Whole life carbon models for the EU27 to bring down embodied carbon emissions from new buildings

Review of existing national legislative measures

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Date	October 2022
Authors	Jacob Steinmann, Martin Röck, Thomas Lützkendorf, Karen Allacker, Xavier Le Den
Description	This report compares existing and proposed national policy models for reducing whole life carbon (WLC). The approaches chosen in Denmark, Finland, France, the Netherlands, and Sweden are compared. This reveals key features, similarities and differences. Because of pre-existing national practices on sustainable buildings, climate impact quantification and general regulation of new constructions, all policy models differ from each other in some form.

Ramboll
35, Square de Meeûs
1000 Brussels
Belgium

T +32 02 737 96 80

https://ramboll.com

Corresponding authors

Jacob Steinmann, jbst@ramboll.com

Martin Röck, martin.roeck@kuleuven.be

Xavier Le Den, xald@ramboll.com

Karen Allacker, karen.allacker@kuleuven.be

Thomas Lützkendorf, thomas.luetzkendorf@kit.edu

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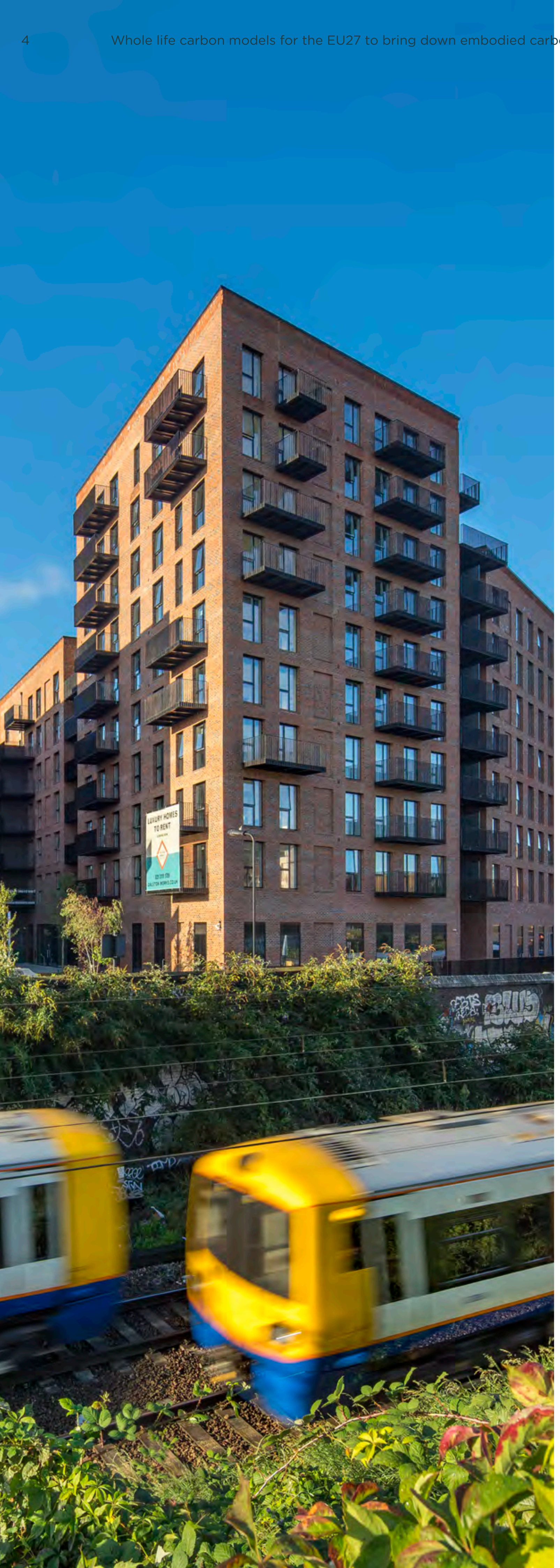
Contents

List of abbreviations

BIM	Building Information Model/Modelling
EC	Embodied Carbon
EN	European Standards
EPD	Environmental Product Declaration
GBC	Green Building Council
GFA	Gross Floor Area
GHG	Greenhouse Gas (Emissions)
LCA	Life Cycle Assessment
MFH	Multi-family house
NHA	Net Heated Area
OC	Operational Carbon
SFH	Single-family house
WLC	Whole Life Carbon



Executive summary

Background and purpose

Operational greenhouse gas (GHG) emissions (or operational carbon) of buildings are regulated at EU and national level through energy efficiency requirements. In contrast to this, legal requirements on whole life carbon (WLC), which also includes the embodied GHG emissions (or embodied carbon) from construction products, processes and end-of-life treatment, exist in only a few EU countries. However, the proposed revision of the Energy Performance of Buildings Directive (EPBD) includes a first step towards WLC legislation at EU level, for which the details are still under development and negotiation.

