is generated in the building's use phase. In effect, building-related CO_2 emissions are released not just in the use phase, but also during the manufacturing, transport, construction, renovation and end of life phases. This is so-called embodied carbon. The summation of the two enables us to calculate a building's total life cycle carbon.

As the recent European initiative Built4People indicates, it has been estimated that embodied carbon in buildings represents a third of the emissions associated with the building sector, accounting for 10 to 12% of total CO_2 emissions worldwide. Along the same lines, it is estimated that by 2050 CO_2 emissions released before a building starts to be used will be responsible for half of the total carbon footprint of new builds[12]. This threatens to consume a large part of the CO_2 emissions promised in the Paris Agreement in order to limit the temperature rise to 2 ºC, our carbon budget. It is vital to highlight the impact of the materials used, as well as the construction processes in both new and renovated buildings.

In this regard, the European Commission has implemented the European Green Deal, the roadmap for equipping the EU with a sustainable economy. It uses the building sector as the fundamental pillar of the Renovation Wave and the Circular Economy Action Plan and thus fosters the principles of circularity in buildings. Furthermore, the proposal to review the EPBD[13] itself introduces the concepts of GHG in the whole life cycle and the need to tackle the whole life cycle carbon approach, which includes both operational carbon and embodied carbon in the building.

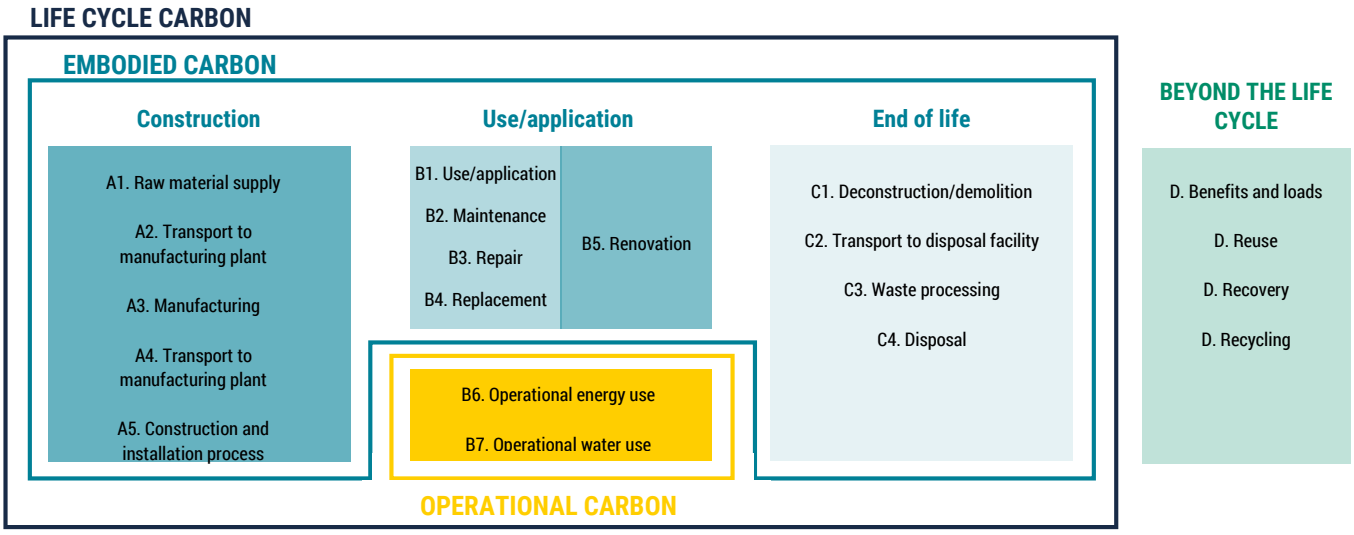


Figure 3. Terminology used in the document relating to the life cycle carbon. Source: Own publication based on standard EN 15978

[12] Architecture 2030, 2020. New Buildings: Embodied Carbon. https://architecture2030.org/embodied-carbon-actions/

[13] European Commission, 2021. Proposal for a directive of the European Parliament and of the Council on the energy performance of buildings (recast) COM/2021/802

European Green Deal

"Europe will cut its emissions by at least 55% by 2030. It puts us firmly on track for climate neutrality by 2050 [...]
The target is ambitious, achievable and beneficial for Europe. We can do it. Ursula von der Leyen.

Faced with the climate emergency, public administration bodies at all levels are upping their commitment to accelerating the ecological transition, particularly to decarbonising the economy. Eager to position Europe as the first decarbonised continent, the European Commission has launched the European Green Deal, which compiles a series of initiatives for becoming climate neutral by 2050.

These include the European Climate Law, which writes into law the strategic goal for reducing GHG by at least 55% by 2030, and the Fit for 55 package, which presents the review of at least 12 directives aimed at accelerating the changes and transformations necessary across the whole European Union.

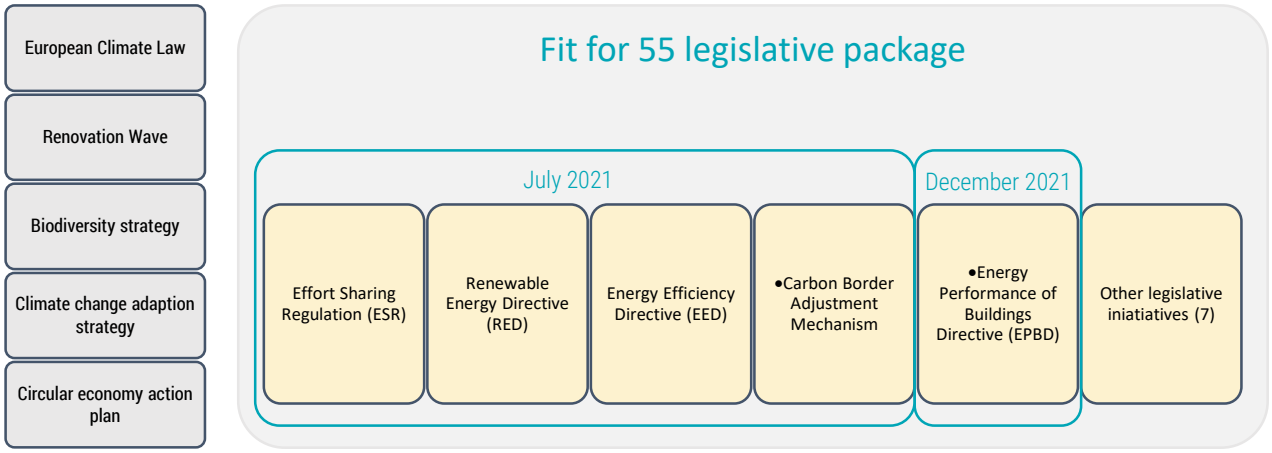


Figure 4. Initiatives within the European Green Deal and the "Fit for 55" package Source: European Initiatives related to the CO_2 Footprint in Building, GBCe

#BUILDINGLIFE

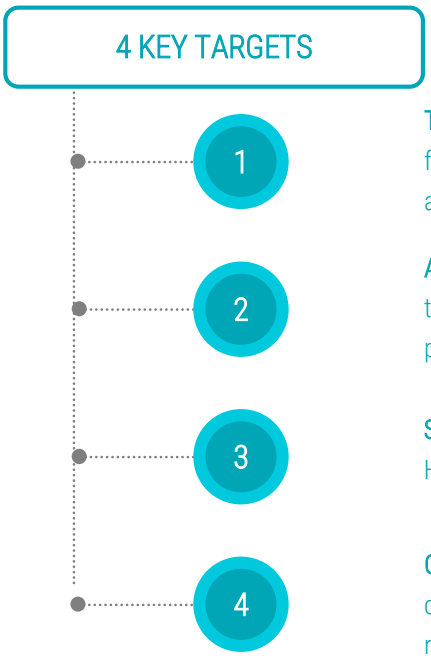
The challenge

The building sector is facing a profoundly transformative challenge: combining the social commitment to providing socially necessary habitable conditions with the duty to reduce greenhouse gas emissions from buildings in all phases of the life cycle, in an attempt to become climate neutral by 2050.

Faced with the urgency of this challenge, the **#BuildingLife** project seeks to accelerate the shift towards a sustainable paradigm, generating a major debate between the sector's key stakeholders and providing a comprehensive vision of building life cycle in order to reduce the sector's impacts and achieve decarbonisation.

Targets

In the interest of promoting collaboration between all the stakeholders in the building value chain and catalysing market action, **#BuildingLife** proposes four key targets:



Trigger a global conversation on net zero whole life carbon buildings and lay the foundations: a clear definition, a common language, principles, milestones and viable actions that can be utilised by all the stakeholders in the value chain.

Advocate for a net zero whole life carbon policy and regulations. Encourage the industry to take action, and highlight best practices in global regulation and policy-making to prove their viability.

Stimulate market demand and facilitate collaboration throughout the whole value chain. Highlight realistic best practices that could rapidly reduce embodied carbon.

Communicate the urgency of the targets and set milestones to reach net zero whole life carbon building globally. Support the development of regional, national and sectoral roadmaps.

Project framework

#BuildingLife is a 2 year-long project, led and coordinated by the World Green Building Council (World GBC) and Green Building Council España (GBCe), in which 10 European Green Building Councils participate: Germany, Croatia, Spain, Finland, France, Ireland, Italy, the Netherlands, Poland and the United Kingdom.

PRINCIPLES OF THE ROADMAP

To produce the roadmap, a series of basic principles, values and criteria have been taken into account which, although not specified, underpin the whole proposal:

- The building scale in order to define carbon metrics. The building scale is the point where decisions affecting its entire life cycle, including its decarbonisation, the circular economy and its own social function take on full meaning and are fully developed.

- Efficiency first. Efficiency in the use of both energy and natural resources is the first of the measures to take to hit decarbonisation targets. It is not about substituting one source of energy for another or one material for another, but rather using resources intelligently to reduce the demand on them. This principle takes up and extends the principle of energy efficiency first recognised at European level.

- Precaution. Although the main purpose of this roadmap is decarbonisation, it does not overlook other environmental and social targets in the ecological transition, and therefore it applies the concept of not doing significant harm or impeding other targets from being met.

- The time factor. Greenhouse gas emissions are accumulative, so the proposed measures that lead to emissions tailing off as soon as possible and that last longest will be prioritised.

- Best technology available. The roadmap does not prefer one solution over another, plus it acknowledges the specificities of the starting point of the different construction product families and the intrinsic difficulties of each one when it comes to achieving decarbonisation.

- Participation and joint responsibility. The roadmap emerged from the essential participation of representatives of the many involved stakeholders in the sector/value chain. This partnership calls for joint responsibility, according to which, all the stakeholders must take on their own responsibilities and ensure accountability among the other parties.

- The people at the centre. First and foremost, the mission of the building sector is to provide people with homes that are habitable. This roadmap proposes a transformation that must go hand in hand with the empowerment of these people, so that they gain in resilience, are joint participants in decarbonisation and become active stakeholders in this process.

2050 VISION

A SHARED VISION

In 2050, every single person in Spain will live in a built environment, rural or urban, in socially acceptable living conditions, and the building sector will provide and maintain this service without emitting GHGs, using a resilient building model that uses resources in a circular way.

Without emitting greenhouse gases (GHG): Renovations and new buildings will have zero embodied GHG emissions and all buildings, including existing ones, will have zero GHG emissions in their operation and maintenance.
Circular: A built environment with net zero resource exhaustion, contributing to the restoration of natural resources and systems within a prosperous economy.
Resilient: A built environmental, rural or urban, adapted to the consequences of climate change, enabling the development of healthy, equitable and resilient communities.

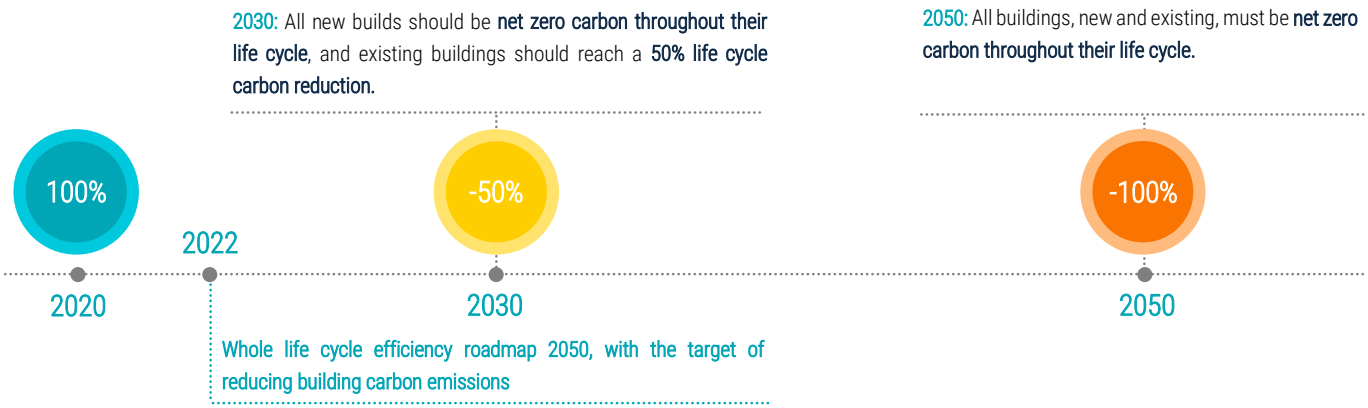
The proposed vision is based on a comprehensive building life cycle approach. It is intended to gradually reduce life cycle or total carbon emissions, not just considering operational carbon but also the CO_2 emissions generated in the manufacturing, transport, construction, renovation and end of life phases, or so-called embodied carbon.

ROADMAP

As part of the framework of the Renovation Wave, the European Commission defined a set of key actions in October 2020 that would help to hit the building sector's decarbonisation targets. The most relevant in the building life cycle approach includes the pre-2023 formulation of a **2050 whole life-cycle performance roadmap, with the aim of reducing carbon emissions from buildings** and fostering a national comparative analysis against other Member States[14].

Decarbonisation goal

In line with Vision 2050 and the WorldWBC guidelines, the gradual transformation of the sector to **fully decarbonise the building stock by 2050** is the Roadmap's main milestone.



[14]European Commission, 2020. Communication Annex, COM(2020) 662 final, Renovation Wave for Europe.

Main milestones

Based on the European climate neutral commitments and taking as a reference the core milestone of 2050, a set of 8 main milestones that express the roadmap to decarbonising the building sector have been defined.

Each of these milestones (M1-M8) have various levels of progression (2025, 2030, 2040) that enable us to assess the fulfilment of the targets set out in the roadmap.

The structure of the 8 milestones is marked by the comprehensive nature of the current roadmap, resulting in the need to set varied targets over time. Targets that will, in turn, require coordinated development of actions belonging to different frameworks of action and that will be carried out by different stakeholders.

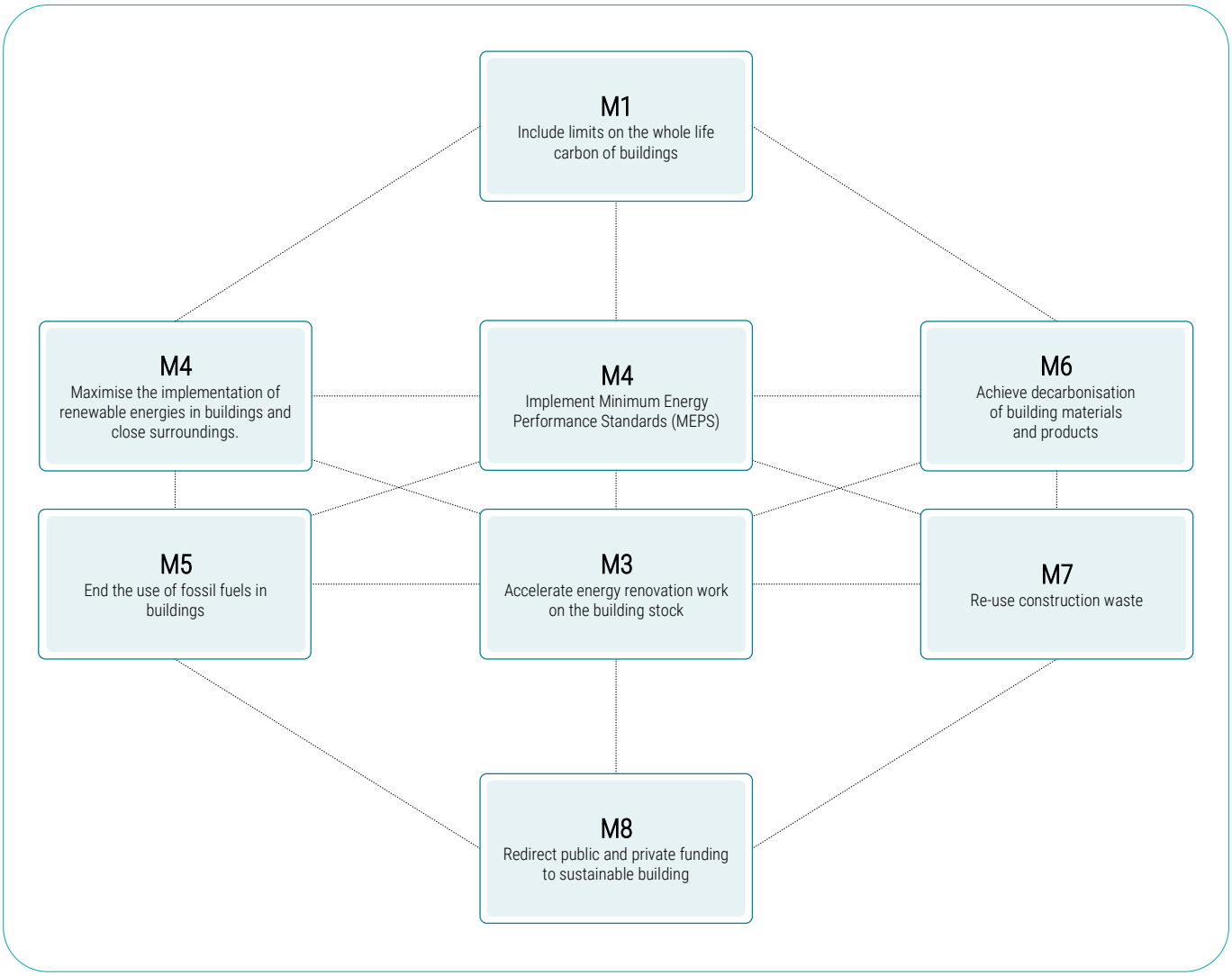


Figure 5. Representation of the 8 milestones for decarbonising the sector. Source: own publication

Frameworks of action

The roadmap is structured around 4 frameworks of action that address the need to promote comprehensive action across all the fronts involved in decarbonising the building sector. Each of these frameworks have identified three challenges that can be tackled through their respective courses of action.

The **Framework >Challenge >Course of action** system is a cross-disciplinary response to the 8 milestones previously described, as efforts will need to be made across each course of action to meet every milestone. Thus, these frameworks should not be understood as stagnant compartments, but rather interdependent categories.

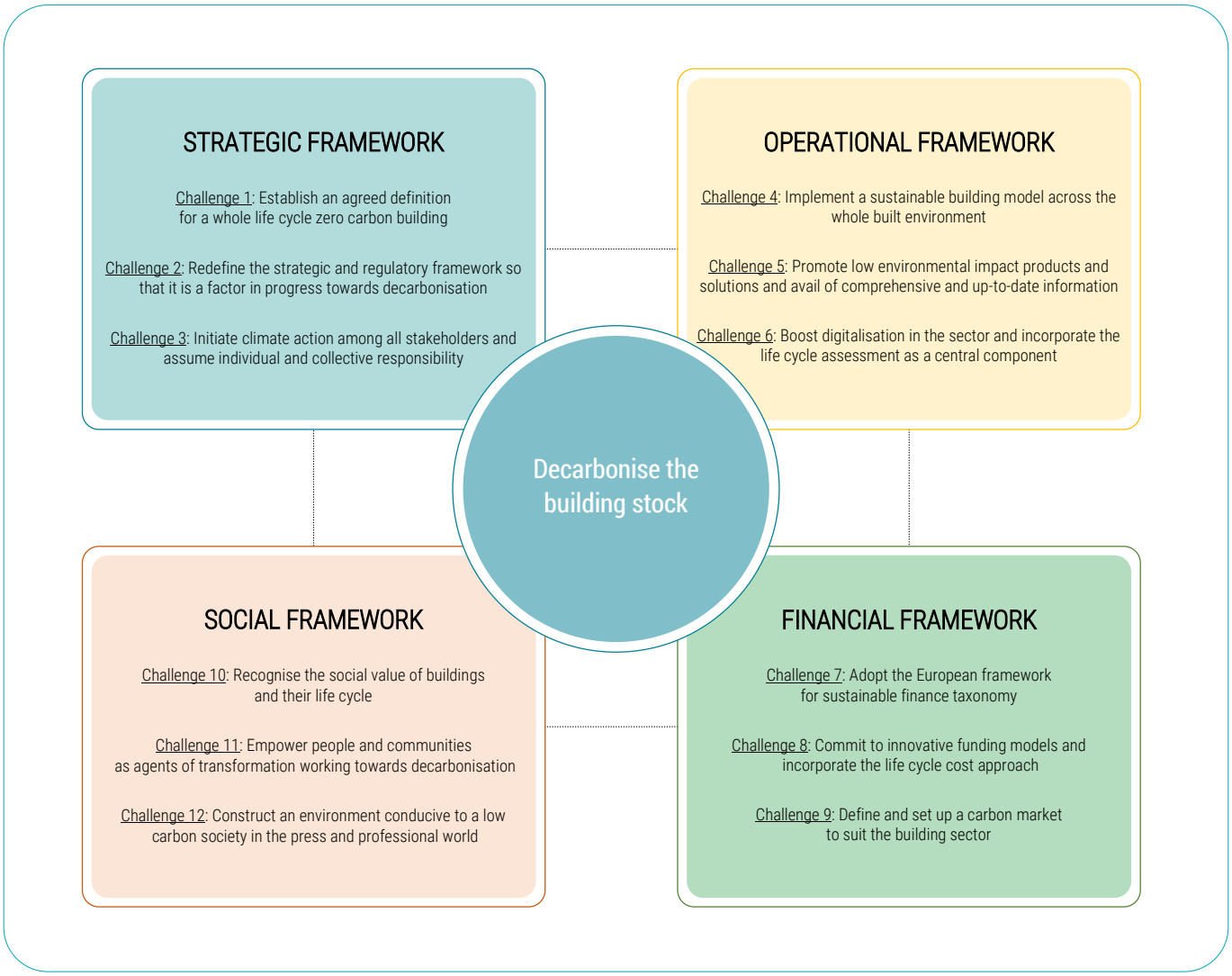


Figure 6. Representation of the 4 frameworks of action. Source: own publication

Stakeholders involved

Finally, the Roadmap acquires a tangible and concrete shape by holding specific stakeholders responsible for the actions in each of the frameworks and courses of action.

Only with the involvement of all the sector's stakeholders and the coordinated development of time-bound actions will it be possible to meet the core objective of the Roadmap.

1. Central government. The central government plays a crucial role in the decarbonisation process as it is the main body in charge of planning the strategic framework. It is responsible for leadership and setting an example, which it can do through legislative and regulatory activity, driving policies, launching tools and decarbonising its own building stock.
2. Local and regional government. Regional governments and local organisations have to ensure that national decarbonisation policies and development policies are properly implemented in their territories. As the administrative bodies closest to citizens, they play an exemplary role. And that's why the government should incorporate the Roadmap, ensuring a just transition.
3. Product and material manufacturers. Manufacturers must supply the sector with products that help to reduce a building's operational carbon and that, in turn, have a lower impact on the manufacturing and installation process. To do so, they will have to rethink and generate business models, plan their long-term investments and invest in R&D, with the aim of becoming climate neutral and circular by 2050. Furthermore, they will have to measure and provide transparent data on the impact of their products.
4. Designers. Professionals from the fields of architecture, technical architecture, engineering and other disciplines have to integrate the whole-life cycle into their work. They have to design and prescribe so that a building's design, materials, construction, operation and dismantlement are as sustainable as possible, taking on a new form of planning and constructing.
5. Construction companies and contractors. Construction companies and contractors must innovate their processes, promote industrialisation and incorporate new management and monitoring tools to improve the quality, safety and management of waste on their sites. They have huge potential to digitalise the sector and advance decarbonisation alongside it.
6. Property management companies. They are the stakeholders in closest contact with citizens and have the ability to facilitate the renovation of existing buildings. They should be aware of the opportunities and innovations in the sector in order to give citizens the best possible options for their buildings. They also manage a large amount of data that can help with the sector's digitalisation.
7. Financial services. Financial services must identify investment niches in the decarbonisation process and generate financial products to suit the new needs of the society and the sector. They must introduce the life cycle approach and the environmental and social values of decarbonisation into their analyses.
8. Property developers. Property developers must ensure that their buildings meet the high standards of habitability and generate the lowest negative impact possible. They have it in their power to focus their business increasingly on renovation, to provide comprehensive and innovative models that include funding, works and management and to assess their buildings to ensure sustainability.
9. Citizens. Citizens need to be aware of the climate emergency and form a social consensus that makes it much easier to decarbonise the building sector and the whole economy. They must move from being passive agents to being individually and collectively involved, demand zero carbon buildings and use and maintain them properly.
10. Academia, the media and the third sector. Academia, the media and NGOs must take on the role of facilitators. They must support and control the other stakeholders, generate and disseminate the knowledge necessary to involve other stakeholders.

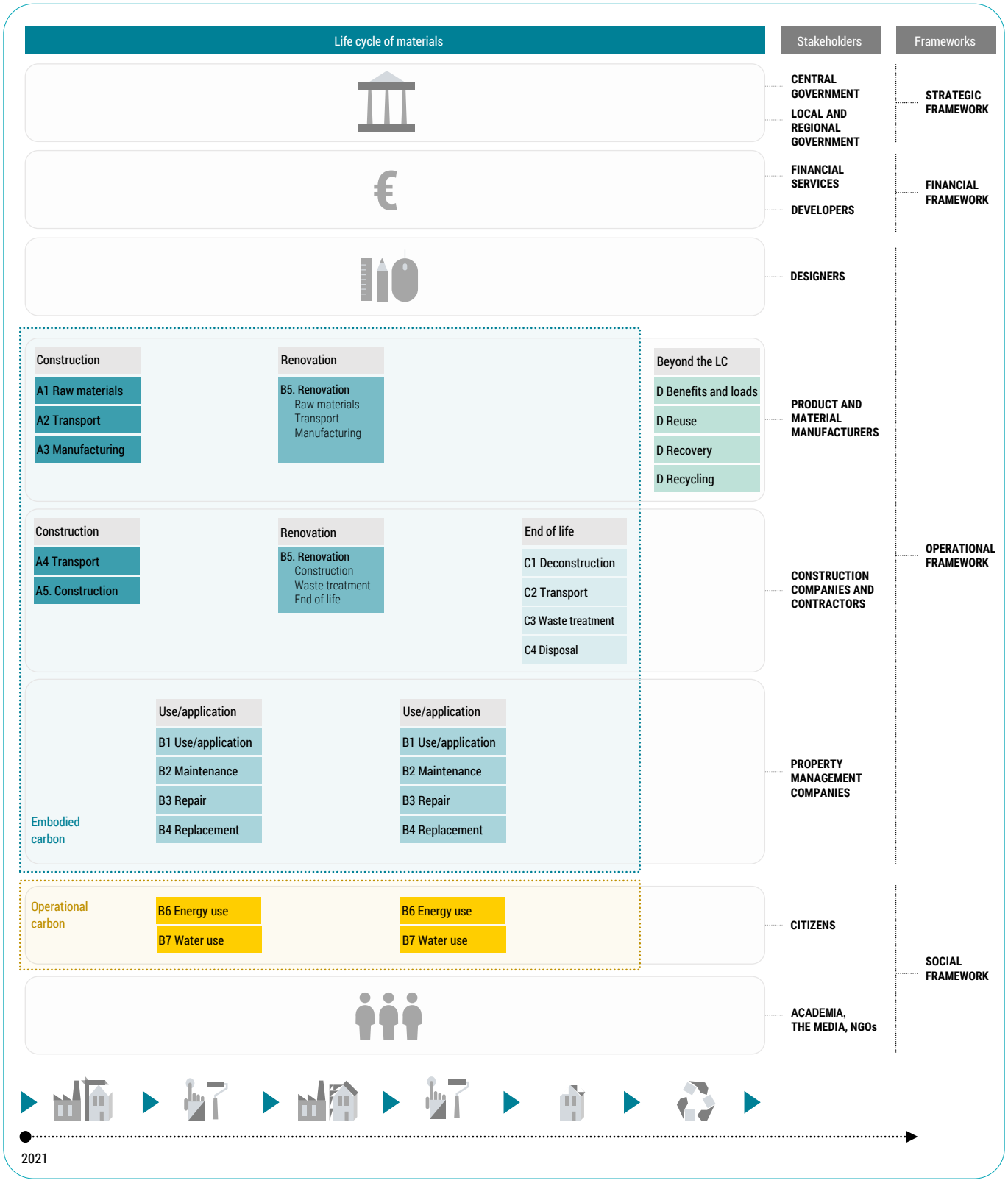


Figure 7. Structure of the roadmap relating life cycle carbon with the stakeholders and frameworks. Source: own publication

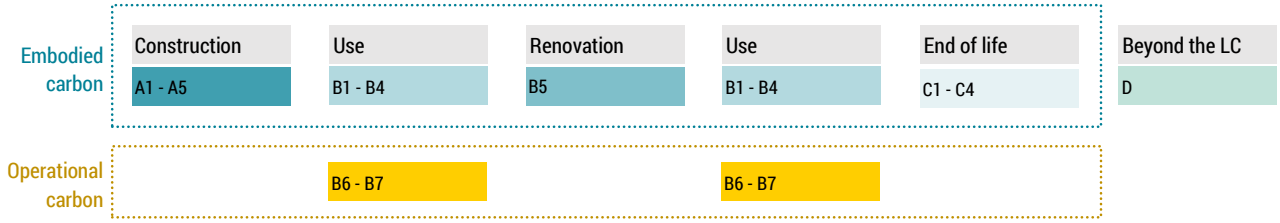
SECTOR IMPACT

LIFE CYCLE CARBON

Operational and embodied carbon

The European target of becoming climate neutral by 2050 is urging us to approach the decarbonisation of the building sector from a comprehensive perspective, which takes into account both operational and embodied carbon and both direct and indirect emissions. While industrial policies are already in place to reduce emissions, tackling them at building level will be more effective in achieving this goal, as embodied carbon accounts for a third of the total emissions associated with the building sector[15].

In effect, according to UNE-EN 15978:2012 "Sustainability of Construction Works"[16], building-related CO_2 emissions are released not just in the use phase in the form of **operational carbon** (B6-B7), but also during the construction (A1-A5), maintenance and repair (B1-B4), renovation (B5) and end of life (C1-C4) phases. This is so-called **embodied carbon**. The summation of the operational carbon and embodied carbon enables us to calculate the **total life cycle carbon** of a building.



Although there are no large-scale studies on the relative weight of both types of carbon, the WBCSD and Arup report[17] estimated the relationship between operational and embodied carbon for the average new building to be 50%, giving a measure of the importance of embodied carbon in the total and, therefore, of its decisive role in the decarbonisation process.

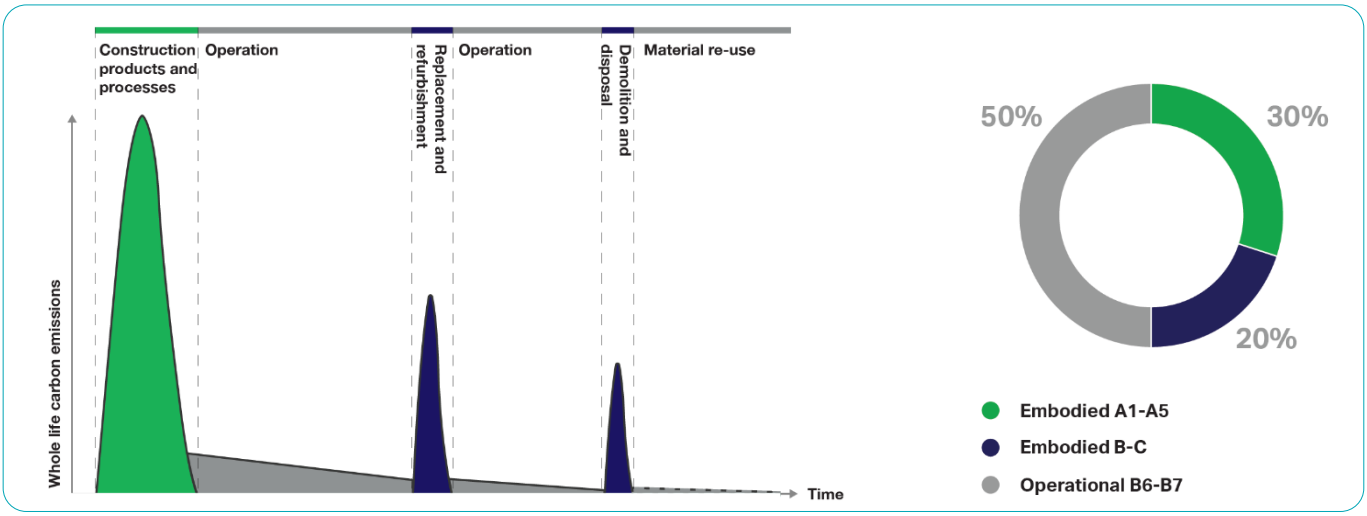


Figure 8. Estimated distribution of CO_2 emissions according to phase of the life cycle. Source: Net-zero buildings. Where do we stand? WBCSD and Arup, 2021.

[15] Built4People, 2020. People-centric sustainable built environment

[16] Spanish Association for Standardisation, 2021. UNE-EN 15978:2012 "Sustainability of Construction Works" Assessment of environmental performance of buildings. Calculation methods"

[17] WBCSD and Arup, 2021. Net-zero buildings. Where do we stand?

And beyond this specific data, it is to be expected that as existing buildings are constructed or renovated in accordance with increasingly ambitious energy efficiency criteria, the relative importance of embodied carbon will drastically increase compared to operational carbon, well above this balance ratio.

Along this line, a study conducted by Röck et al. (2020)[18] comprising a systematic review of more than 650 cases of LCA shows how the successive energy efficiency standards, in our case from NBE-CT/79 to the updates to the Spanish Technical Building Code (CTE) in 2007 and 2019, have led to a reduction in the life cycle carbon due to improved energy performance in the use phase. However, the embodied carbon analysis reveals an increase in the relative and absolute contributions. Therefore, **the building sector cannot be decarbonised without considering the role of embodied carbon.**

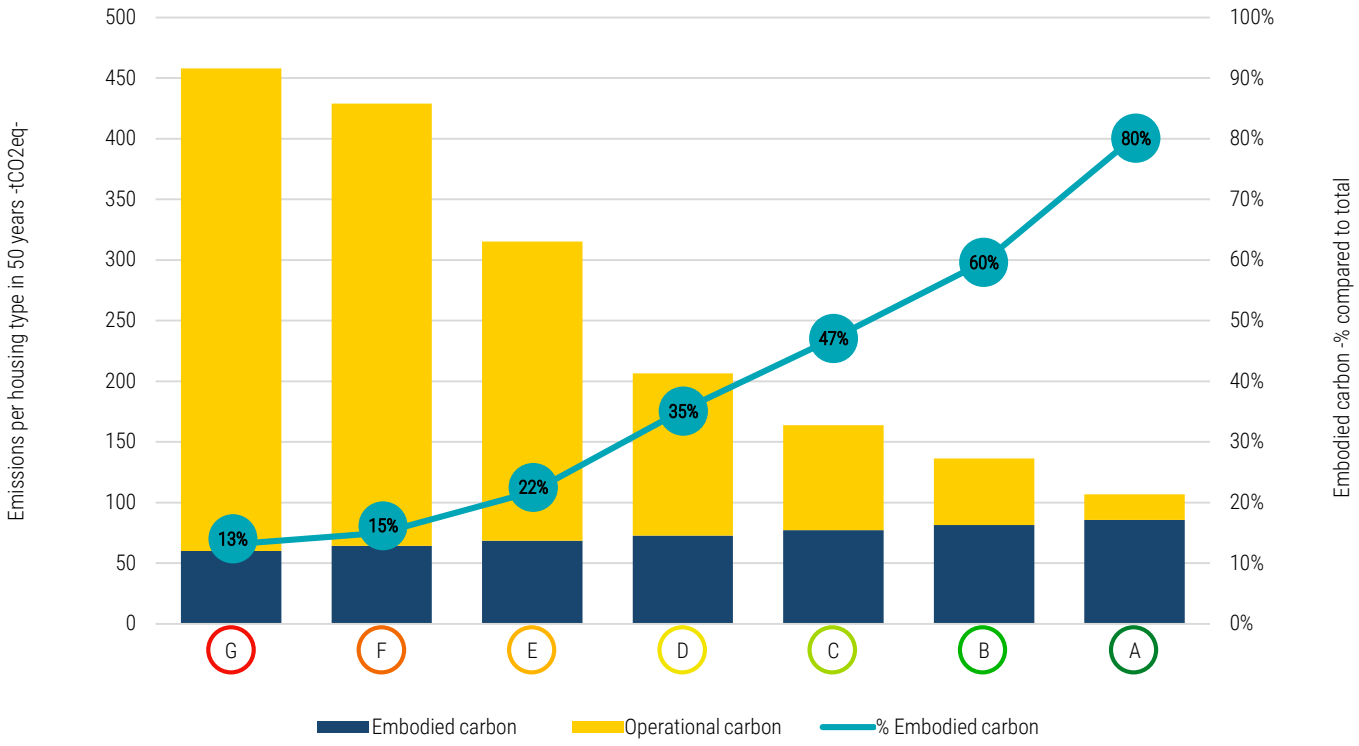


Figure 9. Embodied and operational carbon trend according to the energy performance rating for housing. Source: Own publication

Carbon in new buildings and carbon in existing buildings

However, we have to consider that the life cycle approach defined in UNE-EN 15978:2012 does not have the same application in new buildings as existing buildings since carbon accounting will not, in theory, be applied retrospectively. This distinction between new buildings and renovation is fundamental in understanding the process of decarbonising the sector.

On one hand, in **new buildings** planned for the 2022-2050 period, the life cycle assessment must calculate all the emissions linked to the building's life cycle. That is to say, from phase A which encompasses the whole construction works process, through to the phase B use and renovation phase, ending at phase C which is end of life.

[18] Röck et al., 2020. Embodied GHG emissions of buildings - The hidden challenge for effective climate change mitigation.

With the current outlook for the sector being strongly influenced by the Nearly Zero Energy Buildings (NZEBs), this will lead to a necessary focus on upfront carbon corresponding to phase A of construction, which is not yet restricted by regulations. Decarbonisation of construction systems will then become the sector's main workhorse in relation to new buildings.

On the other hand, when it comes to existing buildings, accounting starts from the present time and calculates the carbon corresponding to phases B of use and renovation and phase C of end of life. Emissions invested in phase A of construction can therefore be discounted.

For this area of the building sector, the discussion must, as a consequence, focus on the role of renovation as a mechanism to drastically reduce operational emissions from the extensive Spanish building stock. The pace of renovation must increase, i.e., a higher number of energy renovations must be produced, with the aim of reaching almost all buildings by 2050. At the same time, it is crucial to increase the profundity of renovations, i.e., more energetically ambitious interventions that bring existing buildings close to decarbonisation standards.

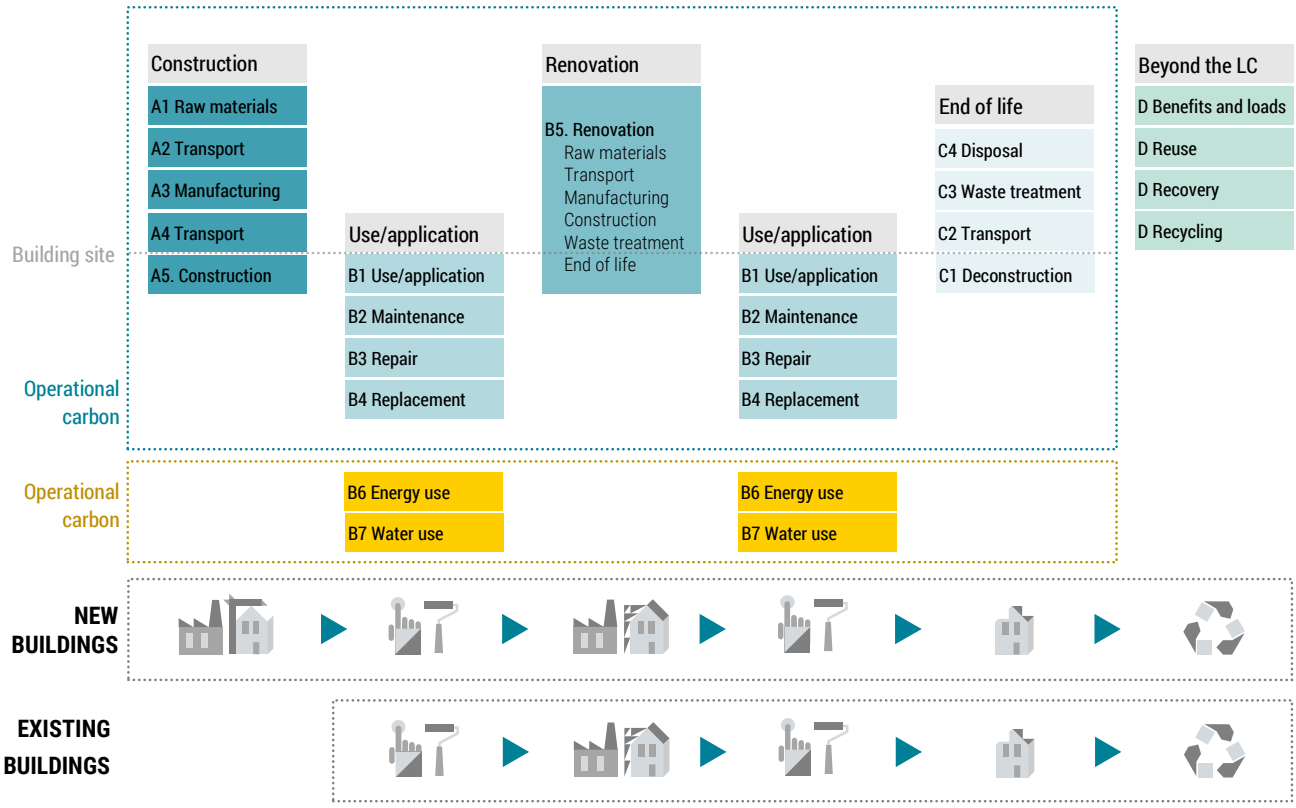


Figure 10. Representation of the life cycle carbon for new buildings and existing buildings Source: Own publication based on standard EN 15978

DIAGNOSIS OF THE WHOLE BUILDING SECTOR

The building sector, as a whole, accounts for approximately 30% of energy consumption in Spain, according to updated data from the Long-Term Renovation Strategy in the Building Sector in Spain (LTRS 2020). This third accounts for operational energy, without taking into account total consumption in the building's life cycle.

Similarly, only 8.2% of direct GHG gases are produced in buildings, according to the National Inventory on Greenhouse Gases[19]. This figure, however, only takes into account the emissions due to fuel consumption in buildings and does not consider the indirect emissions due to power supply (energy mix) nor the embodied emissions generated in the other phases of the building's life cycle.

Considering only operational consumption associated with the building sector, formed mainly by residential and tertiary buildings, the breakdown shows that the residential housing stock is the main consumer of final energy with 60% of the total. A value that has shown some stability over the last decade.

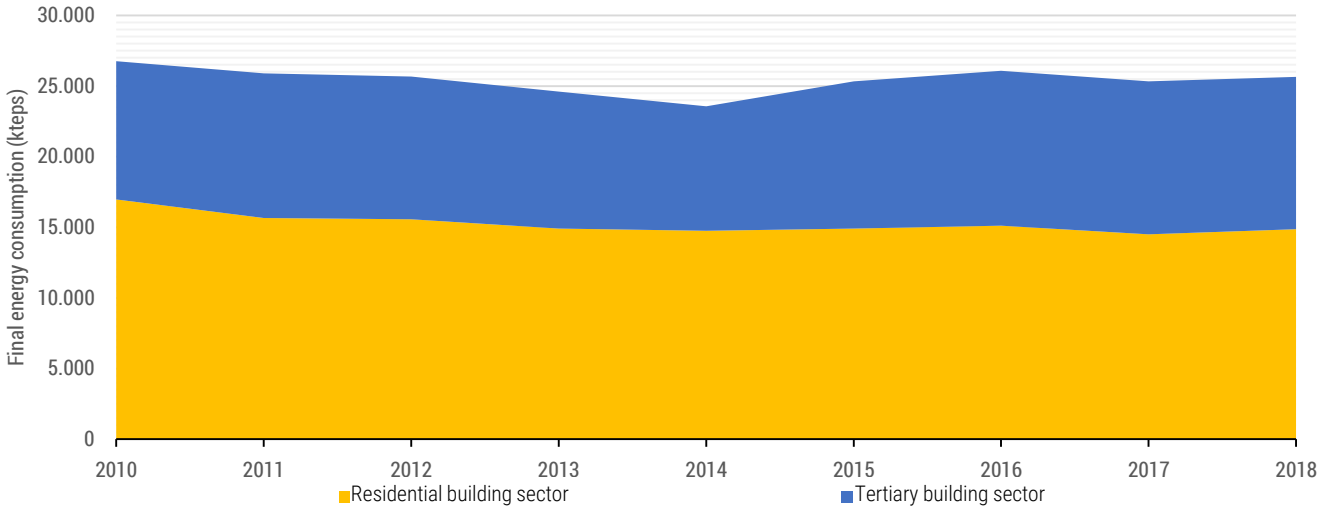


Figure 11. Final operational energy consumption evolution per sector. Source: own publication based on the Final Energy Balances 1990-2018 series, IDAE-MITERD.

Furthermore, the breakdown of consumption per energy sources of each of the sub-sectors shows a low electrification rate in the residential housing stock compared to the tertiary stock. This entails an added challenge because the decarbonisation pathway defined by the European Commission and implemented nationally by the Member States relies heavily on the electrification process.

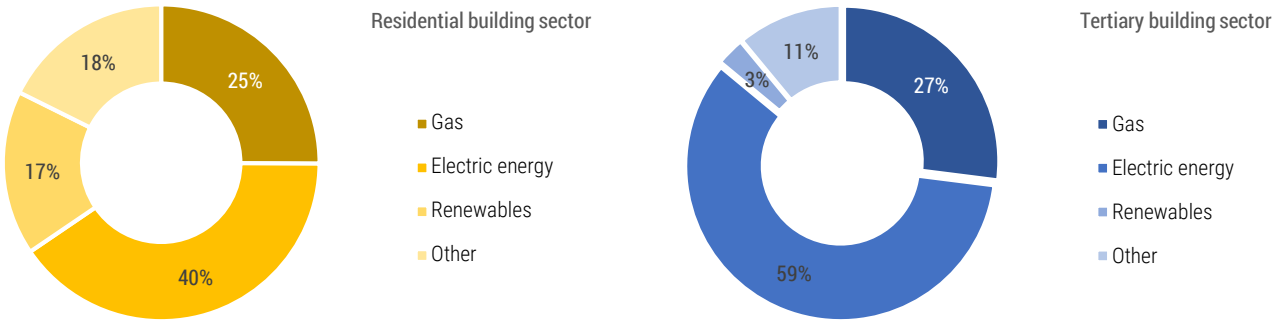


Figure 12. Breakdown of energy consumption per source. Source: own publication based on the Final Energy Balances 1990-2018 series, IDAE-MITERD.

[19] MITERD, 2021. National Inventory of Greenhouse Gas Emissions

RESIDENTIAL SECTOR SCENARIOS

Housing stock evolution

The residential sector is a crucial area when it comes to the challenge of decarbonising the building sector in Spain and must be analysed using the comprehensive life cycle carbon approach, addressing the need to approach new housing and existing housing differently.

Unlike the tertiary sector, the LTRS provide a very well-rounded and long-term basis for the analysis of the residential sector, which makes it possible to determine the current inventory of main houses and their evolution over the next 30 years.

In 2020, the residential housing stock comprised almost 16.6 million main homes, 50.8% of which were built before 1980 and, therefore, energy efficiency considerations did not apply, and 43.9% were built between that year and 2007, i.e., before the Spanish Technical Building Code became effective.

The majority of the current housing stock has renovation needs, probably needs to restore or improve the overall quality of the building and not just the energy performance. And, in this regard, the LTRS anticipate the renovation of 7.1 million homes which are those with the highest rates of energy consumption across all periods of construction prior to the Spanish Technical Building Code.

In parallel to the renovation activity, the LTRS predict the volume of new houses to be 4.15 million, mainly constructed under the NZEB standard regulated by the latest edition of the Spanish Technical Building Code. As a result of this intense renovation and new build activity, by 2050 the housing stock will comprise 20.7 million main homes; 45.8% of which will be those currently existing and unrenovated, in general, with average to very high energy consumption; 34.2% will be currently existing homes subject to deep energy renovation at some point over the next 30 years; and 20% will be new builds with high energy efficiency.

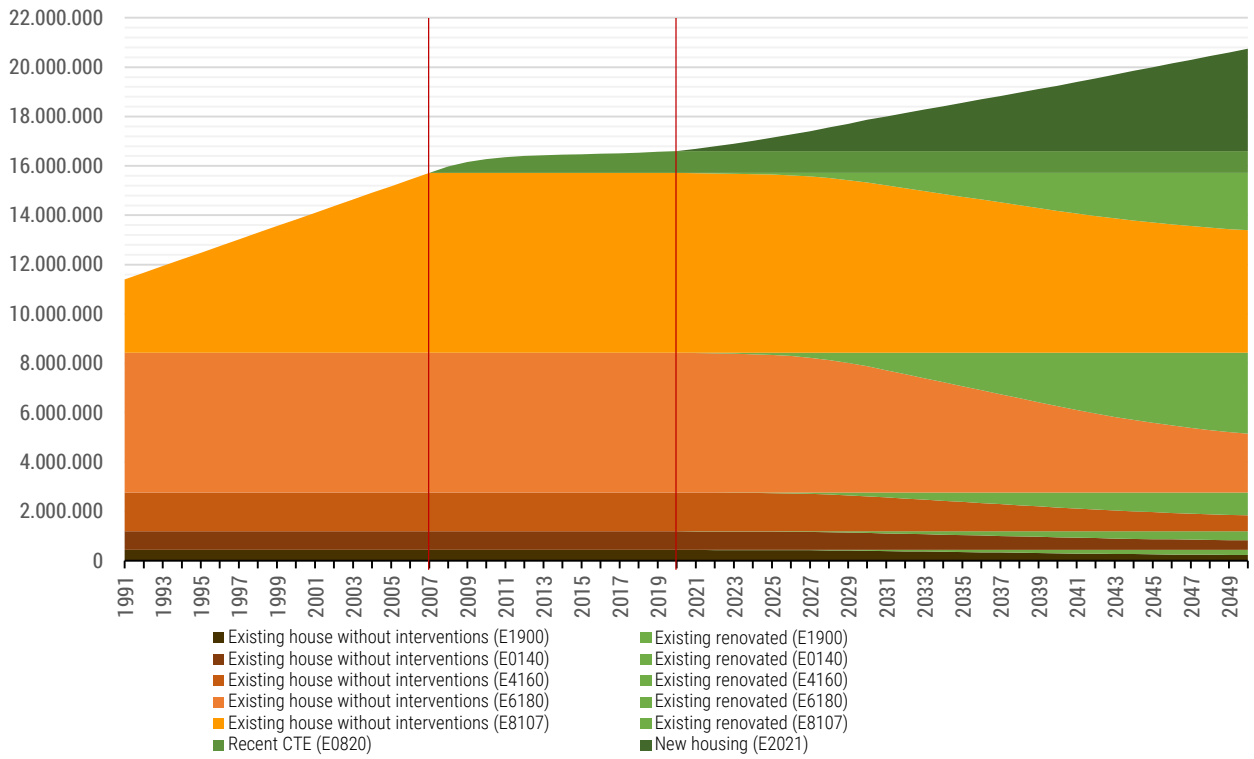
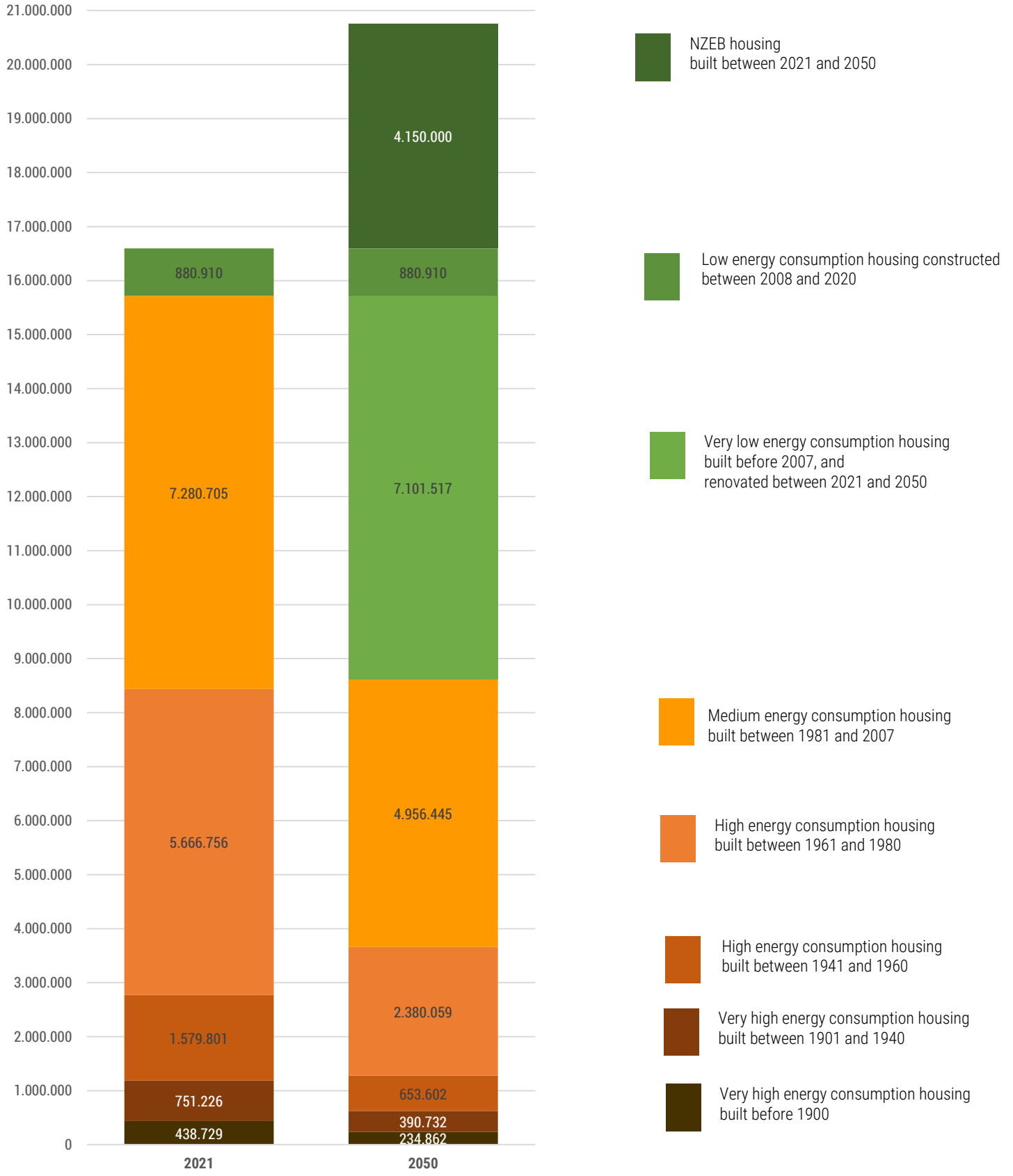


Figure 13. Breakdown of existing housing and housing to be renovated according to building phase Source: Own publication based on data from the LTRs 2020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880.910
7.280.705
5.666.756
1.579.801
751.226
438.729
4.150.000
880.910
7.101.517
4.956.445
2.380.059
653.602
390.732
234.862
2021
2050
NZEB housing built between 2021 and 2050
Low energy consumption housing constructed between 2008 and 2020
Very low energy consumption housing built before 2007, and renovated between 2021 and 2050
Medium energy consumption housing built between 1981 and 2007
High energy consumption housing built between 1961 and 1980
High energy consumption housing built between 1941 and 1960
Very high energy consumption housing built between 1901 and 1940
Very high energy consumption housing built before 1900

Carbon scenario definitions

Accepting the path of evolution of Spain's housing stock proposed by the LTRS 2020, both in relation to the evolution of new houses as well as renovation operations on existing housing, raises the possibility of approaching the two future scenarios linked to building-related CO_2 emissions: the trend scenario and the sector scenario.