The most advanced countries in Europe are Denmark, Finland, France, the Netherlands and Sweden. They all have reporting requirements on embodied carbon in place or proposed for new building projects, accompanied by mandatory limit values which set maximum thresholds of GHG emissions.

These countries show that regulation of buildings climate footprint beyond operational energy/carbon is possible and that this can be implemented in the national frameworks of EU countries. All five country frameworks include methodologies to life-cycle assessments of buildings based upon the international standard EN 15978:2011 which is also the main reference standard of the European framework LEVEL(s) for calculating the global warming potential (GWP) of buildings. The standard EN 15978:2011 however allows for a large degree of flexibility in the building assessments i.e., for which emissions or stages of buildings are counted, how these emissions are weighted, and the data used in calculating buildings' GWP.

This report compares the five national policy models to reveal similarities, differences and best practices in the approach they take to LCA methodologies, reporting obligations, performance requirements, governance and development processes.

This report highlights the relevant elements and processes to develop for national WLC legislation. It hopes to inspire a broader decarbonisation of Europe's building stock beyond operational carbon and energy efficiency requirements, by showcasing examples for inspiration and knowledge exchange. It also aims at informing the policy debate about the ambition level, timeline and building blocks of a WLC component for
the upcoming revision of the EPBD.

This work is part of a study funded by the European Climate Foundation and carried out by Ramboll in collaboration with KU Leuven. Based on the insights gained in this work, a proposal to anchor WLC policies in the EU-level framework can be developed.

Findings and conclusions

The policy models in the five countries differ in some of their main features. Table 1 summarises the findings of the analysis based on the **list of features that define WLC regulation.** The detailed information is described in a country sheet for each of the five countries in the Appendix.

All five countries are regulating embodied carbon in addition to operational carbon, with the objective of reducing WLC emissions. The approaches chosen differ from each other, but show that **legislation on regulating WLC is feasible** in a diversity of contexts.

However, the comparison also shows that all **existing or proposed policy models differ in at least some of their key features.** The pre-existing national practices around sustainable buildings, climate impact quantification and the regulation of new construction greatly shape WLC legislation.

As shown in Table 1, among these different policy models are examples of best practices to inform policymakers working on the development of WLC legislation. Exchange with the authorities in charge of these policies can be a useful step towards strengthening future policy models. Still, further action is recommended on integrating carbon budget considerations, as well as increasing the transparency of WLC performance from collected LCAs.

To increase the speed of decarbonisation across all of Europe, policy instruments at EU level could be useful. Such a step could strengthen the harmonisation of approaches across different countries to ensure comparable decarbonisation efforts. However, the high context dependence of existing national approaches means that there will be **trade-offs between harmonisation and alignment with common national practices.** Possible pathways for an EU-level initiative are explored in a second report, with the aim of proposing possible approaches for the EU.

Table 1. Key features of WLC legislation and summary of their variation across national policy models.

WLC feature	Description of variation between national models	Identified best practice
Building types	Always includes new residential and office buildings, while other building types are foreseen to be integrated in the future. Different exemptions exist based on the size or legal status of the developer.	Few exemptions Example: France Note: Need to develop a method for refurbishments
Building elements	Always includes the main elements of sub- and superstructure. However, Sweden takes a much narrower selection of building elements than France, which also requires the inclusion of utility connections and decorative finishes.	Comprehensive list of building elements Example: France
Life cycle stages	Varies from only upfront embodied carbon (Sweden) to almost all LCA stages, including benefits beyond the life cycle (France). Also varies on whether operational carbon is included (Denmark) or excluded (Netherlands, France, Sweden).	Complete LCA, including end-of-life and benefits beyond life cycle to incentivise circularity Examples: Denmark, Finland, France
LCA calculation	Relies on different definitions of input parameters. The floor area definition varies but mainly uses a variation of the gross floor area. Further, the calculation approach varies between a dynamic one (France) and a static one (all other countries). These points mean that results are not directly comparable between countries.	All options have their merits, but harmonisation would be highly beneficial for comparison
Data requirements	Can be based on product-specific emission data from environmental product declarations or default values based on averages of product groups. Most countries have a national database with both specific and default values. Often, both types of data receive the same status, but France and Sweden apply conservative factors to default values to incentivise the use of product-specific data.	Incentives for using product-specific data support the selection of low-carbon materials Examples: France, Sweden
WLC metric	Can be based on product-specific emission data from environmental product declarations or default values based on averages of product groups. Most countries have a national database with both specific and default values. Often, both types of data receive the same status, but France and Sweden apply conservative factors to default values to incentivise the use of product-specific data.	Incentives for using product-specific data support the selection of low-carbon materials Examples: France, Sweden