The Trend Scenario is characterised by studying the predictions set out in the legislation, regulations and strategic planning undertaken by Government departments.

It is, therefore, a path that assumes medium- and long-term upgrades in the building sector that are already consolidated for certain variables. And for those fields in which no public commitments or requirements are available, it uses the values currently available as a reflection of the business-as-usual model.

In this scenario, when it comes to the change in heating and DHW technologies, the projection set out in the LTRS is assumed. In the case of variables in the evolution of embodied carbon in construction, renovation, use and maintenance, they remain stable over the long term according to current estimations.

TREND SCENARIO	2020	2030	2050
Stock evolution of main houses	Current value according to LTRSs	Variable according to the LTRSs	Variable according to the LTRSs
Current and new heating and DHW equipment performance	Fixed values according to LTRSs	Fixed values according to LTRSs	Fixed values according to LTRSs
Evolution of passing factors EF-EPNR-emissions	Current values according to the IDAE for all vectors	Upgrade to electricity until a mix is reached with 85% of non-emitting energy. Fixed according to current IDAE values for the rest of the vectors	Upgrade to electricity until a mix is reached with 95% of non-emitting energy. Fixed according to current IDAE data for the rest of the vectors
Evolution Change in Heating and DHW technologies	Values according to the LTRSs	Values according to the trend scenario LTRSs	Values according to extension of the LTRSs trend scenarion, until 78% of renewable energy in heating equipment and 80% in DHW
Evolution Embodied Carbon Construction	Fixed value estimated at 650 kgCO2/m2	Fixed value estimated at 650 kgCO2/m2	Fixed value estimated at 650 kgCO2/m2
Evolution Embodied Carbon Renovation	Fixed value estimated at 265 kgCO2/m2 in single-family housing and 105 kgCO2/m2 in multi-family housing	Fixed value estimated at 265 kgCO2/m2 in single-family housing and 105 kgCO2/m2 in multi-family housing	Fixed value estimated at 265 kgCO2/m2 in single-family housing and 105 kgCO2/m2 in multi-family housing
Evolution Embodied Carbon Use Maintenance	Fixed value estimated at 2.kgCO2/m2 applicable 15 years from construction	Fixed value estimated at 2.5kgCO2/m2 applicable 15 years from the date of construction	Fixed value estimated at 2.5kgCO2/m2 applicable 15 years from the date of construction

The Sector Scenario is distinguished by the fact that it incorporates the additional improvement forecasts currently referred to by the building sector stakeholders.

Unlike the Trend Scenario, the Sector Scenario is a pathway that incorporates the best forecasts made by Government departments and the initiatives of the sectors private stakeholders, even though these cannot currently be considered as legally enforceable commitments.

In this scenario, when it comes to the change in heating and DHW technologies the projection set out in the LTRS is assumed. In the case of variables in the evolution of embodied carbon in construction, renovation, use and maintenance, they present substantial long-term changes according to the estimations made by the government and the sector's main stakeholders.

In this regard, it should be noted that, in terms of embodied carbon, the reductions expected for the cement[20], steel[21] and aluminium[22] sectors have been used without considering the effect of re-carbonisation and carbon capture and storage mechanisms.

SECTOR SCENARIO	2020	2030	2050
Stock evolution of main houses	Current value according to LTRSs	Variable according to LTRSs	Variable according to LTRSs
Current and new heating and DHW equipment performance	Fixed values according to LTRSs	Fixed values according to LTRSs	Fixed values according to LTRSs
Evolution of passing factors EF-EPNR-emissions	Current values according to the IDAE for all vectors	Upgrade to electricity until a mix is reached with 85% of non-emitting energy. Fixed according to current IDAE values for the rest of the vectors	Upgrade to electricity until a mix is reached with 95% of non-emitting energy. Fixed according to current IDAE values for the rest of the vectors
Evolution Change in Heating and DHW technologies	Values according to LTRSs	According to the objective scenario LTRSs	Values according to extension of the LTRSs trend scenarion, until 95% of renewable energy in heating equipment and 95% in DHW
Evolution Embodied Carbon Construction	Value estimated at 650 kgCO2/m2	Value according to various main pathways to decarbonising the sector estimated at 529 kgCO2/m2 (-19%)	Value according to various main pathways to decarbonising the sector estimated at 313 kgCO2/m2 (-52%)
Evolution Embodied Carbon Renovation	Fixed value estimated at 265 kgCO2/m2 in single-family housing and 105 kgCO2/m2 in multi-family housing	Value estimated at 252 kgCO2/m2 in single-family housing and 100 kgCO2/m2 in multi-family housing (-5%)	Value estimated at 225 kgCO2/m2 in single-family housing and 89 kgCO2/m2 in multi-family housing (-15%)
Evolution Embodied Carbon Use Maintenance	Fixed value estimated at 2.5kgCO2/m2 applicable 15 years from the date of construction	Value estimated at 2.4 kgCO2/m2 (-5%) applicable 15 years from the date of construction	Value estimated at 2.1 kgCO2/m2 (-15%) applicable 15 years from the date of construction

[20] OFICEMEN, 2020. Spanish cement industry roadmap for becoming carbon neutral by 2050.
[21] EUROFER, 2019. Low carbon roadmap. Pathways to a CO2-neutral European steel industry.
[22] International Aluminium, 2021. Aluminium Sector Greenhouse Gas Pathways to 2050.

Trend scenario

In the trend scenario, the **operational carbon** emitted in the year 2050 by the residential sector as a consequence of heating and DHW energy consumption will have experienced a sharp drop of -72% compared to carbon emitted in the year 2021, moving from 28.6 million tonnes of CO_2 in the year 2021 to 8.1 in the year 2050.

In line with the European decarbonisation target, this substantial reduction will essentially be the result of the combination of applying passive energy renovation measures and active heating and DHW technology changes to the currently existing housing stock.

During this period, 528 million tonnes of cumulative CO_2 will have been emitted, mainly in the category of existing housing. 47% of these emissions correspond to the 8.6 million existing houses for which no type of intervention is planned; 45% of the cumulative emissions are generated in the 7.1 million houses scheduled to be renovated over the next 30 years.

Therefore, the cumulative operational carbon over the next 30 years of new housing and recently built housing complying with the Spanish Technical Building Code requirements is 7%.

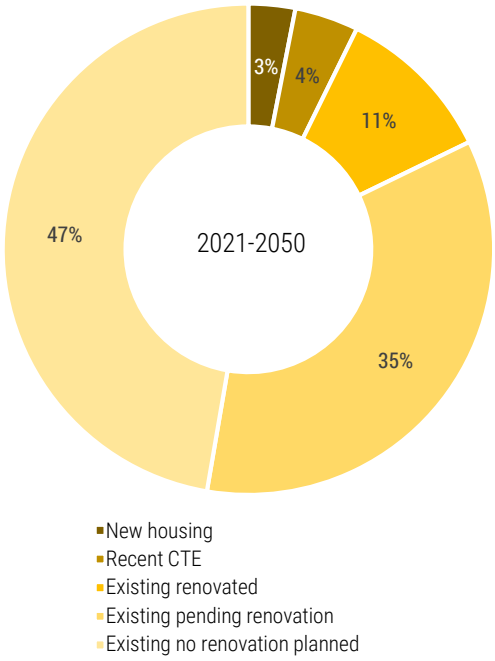


Figure 14. Percentage of cumulative operational carbon emissions by building typology. Source: own publication Unit: %

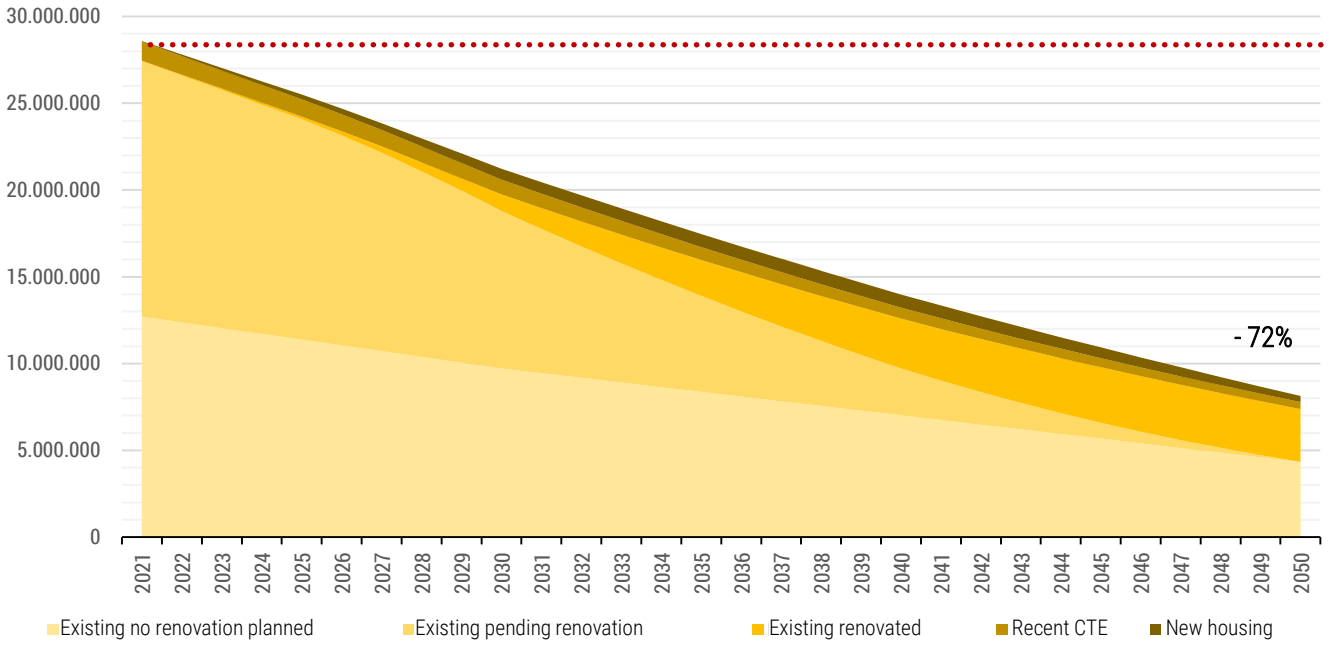


Figure 15. Annual operational carbon emissions by building typology. Source: own publication Unit: CO_2 tonnes/year

In the trend scenario, the **embodied carbon** emitted in the year 2050 by the residential sector as a consequence of construction, renovation and maintenance activities will have experienced, unlike operational carbon, a notable increase of +56% compared to that emitted in the year 2021, moving from 11.4 million tonnes of CO_2 in the year 2021 to 17.8 in the year 2050.

This increase will mainly be the responsibility of the new housing sub-sector, which is expected to be building by 2050 approximately 150,000 units and, to a lesser extent, of the existing housing renovation sub-sector, which will also be working on around 150,000 additional units.

Likewise, these two activities along with their corresponding maintenance actions will be responsible for 87% of the 552 million cumulative tonnes of CO_2 of embodied carbon between 2021 and 2050. New housing will reach 57% of the total for this period, and existing renovated housing, for its part, will be responsible for more than 30% considering both the improvement and maintenance interventions over the next 30 years.

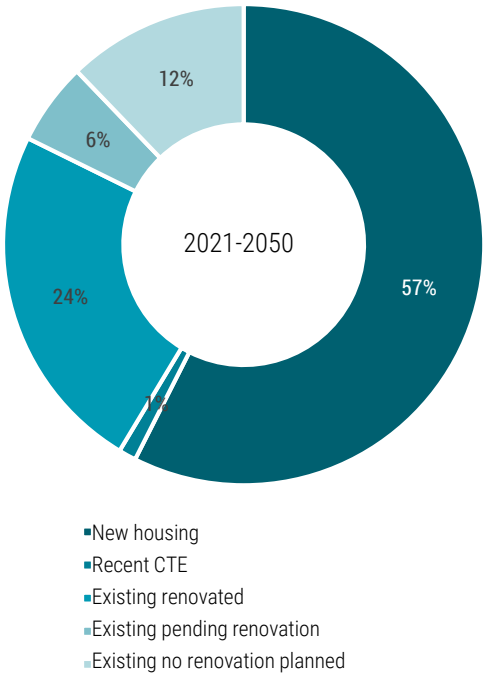


Figure 16. Percentage of cumulative operational carbon emissions by building typology. Source: own publication Unit: %

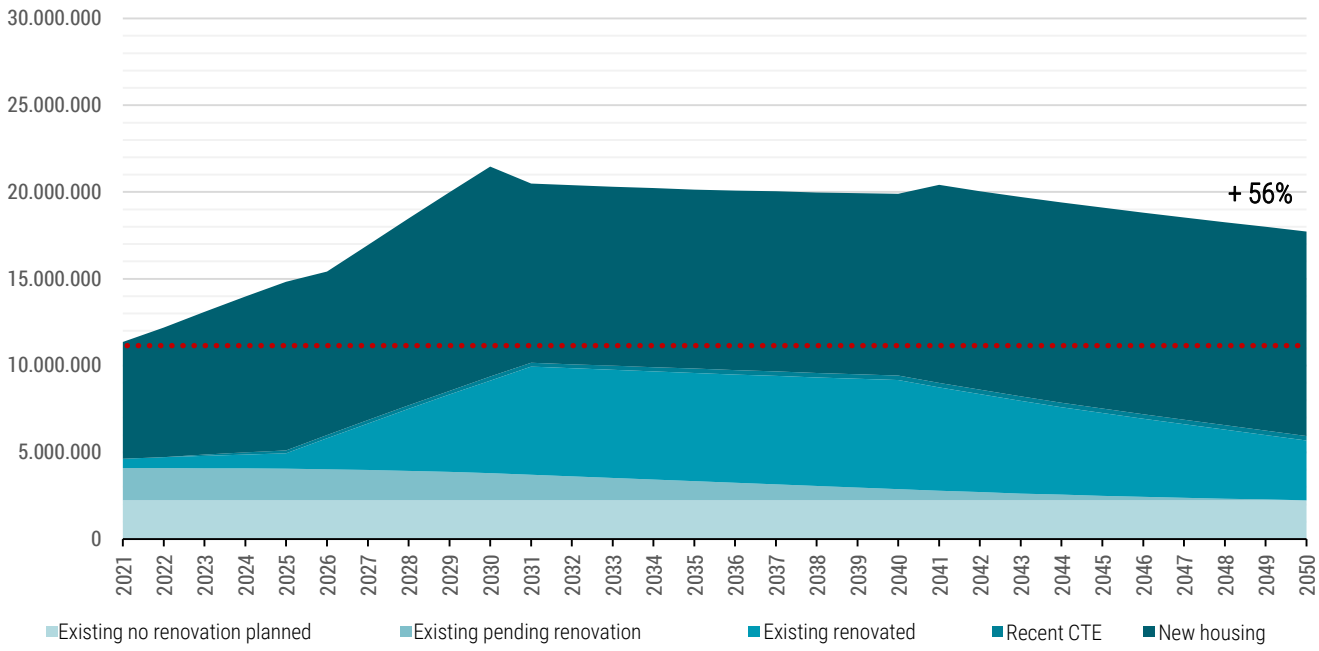


Figure 17. Annual embodied carbon emissions by building typology. Source: own publication Unit: CO_2 tonnes/year

In the trend scenario, the **life cycle carbon** emitted in the year 2050 by the residential sector as a consequence of all the activities will fall by -35% compared to the life cycle carbon emitted in the year 2021, moving from 40.0 million tonnes of CO_2 in the year 2021 to 25.9 in the year 2050.

This value confirms that with the current trends, commitments and public requirements stated thus far, achieving the decarbonisation targets for the building sector in Spain in the next 30 years will not be possible.

And this will be due to the fact that until now a sufficient enough effort has not been made to understand that the sector's CO_2 emissions need to be looked at from a life-cycle perspective and therefore incorporate operational and embodied carbon.

In this regard, the change in the weight of operational and embodied carbon in the total annual emissions over the period of 30 years is significant. In the year 2021, operational carbon accounts for 71% of the 40.0 million tonnes of CO_2. However, in the year 2050 operational carbon only accounts for 31% of the 25.9 million tonnes of CO_2. This change in trend endorses the need to take measures intended to reduce the embodied carbon of buildings.

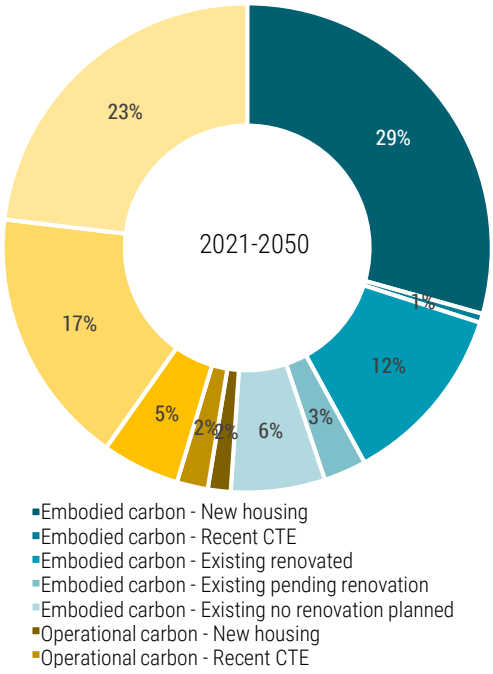


Figure 18. Percentage of cumulative life cycle carbon emissions by building typology. Source: own publication Unit: %

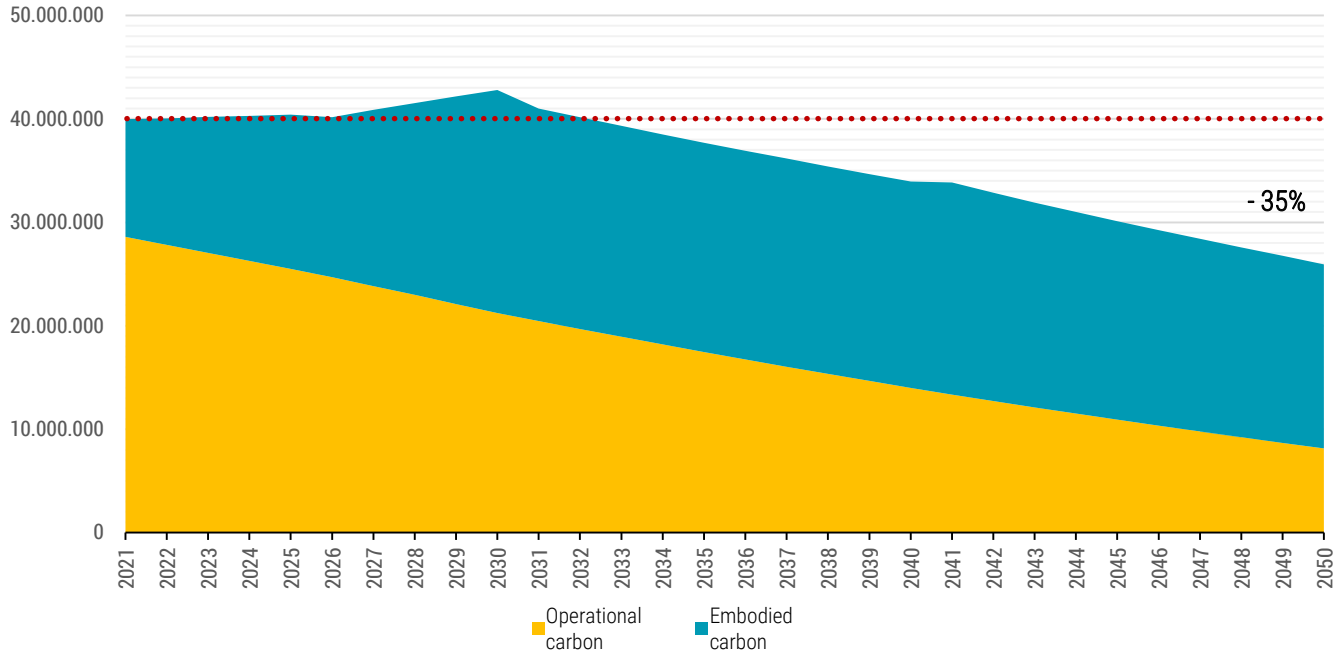


Figure 19. Annual life cycle carbon emissions by building typology. Source: own publication Unit: CO_2 tonnes/year

Sector scenario

In the trend scenario, the **operational carbon** emitted in the year 2050 by the residential sector as a consequence of heating and DHW energy consumption will have experienced a sharp drop of -96% compared to carbon emitted in the year 2021, moving from 28.6 million tonnes of CO_2 in the year 2021 to 1.2 in the year 2050.

This reduction accounts for a substantial improvement compared to the trend scenario largely due to electrification and a greater presence of renewable energy in the heating and DHW consumption mix. Furthermore, a combination of passive energy renovation measures and active measures to change heating and DHW technologies in the housing stock is also envisaged.

During this period, 390 million tonnes of cumulative CO_2will have been emitted, mainly in the category of existing housing. 46% of these emissions correspond to the 8.6 million existing houses for which no type of intervention is planned. 47% of the cumulative emissions are generated in the 7.1 million houses scheduled to be renovated over the next 30 years. In this regard, the breakdown of emissions per typology remains the same compared to the trend scenario.

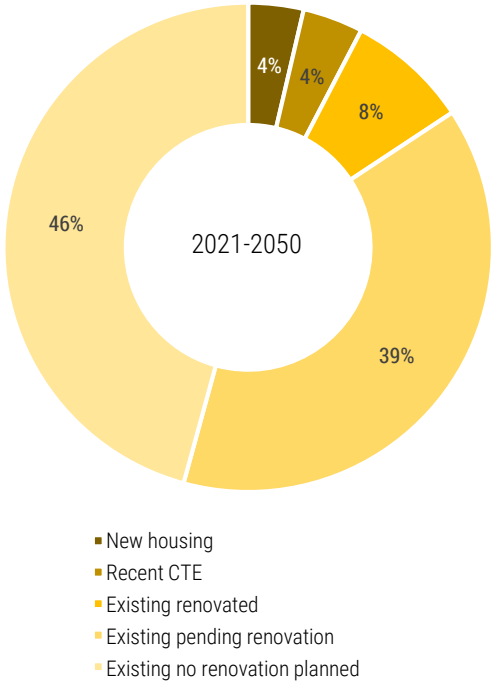


Figure 20. Percentage of cumulative operational carbon emissions by building typology. Source: own publication Unit: %

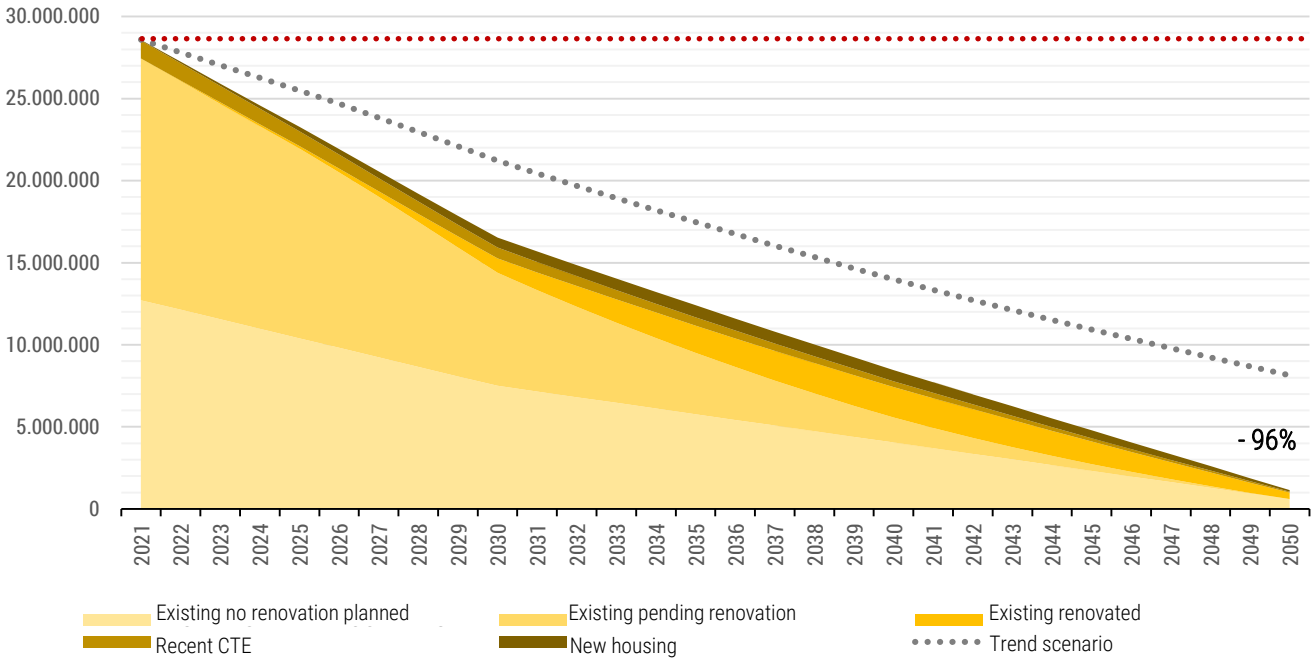


Figure 21. Annual operational carbon emissions by building typology. Source: own publication Unit: CO_2 tonnes/year

In the sector scenario, the **embodied carbon** emitted by the residential sector by the year 2050 as a consequence of construction, renovation and maintenance activities will have seen a slight drop of -2% compared to that emitted in the year 2021, moving from 11.4 million tonnes of CO_2 in the year 2021 to 11.2 in the year 2050.

This reduction accounts for a substantial improvement compared to the trend scenario with an increase of +56% due to the building sector's estimated reduction of embodied carbon in materials to be used in new builds and renovations.

Furthermore, just like the previous scenario, the new build and renovation actions along with their corresponding maintenance actions will be responsible for 86% of the 451 million cumulative tonnes of CO_2 of embodied carbon between 2021 and 2050.

It is worth pointing out that with regard to the trend scenario, his value accounts for a reduction of 100 million tonnes of CO_2 in the base period of 30 years.

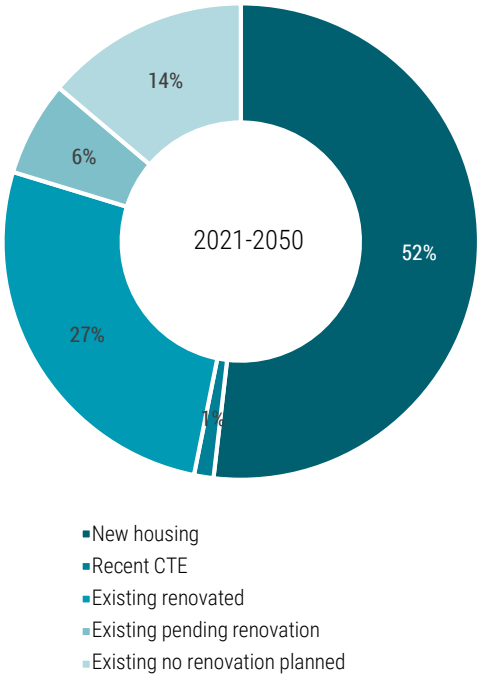


Figure 22. Percentage of annual embodied carbon emissions by building typology. Source: own publication Unit: %

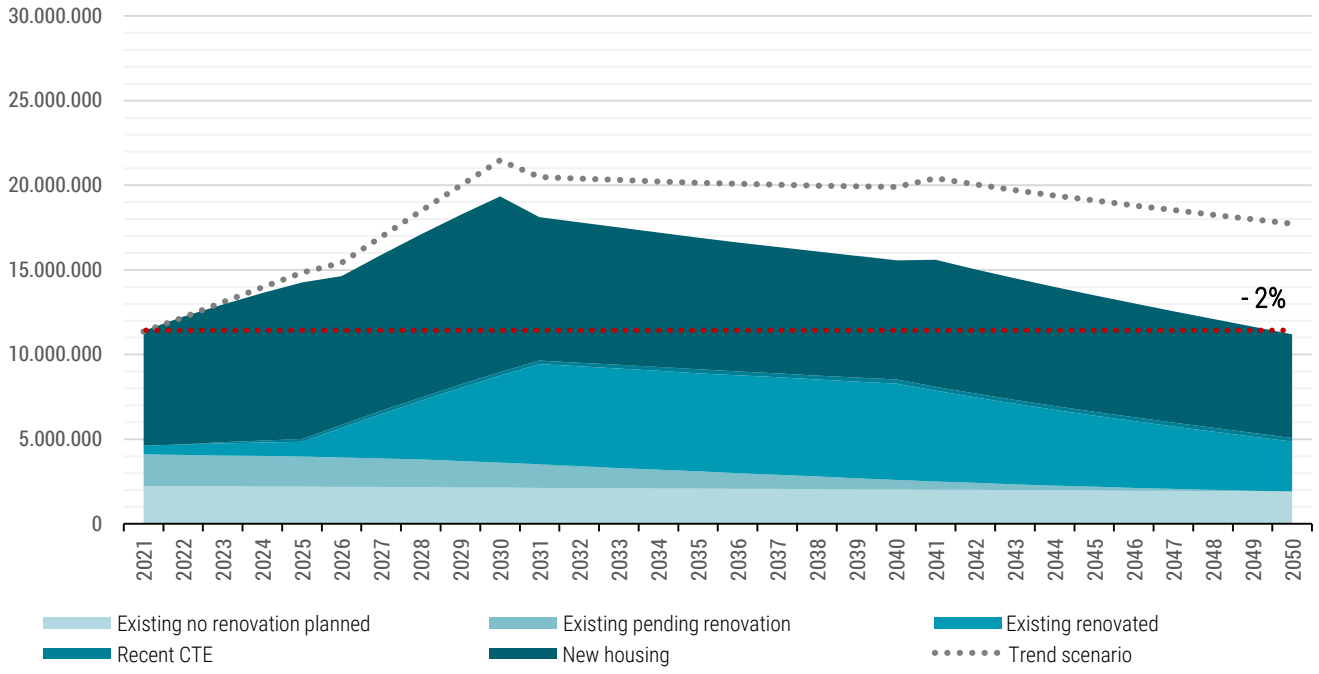


Figure 23. Annual embodied carbon emissions by building typology. Source: own publication Unit: CO_2 tonnes/year

In the sector scenario, the **life cycle carbon** emitted in the year 2050 by the residential sector as a consequence of all the activities will fall by -69% compared to the life cycle carbon emitted in the year 2021, moving from 40.0 million tonnes of CO_2 in the year 2021 to 12.3 in the year 2050.

This value confirms that despite the improvements made to the sector's strategies it will not be possible for the building sector in Spain to reach the decarbonisation targets over the next 30 years. This is largely due to the impact of the embodied carbon in the life cycle carbon by 2050.

In this regard, the change in the weight of operational and embodied carbon in the total annual emissions over the period of 30 years is significant. In the year 2021, operational carbon accounts for 71% of the 40.0 million tonnes of CO_2. However, in the year 2050 embodied carbon will account for 91% of the 12.4 million tonnes of CO_2 emitted, highlighting the need to take measures intended to reduce the embodied carbon of buildings.

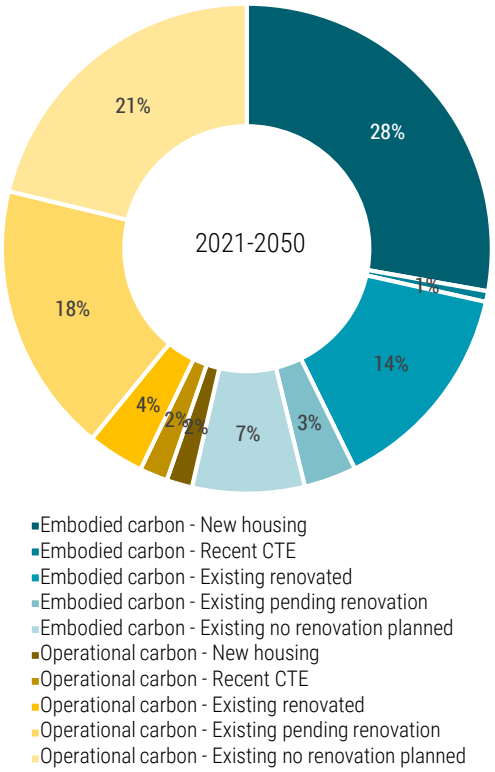


Figure 24. Percentage of cumulative life cycle carbon emissions by building typology. Source: own publication Unit: %

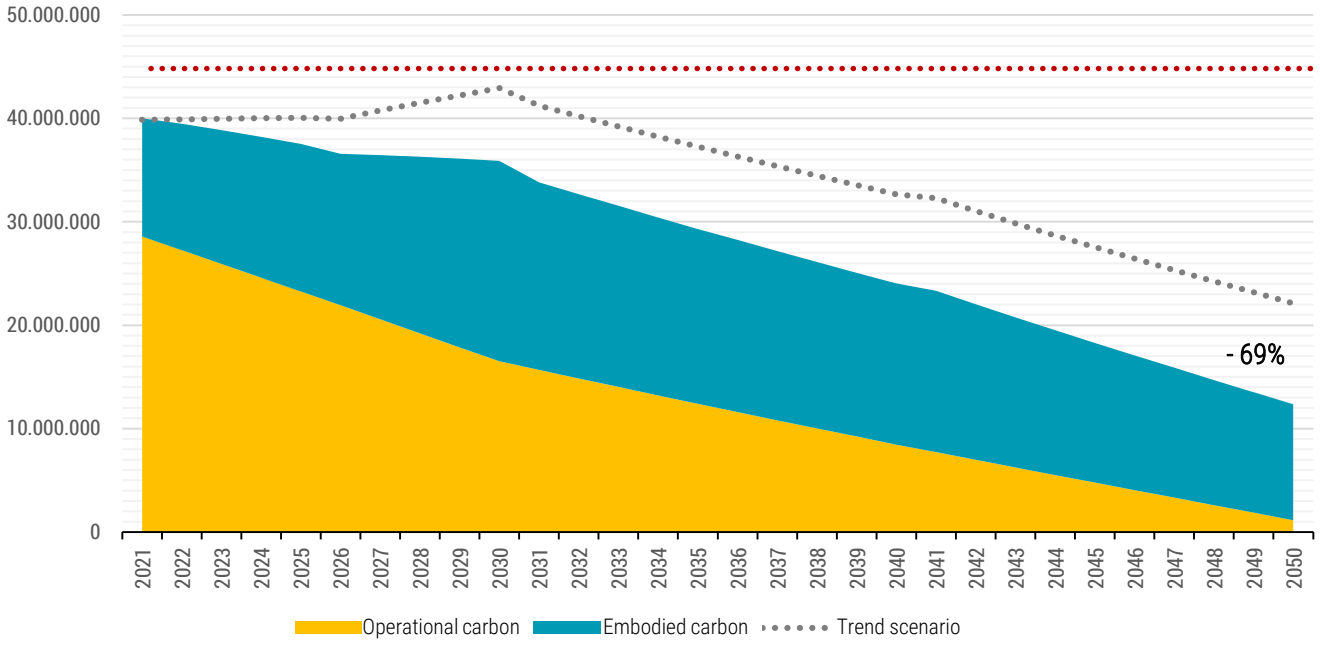


Figure 25. Annual life cycle carbon emissions by building typology. Source: own publication Unit: CO_2 tonnes/year

Key points for the future

If we want to decarbonise the sector by 2050:

- We must tackle the life cycle carbon.

  Embodied carbon accounts for more than 50% of the sector's cumulative emissions over the next 30 years. Therefore, long-term planning concerning embodied carbon needs to be just as ambitious as operational carbon planning.

- We must take urgent action.

  By the year 2050, life cycle carbon emissions can be reduced by up to 69% compared to 2021 according to the sector scenario; 34% more than in the trend scenario.

  However, cumulative emissions during this period can only be reduced by 19% if we compare the trend scenario to the sector scenario.

  This leads us to conclude that in parallel to increasing the ambitiousness of the final target, increasing the pace of implementation of carbon reduction measures is also necessary.

- We must leverage the carbon investment in the existing stock that has already been made.

  Our available building stock comprises 16.6 million main houses, 7.1 million of which are planned for intervention by 2050. This strategy leaves the largest group of housing, a total of 9.5 million that account for 46% of housing planned for 2050, without any planned interventions and with medium to high energy consumptions.

  Furthermore, this same strategy foresees the construction of 4.15 million houses by 2050, which will provide just 11% of housing services. These interventions on newly built works will emit between 32% and 29% of cumulative emissions over 30 years, based on the sector or trend scenario.

  In this regard, the data available casts doubt over the strategy's approach to the rate of new construction and its associated emissions, which, with a view to decarbonising the sector and maximising the housing's services, could be redirected towards the renovation package for the existing 9.5 million houses and its potential could be leveraged as a resource pool over coming decades. Moreover, this strategy could contribute to the regeneration of areas that are currently becoming depopulated.

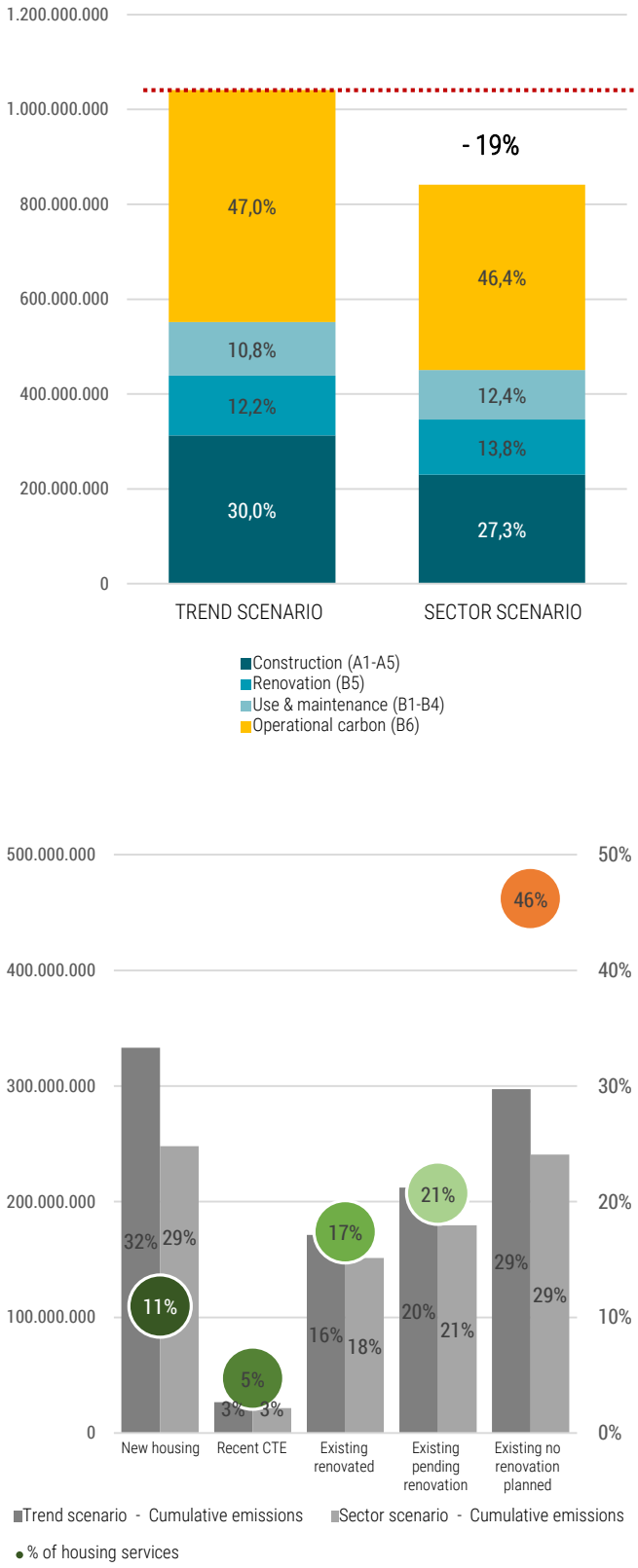


Figure 27. Cumulative carbon cycle emissions and percentage of housing utilities between 2021 and 2050 by sector. Unit: TCO2 and %

ROADMAP

THE 8 MILESTONES FOR DECARBONISATION

Based on the European commitment to decarbonising our society by 2050, now the core milestone of the document, a set of 8 main milestones have been defined to map out the pathway towards decarbonising the building sector.

This pathway uses the different deadlines in each milestone, which enables the most urgent initiatives to be planned and implemented without losing sight of the long-term vision to 2050. This complex pathway is marked by the well-defined milestones, which is not just a simple statement, but rather breaks down the scope of the roadmap into 19 sub-milestones.

Depending on the nature of each milestone, the timing is set out either in response to external constraints such as legislative or regulatory reviews, or on the basis of objective data about the sector's impact, which takes into account both the optimal time for taking each action as well as the consequences of not reaching the milestones and sub-milestones set.

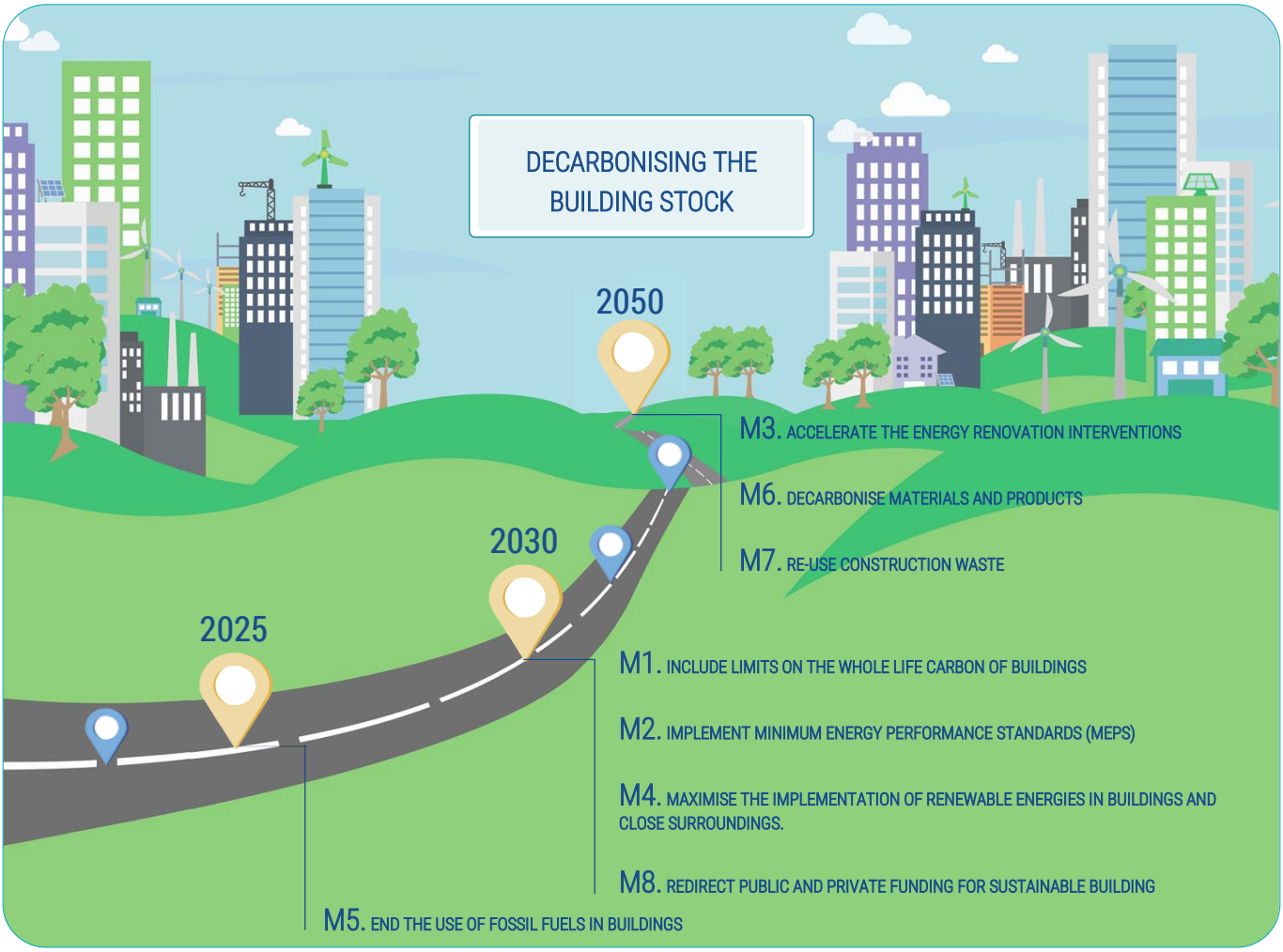


Figure 28. Representation of the milestones on the road map Source: own publication from the image based on the WorldGBC's ANZ project.

M1. Include limits on the life cycle carbon of buildings

The building sector can only be decarbonised by directly tackling the object in question: buildings. This milestone entails measuring the operational and embodied carbon in buildings as early as possible and the fulfilment of this milestone signifies the success of this roadmap. Carbon capping should first occur in new buildings (more data on this is available), and then in comprehensive renovations, without accounting the embodied carbon in existing elements.

M2. Implement Minimum Energy Performance Standards (MEPS)

MEPS limit the sale or rental of highly inefficient buildings, usually with reference to the letter on the Energy Performance Certificate of the building. This policy is already applicable in a range of countries near us, such as the United Kingdom, Belgium, the Netherlands and France. A review of the Energy Performance of Buildings Directive proposes extending it to all of Europe. It must be applied gradually over time according to its typology and energy rating.

M3. Accelerate the energy renovation interventions in the building stock

Already planned in the Long Term Renovation Strategy for the building sector in Spain (LTRS 2020), this milestone must be consolidated to obtain the best cumulative energy saving possible. The launch of recovery, transformation and resilience funds provides an opportunity to raise levels of ambition and accelerate the pace of renovation beyond what was planned in 2020.

H4. Maximise the implementation of renewable energies in buildings and close surroundings.

As defined in the Self-Consumption Strategy, the technical potential for the installation of renewable energies in buildings in Spain is enormous, especially by using building roofs. However, to take advantage of it a range of measures drawing us closer to a credible scenario will be necessary, taking into account the social and financial factors. Thermal and electrical self-consumption, hybrid technologies, Local Energy Communities, district energy systems, storage and e-mobility are factors that will make the most of installing renewable energies in buildings.

M5. End the use of fossil fuels in buildings

The lifespan of fossil fuel installations is 25 years at least. Their use must be prohibited by 2025 so that by 2050 Spain's building stock is not still depending on these sources of energy and therefore comes closer to real decarbonisation. The prohibition of fossil fuels in new buildings must be immediate as the same systems can be designed with decarbonised mechanisms.

M6. Decarbonise construction materials and products

Each family of materials will encounter different challenges and strategies on the road to providing the market with decarbonised products. To overcome these challenges, each sub-sector will need to draw up its own roadmap and monitor and review it every 5 years. They must ensure that the common targets for 2030 and 2050 are met alongside it. The electrification of processes, investment in R&D, the circular economy and the promotion of decarbonised products are some of the strategies common to the whole industry. The increased use of natural materials and sustainable exploitation can help to accelerate the pace towards this milestone.

M7. Re-use construction waste

A circular economy must reintegrate the generated waste into the cycles, both in factories as well as on building and demolition sites, the latter being the case where it will be most difficult to apply the principles of the circular economy. The initial producer of the waste, its current owner or previous owner are responsible for the waste. They must all ensure that as much as possible of the waste by weight is recovered, excluding earthworks.

M8. Redirect public and private funding for sustainable and decarbonised building

This roadmap proposes a transformation that needs major investments, not just to achieve decarbonisation but rather to do it by not leaving anyone behind. Private investment needs to be drawn to the sector. Both public and private funding must generate substantial contributions to the environmental targets and adhere to the principle of 'doing no significant harm' in line with the European Taxonomy.

MAIN MILESTONES OF THE ROADMAP

H1. INCLUDE LIMITS ON THE LIFE CYCLE CARBON OF BUILDINGS

- Include the obligation to measure life cycle carbon in all buildings (2025)
- Define and implement life cycle carbon limits in new buildings (2028)
- Define and implement life cycle carbon limits in comprehensive renovation interventions (2030)

H2. IMPLEMENT MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS)

- Do not allow the purchase, sale or rental of tertiary buildings with a rating below E (2028)
- Do not allow the purchase, sale or rental of residential buildings with a rating below E (2030)

H3. ACCELERATE ENERGY RENOVATION INTERVENTIONS

- Meet the target of 1,8 million homes renovated (2030)
- Meet the target of 9 million homes renovated (2050)

H4. MAXIMISE THE IMPLEMENTATION OF RENEWABLE ENERGIES IN BUILDINGS OR THE IMMEDIATE ENVIRONMENT

- Reaching the target of 14 GW of PV self-consumption (2030)

H5. ELIMINATE THE USE OF FOSSIL FUELS

- Not allowing the use of fossil fuels in new and existing construction sites (2025)

H6. MEET THE PACE FOR DECARBONISING CONSTRUCTION MATERIALS AND PRODUCTS

- Develop a decarbonisation roadmap and strategy for 2050 for all major families of building materials and products. (2025)
- Meet the Roadmap's targets regarding the different construction materials and products (2030)
- Meet the decarbonisation targets of the different construction materials and products (2050)

H7. REVALUING CONSTRUCTION WASTE

- Revaluing 70% of waste (2025)
- Revaluing 90% of waste (2030)
- Revaluing 100% of waste (2050)

H8. REDIRECT PULIC AND PRIVATE FINANCING TO SUSTAINABLE AND DECARBONISED CONSTRUCTION

- Ensuring 80% of public and 50% of private funding in buildings complies with the taxonomy (2025)
- Ensuring 100% of public and 90% of private funding in buildings complies with the taxonomy (2030)

4 FRAMEWORKS OF ACTION

The Roadmap is structured around 4 frameworks of action, addressing the need to promote comprehensive action on all the fronts involved in decarbonisation of the building sector: the strategic framework, the operational framework, the financial framework and the social framework.

Each of these frameworks is linked to reaching the decarbonisation milestones in the building sector. And to make it possible, there is a series of specific challenges that are addressed through 14 specific courses of action. Based on this level of definition, the Roadmap deploys concrete actions, defines deadlines and holds stakeholders accountable.

1. Strategic framework

   The Roadmap's first group of actions seek to redefine the strategic framework for decarbonising the building sector. The first framework is structured around 3 courses of action and addresses common challenges such as the decarbonisation governance system, the definition of the net zero whole life carbon building, the regulatory update to the Spanish Technical Building Code (CTE) to introduce new criteria and business strategies. In short, the strategic framework brings together a set of necessary actions to integrate the life cycle approach into all levels of public and private spheres, to redefine the legislative and regulatory framework, and finally generate leadership that empowers this shift in the sector's paradigm.

2. Operational framework

   The roadmap's second group of actions seeks to transform the operational framework to advance towards a sector that sees decarbonisation as an imperative condition and deep renovation as the main focus of activity. In this regard, this roadmap sees it necessary to define the technical framework for decarbonisation, to have rigorous and open information for measuring the decarbonisation process over the next 30 years, to steer the transition of the materials market towards low emissions products and to facilitate the use of new tools intended to digitalise the building sector.

3. Financial framework

   The roadmap's third group of actions seeks to adapt the financial framework to incorporate all the values of decarbonisation, to incorporate the life cycle cost analysis, compliance with the European Taxonomy and the “principle of doing no significant harm” to environmental objectives. It is all about the actions needed to drive investments in the sector's decarbonisation, promoting innovative funding models and establishing a specific emissions market for the building sector.

4. Social framework

   The fourth group of actions cuts across the 3 previous frameworks and focuses on incorporating the social framework into the sector's decarbonisation process, with the main objective of leaving no one behind. The social framework brings together a set of actions necessary to ensure a just transition that recognises the building sector’s social dimension, to raise awareness and to mobilise citizens under the banner of sustainability and decarbonisation, and to train up sector professionals with the skills to decarbonise the building sector.

FRAMEWORKS FOR ACTION OF THE ROADMAP

1. STRATEGIC FRAMEWORK DEFINITION

- E1. Integrate the life cycle approach into all levels of the building sector
- E2. Redefine the legislative and regulatory framework integrating the life cycle approach in the building sector
- E3. Develop specific decarbonisation strategies for each company and institution

2. OPERATIONAL FRAMEWORK TRANSFORMATION

- O1: Establish the technical framework for decarbonising the building sector
- O2: Avail of rigorous and open information to measure the decarbonisation of the building sector
- O3: Encourage the material market to shift towards low emissions products
- O4: Facilitate the use of new tools intended for the digitalisation of the building sector
- O5: Decarbonise the conditioning in buildings (heating, DHW and cooling) with integrated renewables

3. FINANCIAL FRAMEWORK ADAPTATION

- F1: Adapt the financial framework to encourage investment in decarbonisation of the building sector
- F2: Promote the development of innovative funding models that encourage decarbonisation of the building sector
- F3: Establish a carbon emissions trading market for the building sector

4. SOCIAL FRAMEWORK INCORPORATION

- S1: Ensure a just transition recognising the social dimension of the building sector
- S2: Raise awareness and promote social activation around sustainability and decarbonisation of our society
- S3: Educate and train sector professionals to achieve decarbonisation of the building sector using the life cycle approach

THE MILESTONE-FRAMEWORK RELATIONSHIP

Based around the two points of the milestones/sub-milestones and frameworks/courses of action, this Roadmap responds to the need to include in a single document a set of varied challenges, objectives and stakeholders, which will require a major coordination effort in order to decarbonise the sector.

The relationship between these two dimensions allows us to define the intentionality of this roadmap based on the number and size of the intersections between them. These intersections contain more information, reflecting the number of actions described to achieve each milestone and sub-milestone, as well as the stakeholders responsible for and involved in each of them.

In this regard, the first group of strategic and operational milestone (M2-3) focuses on the importance of intervening on the existing stock, based on the definition of compulsory energy rating thresholds that help accelerate the pace of intervention. The actions in the social and financial frameworks are very important in this group of milestones.

Furthermore, there is a second group of strategic and social milestones (M4-5) that focuses on the need to shift to renewable energy vectors and stop using fossil fuels, relying on the central role that citizens play in ensuring a just transition. The actions in the operative and financial framework are less important in this group of milestones.

On the other hand, there is a third group of operational milestones (M6-7) that has to do with the need to decarbonise manufacturing and construction processes, as well as recovering construction waste. The strategic framework actions have some importance in this group of milestones.

Lastly, milestones M1 and M8 focus on the strategic and financial frameworks respectively.