WLC feature	Description of variation between national models	Identified best practice
WLC metric	Variation of metrics to express and regulate the WLC depending on LCA scope. While Denmark uses kgCO2eq/m2/year (to include life cycle stages on both embodied and operational carbon), France and Sweden use kgCO2eq/m2. The Netherlands, on the other hand, monetises environmental impact and defines the impact in EUR/m2/year.	All options have their merits
Performance requirement	In place, proposed, or foreseen in all five countries. In all existing cases, a limit value is set based on an empirically established baseline and reduces in steps over time. In France, the limit value is calculated for each building based on individual parameters. In the other models, a standardised limit value is in place.	Need for alignment with the carbon budget Example: N/A
Governance and implementation	Legislation is developed by national policymakers but often implemented by local authorities. Only in Sweden is a national public authority involved in the verification of the WLC calculations. A difference also exists concerning when the calculation is required, with a trade-off between accuracy and enforceability. This can be at the construction permit stage based on the conceptual design, or after completion of the project, based on more accurate information on material selection and use.	All options have their merits
Data governance	Usually no central data collection under a legal requirement. Sweden collects data centrally but without systematic public access. In France, an anonymised database was in place under the voluntary predecessor to the mandatory WLC reduction obligation.	A central and accessible database would increase transparency and steering of policy development Example: N/A
Capacity development	Accompanies the introduction of mandatory limit values in order to ensure the private sector has the skills needed to comply. Voluntary systems were in place previously in France and Denmark. Finland built capacity to a Level(s) pilot phase. Sweden requires declarations only before introducing limit values in 2027.	Enabling the build-up of capacity in the sector Examples: all
Stakeholder engagement	Largely similar across all countries. Strong engagement, through institutionalised and permanent platforms, was in place in all countries during the development process.	Strong stakeholder engagement process Examples: all

About Ramboll and KU Leuven

Ramboll is a global consultancy delivering sustainable change across 35 countries. With a civil engineering legacy, Ramboll also comprises management consulting, architecture, and environmental services to deliver a holistic take on the green transition – in the buildings sector and in similar industries.

Specifically in the building sector, Ramboll has worked to develop understanding of whole life carbon (WLC) in theory and contribute to its reduction in practice. Studies for the World Green Building Council, the Laudes Foundation, the European Commission's Directorate-General for Environment, and publications based on practical experience of working with Life Cycle assessment frameworks across Europe bring embodied and WLC to the centre of the industry-policy-research nexus. At the same time, Ramboll's experts help clients in the construction industry to understand life cycle impacts and costs and are pioneering low embodied carbon construction in building design across high-profile development projects to reduce embodied and operational carbon emissions.

KU Leuven is Europe's most innovative university. Located in Belgium, it is dedicated to education and research, and as such to service to society. KU Leuven is a founding member of the League of European Research Universities (LERU) and has a strong European and international orientation. Our scientists conduct basic and applied research in a comprehensive range of disciplines.

The Architectural Engineering research group aims for innovation in the design of buildings by approaching architecture from an engineering point of view. The emphasis is on the technical aspects of architecture – structure, materials, services and comfort requirements – are considered in a multidisciplinary setting in order to quantify, assess and improve the quality, cost and sustainability of buildings and the built environment. In order to achieve this goal, fundamental, applied and policy-oriented research is performed, and a continuous effort is made to bridge the gaps between research, education and practice. The research group offers deep expertise in life cycle environmental impact assessment and life cycle costing of the built environment. Various scale levels are focused on building materials, building elements, buildings, neighbourhoods and cities, as well as national and trans-national building stocks.