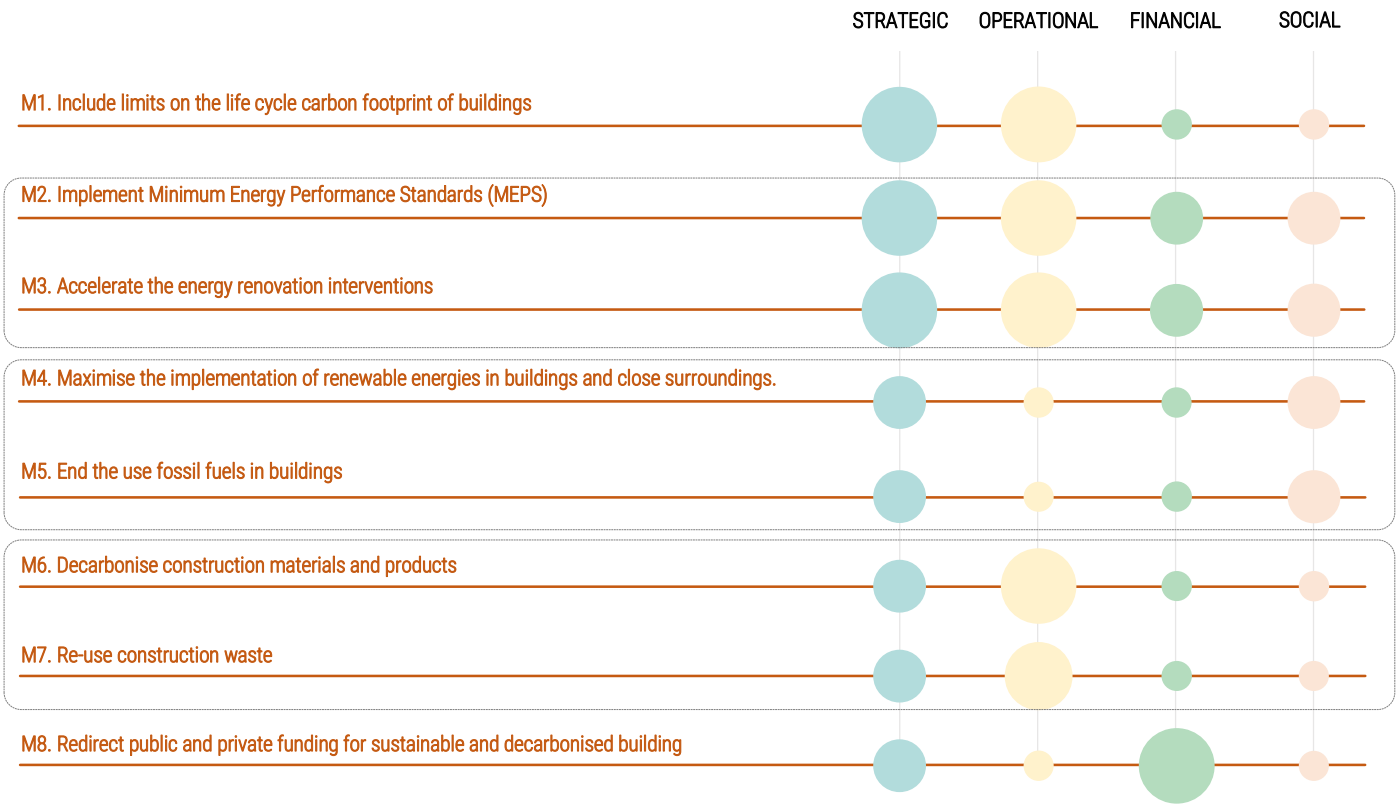


Figure 29. Relationship between the roadmap's milestones and frameworks. The size of the dot represents the number of actions at each cross point. Source: own publication

DEFINITION OF THE STRATEGIC FRAMEWORK

Considering the whole life cycle of buildings in the pathway towards becoming climate neutral requires a strategic focus to align all the policies and courses of action, in addition to mobilising the resources necessary to put them into practice.

Thus, a strategic framework that measures the problem and describes clear objectives is necessary so that each stakeholder (companies, administrative bodies, organisations, etc) can define their own pathway to decarbonisation. For this to happen, we need legislation that provides stable guarantees over time, as well as regulations and standards that effectively establish the minimum quality requirements of buildings and their installations for their decarbonisation.

Lastly, governance that identifies the leadership and collaborations needed to undertake the transformations proposed in this roadmap is necessary. We are not starting from scratch, huge steps have already been taken in Spain, but it is important to adjust the strategic and regulatory lines to tackle decarbonisation across the whole life cycle.

National decarbonisation definition and objectives

Nationally legislative and regulatory steps have been taken that have advanced the construction sector's decarbonisation process, especially regarding the increasingly restrictive energy efficiency criteria, although adoption of measures is moving slowly. Take for example Nearly Zero Emission Buildings (NZEB), whose mention dates back to European Directive 2010/31/EU of 2010, yet is not included in the national regulatory framework until the most recent update to the Spanish Technical Building Code (CTE) in 2019—that is, 9 years later.

The ambition around the challenge set by the European Union to reduce net GHG emissions by at least 55% by 2030 requires speedy adoption of measures over the coming years that tackle the decarbonisation of the building sector from a life cycle perspective, which considers both operational carbon—particularly in existing buildings—as well as embodied carbon. In this regard, the next updates to the National Energy and Climate Plan (NECP), the Long-Term Decarbonisation Strategy 2050 (LTDS 2050), the Long-Term Renovation Strategy for the Building Sector in Spain (LTRS) and the Spanish Technical Building Code (CTE) must introduce the life cycle approach without delay, in order to foster and facilitate the shift towards a decarbonised model among the building sector's stakeholders.

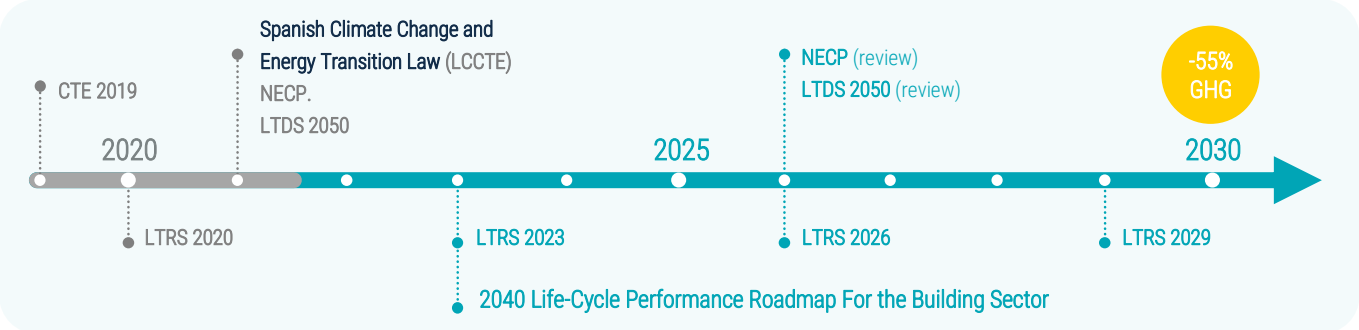


Figure 30. Timeline to 2030 with the main legislative and regulatory instruments Source: Own publication

Governance framework for decarbonisation

The decarbonisation process defined by the European Parliament and the Council is associated with the first governance framework for cooperation between the EU and State Members,[23] to ensure that national and EU trajectories are best aligned to meet the EU's 2030 decarbonisation targets for energy and climate change. The governance mechanism is based on each Member State developing its own National Energy and Climate Plans and Long-Term Decarbonisation Plan, as well as on the different information and follow-up measures.

In the national context, in alignment with this first general framework, the State must define its own multi-level governance framework with the different public institutions, from autonomous communities to municipalities depending on the powers of each organisation. This framework must be governed by the principles of precaution, subsidiarity and participation, usual in territorial processes in which there are effects on citizens as users of the territory and the environment. Furthermore, given that it is a mid- and long-term structural change process that covers numerous political cycles, within its scope each authority will have to ensure the social, political and corporate support, a decisive factor in the success of the decarbonisation process over the long term.

On the other hand, the private sector must strengthen its collaboration in order to participate in this governance framework on a sectoral basis. Each of the sub-sectors and companies involved must be capable of setting their decarbonisation targets and scenarios so that they can enter a dialogue with the rest of the public and private stakeholders to reach common objectives and launch courses of action.

European legislative framework

The European Union has adopted a political and regulatory leadership role in the international fight against global warming. After it was passed in the European Parliament, the new European Climate Law, which sets the legally binding target of net zero greenhouse gas emissions by 2050, came into force. The new law thus writes into law the target set in the European Green Deal of becoming climate neutral by 2050, as well as the reduction of net greenhouse gases by at least 55% by 2030 compared to 1999 levels.

The increased ambition to reduce GHGs by 2030 set in the European Green Deal has entailed a review of the current and planned policies, with the conclusion that they fall short of the new target. Therefore, the 'Fit for 55' legislative package was launched. It involves a review of the main political and legislative instruments in this area. In this regard, the reviews of the Energy Efficiency Directive (EED) and the Energy Performance Buildings Directive (EPBD) were presented in July and December 2021 respectively. A review of the Construction Products Regulation (CPR) is still pending and work is being done to create an emissions trading system for road transport and buildings in 2025 [24]. These review processes provide an opportunity to incorporate the construction life cycle approach into the EU's political and legislative framework and to align the actions across all phases of the process, from raw material extraction and material production, to construction and renovation, and even the building's end of life.

In the context of life cycle carbon emissions regulation, certain countries are one step ahead of the EU. A review conducted by the BPIE[25] on the main life cycle carbon regulations shows how the countries that adopted more restrictive measures concerning energy efficiency in the building sector are, in turn, those leading the way in the implementation of measures with a life cycle approach. In this regard, Norway already has life cycle carbon regulations for public buildings. Sweden, Denmark and Finland are planning to introduce these regulations in 2022, 2023 and 2025 respectively in order to limit GHG emissions in the whole life cycle of new buildings. The Netherlands and France require new buildings to report their incorporated impacts based on simplified LCA

[23]European Parliament, 2018. Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action.

[24] European Parliament Legislative Train. https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/

[25] BPIE (Buildings Performance Institute Europe), 2021. Whole-life carbon: challenges and solutions for highly efficient and climate-neutral buildings.

methodologies. And finally, Germany, Switzerland and United Kingdom have introduced LCA requirements for public buildings and projects.

National regulatory framework

A part of the national regulatory framework, the Spanish Technical Building Code (CTE) stands out as it establishes the requirements that buildings must meet in relation to the basic safety and habitability requisites set out in the Spanish Building Standards Law (LOE). With regard to decarbonising the building sector, the latest update in 2019 incorporates the definition of Nearly Zero Energy Buildings as well as greater requirements in terms of emissions, considerations focused on the use phase of the building and so-called operational carbon.

As the document is constantly being updated and given the recent obligation under the new European Climate Law to adopt the necessary regulatory measures to meet decarbonisation targets, there is an urgent need to introduce a life cycle approach to the definition of decarbonisation. This update can be used to strengthen the tools that quantify the real impacts on all the phases of the building, some already existing (the Energy Performance Certificate) and other new tools that arise from the EU's commitment to innovation in the sector (the Digital Building Logbook or the Building Renovation Passport).

When it comes to the existing tools, the Energy Performance Certificate (EPC) stands out as a tool present in all the EU Member States to improve the energy efficiency of the real estate stock. Despite its current poor reputation, it is considered to be the centrepiece of the EU's strategy, for example, in the taxonomy[26], which seeks to strengthen public and professional confidence in this instrument, improve its verification and give it greater importance in decarbonisation policies. It also incorporates new indicators that enable it to be adapted to the new information needs of the life cycle approach by way of simplified LCA methodologies or similar.

Furthermore, the new regulatory framework is closely linked to digitalisation, as a result of the commitment to innovation in the sector. In effect, the different stakeholders that intervene in the process will need access to the information concerning the building generated throughout all the phases of the life cycle. In this regard, it is worth highlighting BIM technology, the Building Renovation Passport and Digital Building Logbook, which incorporate a constantly updated database that integrates and centralises all the information and documents related to the building and its users. Having a central data repository that stores all the information pertinent to the life cycle of buildings facilitates the access to and management of the information needed to calculate the new metrics.

Role of government departments

Nationally, the new European Climate Law compels the Member States to adopt the legislative and regulatory measures they believe necessary to become climate neutral. In this regard, the Spanish Climate Change and Energy Transition Law (LCCTE), passed in May 2021, establishes the national legislative framework on which to build the compulsory pathway to decarbonisation by 2050 in accordance with the targets defined by the EU.

The new LCCTE, in turn, establishes the two major climate and energy governance tools: the National Energy and Climate Plan (NECP) and the Long-Term Decarbonisation Strategy 2050 (LTDS 2050), which must be coherent with each other in the integration of actions in order to hit the targets set. Furthermore, the Long-Term Renovation Strategy in Spain (LTRS) with their respective reviews stands out in the building sector.

On the basis of the new LCCTE and the range of new tools available, government departments have a responsibility to invigorate the sector in this initial phase in order to facilitate their transition towards decarbonisation. Firstly, there must be a long-term definition

[26] European Commission. EU taxonomy for sustainable activities

for the quality objectives of the entire building stock which is in synergy with environmental targets, sustained by a safe and stable climate in such a way that companies in the sector can adapt to and take on investments in R&D with a view to the medium and long term. Moreover, the government must set an example with regard to its own housing stock by way of procurement mechanisms. Finally, the shift towards decarbonisation must be built around an aware society, which is why providing information and raising awareness about the footprint of their behaviour and opportunities for new behaviours must be promoted among citizens and opportunities for new habits that are resilient to climate change must be identified.

In relation to the mechanisms available to the government, it is worth highlighting the Green Public Procurement Plan for the General State Administration, which is voluntary, as well as a range of initiatives run by autonomous communities to include sustainability criteria in the procurement processes. In addition, Article 31 of the new LCCTE envisages the introduction of award criteria intended to reduce emissions and the carbon footprint, the *"use of sustainable construction materials, taking into account their lifespan"* and *"measures to reduce greenhouse gas emissions and other atmospheric pollutants in the different phases of the public works construction process"* or *minimising waste generation"*.

In this regard, Green Public Procurement (GPP) has the potential to influence the market in a broader sense, from the point of view of both supply and demand, fostering a building sector that considers the "cradle to cradle" approach to be a core concept for decarbonisation. Public procurement management is a fundamental factor in increasing investment in low impact activities and can be supported by existing tools such as environmental certification, the LCA methodology or the life cycle cost analysis (LCCA) developed as part of the European Level(s) framework that uses criteria that go beyond price and can serve as an inspiration to encourage public procurers to use public procurement as a means of advancing the sector's decarbonisation and achieving a positive social and environmental impact.

Role of the private sector

The climate emergency calls for initiatives that outpace the legislation, opening pathways and anticipating results. For this, we are reliant on the private sector which has the tools in its hands to mark out a direction that integrates all the stakeholders and facilitates an orderly, balanced and just transition.

The direction is mapped out by the existing regulatory frameworks such as the aforementioned LCCTE, the NECP and those currently being developed such as the new EPBD and the Sustainable Finance Taxonomy. To meet the objectives, we have set ourselves as a society, there is a range of areas to which the private sector can contribute:

- Being prepared and equipped to implement the actions derived from the regulations developed or being developed, thereby consolidating responsible leadership and creating safety and stability in the markets instead of crisis and uncertainty which may lead to unanticipated and completely undesirable scenarios for all stakeholders.
- Considering this regulatory framework as the basis of work and being capable of outpacing it by offering more demanding and innovative solutions that accelerate the decarbonisation process and make it a source of best practices and inspiring examples.
- Anticipating the changes and creating flexible and resilient structures capable of transforming production processes at the lowest cost from both an economic point of view and a social one, thereby guaranteeing the necessary stability to achieve a just and peaceful transition.
- Facilitating public-private partnerships that are an active part of the change, placing their resources at the service of society and knowing how to balance its economic development with this principle.
- Remaining open-minded and open to dialogue that facilitates participation in forums to discuss new strategies and listening and being listened to, so that needs are included and the opportunities that different companies can provide are brought to the fore. Many private companies and associations are already participating and this best practice could be extended to those who have not yet gotten involved.

- Fostering transparent data and actions has a threefold consequence: firstly, discovering which internal data is useful for decarbonisation will make process improvement easier and will accelerate the pathway towards decarbonisation; secondly, large scale data management helps to establish realistic policies and strategies; and thirdly, society's trust in its business and production fabric increases thereby creating stability.

  The environmental, social and governance criteria are a key tool to support this change. The World Economic Forum's International Business Council published a report entitled ''Measuring Stakeholder Capitalism: Towards Common Metrics and Consistent Reporting of Sustainable Value Creation' in September 2020 as a result of the annual Davos summit that year. This report included the private sector's commitment to publish metrics on **environmental, social and governance (ESG) factors** and proves that these factors are increasingly seen as fundamental to the long-term success and viability of all companies and the sustainable development of the planet.

It is necessary to go beyond mere compliance with the minimums established in legislation and regulation, to achieve a strategic dimension guiding political and corporate action that will help to:

- Establish an agreed consensus on the concept of a net zero **whole life carbon building,** the targets and roadmap for the adaptation of the building stock to this standard, with a circular economy model.
- Redefine the legislative and regulatory framework so that it is a factor for advancement towards decarbonisation
- Develop decarbonisation strategies inherent to each company and institution

Challenges in defining the strategic framework

Challenge 1: Establish an agreed consensus on the concept of a net zero whole life carbon building, the targets and roadmap for the adaptation of the building stock to this standard, with a circular economy model.

The first challenge the sector must face is reaching a consensus on the methodology and scope used to define a net zero whole life carbon building. The balance between embodied emissions, the durability and flexibility of the solutions adopted in the construction of buildings must define new decarbonised architecture. The scale we use to measure the climate neutrality of cities can shed light on the offsetting limits for reaching net zero in our buildings. It is by using this definition and a clear, shared roadmap that the investments in decarbonising our built environment can be made with the necessary guarantees and at the pace required.

Becoming circular not just in terms of the economy but also in terms of building, by extending and upgrading the life of the building and reincorporating its components, inspires design and construction that does not just neutralise emissions but also sequesters them in the building for a longer term.

Challenge 2: Redefine the legislative and regulatory framework so that it is a factor in progress towards decarbonisation

The recently approved Spanish Climate Change and Energy Transition Law, which is supposed to steer Spain's energy transition, has missed the chance to explicitly include the ambition to decarbonise the whole life cycle of buildings. Nevertheless, when it comes to the strategic scope, the Long-Term Decarbonisation Strategy, the NECP and the LTRS can and should overcome this challenge in their upcoming reviews. Coordinating and communicating cross-cutting measures to various sectors is also fundamental, as is providing the right legal hierarchy for decarbonisation, along with the other associated climate objectives.

In addition to ensuring the minimum quality of our buildings, the regulatory framework must take decisive steps to underpin decarbonisation and reduce the environmental impact of our buildings in general. As it is often reviewed, the regulatory framework can implement measures that include the whole life cycle of the buildings and gradually increase the minimum requirements.

Challenge 3: Kick-start climate action among all stakeholders and assume individual and collective responsibility

Each stakeholder involved in this roadmap is responsible for the impacts of their own buildings and activity. They must position themselves as the leaders of the ecological transition in order to convince other stakeholders of the urgency, need and opportunity of decarbonisation.

The private sector must be ambitious when it comes to reducing the emissions from its processes, products and own buildings, generating a new corporate culture and leading the way for decarbonisation in each of its sub-sectors.

The public sector must set an example to society and the sector by encouraging innovation and pilot experiences. The renovation of its existing housing stock, the main users of which are citizens in general, is the main way of doing so.

Courses of action in the strategic framework

E1. Integrating the life cycle approach across all levels of the building sector

In order to integrate the life cycle approach across all levels of the building sector, we need to:

1. Define the multi-level governance framework that will help us to add a strategic dimension.
2. Agree on a definition for net zero whole life carbon building
3. Define the national decarbonisation targets with a mid- and long-term life cycle approach (2030 and 2050) in accordance with the Paris agreement.
4. Define the national Road Map that determines the actions required to meet these decarbonisation targets for 2030 and 2050.

E2. Redefining the legislative and regulatory frameworks integrating the life cycle approach into the building sector

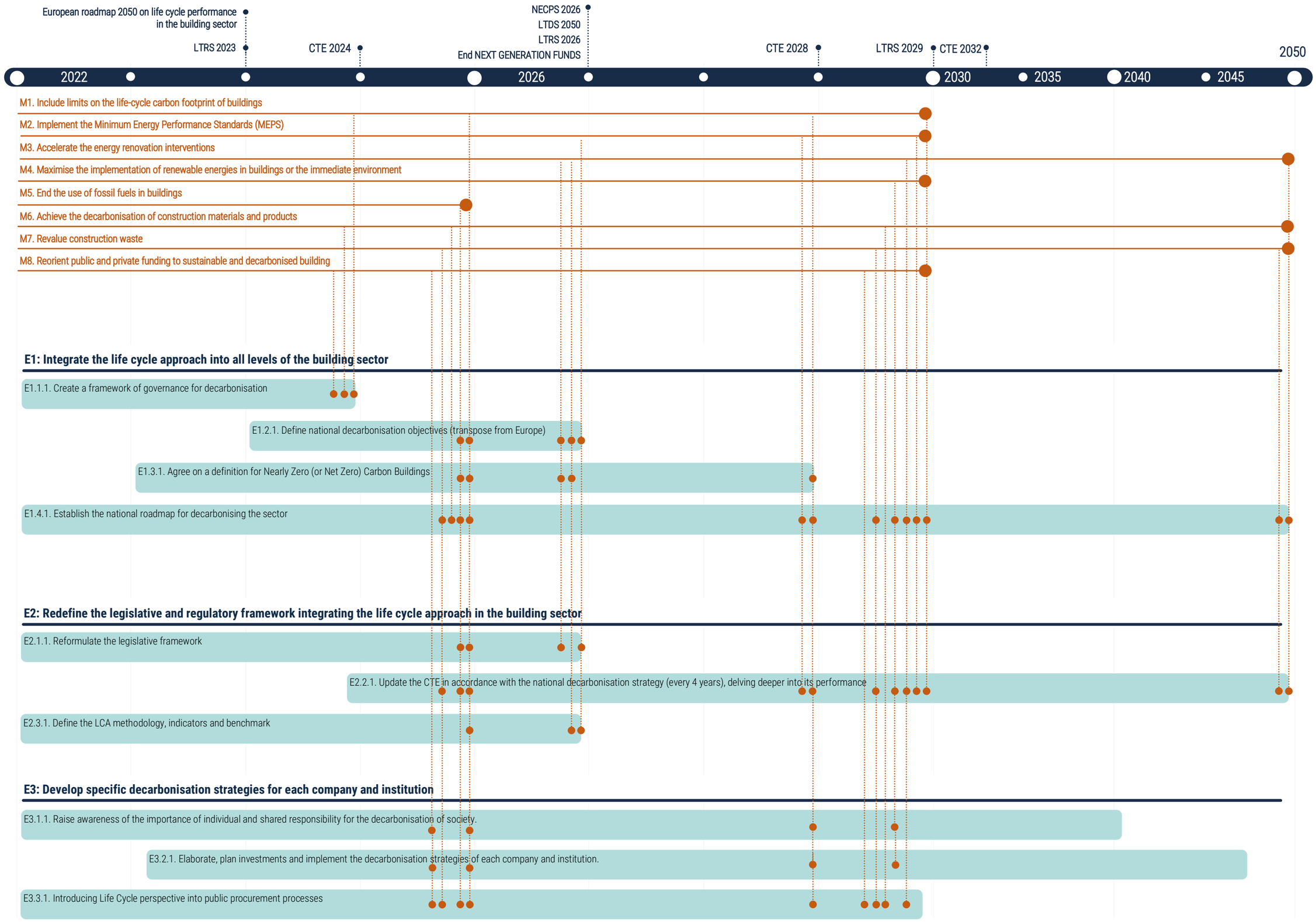
In order to redefine the legislative and regulatory frameworks integrating the life cycle approach into the building sector, we need to:

1. Define and schedule the activities necessary to integrate the life cycle approach into the future reviews of the national plans and strategies (LTRS 2023-2026-2029; NECP 2026; LTDS 2050 2026; CEAP)
2. Redefine the legislative framework on which to build the compulsory decarbonisation pathway to 2050 with the life cycle approach (LCCTE)
3. Define and schedule the activities necessary to integrate the life cycle approach into the future reviews of the regulatory frameworks (CTE)
4. Gradually establish more restrictive regulatory limits, indicators and requisites for the life cycle carbon of buildings.

E3. Develop decarbonisation strategies inherent to each company and institution

In order to provide leadership and accelerate the actions for decarbonisation, we need to:

1. Assume individual and collective responsibility, rely on a life cycle approach and become the leaders in implementing the necessary measures to make decarbonisation a reality.
2. Develop and commit to the decarbonisation strategies inherent to each company and institution.
3. Plan the investments necessary so that companies can tackle their own long-term decarbonisation.
4. Integrate life cycle requirements in tendering procedures and other administrative body procurement processes.


European roadmap 2050 on life cycle performance in the building sector
LTRS 2023
CTE 2024
NECPS 2026
LTDS 2050
LTRS 2026
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M1. Include limits on the life-cycle carbon footprint of buildings
M2. Implement the Minimum Energy Performance Standards (MEPS)
M3. Accelerate the energy renovation interventions
M4. Maximise the implementation of renewable energies in buildings or the immediate environment
M5. End the use of fossil fuels in buildings
M6. Achieve the decarbonisation of construction materials and products
M7. Revalue construction waste
M8. Reorient public and private funding to sustainable and decarbonised building
E1: Integrate the life cycle approach into all levels of the building sector
E1.1.1. Create a framework of governance for decarbonisation
E1.2.1. Define national decarbonisation objectives (transpose from Europe)
E1.3.1. Agree on a definition for Nearly Zero (or Net Zero) Carbon Buildings
E1.4.1. Establish the national roadmap for decarbonising the sector
E2: Redefine the legislative and regulatory framework integrating the life cycle approach in the building sector
E2.1.1. Reformulate the legislative framework
E2.2.1. Update the CTE in accordance with the national decarbonisation strategy (every 4 years), delving deeper into its performance
E2.3.1. Define the LCA methodology, indicators and benchmark
E3: Develop specific decarbonisation strategies for each company and institution
E3.1.1. Raise awareness of the importance of individual and shared responsibility for the decarbonisation of society.
E3.2.1. Elaborate, plan investments and implement the decarbonisation strategies of each company and institution.
E3.3.1. Introducing Life Cycle perspective into public procurement processes

OPERATIONAL FRAMEWORK TRANSFORMATION

In Europe, the building sector is currently responsible for 39% of energy consumption and 36% of GHG emissions derived from energy [27]. These building-related GHG emissions are released not just in the use phase, but also during the manufacturing, transport, construction, refurbishment and end of life phases. They are called **embodied carbon.** As the recent European initiative Built4People indicates, it has been estimated that embodied carbon in buildings represents a third of the emissions associated with the building sector, **accounting for 10 to 12% of total CO_2 emissions worldwide.** Along the same lines, it is estimated that by 2050 GHG emissions released before the building starts to be used will be responsible for half of the total carbon footprint of new builds.

In this regard, there are currently very few examples of net zero whole life carbon buildings in line with the ambition of the decarbonisation targets, due to both a lack of demand from society and a very fragmented supply. In effect, the construction sector encompasses a large variety of stakeholders and depends on a wide range of materials, processes and products with long and complex supply chains.

In relation to the carbon footprint of construction materials, the most noteworthy are those from **carbon-intensive heavy industries** such as cement, steel, aluminium, glass and ceramics. Worldwide, cement and steel are the sources of the two most significant construction-related emissions. According to the International Energy Agency, cement manufacturing is responsible for around 7% of global CO_2 emissions[28] and steel contributes to between 7 and 9% of total GHG emissions worldwide[29], around half of which are attributed to the construction sector. In addition, global consumption forecasts indicate an increase of between 12 and 23% by 2050[30] in the case of cement and around 30% in the case of steel, with a greater increase in recycled steel compared to primary production.