Ramboll and Martin Röck (KU Leuven) have cooperated with Aalborg University on the project "Towards embodied carbon benchmarks for buildings in Europe" funded by the Laudes Foundation. Currently, together with BPIE, Ramboll and KU Leuven are working on the ongoing study "Supporting the Development of a Roadmap for the Reduction of Whole Life Carbon of Buildings", contracted by the European Commission's DG ENV.

[1] Reports and additional information available at https://c.ramboll.com/lets-reduce-embodied-carbon and https://doi.org/10.5281/zenodo.6397514

[2] More information available at https://c.ramboll.com/whole-life-carbon-reduction

1. Introduction

With the EU's aim to decarbonise its economy and be fully climate-neutral by 2050, significant greenhouse gas (GHG) emission reductions will be required from all sectors and industries. The EU's construction and real-estate sectors are responsible for 36% of the EU's energy-related GHG emissions, of which embodied carbon – emissions from the construction phases and, most significantly, the manufacturing of the construction materials used in buildings, such as cement, steel, glass and insulation – is responsible for 10-20% of buildings' GHG footprint.

So far, political and regulatory efforts in the EU and its Member States have focused on operational energy use and GHG emissions which are caused by the day-to-day operation of a building. A key policy in this respect is the EPBD, Directive 2010/31/EU), which has been transposed and implemented in all EU countries.

In contrast to operational emissions, legislation on embodied emissions or WLC, as the sum of both emission categories, is rare. Only a few EU Member States have so far either already implemented or have plans in place for the implementation of different models to regulate buildings' life cycle-related emissions more comprehensively. Of these countries, Denmark, France, Netherlands, Finland and Sweden are the most advanced and their experiences may prove valuable.

As a result of the Renovation Wave plan of the EU Commission, the EPBD is currently under revision. The proposed version and latest discussions introduce the concept of WLC to the Directive. This has sparked a debate around the level of ambition, timeline and possible performance requirements. This report contributes to the debate by highlighting how ambitious policies could be designed.

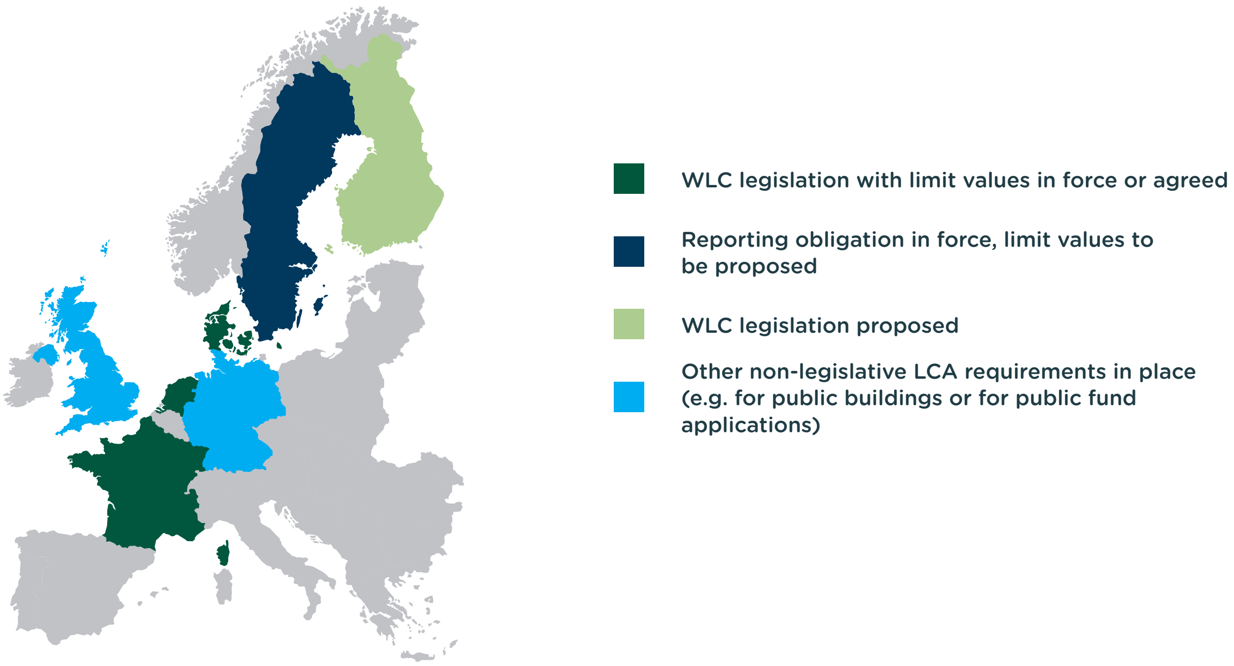
The five frontrunner countries on WLC legislation have shown that policy initiatives based on international standards are feasible. Still, all have chosen different approaches to develop, quantify, limit and enforce their national policy model. Therefore, all five approaches vary with respect to the Life Cycle Assessment (LCA) methods and scope, timeline and reduction ambition, the governance and stakeholder engagement and several other relevant parameters.