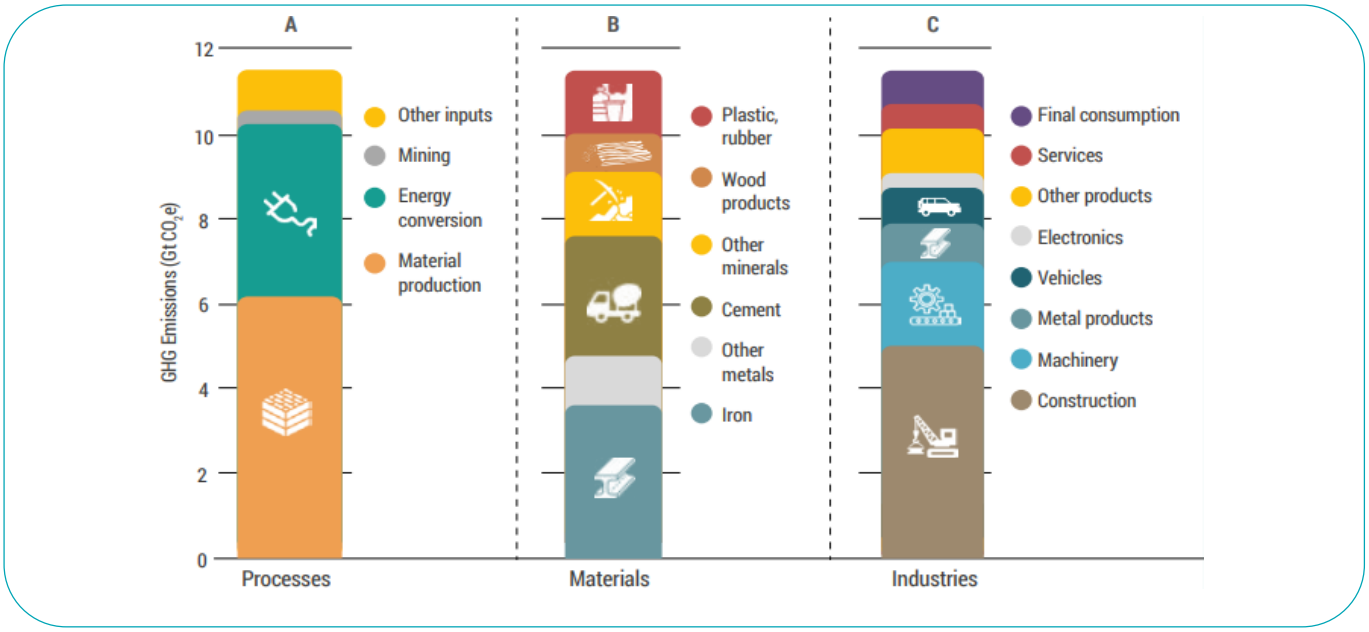


Figure 31. The Carbon Footprint of Materials 2015, according to: (A) Processes, (B) Material, (C) Sector Source: Hertwich et al., 2019[31]
Note: The GHG emissions values are not limited to the construction sector, instead they refer to all the sectors.

[27] International Energy Agency, 2019. Global Status Report for Buildings and Construction 2019.
[28] International Energy Agency, 2018. Technology Roadmap: Low-Carbon Transition in the Cement Industry.
[29] Stockholm Environment Institute, 2018. Low-emission steel production – decarbonising heavy industry.
[30] Energy Transitions Commission, 2018. Mission Possible - Reaching Net-Zero Carbon Emissions from Harder-to-Abate Sectors by Mid-Century.
[31] IRP, United Nations Environment Programme, 2020. Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future.

In relation to the carbon footprint of materials worldwide, the construction sector is the main emitter, responsible for 40% of total GHG emissions (Figure 31.C). Furthermore, the analysis according to process (Figure 31.A) shows how more than half of the cradle-to-gate GHG emissions are generated during material production processes and a third is due to energy supply. Impacting the manufacturing processes is a necessary strategy for decarbonising the sector. And even more so when some high carbon footprint materials with a costly and complex decarbonisation process play an essential role in the building sector as they offer services that could hardly be replaced by others with a lower environmental impact. The optimised and intelligent utilisation of materials for these purposes must go hand in hand with the widespread use of very low impact and even positive impact solutions.

The quest for decarbonisation has to be seen as an opportunity to develop the construction sector, particularly for materials companies. In effect, sustainability does not curb technical process, but rather provides the possibility to research and develop new materials such as biocomposites, processes that integrate circularity of materials or new tools such as the LCA or the materials passport, which allow us to quantify reusable materials in buildings.

Sustainability is not a circumstantial requirement. It is an unstoppable structural trend that is going to require constant adaptation, as we can see in other sectors such a food and transport. Therefore, companies in the sector, both small and large, with higher or lower carbon intensity, have to accept responsibility for decarbonisation and lay the foundations for the development of innovative low carbon solutions so they can remain competitive in the future. Investment today is the decarbonisation of tomorrow

Circular Economy

The construction sector based on the dominant model of a linear economy requires **profound transformation to a circular model** which would enable decarbonisation targets to be reached by 2050. Given the importance of the construction sector in the new economy and the current roadmap defined by the European Green Deal, the circular economy signifies **an opportunity that as a sector we cannot ignore**. It is able to drive innovation, competitiveness, employment and the environmental recovery of construction materials and products.

The shift to a life cycle approach must be addressed through comprehensive **strategies that incorporate all the stakeholders in the value chain.** Given the complexity of map of stakeholders who intervene and the importance of the expected shifts in production models, business models, forms of management and even governance, this approach makes it possible to integrate different technical, social, environmental and economic criteria to include the externalities generated in the life cycle of products in the decision-making process.

The New Circular Economy Action Plan 2020 and the I Circular Economy Action Plan (CEAP), approved in May 2021, anticipate an update to the EU Construction Products Regulation to drive the use of recycled material in construction products and the definition of objectives for the recovery of materials in their end of life phase among others, with the aim of ensuring that the resources used remain within the EU economy for as long as possible. According to the new CEAP, the production of construction and demolition waste accounts for 35% of the total in the EU. In the national case, according to the data provided by the European Union, production stands at around 45 million annual tonnes, only 25% of which is managed in plants that meet the standards and guarantees that certify the recovery of this waste as useful new resources[32].

In this regard, the successful development of these new solutions that incorporate the life cycle approach will be determined by the demand generated around this market in addition to the industry's capacity to innovate. At this point, **public administration bodies have to take on a double leadership role.** In terms of education, they have to get the message across to society about the added value

[32] Spanish Federation of Construction and Demolition Waste Recovery, 2017. Spanish Federation of Construction and Demolition Waste Recovery warns that more than 75% of construction waste produced in Spain is inconsistently managed.

of these solutions and thus unblock the barrier to the cheapest solution. When it comes to public procurement, it has to incorporate requisites that encourage the introduction of these solutions into building works.

Level(s) framework

Level(s) is the framework provided by the European Commission to define the key sustainability indicators in a building. It provides a consolidated and clear calculation method that generates standardised performance reports that provide a common European language for discussing and defining sustainability in the building sector. Level(s) is structured around six key areas: whole life cycle GHG emissions, resource efficiency, water use, health and comfort, resilience and adaptation to climate change, life cycle cost optimisation and value creation.

In turn, it provides a calculation of the indicators divided into three levels. Level 1 is conceptual design, Level 2 is detail and construction, and Level 3 is constructed building and use. This helps to advance knowledge about sustainability as the construction project is developed, making Level(s) a framework for implementation from the early stages of the project right through to the use of the finished building.

Level(s) is the basis for drawing up building-related policies, both European as well as national and local, with a special interest in public procurement.

Environmental information

The construction sector's progress towards decarbonisation requires a double commitment from construction material companies. Firstly, these companies have to guarantee that the information relating to their products and processes is transparent by providing reliable information that quantifies the environmental impact of a product's whole life cycle. Secondly, based on this environmental information, companies have to make a commitment to improve that allows low impact environmental products and solutions aligned with the decarbonisation targets to be developed. This is gradually achieved through three types of environmental product label, where the third (EPD) requires external verification. For their part, the verification processes are quickly evolving with new processes and digitalisation tools like blockchain and smart contracts, which improve the work of specialist organisations and open the door to new forms of verification such as participatory guarantee systems.

In effect, increasingly more material manufacturing companies are issuing environmental product declarations (EPDs), which are vital for steering decarbonisation efforts in the building sector in the right direction. Voluntary and third party-verified, these EPDs are based on the life cycle assessment (LCA) and should ideally include all the phases of the life cycle (cradle-to-grave), including the benefits after end of life (phase D). Therefore, they are an important source of data for the analysis of the building with a life cycle approach. As part of this growing trend, some European countries such as France, the Netherlands and Finland are moving towards legislative adoption of LCA requirements for the construction industry, which will be a catalyst for greater market penetration of EPDs.

There are international regulations on which the EPDs are based such as ISO 14025 or the Product Category Rules intended to guarantee that all the EPDs of a certain material are based on the same calculation methods. This level of transparency, quality and credibility is fundamental for stakeholder confidence in the EPDs. At sector level, developed by the Sustainability Agenda in Construction, the EPD Construction programme has led to EPDs in construction being drawn up based on the collaboration of companies committed to sustainability.

In the process of digitalising the construction sector, the development of online databases incorporating EPDs is being encouraged. The most well-known include the BEDEC (Structured Bank of Data on Construction Elements) of the Instituto de Tecnologia de la Construcción and OpenDAP which is part of the European inData project. The idea is to generate a network to harmonise environmental data. This information is particularly relevant since it allows the rest of the stakeholders in the sector, such as architects and engineers, to have a platform that brings together all the information about products and materials, facilitating the

LCA assessment of buildings. Likewise, the need to digitalise the sector along with a trend towards greater transparency of information related to our buildings opens the door to new tools such as the Materials Passport and the Digital Building Logbook, which could become benchmark tools that centralise the information developed over the building's life cycle.

Industrialisation

It is a known fact that, compared with other industrial sectors, the construction sector is known to lack efficiency concerning the set of processes it uses and the utilisation of resources. In this regard, material manufacturers are transforming their processes to improve the cost, quality and time efficiency of their products, advancements that are still to be applied to the building construction, renovation and end of life processes.

Meeting the sector's decarbonisation targets by 2050 requires a transformation where the industrialisation of products and processes emerges as one of the sector's recurring petitions. However, it is necessary to remember that, as a process, industrialisation can only come about and be sustained by way of a continuous increase in demand, construction being a sector subject to extensive growth cycles. In fact, this need for continuous growth in demand which requires a material basis to make it possible collides with the principle of sustainability.

The circular economy could become the trigger to shift the sector towards a new technical system based on sustainable territory management, that is, a sector focussed not only on maintenance but also on the regenerative culture of the environmental quality, supported by the internalisation of all the costs, time control of all the processes it triggers and efficiency in the use of resources.

Low environmental impact solutions

Because of the new framework of the Spanish Climate Change and Energy Transition Law, construction material manufacturers have to assume, as their own, the commitments to decarbonisation and move towards new business models that consider the life cycle of products and the life cycle of the buildings into which they are incorporated. According to Article 8 of the aforementioned LCCTE: "*The construction materials used in both the construction and renovation of buildings should have the smallest possible carbon footprint in order to reduce total emissions in the whole action or building*." The decarbonisation of materials that currently have a high environmental impact, the use of reused materials or materials with recycled content or the scalability and industrialisation of materials with a low environmental impact are key strategies to help this principle to be met.

With regard to these strategies, a huge untapped potential lies in natural materials which in general have a low carbon footprint because of their local production and low level of processing, in addition to other environmental and social benefits. Some products—plant-based ones with a certified sustainable origin—can even capture atmospheric carbon. Despite the advantages these materials can contribute to construction, their use has been rare over the last century in our country, which is why a solid business fabric that responds to the sector's needs has not been developed. The manufacturers of these products are faced with the challenge of industrialising their solutions and scaling their offer to provide reliable, reusable, recyclable and decarbonised solutions for the whole sector.

Sector digitalisation

Over recent years, the sector used digitalisation to push innovation, with the areas of building design and engineering leading the way in the implementation of new digital solutions and business models[33]. A clear of example is the development of the BIM methodology in public procurement and the advancements in smart building regulations. However, in practice, the building sector is

[33] COTEC and the University of Seville, 2021. COTEC report: Gacela Business Observatory 2021.

still one of the least digitalised, with corporate structure being the main obstacle, often with poor technological expertise and limited budgets for R&D, which still have not bounced back to pre-2008 economic crisis levels[34].

BIM as a collaborative methodology for building project creation and management is mapping out the path towards digitalising the sector. The main challenge behind this methodology, whose implementation is cost and time optimisation, is to generate a shared data platform that gives us a better knowledge of the building sector's value chain, in addition to being able to provide a life cycle assessment including construction product and material traceability in the BIM models[35].

Thanks to the use of BIM and advances in smart buildings and their predictive maintenance, the sector is pursuing digital twins and virtual representations of an object or physical system throughout the whole life cycle. These models provide real time information from the systems integrated into a building and are rather true to reality. They have a high level of autonomy and are equipped for machine learning based on the data they generate.

Parallel to the fostering of new technologies emerges the Building Renovation Passport, a tool proposed in the latest European building energy efficiency directive, which contains the Digital Logbook. This new building book is defined as a shared repository of building-related information and documents, allowing users to find out more about the spaces they live in. It also facilitates communication between the stakeholders involved in the building's management, running and renovation.

LCA: Methodology and tools

The life cycle assessment or LCA applied to the building sector is the methodology that enables us to find out about building's life cycle throughout its lifespan. It is all about the most comprehensive sustainable design technology since it evaluates the inputs, outputs and potential environmental impacts of a system in each phase of the building's life cycle, from material extraction to construction and use, including the building's demolition.

In this regard, the LCA assessment allows the different agents, designers, clients or developers to select alternatives with the lowest environmental impact from a range of solutions, thus aligning with the defined decarbonisation targets.

The tools for LCA assessment include computer software programmes such as SimaPro, GaBi and OpenLCA, or LCA calculation modules integrated into BIM methodologies, the application of which is standardised according to UNE-EN 15978. It presents the general structure and definition of the stages of the building life cycle and is applicable to both new buildings and renovations.

These tools feed off the information from the environmental product declarations (EDP), which are more frequently made public by manufacturers of construction products and generic values are provided by the different databases. In this regard, in addition to the aim of agreeing on a common LCA assessment methodology for the building sector, one of the main limitations is the availability of comparable information, which is why having a more accessible and reliable integrated database of reference for the stakeholders who intervene in a building's construction or renovation process is a priority.

At this point, we must highlight the Level(s) framework, driven by the European Commission and designed as an entry point to the assessment of sustainability in the building sector, based on methodology and database integration work, enabling comparability of buildings across Europe, data availability and benchmarks. At EU level, the most likely political initiatives into which Level(s) can be integrated is the green public procurement criteria and the EU taxonomy for sustainable finance.

Decarbonising the energy used in buildings

The sector's decarbonisation will undoubtedly require action to be taken around the energy consumed in the buildings themselves. In

[34] COTEC 2021. COTEC Report: R&D evolution
[35] PTEC, 2021. Digital Transformation Consultation Report

this regard, the sector's trend sets a clear pathway: **electrification of domestic thermal uses** (space heating and cooling, DHW and cookers). The residential sector's rate of electrification currently stands at 40% while in the tertiary sector this value increases to 59%. Therefore, this shift in the energy paradigm poses a challenge in itself, which will progress in parallel to this roadmap.

With regard to the building itself, electrification involves **eliminating as soon as possible the use of combustion technology that uses fossil fuels,** that is, natural gas, diesel fuel and the different liquefied petroleum gases, both in multifamily buildings as well as single family dwellings, thereby significantly reducing direct GHG emissions. In addition to considering the 25-year lifespan of boilers and the time horizon of 2050, this level of urgency means that no new boilers can be installed from 2025 in either new buildings or renovations.

Furthermore, in order to enhance the impact of electrification on the decarbonisation of the energy consumed in the buildings themselves, **an increase in the generation of renewable energies as close as possible to the points of consumption is anticipated,** that is to say, in the building itself or its immediate surroundings, making the most of the roofs on existing residential buildings. These types of interventions transcend the scale of the building, reaching community or neighbourhood scales. This enhances equipment performance optimises maintenance and review processes. This measure is used to drive the creation of energy communities.

We need to make progress towards a sector stakeholder operating system that considers intense renovation as the main point of activity and decarbonisation as an essential condition, so that we can:

- Implement a sustainable building model across the whole built environment
- Promote low environmental impact building products and solutions and avail of comprehensive and up-to-date information about them.
- Drive the digitalisation of the sector and incorporate the life cycle assessment as the core element in the constructive process, defining the targets that will lead to minimising or cancelling the impacts of the building, with special attention given to the carbon footprint.

Challenges in transforming the operational framework

Challenge 4: Implement a sustainable building model across the whole built environment

Sustainable building has in recent years been a standard limited to a very small part of the market. Only public and private development companies aware of their environmental responsibility or seeking to stand out in the market, have produced, often with the help of environmental certification seals, a building model that seeks to minimise their environmental impact and maximise the social performance of new building and/or renovations, while maintaining a fair and viable economic approach.

It is crucial that this sustainable building model spreads to the majority of our buildings, both new and existing. The culture of sustainability must permeate decision making, the sector's internal and external communication and the organisational structure of its network of stakeholders.

Challenge 5: Promote low environmental impact building products and solutions and avail of comprehensive and up-to-date information about them.

Embodied carbon due to materials accounts for a very significant part of the total carbon of buildings. Since to supply all a building's needs many types of products and services are required, their design and use need to be optimised to achieve the lowest possible carbon footprint at building level. Products from high emitting industries are faced with the challenge of transforming their production processes to offer decarbonised solutions to the market. Manufacturers of materials that already have a low carbon footprint must work on enhancing their business model, industrialising and scaling up their solutions to provide the market with decarbonised solutions from now on.

All manufacturing companies must make an effort to measure their impacts and provide transparent and verified information to the sector in order to ensure compliance with the climate targets for buildings.

Challenge 6: Drive the digitalisation of the sector and incorporate the life cycle assessment as the core element in the construction process, defining the targets that will lead to minimising the impacts of the building, with special attention given to the carbon footprint.

The life cycle carbon assessment is the most comprehensive scientific-based methodology for the evaluation and implementation of sustainability policies, including decarbonisation. It prevents possible externalities as it assesses the environmental impacts of the building sector. However, for it to be implemented properly, reliable, up-to-date, harmonised, environmental data about the products and processes that are part of the life cycle of the building are required. Digitalisation is a very powerful tool which, in addition to making the construction process more efficient, can and must facilitate the management of environmental data about our buildings. Such management of massive and detailed information must go hand in hand with visualisation and analysis mechanisms that are accessible, affordable and appropriate for the various stakeholders in the sector, as well as transparent, responsible and democratic data processing ethics.

Courses of action in the operational framework

O1. Establish the technical framework for decarbonising the building sector

To establish the technical framework for decarbonising the building sector, we need to:

1. Adopt the Level(s) framework in future reviews of plans, strategies and policies, and integrate it into the LCA calculation tools.

O2. Have rigorous and open information for measuring the decarbonisation of the building sector

To have rigorous and open information for measuring the decarbonisation of the building sector, we need to:

1. Develop a public database of reference that integrates all the information relating to products and buildings.
2. Produce type III ecolabels and environmental product declarations (EDP) for all the products used in the building.
3. Gradually incorporate LCA calculations for all the works, both new buildings and renovations.

O3. Encourage the material market to shift towards low emissions products

To encourage the material market to shift towards low emissions products, we need to:

1. Limit life cycle carbon at building level and integrate the material impacts from the overall life cycle perspective
2. Invest in digitalisation, scalability and innovation over a short, medium and long term that allow decarbonisation targets for each material to be met by the 2030 and 2050 deadlines.
3. Promote the reused, recycled and decarbonised materials market

O4. Facilitate the use of new tools intended to digitalise the building sector

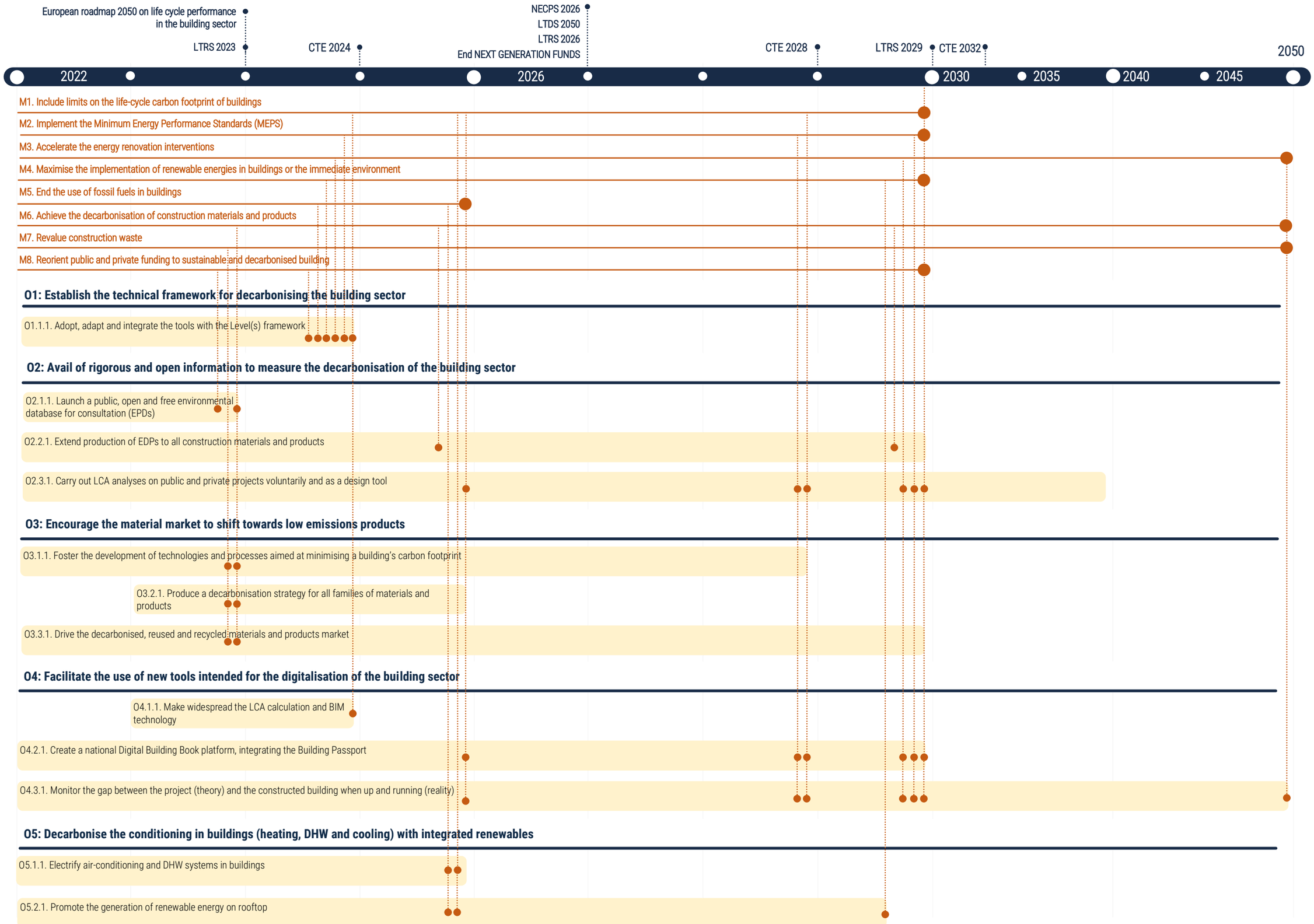
To facilitate the use of new tools intended to digitalise the building sector, we need to:

1. Foster the use of BIM and the digital twin in highly important projects, both new works and renovation.
2. Foster the use of the Digital Building Logbook and Building Renovation Passport in all works, both new works and renovation, as well as property transactions.
3. Promote building monitoring systems to reduce the gap between design and construction.

O5. Decarbonise thermal conditioning in buildings (heating, DHW and cooling) with integrated renewables

To decarbonise thermal conditioning systems in buildings (heating, DHW and cooling) with integrated renewables, we need to:

1. Electrify the air conditioning and DHW system in buildings.
2. Make the generation of roof-installed renewable energy systems more widespread
3. Promote actions at building, community and neighbourhood levels.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M5. End the use of fossil fuels in buildings
M6. Achieve the decarbonisation of construction materials and products
M7. Revalue construction waste
M8. Reorient public and private funding to sustainable and decarbonised building
O1: Establish the technical framework for decarbonising the building sector
O1.1.1. Adopt, adapt and integrate the tools with the Level(s) framework
O2: Avail of rigorous and open information to measure the decarbonisation of the building sector
O2.1.1. Launch a public, open and free environmental database for consultation (EPDs)
O2.2.1. Extend production of EDPs to all construction materials and products
O2.3.1. Carry out LCA analyses on public and private projects voluntarily and as a design tool
O3: Encourage the material market to shift towards low emissions products
O3.1.1. Foster the development of technologies and processes aimed at minimising a building's carbon footprint
O3.2.1. Produce a decarbonisation strategy for all families of materials and products
O3.3.1. Drive the decarbonised, reused and recycled materials and products market
O4: Facilitate the use of new tools intended for the digitalisation of the building sector
O4.1.1. Make widespread the LCA calculation and BIM technology
O4.2.1. Create a national Digital Building Book platform, integrating the Building Passport
O4.3.1. Monitor the gap between the project (theory) and the constructed building when up and running (reality)
O5: Decarbonise the conditioning in buildings (heating, DHW and cooling) with integrated renewables
O5.1.1. Electrify air-conditioning and DHW systems in buildings
O5.2.1. Promote the generation of renewable energy on rooftop

FINANCIAL MARKET ADAPTATION

Creating value around decarbonisation of the construction sector is a reality that is gradually being integrated into the property calculation, a calculation in which the level of market stress, the location of the property and surface area of the home have long been more decisive factors in their value until now. In effect, products such as green mortgages or energy performance contracts are starting to be used and serve as a launch pad for the introduction of the principles of sustainability in property valuation. However, despite the fact that operational carbon is becoming a relevant factor, embodied carbon is still the great unknown for both property sector stakeholders and society, which is why creating economic value with a life cycle approach still has a long way to go.

With regard to creating value based on energy efficiency criteria, the Joint Research Centre (JRC) indicates in its 2019 report that investments in energy renovation focussing on the use phase increase the value of the asset in the European context by between 3 and 8% and between 10 and 20% for commercial buildings[36]. These results signify progress in the integration of energy criteria into property valuation activities, although energy efficiency should not be the only new criteria when it comes to assessing the value of a building. Users certainly perceive and are more greatly affected by certain shortcomings in their homes relating to their health, and thermal, visual and acoustic comfort[37] as the Covid-19 pandemic has proven. Upgrades that are part of the "right to decent and adequate housing" enshrined in Article 46 of the Spanish Constitution as well as maintenance duty enshrined in Article 9 of the Spanish Horizontal Property Law.

The life cycle approach involves introducing new criteria in the property valuation process with a wider perspective. In addition to the intrinsic cost of manufacturing the product or construction of the building, its application to construction costs may allow the projected costs associated with running and maintenance, repair and replacement of the building's components and life cycle costs to be considered, calculated on the basis of EN 16627 and ISO 15686-5. Included in the Level(s) framework, life cycle costing (LCC) stands out as one of the existing methodologies for valuing life cycle costs. This methodology incorporates tools to support property valuation that calculate the potential positive influences on future performance such as increased income due to market recognition and a lower vacancy rate, reduced operating costs, maintenance, repair and replacement costs, or a lower risk in the future of indirect costs rising or a loss of income.

Creating value around the decarbonisation of the construction sector also requires the Government to take on a leadership role geared towards incentivising low environmental impact projects across their whole life cycle. This makes stakeholders become more engaged, both on the supply and demand side, in the process of integrating embodied carbon in the property valuation and in seeing it as a determining factor when buying or renovating a property.

Taxonomy

The challenge of decarbonising the construction sector by 2050 is going to require major mobilisation of public and private investments with sustainable criteria. In this regard, the taxonomy is the classification system fostered by the EU which defines the list of environmentally sustainable economic activities based on a set of environmental, social and economic indicators. The main objective of the taxonomy is to channel investments into the activities that align with the objectives of the European Green Deal based on the creation of a categorisation system that provides investors with security and protection.

The implementation of the taxonomy in the EU needs to increase the reliability of a building's energy and environmental performance-related information. In this regard, the "*Evaluating the market-readiness of the EU taxonomy criteria for buildings*"[38] report indicates that the Energy Performance Certificate (EPC) must be considered as a central element in the EU's strategy in order

[36] Joint Research Centre, CE, 2019. Energy Efficiency, the value of buildings and the payment default risk.
[37] Observatori Metropolità de l'Habitatge de Barcelona (O-HB), 2020. 'Living in confinement' survey. Housing habitability conditions
[38] DGNB, DK-GBC, GBCe, ÖGNI, 2021. EU Taxonomy Study - Evaluating the market-readiness of the EU taxonomy criteria for buildings.

to improve the energy performance of the European building stock, as it is an established tool in all the Member States. European policies seek to enhance this instrument, guarantee its quality and widen its reach so that it can be used as a source of information for the analysis of funding and can be taken into account in risk assessments, as well as in the resulting investment decisions.

Furthermore, the new classification system is closely linked to the digitalisation of the sector, since the information generated about the building during all the life cycle phases will have to be gathered and managed to help the different stakeholders to access it. In this regard, it is worth highlighting the Digital Building Logbook which incorporates a permanently updated database that integrates and centralises all the information and documents related to the building and the community. Having a central data repository that stores all the information pertinent to the life cycle of buildings will increase the stakeholders' internal capacity to manage the information necessary for the EU taxonomy and thereby facilitate investments in decarbonising the construction sector.