This report analyses the five national models for WLC legislation and their key features, compares what options have been selected and highlights advantages, disadvantages and best practices. The work is part of the project Whole Life Carbon Models for EU27 to Bring Down Embodied Carbon Emissions from New Buildings, funded by the European Climate Foundation (ECF). In a second step, the findings of this comparison will be used to develop and propose a model that could fit other EU Member States. The report herein is the first report in this series.

The purpose of the report herein is to summarise the insights gained on embodied carbon data from life cycle assessments (LCA). A search for such data was carried out across EU countries (and the United Kingdom) to form a basis for the baseline setting process and for drawing up a benchmarking framework.

The report presents the current situation as encountered in the EU countries and the UK, points to the key issues in LCA data and provides solutions for overcoming these challenges. The findings in the report are supplemented with country sheets for the five countries for which sufficient data was available: Belgium, Denmark, Finland, France and the Netherlands.

Figure 1: Status of LCA and WLC legislation in Europe. Source: own research and BPIE 2021.



2. Approach

The five countries for review were selected due to their progress in legislative measures to quantify the WLC emissions of new buildings through LCA and efforts to reduce these emissions through limit values. Recent publications from Ramboll and Aalborg University,[4] World Green Building Council,[5] and BPIE[6] provided high-level analysis of such legislation across Europe.

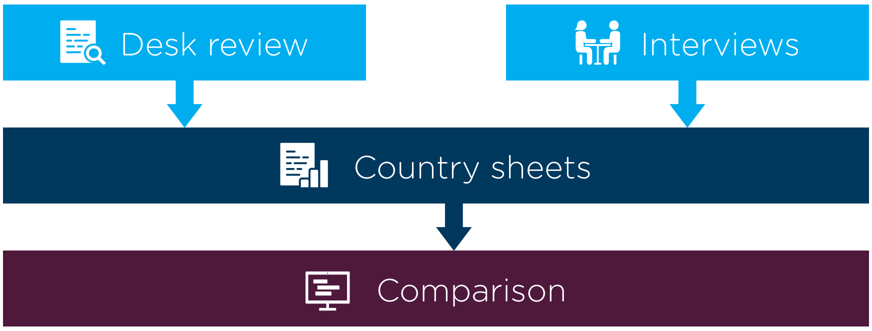
Regulatory measures at national level are not the only initiatives aiming to bring down WLC. Some European countries have developed instruments that are specific, e.g. for a local context, or focused on public buildings only (e.g. Germany, Switzerland, Norway, the United Kingdom) or only apply to building projects seeking subsidies from national funding programmes (Germany). In addition, several sustainability reporting and certification schemes exist (e.g. LEED, BREEAM, HQE) and may even have limit values for embodied or WLC (e.g. DGNB/BNB).

However, this report seeks to understand and compare explicitly legislative policy models. This is because such widely applicable and mandatory approaches developed by national governments are the result of public processes and face particular scrutiny. These specificities are important success factors for further policy action in other EU countries or at European level.

Information on the national legislative models is collected in two steps, as illustrated in Figure 2. Building on the existing sources, a desk review was carried out in each country by a native or fluent speaker, to access and process all relevant public documents. This revealed information on scope, legal instruments and formulations, LCA methods and the applicable legal limit values. In the following, interviews, gap filling and validation with experts were conducted to complement the desk review findings, in particular on the historical development, governance, and implementation details

[3] Building Performance Institute Europe. (2021). Whole-life carbon: Challenges and solutions for highly efficient and climate-neutral buildings. Available at: https://www.bpie.eu/wp-content/uploads/2021/05/BPIE_WLC_Summary-report_final.pdf

Figure 2: Research process



The collected information is summarised in a description sheet per country in Appendix 1: Country sheets and tables. These sheets contain details on the approach used in the legislative models and their context. This forms the basis for the description of key features of WLC legislation and their comparison.