The precursors to the European Sustainable Financial Taxonomy are the ESG factors previously described in the strategic framework. Aimed at environmental, social and governance aspects of activities and management of private companies, over recent years their criteria have focused on selecting investors for transparent companies who are clearly committed to these three areas. The Spanish Observatory's Annual Sustainability Report (OFISO) states that sustainable finance made solid progress with 54,951million euros in Spain in 2021. This report shows a notable rise in green investing in our country and this rise is expected to continue in 2022 and following years.

Innovative business models

The construction sector's shift towards a sustainable and circular economic model that reduces the flows of material and energy necessary to be habitable is the basis for fulfilling the EU's decarbonisation ambitions by 2050.

The sector is characterised by a constellation of very diverse stakeholders involved in the successive phases, from material production to their end of life, which under the life cycle approach are integrated into a holistic view of the construction or renovation process. This allows the innovation that a certain agent can bring to a new technical system or digitalisation process will have repercussions on the rest of the stakeholders in the value chain. Therefore, contract, financing and development models should also be adapted to the sector's successive transformations.

In relation to funding models in the sustainable construction sector, there is a certain lack of awareness partly due to banking products that are not very specialised and poorly adapted to the characteristics of this type of operation. However, new products and services have recently started to emerge, incentivised by the arrival of the Recovery, Transformation and Resilience Funding, combined with public grants[39]. We must highlight that Brussels is aiming to align investments with national decarbonisation policies, that is, with activities that meet the EU taxonomy's objective of mitigating climate change. Therefore, relying on alternative financing models that build bridges between both sectors is necessary. As the report drawn up as part of the AUNA project[40] states, there are innovative public, private and public-private funding models, which can serve as triggers for the energy renovation processes and more widely to decarbonise the built environment. In this regard, these funding models are promoted by specialised stakeholders, where public-private partnership focussing on the common good is one of the paths with greatest impact when it comes to fostering operations as the Property Assessed Clean Energy Programmes (PACE)[41] demonstrate. Just as occurs in the case of the taxonomy, these alternative models of funding, need the sector to become digitalised for more rigorous management of the model's determining parameters as well as the consolidation of energy performance certificates as a reliable instrument.

[39] COAM & UCI, 2021. UCI and COAM, first alliance for the promotion of renovation funding in the capital through the new Renovation Office.
[40] AUNA, 2020. D1.2. Report on the status of funding
[41] Property Assessed Clean Energy Programs (PACE). https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs

In addition to its innovative financial model, new business models are also distinguished by their single-representative approach as pointed out in the report drawn up by EIT InnoEnergy[42] and in more detail by the report published by Milin and Bullier[43]. In this regard, the figure of the single representative applicable to the energy and development service models facilitates the management and communication between all the parties and reduces the complexity for users and for the stakeholders participating in the successive phases of the construction or renovation works. On the basis of the single representative figure, another innovative solution in the design of business models is the creation of collaborative networks among competitor organisations that offer the client improvements in terms of standardisation, credibility, choice, reduction of administrative costs and solution visibility.

On the basis of the single representative figure, another innovative solution in the design of business models is the creation of collaborative networks among competitor organisations and partnerships at various levels that offer the client improvements in terms of standardisation, credibility (assurance around the operations and their guarantees), choice, reduction of administrative costs and solution visibility. In turn, these partnerships facilitate the alignment and adequate sharing of risk between the comprehensive service parties, for example, between the ESCO (or the operating company) and the financier.

Specific carbon market for the building sector

As part of the "*Fit for 55*" regulatory package launched by the European Commission in July 2021, one of the measures is the creation of a specific commercial emissions trading system for the building and transport sectors. However, it is predicted that this system will not be up and running until 2025. It should force the cost of CO_2 emissions to be included in the methodology for determining the optimal cost in the life cycle of the building, the basis for establishing the minimum energy requirements for buildings.

That is to say, the draft of the next review of these minimum building requirements must incorporate the costs of the emissions produced in the running of the building, since those produced in the manufacturing of the materials are already taken into account the current emissions trading system, which include electricity generation and heavy industry, in which we find the materials with the largest carbon footprint (cement, steel, glass, lime, aluminium, oil derivatives, ceramic).

For these purposes, it is worth remembering that, according to the proposed EU Directive on the Energy Performance of Building of the European Commission and of the Council of December 2021, all new residential buildings or offices must be operational carbon neutral by 1 January 2030 (from 1 January 2027 for publicly owned buildings or buildings for public use) and all existing buildings for such uses should be operational carbon neutral by 2050. When it comes to tertiary buildings for other uses, they must comply with the NZEB requirements established in the national construction codes by the same deadlines as those required for residential and office use (2030 or 2027 for new buildings and 2050 for the existing ones).

We need to rethink economic dynamics based on the definition of the business model inherent to a decarbonised and resilient building sector, starting by:

- Adopting the European framework for the taxonomy of sustainable finance.
- Building partnerships between financial stakeholders and administrative bodies to create innovative funding bodies between private and public-private parties and integrated renovation services that incorporate the life cycle costing perspective.
- Defining and implementing a carbon market adapted to the building sector.

[42] EIT Innoenergy, 2021. Initiatives and business models for building renovation. A global comparison. (Published by the Naturgy Foundation)
[43] Milin, C. & Bullier, A., 2021. Towards large-scale roll out of "integrated home renovation services" in Europe.

Challenges in transforming the financial framework

Challenge 7: Adopting the European framework for the taxonomy of sustainable finance

The European taxonomy is a classification of economic activities and the criteria that they must meet to qualify as sustainable investments and thus be eligible for sustainable EU funding. This instrument aims to direct investments to activities contributing to the aim of becoming climate neutral in Europe by 2050. The construction and renovation of buildings as well as the purchase and possession of properties are classified in this taxonomy, which will be completed over the coming years, but it can already be seen in very significant investments such as the European Recovery, Transformation and Resilience Funds for the España Puede plan.

When banks and investors adopt the taxonomy, it gives them a unique opportunity to receive the necessary funding to transform our building stock.

Challenge 8: Getting behind the creation of public-private integrated and innovative financial models, and incorporating the life cycle cost approach into finances.

The investment necessary for decarbonising our built environment is going to necessarily require innovative funding models, which meet new needs such as large-scale renovation. Over recent years, schemes such as green mortgages and public-private equity funds have emerged, however, they still need to be rolled out on the scale required.
In addition, incorporating the life cycle cost approach into finances could generate a new property value culture, facilitating the implementation of sustainable, circular and decarbonised building models.

Challenge 9: Defining and implementing a carbon market adapted to the building sector

The *Fit for 55* package of measures proposed by the European Commission includes extending the carbon trading market to diffuse sectors, including the building industry. The sector faces a tremendous challenge in adapting the emissions trading market to the building sector and vice versa, so that it complies with the "Polluter Pays" principle, measuring the potential social impact and complying with the maxim of protecting consumers, while helping them with their transition to zero-emission consumers. The market as exchange mechanism for goods, services and externalities should incorporate the increased durability (*alargascence* as opposed to obsolescence) of buildings as a positive value. This allows us to introduce certain construction designs and decisions such as offsetting by sequestering in minimally processed materials, in their circularisation and reincorporation into the building.

Courses of action in the financial framework

F1. Adapting the financial framework to drive investments around decarbonising the building sector

To adapt the financial framework to drive investments around decarbonising the building sector, we need to:

1. Adopt the support tools such as the life cycle cost (LCC) analysis aligned with the Level(s) framework.
2. Introducing the European Taxonomy criteria into national, autonomous community and local public funding.

F2. Promoting the development of innovating funding models that drive decarbonisation in the building sector.

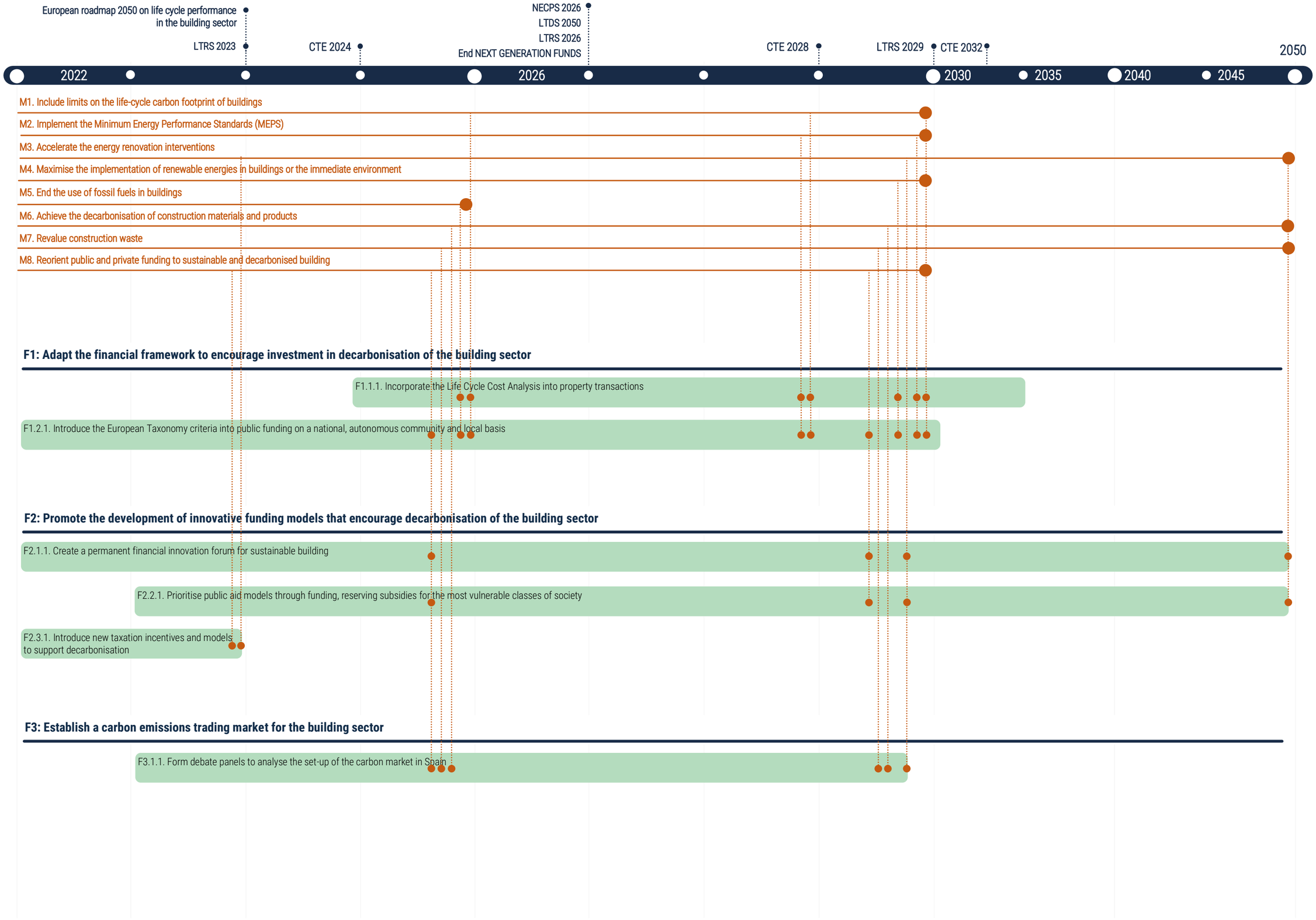
To promote the development of innovating funding models that drive decarbonisation in the building sector, we need to:

1. Facilitate the implementation of new private funding models that promote collaboration between the stakeholders and make the paperwork easier for final users.
2. Prioritise public aid models through funding, reserving subsidies for the more vulnerable classes of society.
3. Develop a green tax system based on the European taxonomy framework with incentive and penalties, ensuring a just transition.

F3. Establishing an emissions trading market for the building sector

To develop emissions trading rules specific to the building sector, in line with European regulations, we need to:

1. Hold discussion panels to analyse the methodology, regulation and creation of the carbon trading market for the building sector in Spain, ensuring socially acceptable implementation of this market.


European roadmap 2050 on life cycle performance in the building sector
LTRS 2023
CTE 2024
NECPS 2026
LTDS 2050
LTRS 2026
End NEXT GENERATION FUNDS
CTE 2028
LTRS 2029
CTE 2032
2050
2022
2026
2030
2035
2040
2045
M1. Include limits on the life-cycle carbon footprint of buildings
M2. Implement the Minimum Energy Performance Standards (MEPS)
M3. Accelerate the energy renovation interventions
M4. Maximise the implementation of renewable energies in buildings or the immediate environment
M5. End the use of fossil fuels in buildings
M6. Achieve the decarbonisation of construction materials and products
M7. Revalue construction waste
M8. Reorient public and private funding to sustainable and decarbonised building
F1: Adapt the financial framework to encourage investment in decarbonisation of the building sector
F1.1.1. Incorporate the Life Cycle Cost Analysis into property transactions
F1.2.1. Introduce the European Taxonomy criteria into public funding on a national, autonomous community and local basis
F2: Promote the development of innovative funding models that encourage decarbonisation of the building sector
F2.1.1. Create a permanent financial innovation forum for sustainable building
F2.2.1. Prioritise public aid models through funding, reserving subsidies for the most vulnerable classes of society
F2.3.1. Introduce new taxation incentives and models to support decarbonisation
F3: Establish a carbon emissions trading market for the building sector
F3.1.1. Form debate panels to analyse the set-up of the carbon market in Spain

SOCIAL FRAMEWORK INCORPORATION

The building sector has been one of the main vectors of social improvement throughout the 20th century, providing homes for society—a fundamental right— and generating economic wealth and local employment. However, having reached the 21st century this model has suffered a profound crisis for many reasons: universal access to housing is no longer a given because of the high number of evictions following the 2008 economic crash and rental prices are rising in cities. The construction sector has become incapable of maintaining its level of business and number of jobs as they based their activity on speculation and we are increasingly aware of the enormous environmental impact that our way of building has caused.

Under the paradigm of sustainability, new approaches have emerged. They can help the building sector to have, once again, a positive impact on society, leading to well-being, wealth and social cohesion. Different studies indicate the need[44] and the possibility[45] of the decoupling economic growth —and individual and social wellbeing to a greater extent— of the environmental impacts, seeking a balance that has been conceptualised in the 'doughnut economy' model[46]. Under this model of sustainability, a just and safe life for humanity will only be possible in an economy that does not exceed the planet's ecological limits or worsen the lives of people at unsustainable levels.

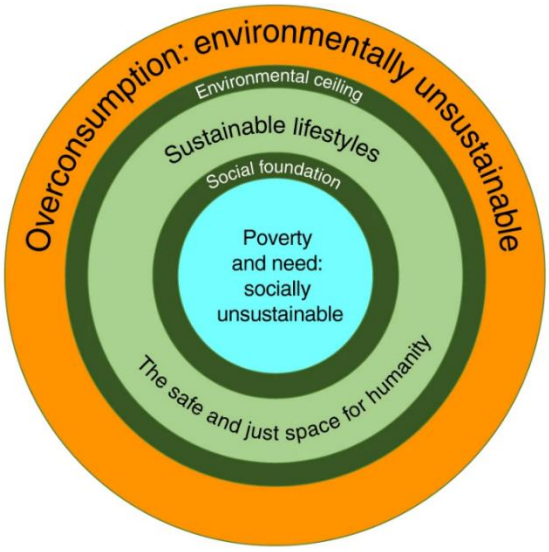


Figure 32. The safe and just space for humanity. Source: Wiedmann, et al., 2020

As a society, we should integrate this vision and bring about a new social pact, a consensus that commits us to ensuring sustainability across its three aspects globally and thus decarbonise our economy without harming other societies. In this transition, building plays an essential role in abating the environmental impacts that we are now overcoming and ensuring that the social impacts in our country do not cross over.

Person-centric approach

Decarbonising the construction sector will come about by putting the person at the centre of the transformation process. In addition to the participation of the sector's stakeholders and public administration bodies, citizen involvement in this process is fundamental,

[44]European Environment Agency, 2021, Growth without economic growth.
[45] Wiedmann, T., Lenzen, M., Keyßer, L.T. et al., 2020. Scientists' warning on affluence. Nature Communications.
[46] Haberl, H. et al., 2020.A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights.

as an agent truly capable of triggering the change necessary to become climate neutral before 2050. The citizen's new role is defined by the multilevel governance framework on the basis of the precautionary principles —preventing measures with potentially serious and unknown consequences—, subsidiarity, —we are all able to act without having to wait on higher authorities, —and participation— to acknowledge the interests of all people and improve transparency.

In the broader context of decarbonisation, not just limited to the building sector, there are several tools to support this vision. Nationally, the National Energy and Climate Plan (NECP) and the Long-Term Decarbonisation Strategy 2050 (LTDS 2050) accentuate the importance of placing citizens at the centre of the energy transition process so that "those who had an exclusively consumption-based role in the conventional model can become proactive agents", laying the foundations to encourage citizens to participate in the energy sector in a broader sense rather than relegating them to a merely consumption-based role. In addition to individual self-consumption, Local Energy Communities (cooperatives, associations or public companies) are an instrument with great potential to help organised citizens to become responsible for their own consumption and energy generation, in addition to bringing huge benefits for a distributed energy network.

However, the main potential for change does not lie in technical advances, but rather in changes in behaviour and consumption habits, the most efficient and inexpensive way of becoming climate neutral. Our society needs a transformative process to mitigate and adapt to the effects of climate change, meaning that solutions need to be adopted that respond to the different facets of our reality in an integrated way. While proposals to decarbonise the sector have until now focussed on the physical, technological and economic aspects of the built environment, European directives have more recently pointed out the importance of the user in the management and use thereof. One could argue that decarbonising the building sector does not just require changes in the nature and materiality of the buildings, but rather it has to be promoted across a broad spectrum of our culture and society.

On the other hand, a person-centric approach means acknowledging not just our capacity and obligations but also the needs and rights that we must secure as a society. In this sense, we must review the role of the building sector because, rather than producing housing, its fundamental purpose is to provide society with an acceptable standard of habitability, which allows human development without harming health and personal development. Social demand for a habitable space, from housing to a city, is where we need to create the conditions so that everyone, regardless of their age, social class or cohabitation model, can have their need for shelter met.

In this sense, renovating homes is one of the main strategies as it will allow existing buildings to provide the socially required habitable conditions in terms of thermal comfort, health and accessibility, without overlooking the cultural and aesthetic value of our buildings, which initiatives like the New European Bauhaus are trying to foster and maintain. A special mention must be given to energy poverty, a phenomenon that affects more than 4 million homes in Spain[47] and which depends on three factors: household income, energy demand—directly related to the quality of housing— and the price of energy, which is increasingly volatile and high. Although public administration bodies have deployed diverse instruments to alleviate it from a social aid point of view (electric and heating rate reduction), the most effective and structure solution over the long term is energy renovation of their houses.

The Just Transition

The shifts necessary to move towards a decarbonised society are undoubtedly going to involve changes in society, which in some cases can lead to poorer quality of human life. The Just Transition is the framework for action proposed by the International Labour Organisation and the United Nations Framework Convention on Climate Change, to maximise benefits in activity and employment and minimise the negative impacts of the ecological transition and decarbonisation. While for a time the focus was on areas in the

[47] Ministry of Transport Mobility and the Urban Agenda, 2020. Long-Term Renovation Strategy in the Building Sector in Spain (LTRS).

process of abandoning coal mining, the wider concept and the future of the decarbonisation policies open a margin of uncertainty as to how they will affect vulnerable homes.

Both the MEPS and the building-specific carbon market are the two policies that promise to stimulate renovation and accelerate climate action in the building sector. However, we still cannot predict the social impact that they will have as the houses that will be most affected —the most inefficient— are usually those occupied by the most vulnerable groups. Policies like district renovation are key to reducing the vulnerability of these homes and generating further causes for inequality.

Social value

An equally important approach to the economic value of sector decarbonisation relates to the social value. Since the principles of habitability and health in the built environment are closely related to the transition towards cleaner, healthier, more adaptable and resilient buildings. In the urban environment, the concept of the social value of interventions is more widespread due to the greater visibility of the impacts associated with GHG emissions, from macro and micro climate overheating with the urban heat island effect, or the greater risk of extreme events, among others. However, despite having an extensive methodological basis and tools, the social value of decarbonising buildings lacks application and interpretation of results, and there is scarce dissemination among citizens.

The most widespread measurement tool is the social life cycle assessment (S-LCA) based on ISO 14040 and fostered by the UNEP's International Life Cycle Initiative. Its "*Social Life Cycle assessment of products and organizations*" compiles the definition and structure the S-LCA, its proposed stakeholders and impacts on them, the idea of a "social footprint", its relationship with other international law and corporate social responsibility rules, as well as examples and application guidelines. In this sense, some of the fundamental rights to be safeguarded through reducing the negative impacts of the building sector are the right to access housing and a decent home, work, education and personal liberty.

Furthermore, we must yet again highlight the Level(s) framework for assessing building sustainability, which includes areas for healthy and comfortable buildings through four indicators: indoor air quality, referring to the concentration of indoor air pollutants and the inspection of pollutants associated with building materials —especially building finishes— and, therefore, to areas of health; hours outside thermal comfort, under climate scenarios that allow adaptation to expect change, related both to health and the usability of the rooms; lighting comfort, which develops aspects related to natural light and the quality of artificial light, with an influence on the individual and social perception; and acoustic comfort and noise protection, which is particularly relevant in urban settings and those close to transport infrastructures.

In the field of social value, progress is being made in the framework of the Sustainable Finance Taxonomy. In July 2021, the European Commission published a draft of the social criteria that proposes a taxonomy parallel to or combined with the environmental taxonomy, encompassing social criteria in both the development of the economic activity itself and the products and services it offers.

An initiative prior to Taxonomy that is already well established in the corporate world is the ESGs (defined in the section on the Role of the Private Sector, p. 44). This framework proposes corporate social responsibility criteria that, once incorporated into a company's strategic plan with a broader vision that integrates aspects of management, building design, construction products or construction activities, can guarantee a more just and decent working environment and buildings that can guarantee that its occupants are healthy and comfortable.

Training

Faced with the new paradigm, society is calling for new skills, which is why training is fundamental at all levels. The majority of the sustainability-related training is currently focussed on higher education. It is in universities, above all at the high level of Master's and Postgraduate degrees, where educational programmes have been designed with new qualifications and subjects, the focus of which

is fundamentally sustainable development. The representation of sustainability in university undergraduate degrees is much lower, but usually in optional subjects.

Thus, training in sustainability is not exactly plentiful in the academic curriculum at all educational levels. And its focus lies primarily on the final stages of education through specific training sessions that are not integrated into the different profiles. In addition, we must remember that a large number of construction sector professionals do not attend university. Therefore, they manage to get out of training in sustainability.

There is a difference in the way that sustainability is addressed in training as can be done from three main angles: through cross-cutting competences, applying sustainability in a common way, across all specialisations; specialisation, focussed on a specific part or programme; and tools, which are used for support, but require previous knowledge of sustainability. In the case of higher education, there is also a shortcoming concerning cross-cutting skills in this area, given that sustainability is very specific (specialised programmes), and much more marginal in university undergraduate degrees and training courses (vocational training). In the case of higher vocational training courses, there are different training programmes. However, none include sustainability as a cross-cutting subject in the curriculum.

To transform the sector, sustainability needs to be included at all levels and for each and every stakeholder in the value chain. The addition of sustainability training for all stakeholders in the value chain is driven by an increasingly growing demand for these kinds of profiles on the market. A disconnection between the training system and market needs is noticeable. For example, the demand for vocational training graduates is now higher than holders of university degrees, even surpassing the supply.

In addition, there is another reason why bottom-up training is required: if sustainability strategies in construction processes are only worked on at the highest level of design and planning, without any link to the work on site or with the stakeholders involved, it will be useless. The sustainability-building relationship must be understood by all, so that site workers, architects and civil engineers all have the skills, to a greater or larger extent, in areas such as waste management, rational use of water and energy and environmental protection on which construction is based, as the role of each of professional is fundamental to the overall result. Therefore, training in sustainability should be for all profiles of the value chain, with an emphasis on the trades that are usually less aware of its relevance.

Communication

To achieve cultural and behavioural change throughout society, communication is emerging as the primary tool, the impact of which can be even greater at a time when all citizens are more aware than ever of the environment in which they live. The Covid-19 pandemic has drawn everyone's attention to the areas of health and indoor air quality in buildings. Quarantines led to the large part of the population being confined, which means we learnt more about —and in some cases suffered— the features and services of our homes. This greater awareness of buildings has made it easier to spread the message about sustainability and decarbonisation to a more receptive public.

Despite this, building sector professionals are still coming across stumbling blocks that get in the way of connecting with citizens who do not understand highly technical messages and for whom the benefits of decarbonisation are not always evident. The main barrier in this sense is the lack of communication skills in the sector, because of how technicians are trained and the incorporation of new professional profiles, such as the retrofitting agent, who acts as a go-between for the technical and social areas. Projects such as Opengela stand out for their management model development. Based on neighbourhood renovation offices, they have brought about excellent communication and coordination with the residents in the different areas to be renovated, making them feel like participants in the renovation process of their own homes.

In addition, tools such as the Energy Performance Certificate (EPC), and in particular its energy labelling scheme, are proving key in helping citizens to understand the performance of their buildings in a simple way. However, EPCs have proven to be insufficient in

catalysing the renovation process, which is why other tools are emerging that aim to complement these certificates and facilitate citizens' decision making and their coordination with technicians, such as the Digital Building Logbook (a repository containing all the building-related information) and the Building Renovation Passport (long-term planning for comprehensive renovation).

The media plays a fundamental role in this cultural change, as it is the curator of social opinion. The popular press in particular, whose audience is the whole society, must make an effort to echo the messages about renovation and decarbonisation. The intention is to feed a virtuous circle in order to mobilise a society that is demanding more and more knowledge and training on these issues and that decarbonisation becomes a social debate in which everyone is involved. The timing is crucial as initiatives such as the European Green Deal, the Recovery, Transformation and Resilience Funding and the proposed Spanish Housing Act are bursting into the social debate and the media.

We need to integrate the "person-centric" principle, promote new perspectives, values and social dynamics that reassess the role of the built environment and the environment in our quality of life, placing special attention on:

- Recognising the social value of buildings
- Empowering people and communities as agents of transformation towards decarbonisation.
- Building an environment that supports a low-carbon society in the media and professional world.

Challenges in transforming the social framework

Challenge 10: Recognising the social value of buildings and their life cycle

Buildings have an intrinsic social function. If they are built in a sustainable way, added social value is generated. This translates into the creation of high quality employment, equal distribution of resources, improved citizen wellbeing and health, increased resilience and stability of local communities, as well as environmental benefits that can be seen locally, but they have a global knock-on effect too.

Quantifying and incorporating this generated value, sometimes intangible but sometimes directly and positively impacting public and private areas, is key to the implementation of a sustainable and decarbonised building model throughout its life cycle.

Challenge 11: Empowering people and communities as agents of transformation towards decarbonisation.

The European Commission has placed people at the centre of the energy transition. They are the citizens who can use information, awareness and commitment to change lifestyles, to make them compatible with human wellbeing and that of future generations.

In the transformation of our built environment, citizens are the triggers for the renovation interventions, in addition to contributing from the demand side to generating a renovated sustainable building market. To do so, they must have the tools necessary to organise and take action, as well as the support of public administration bodies and professionals in the sector, to ensure that no one is left behind in this transition of our built environment.

Challenge 12: Building an environment that supports a low-carbon society in the media and professional world.

The media is responsible for informing society and using its activity to generate a setting favouring the adoption of measures that move us toward a low carbon society.

Last but not least, it is essential that we educate society for the transition, particularly equipping the sector for sustainable renovation and construction. The construction sector faces, furthermore, the added challenge of attracting new generations of workers, demonstrating that decarbonisation of our built environment can generate high quality employment over the coming decades.

Courses of action in the social framework

S1. Ensuring a just transition acknowledging the social dimension of the building sector

To incorporate a fair, just, inclusive, healthy and life-enhancing framework of reference in building decarbonisation, we must:

1. Adopt the social life cycle assessment (S-LCA) support tool for building and town planning projects.
2. Redefine the concept of habitability within the limits of the planet and develop criteria to ensure habitability and human health in the building sector.