3. National legislative models

The assessment of life cycle impacts from a building is standardised at international level by EN 15978. The standard aims to provide harmonised calculation rules for the environmental performance of new and existing buildings. The standard is prepared by Technical Committee CEN/TC 350, "Sustainability of construction works", and is currently under revision. It is part of a suite of European Standards, Technical Specifications and Technical reports for the assessment of the environmental performance of buildings. Together, these documents support the quantification of the contribution of buildings to sustainable construction and sustainable development. EN 15978 Sustainability of construction works — Methodology for the assessment of environmental performance of buildings, relates to the framework standards of EN15643, which also include other sustainability-related aspects such as social and economic performance of buildings. EN15978 is a widely used reference for the assessment of environmental impacts of buildings across their full life cycle — such as WLC emissions. The standard is promoted by the European Commission with references in various key policy documents.

The EU has developed the Level(s) framework with a WLC component based on EN 15978. Level(s) enables the assessment and reporting of environmental impacts of a building project through a common language. Besides quantifying and reducing WLC, five other macro objectives form part of the framework. Requirements are defined at three levels along the project completion timeline — first for the conceptual design, then for the detailed design and construction, and lastly for as-built and in-use status.

All five countries have developed their legislation for WLC calculation based on EN 15978 and therefore in general conformity with Level(s). However, the standard offers enough flexibility and countries have selected different focuses on building components, LCA scopes and emission data, which creates significant differences between their approaches. Therefore, this comparison was performed to reveal differences and similarities.

[4] Röck, Martin, Sørensen, Andreas, Steinmann, Jacob, Lynge, Kirsten, Horup, Lise Hvid, Tozan, Buket, Le Den, Xavier, & Birgisdottir, Harpa. (2022). Towards embodied carbon benchmarks for buildings in Europe - #1 Facing the data challenge. https://doi.org/10.5281/zenodo.6120522

[5] World Green Building Council. (2022). EU policy whole life carbon roadmap. Available at: https://viewer.ipaper.io/worldgbc/eu-roadmap/

[6] Building Performance Institute Europe. (2022). A life-cycle perspective on the building sector. Good practices in Europe. Available at: https://www.bpie.eu/wp-content/uploads/2022/04/BPIE-BE_Good-Practices-in-EU-final.pdf

3.1 Comparison of the national legislative approaches

The detailed review of national legislative models reveals differences and similarities between the approaches chosen. An overview of key features is provided in Table 2, which summarises most of the features of the national models.

The first main similarity is the scope of buildings to which the legislation applies. This always includes new residential and office buildings. However, in some countries, subgroups of these buildings may be exempt based on their size (Denmark, Finland), or the legal status of their developer (Sweden). Still, the norm is to apply WLC legislation to residential and office buildings. Requirements and respective methods for other building typologies are so far only foreseen to be developed and adopted in the future. Moreover, building renovations, technically named refurbishments, are not yet considered in the scope of these policy models. Refurbishments are strongly encouraged as part of the EU's strive to reduce operational carbon. While the process of re-using an existing building creates less embodied carbon than new construction, the material use and related emissions may still be substantial. However, the huge variation between refurbishment projects results in difficulties in regulating their WLC footprint in the same way new buildings are regulated. Denmark and Finland are developing approaches for this, but their entry into force is not foreseen in the near future.

Similarly, the scope of building components largely overlaps. Foundations, load-bearing structures, floors and facades are mentioned throughout as the main drivers of embodied carbon impacts. Therefore, these components are required in all countries. Technical systems can also create high embodied carbon levels and are often included as well. In general, the component scope is often determined in relation to other requirements or tools. For example, the degree of detail is often connected to that of the building permit request or realised in building information modelling (BIM).

The life cycle scope is more diverse and varies between countries. Sweden only requires upfront embodied emissions to be calculated, while France and the Netherlands cover all life cycle stages but address operational emissions in other policy instruments. In between, Denmark and Finland specify certain modules which need to be calculated and include (most likely in the case of Finland) operational emissions. Figure 3 illustrates these variations.

On a more detailed level, the input parameters of the LCA method differ substantially between each of the countries. This relates most strikingly to the definition of floor area, emissions factor data when using default values and the accounting for biogenic carbon storage in materials.

- First, the floor area used as a reference unit to calculate emissions per m2 is defined based on varying scopes. Most common is the gross floor area (GFA), while Finland and France use the net heated or liveable area, excluding walls and parts of the building kept at outdoor temperatures. However, the GFA is also not calculated in the same way across the remaining countries. Specific building parts such as basements for non-residential use or outside stairs and ramps may be excluded, included (e.g. Sweden) or discounted at different rates (Denmark). This affects the area over which WLC emissions are spread and makes a comparison highly challenging.

- Second, databases on emission factors of construction products and processes differ. These contain the impact factors for all materials, for which environmental product declarations (EPDs) are not used. Using product-specific data increases the accuracy of the calculation and also incentivises the selection of materials with (comparatively) low carbon footprints. In France and Sweden, the use of product-specific data is supported through a penalty factor on default average values. In others this is not the case. However, also the default values can differ between databases that are often based on national product averages or specific assumptions. In most countries, such a national database is used, but Denmark (using the German ÖKOBAUDAT) and Finland do not have national databases as of now.
- Third, the processing of biogenic carbon content is a topic debated by academics and practitioners. To reflect this, the calculation approach differs in the countries as well. Denmark, Finland, the Netherlands and Sweden all use a static approach where the carbon content is not reflected in any specific form. In France, however, a dynamic approach is applied. This means that the future release of the carbon content fixated in biomaterials is reflected in the calculation discounted at the time of construction, as it will only be released at the end-of-life stage. A further explanation of the two approaches is provided in Box 1. This is chosen to incentivise the use of materials with a short-term climate benefit, to achieve rapid decarbonisation. However, this choice has faced criticism from stakeholders because it does not align with current EU practices and is perceived to distort between industrial sectors in favour of bio-based materials.

Figure 3 below provides a comparative overview of the scope of LC modules in existing WLC legislation.