S2. Raising awareness and social activation around the decarbonisation and sustainable development of our society

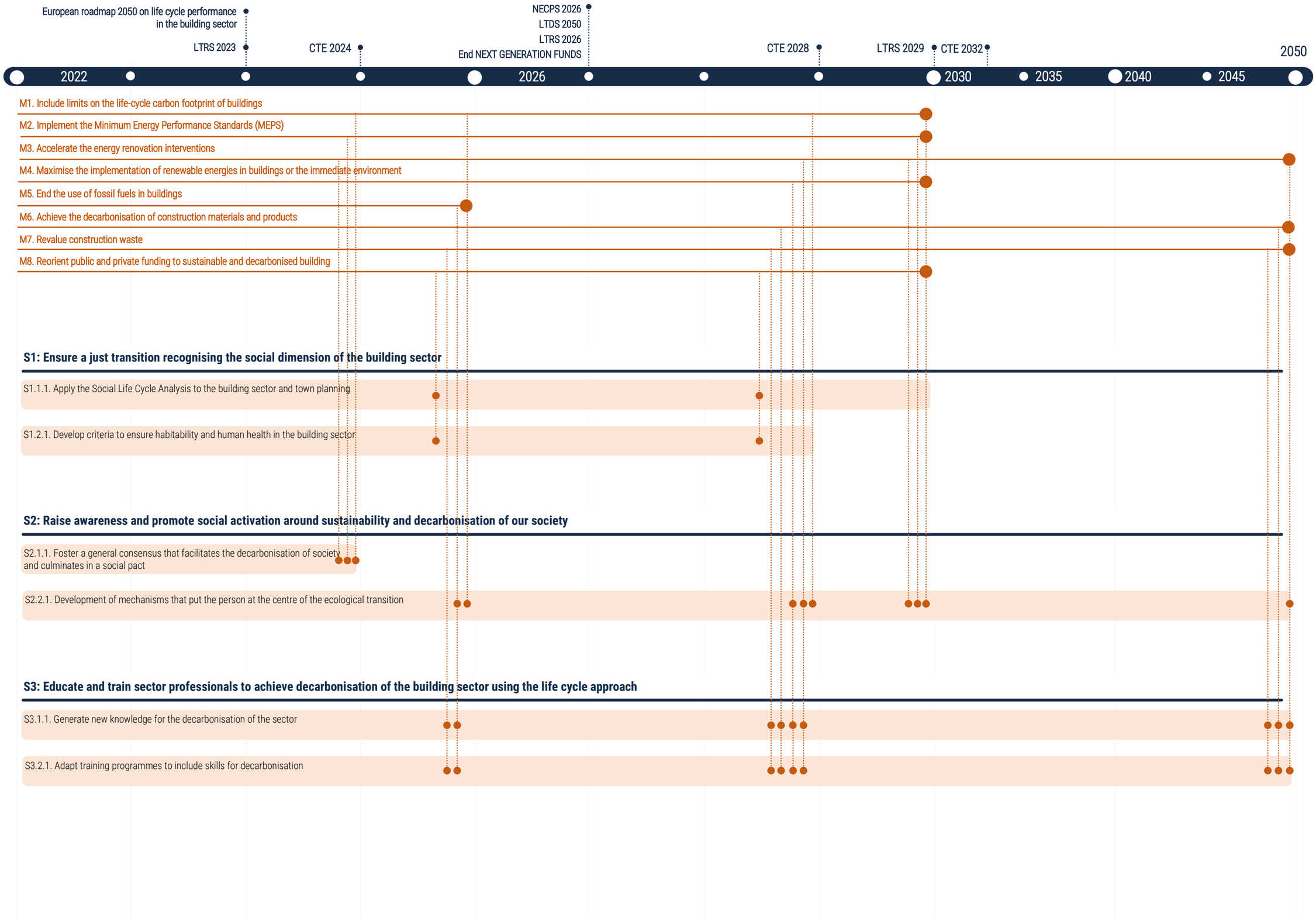
To raise awareness and social activation around the decarbonisation and sustainability of our society, it is necessary to:

1. Foster a social consensus around the need for decarbonisation and its importance.
2. Commit to models that place citizens at the heart of decarbonisation processes.
3. Promote dissemination and communication about the importance of sustainability among citizens.

S3. Training and equipping sector professionals to decarbonise the building sector using a life cycle approach

To train and equip sector professionals to decarbonise the building sector using a life cycle approach, we need to:

1. Generate new knowledge about materials, techniques and processes.
2. Promote professional training and education on the new tools necessary to tackle decarbonisation of the building sector.


European roadmap 2050 on life cycle performance in the building sector
LTRS 2023
CTE 2024
NECPS 2026
LTDS 2050
LTRS 2026
End NEXT GENERATION FUNDS
CTE 2028
LTRS 2029
CTE 2032
2050
2022
2026
2030
2035
2040
2045
M1. Include limits on the life-cycle carbon footprint of buildings
M2. Implement the Minimum Energy Performance Standards (MEPS)
M3. Accelerate the energy renovation interventions
M4. Maximise the implementation of renewable energies in buildings or the immediate environment
M5. End the use of fossil fuels in buildings
M6. Achieve the decarbonisation of construction materials and products
M7. Revalue construction waste
M8. Reorient public and private funding to sustainable and decarbonised building
S1: Ensure a just transition recognising the social dimension of the building sector
S1.1.1. Apply the Social Life Cycle Analysis to the building sector and town planning
S1.2.1. Develop criteria to ensure habitability and human health in the building sector
S2: Raise awareness and promote social activation around sustainability and decarbonisation of our society
S2.1.1. Foster a general consensus that facilitates the decarbonisation of society and culminates in a social pact
S2.2.1. Development of mechanisms that put the person at the centre of the ecological transition
S3: Educate and train sector professionals to achieve decarbonisation of the building sector using the life cycle approach
S3.1.1. Generate new knowledge for the decarbonisation of the sector
S3.2.1. Adapt training programmes to include skills for decarbonisation

STAKEHOLDERS INVOLVED

#BUILDINGLIFE NATIONAL FORUM

All of the abovementioned points in the roadmap, will only be possible with the commitment of the different stakeholders involved. From their position in the sector and society, each stakeholder must become aware of their enormous ability to act, the responsibilities they must take on and their own interests. And this last point is probably the most critical in ensuring the implementation of this roadmap. In order to gather together all the opinions and align the interests of each stakeholder in the common objective of decarbonising the sector, the #BUILDINGLIFE project has launched an intense participatory process.

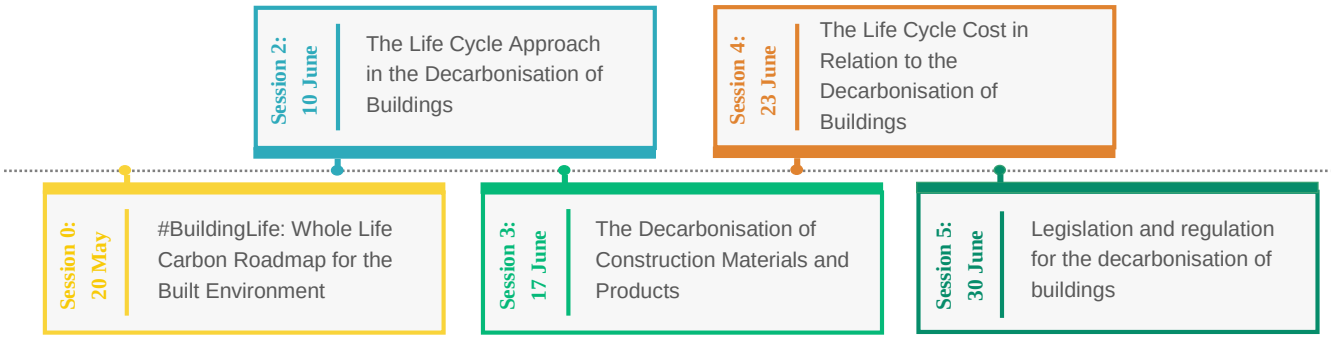


Figure 33. #BUILDINGLIE National Forum participatory sessions

Throughout the five participatory sessions, the specific meetings with key stakeholders and the open review processes, the opinions of 239 organisations and the voices of 471 people who form the #BUILDINGLIFE National Forum were compiled at the time of the publication of this document. Its aim is to reach the greatest consensus possible concerning the objectives and visions for decarbonising the sector: a target that arises from the very stakeholders involved.

THE ROLE OF EACH STAKEHOLDER

In order to make it easier to identify which tasks are to be taken on, the stakeholders have been categorised into 10 groups that are key for decarbonising the building sector. This categorisation has, on one hand, made it possible to assign each stakeholder with the tasks to which they can contribute most and, on the other hand, to better structure the necessary governance for the implementation of this roadmap. And the actions compiled in this roadmap can only be tackled if all the stakeholders work together.

This roadmap's stakeholder-by-stakeholder perspective will be an ongoing piece of work, which over the next few months will be summed up in specific documents. A series of publications focusing on recognising the ability and responsibility of each of us and encouraging each stakeholder to take action from now on.

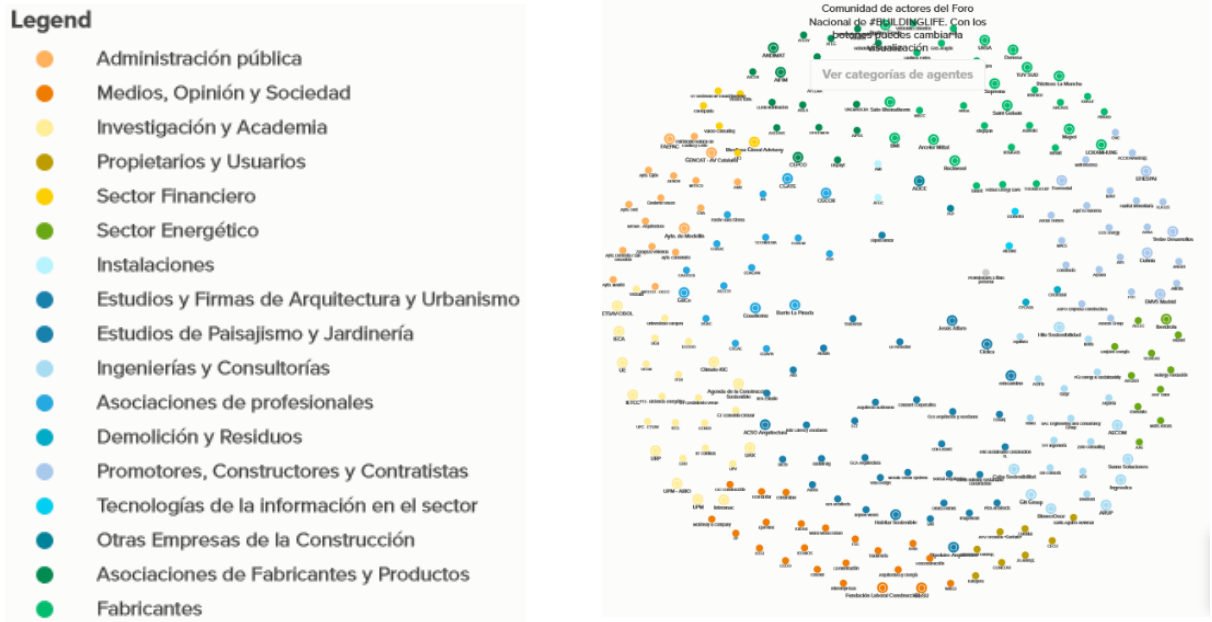


Figure 34. Organisations participating in the #BUILDINGLIFE National Forum

PUBLIC ADMINISTRATION BODIES, THE FRONT LINE OF THE TRANSITION

National, autonomous community and local public administration bodies have enormous power to steer the private sector and society. Therefore, they have the leadership capacity that will help them to accelerate changes in habits and the necessary processes launched by the sector and citizens to achieve climate neutral buildings by 2050.

The first area for action available to them is regulatory. The national and territorial scenarios and objectives are a key element for governance and they direct the political, social and corporate conversation towards sustainability. This work began with the publication of diverse strategies although a **robust, realistic and binding strategic framework needs to be established** to decarbonise the sector and provide the direction for the next 30 years. To do so, revisions of the national strategies including the LTDS, the NECP, the LTRS and the Self-Consumption Roadmap will be crucial moments, which should underpin the **national renovation requirements** (1.8 million houses in 2030 and 9 million in 2050 (milestone 3)) and the **phasing out of fossil fuels and self-consumption** (milestones 4 and 5). To adapt to the existing regulatory framework, it is necessary to comply with these strategic scenarios. This means that throughout this decade **the definition of the net zero whole life carbon building and its regulatory limits (core milestone) should be incorporated into the Spanish Technical Building Code and other regulatory documents.**

On the other hand, public initiative is key to fostering, and even imposing, tools that promote decarbonisation of the building sector, including the life cycle analysis (LCA) methodology, the Level(s) sustainability assessment framework, the Digital Building Logbook and Renovation Passport and the public environmental database. Their implementation will support the private sector and citizens as they adapt to the new requirements, although it is in the institutions themselves that these tools can be applied along with other tools specific to the public sector. The specific administration tools include the European Taxonomy and its application to Green Public Procurement (GPE). Both tools allow public finance to be **redirected towards sustainable activities** (milestone 8), which from 2025 must comply with European Taxonomy.

It is undoubtedly the policies developed over the coming years that will have a major impact both on the building sector and the citizens. And buildings are a key factor in our quality of life as it is the place where we spend more time, which is why we need our

own citizens to form part of this transition. All our citizens. This means that the "person-centric" principle and the "just transition" must be at the heart of the decarbonisation policies developed. One of the policies that will be crucial over coming years and has huge transformative potential is the **implementation of Minimum Energy Performance Standards or MEPS** (milestone 2), listed in the proposed review of the Energy Performance of Buildings Directive (EPBD)[48].

THE BUILDING SECTOR, PROMOTING CHANGE

A huge challenge in adapting and changing its way of working and producing lies in front of the building sector. The models that have been in place for years are not good enough to face up to the challenge of decarbonisation and sustainability in general. However, this transition provides a window of opportunity to generate new business models, jobs and ways of working that are more beneficial for the environment, people and the economic system itself. A large part of the sector is aware of this change in paradigm and it is already defining a new strategic framework using sectoral and corporate roadmaps that would lead us to becoming climate neutral by 2050.

Furthermore, all those involved are responsible for leading the discussion so that other companies in the sector incorporate sustainability as a fundamental point in its activity. Generating new knowledge, communicating it and convincing other stakeholders will not just help to make progress with decarbonisation but the companies that invest in it will be at the forefront and become a benchmark for the whole sector.

Construction companies and contractors

Construction companies and contractors play a major role in the building renovation or construction phase, a phase in which many processes present huge potential for innovation which is not always fully exploited. In this sense, digitalisation provides multiple solutions for improving construction control, communication between the trades involved and the management of the information that is generated. These measures result in more efficient processes leading to less waste and, ultimately, fewer emissions.

However, the impacts generated in this phase are much broader than the very emissions or the waste. The social impacts are not insignificant. Firstly, we must continue to insist on upgrades to the health and safety of sector workers, and, secondly, to implement measures to reduce noise emissions and pollutants that affect their immediate surroundings and their neighbours. Both areas can be tackled through industrialisation, workshop work and the use of state-of-the-art machinery, which, will also make the trades more attractive for future generations.

Lastly, the area where construction companies and contractors can assume a stronger role in decarbonisation is the circular economy. The efficient use of materials on construction and demolition sites, clearly defining the responsibilities for their management, will allow waste to be reduced and reincorporated into material cycles through recovery and recycling. **Reusing or recycling 70% of demolition and construction waste by 2025**, excluding landfill, is milestone 7 of this roadmap, rising to 90% and 100% by 2030 and 2050, respectively.

In short, construction companies and contractors must be ambitious and set their own targets for becoming increasingly efficient and innovative, targets that should be reflected in transparent data that allows other stakeholders to integrate their processes in life cycle assessments.

[48]European Commission, 2021. Communication from the European Commission to the European Parliament and the European Council (COM (2021) 802 final) for the consolidated text of the Energy Performance of Buildings Directive

Designers: architecture professionals, technical architects, engineers and other disciplines

Design and prescriptions are placed in the hands of designers. Two of the skills with the most impact towards achieving real decarbonisation. On one hand, the design of a decarbonised building must meet the needs required of them by generating the minimum impact possible: modular and industrialised solutions, optimised structures with the minimum material possible, bioclimatic buildings that use little energy, items recovered from deconstruction. On the other hand, as prescribers they must be aware of the characteristics of the products they select and choose the right solutions with low impact, with the aim of achieving Zero Carbon Buildings (milestone 1).

This new context requires new knowledge and concepts that will have to be integrated individually by designers and by professional associations: the life cycle approach and the LCA, materials circularity, digitalisation, integration of renewable energies, the emergence of new tools such as the Digital Logbook or the Building Renovation Passport, new standards of health and habitability. These areas will define a new way to design buildings and to work.

On the other hand, designers are increasingly working collaboratively, integrating the interests of the different stakeholders in the design process. In this sense, they are in a privileged position to inform society of the importance of sustainability and decarbonisation and to integrate the new needs of society (new ways of living like co-living and co-working) into buildings and, in short, to create a new architectural and building language and culture.

Management and maintenance

In addition to the users themselves, different stakeholders are involved in the building's use phase: estate managers, maintenance companies, energy service companies, handymen, etc. Their job is to ensure that the building and its technical systems run smoothly.

With respect to the facilities—one of the key elements for tackling decarbonisation—, there are stakeholders with diverse business models. On one hand, facility managers already play an essential role in buildings of a certain size, especially tertiary buildings. In addition to ensuring that the facilities run smoothly, facility managers understand how these buildings work overall and, therefore, they have a great ability to influence the habits of users: better regulated temperatures, better air circulation, campaigns to raise awareness among users, etc. On the other hand, Energy Service Companies (ESCOs) are basing their business model on the assessment of energy efficiency, so they are key to promoting renovation (milestone 3) and substituting combustion units with decarbonised and renewable ones (milestone 4 and 5) as well as their management.

Furthermore, small repairs and continuous maintenance is required in the lifespan of the building: builders, plumbers, electricians and joiners, etc. Although small jobs do not have a large impact on decarbonisation, they do improve the building's comfort and services —even energy services—. Integrating the building life cycle perspective could also incorporate more sustainable and decarbonised materials.

Lastly, estate managers are an essential stakeholder in the promotion of housing renovation, one of the main courses of action to decarbonise the building sector. Its position gives it the ability to influence citizens and homeowners' associations. They are, above all, process and decision-making facilitators. In many cases they are responsible for maintaining the properties, which is why it is important that they know all about the building's technical aspects in order to encourage fossil fuels to be phased out (milestone 5), the installation of renewables (milestone 4), and particularly, phased or full renovation of buildings (milestone 3). To this end, new tools are emerging that will help property management, such as the Digital Building Logbook, the Building Renovation Passport and Digital Twins.

As catalysts, they have the ability to help with the search for public aid and private funding to launch building renovation (milestone 8) and will have a relevant role in the implementation of Minimum Energy Performance Standards or MEPS (milestone 2).

Product and material manufacturers

Manufacturers play a fundamental role in decarbonisation, both in reducing the use of energy in the use phase (providing renovation-specific solutions) and in offering decarbonised products that, alongside an optimised design, will help to achieve a zero carbon building.

Although each family of materials has different benefits which make them optimum for certain functions in the building, they all have a role to play in gradually reducing their emissions to become climate neutral by 2050. Generally speaking, this roadmap recognises the need for every family of products to have its own carbon roadmap before 2025 and ensure its targets are met (milestone 6). Below are a number of strategies that help reach this milestone.

The participation of these companies in a strategic framework shared by the whole sector that is based on the conviction that limiting the life cycle carbon of buildings (milestone 1) is fundamental. The definition of a net zero whole life carbon building, the establishment of embodied carbon and the implementation of a specific carbon emission trading market for the building sector are open debates that require the view of manufacturers for the fair and effective implementation of these policies.

Companies themselves have to make major efforts to decarbonise their production, which entails planning their long-term investments from now on and enhancing their R&D. Innovation will be key for controlling the chemical processes that occur in the transformation of some materials. The carbon cycle of each material is different. Some are able to capture large amounts of carbon while others emit more carbon than they are capable of absorbing. The challenge here is to maximise carbon absorption and reduce chemical emissions, which will require sustainable investments from now on (milestone 8).

One of the other main strategies for reducing embodied carbon in products is to reduce their dependence on fossil fuels. Electrification, the impact of which on the national energy system is a matter to bear in mind, and, in the very long term, green hydrogen, will be the main sources of energy for transport and the production of materials, which, along with less energy-intensive processes like recycling, will help to drastically reduce embodied carbon.

On the other hand, the circular economy is a paradigm that will enable companies to become more efficient by recovering all their manufacturing by-products and even take charge of the leftovers and waste generated on site which can be reincorporated into production. Tools such as the materials passport will be vital to this. In general, waste recovery must quickly reach 70% (2025), increasing to 90% and then 100% in 2030 and 2050 respectively (milestone 7).

Generally speaking, all these strategies must enable manufacturers to bring to the market products with as little embodied carbon as possible, for which quantification of their impacts is necessary so that prescribers have true information they can use to design buildings and carry out the LCA. Besides other types of eco-certificates, Environmental Product Declarations (EPDs) are the only ones that quantify the main environmental impacts and are verified by third parties. It is time to make a strong commitment to the development of EPDs. A compilation of them in a unique environmental reference database should cover all the families of products on the market. This objective will not always be easily reached as drawing up EPDs can be costly, especially for small- and medium-sized companies. Sector-based EPDs by family of material and public support will be fundamental.

Many companies have already started to make these changes and we can currently find products with a very low environmental footprint on the market: recycled steel, low-carbon concrete, compressed earth blocks, natural fibres, mineral insulation, etc. These products are faced with the challenge of increasing their production and demand in order to take the larger share of the market. These companies must make a firm commitment to such products, organise themselves into sectors, industrialise and scale up the materials that have until now been almost handcrafted and have major virtues for the ecological transition, as they can end up generating positive and regenerative impacts.

INVESTMENT AND FINANCE, ACKNOWLEDGING THE VALUE OF DECARBONISATION

Beyond the building's materiality, the investment decisions of economic stakeholders in the building sector value chain wield huge influence over processes. Until relatively recently, these decisions were mainly based on monetary analyses that left out the other impacts they generated. Under the paradigm of sustainability, these externalities are being incorporated into analyses and economic systems, which, moreover, sheds light on the building sector's intrinsic values and the decarbonisation process which can be economically monetised.

One of the tools with the most potential to unveil these values is the life cycle assessment (LCA) (its environmental, social (S-LCA) and economic (life cycle cost) aspects), which includes the analysis of all the building-associated processes and all the stakeholders in the value chain under a single methodology. An analysis of the impacts is major if we want to justify and secure private investments in sustainable buildings. The Level(s) Framework provides methodologies and indicators of reference and the European Taxonomy —the financial instrument with the greatest potential for change— lays down the indicators and limits that make an economic activity sustainable, which impacts the health of the investment portfolio and its recognition.

Generally speaking, the involvement of these stakeholders in decarbonisation and the strategic framework is fundamental in making this transition economically viable. Above all, because new investment opportunities, new types of properties, new financial products for renovation and new types of company are emerging. Collaboration between the other stakeholders will be necessary if we want to establish an intersectoral dialogue that enables us to make the most of this window of opportunity to generate an economic flow around sustainability.

Financial services

Decarbonisation requires new funding models that allow for large investments with a long payback period yet with low risk. This is the case of renovation, as it has the added difficulty that property, particularly the residential housing stock, is highly dispersed in Spain. Given that renovation largely depends on the economy of each home, making citizen-focussed, innovative financial products available is key. And even more so when coercive measures such as the building-specific carbon emissions market or the Minimum Energy Performance Standards or MEPS (milestone 2) emerge.

Thus, it is increasingly common for financial companies to form alliances with companies directly involved in the works process, generating comprehensive (or turnkey) models that make the process easier for the proprietor. On the other hand, there are increasingly more products that monetise the value of decarbonisation in different ways: energy savings, white certificates or sustainable investment according to the European Taxonomy, etc.

Developers

Developers are undoubtedly the financial stakeholders with the greatest specialisation in the building sector. Until now they have been the main driving forces behind the construction of new buildings, providing the homes and buildings that Spanish society has needed in its urbanisation process. However, forecasts for the construction sector foresee an exponential growth in building renovation compared to the construction of new builds (milestone 3). Moreover, the future of the policies would prefer the former over the latter, with carbon limits in the life cycle of the buildings and, most notably, with Minimum Energy Performance Standards or MEPS (milestone 2), which will kick-start demand for renovation.

Many developers are already shifting their business model towards renovation, which presents huge business potential and greater environmental, social and even economic benefits. This transition calls for developers to cultivate new skills and ways of working adapted to interventions on the existing building stock. The diverse innovations that may come about in development include those that entail new forms of ownership (co-housing, co-living, co-working, etc); servitisation of parts of the building such as the façades; and the supply of comprehensive renovation products alongside other stakeholders, etc.

In any case, property developers need to be ambitious about their objectives, develop high quality and highly habitable buildings and aspire to having a minimum negative impact on climate change. To do so, the LCA and, particularly relevant to its business model, the life cycle cost analysis (LCCA), are tools that will enable us to quantify the impacts on new renovations and constructions, without overlooking the fact that the finals users of the buildings are the citizens.

A DIRECTLY INVOLVED SOCIETY

Citizens

A social consensus about the climate emergency needs to be generated. If citizens do not understand why they are required, and on occasions forced, to change their habits and way of thinking, then we run the risk of causing adverse reactions that stop us from becoming a decarbonised society. Citizens, both as individuals and as a collective, have a huge capacity for transformation, but to kick-start it, areas of action need to be identified. Although we are not always aware, our buildings and houses are the cause of many greenhouse gas emissions and, therefore, doing work to them is one of the best actions we can take against climate change. The target is 1.8 million renovated homes by 2030 and 9 million by 2050 (milestone 3).

There are already a number of initiatives that encourage citizen participation in decarbonisation, such as the Asamblea Ciudadana por el Clima (Citizen's Climate Assembly) in which 100 randomly chosen citizens can give their opinion about climate change-related matters; the fostering of Local Energy Communities, citizen clusters in the form of a cooperative or public company steering the energy empowerment of citizens; and the drive behind the new forms of ownership and inhabiting such as co-housing and co-working, etc. Citizens can go from having a passive role to becoming real agents of change.

But this transformation is not automatic or evident: the efforts of the other stakeholders involved, particularly estate managers are fundamental as they can act as a connection between the sector and small owners, who represent a large number of citizens. However, in the case of the most vulnerable homes this is just not enough. This group needs special support from the public powers to ensure a just transition and reduce energy poverty.

Academia, the media and the third sector

Finally, there is a series of necessary stakeholders that are transversal to the majority of the actions which, despite not forming part of the construction process, provide knowledge, facilitate processes and connect the sector to society in general.

Universities and training centres must upgrade their academic programmes to train professionals and technicians with the necessary skills for the ecological transition and decarbonisation of the building sector, workers who are highly sought after by the building sector, a sector that cannot manage to cover its job vacancies. However, at a technical level in particular, society and new generations do not find the job opportunities in this sector attractive. Beyond that, university research groups and innovation centres are now demonstrating enormous potential for research that will provide the sector with new solutions and essential processes for decarbonisation. Although technology has advanced in many areas, new lines of research are developing that will provide the industry and the sector with solutions for the next 30 years.

The media, both trade and popular press, must be proactive and give increasingly more space and relevance to the ecological transition and decarbonisation. And although decarbonisation is already a hot topic, generating pertinent and rigorous information is key if we want to lead the way in the social discussion and ensure that citizens are involved.

Third sector organisations such as NGOs play a regulatory, control and knowledge dissemination role. It is organisations that can facilitate the partnerships needed to accelerate the decarbonisation process and push the sector forward using its environmental, social and economic responsibility.

Our #BuildingLife Ambassadors

Our #BuildingLife Ambassadors

Draft Whole Life Carbon Roadmap for the Built Environment

Whole Life Carbon Roadmap for a decarbonised built environment in Spain

Edition: April 2022

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