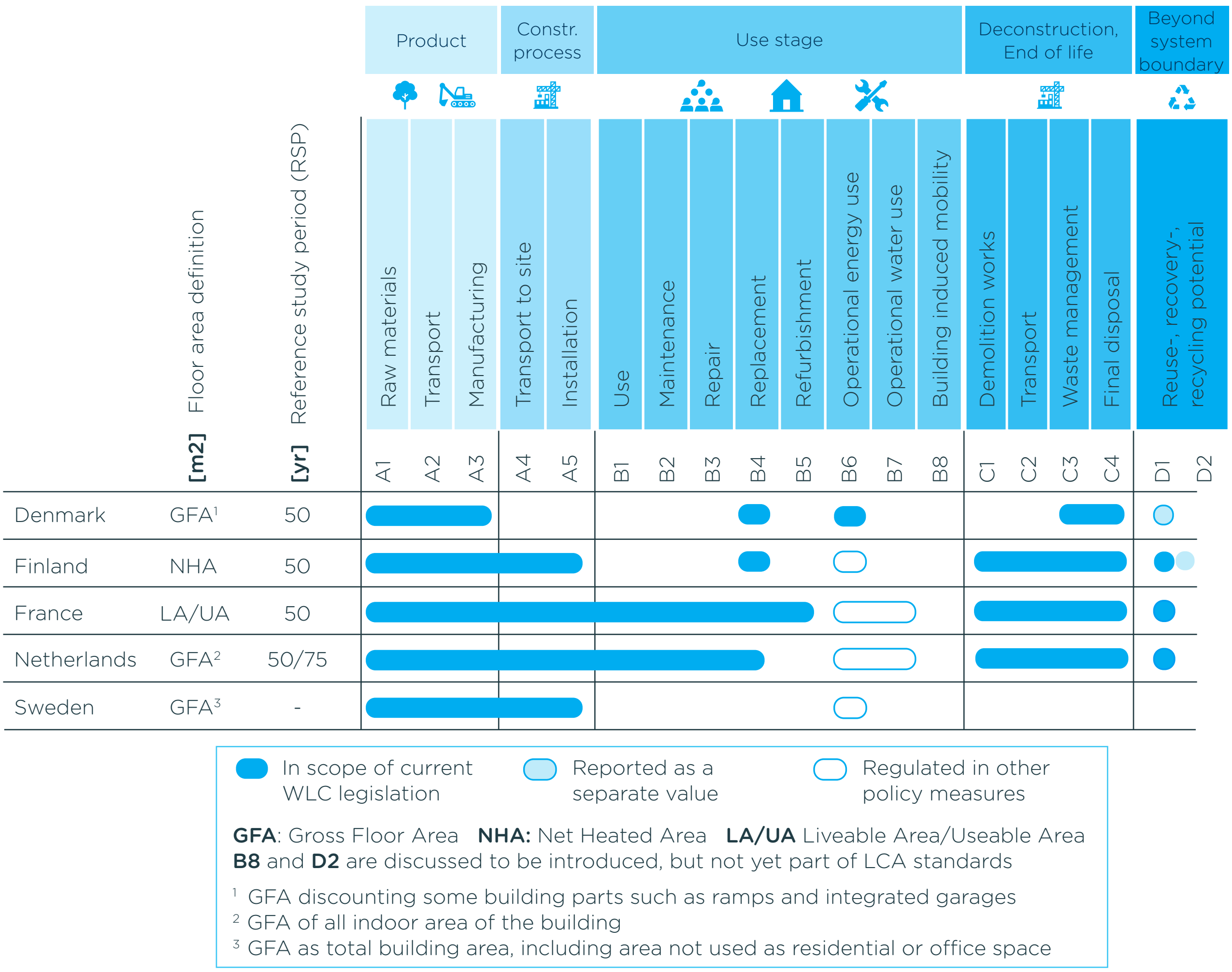
Box 1. Static vs. dynamic LCA method

Static and dynamic represent two ways of thinking about the life cycle of a building. On the one hand, in static approaches, all features are assumed to stay the same as they were during the performance of the LCA. This means that changes for end-of-life treatments, production technologies for replacement materials, or improvements in operational energy use are not considered. This represents the standard and most common LCA approach, as it relies on fewer assumptions and emphasises the environmental impact according to the current situation. Because of its fewer assumptions, simplified LCA methods based on a static approach can also be found.

On the other hand, dynamic approaches aim at reflecting the potential developments that can take place during the building's lifetime and consider differences in the accounting for emissions when they occur. One crucial difference between dynamic approaches, therefore, lies in the handling of carbon content in bio-based materials and related effects of carbon uptake and release. The benefit of dynamic approaches is potentially greater accuracy and incentives for materials that can take up carbon during (re-)growth right now, but lack of harmonisation in calculation methods and the higher calculation efforts limited the use of dynamic LCAs until recently.

[7] Biogenic carbon refers to carbon that is stored in biological materials, such as trees and other plants.

Figure 3: Scope of LCA modules in WLC legislation (Life cycle stages acc. EN 15978).



The three input parameters mentioned above determine the comprehensiveness and method details of the LCA calculations that form the basis of the WLC reduction legislation. In addition to this, the type of metric and the definition of performance requirements constitute a notable field of variation.

At the output of the LCA, the metric used to report environmental impact sees several options selected. The choice is shaped in part by the inclusion or exclusion of operational emissions. If included, a value of CO2eq per building area (m2) and time (years of the reference study period) is needed. This allows yearly operational emissions and peaks of embodied emissions to be combined. If only embodied emissions are quantified and regulated, a single CO2eq value per building area is feasible and chosen in the case of France. An advantage of the non-annualised value is that it highlights the climate impacts at the start of a building project and the urgency to reduce them. For embodied emissions, this is much more accurate, as two-thirds of these emissions occur upfront. The Netherlands has opted for a different approach and monetises the climate impact together with a series of other environmental impacts in a shadow price of the building. This results in a metric of EUR/m2/year that does not allow to express the climate impact in a single number, but instead takes a more holistic perspective on environmental performance.

Table 2. Overview of key features of the national policy models.

	Denmark	Finland	France	Netherlands	Sweden
Legal framework	Bæredygtighedsklassen[8]	Ilmastoselvitys[9]	Réglementation environnementale 2020[10]	Milieuprestatie Gebouwen[11]	Klimatdeklarationen[12]
Legislative status	Agreed to come into force in January 2023	Proposed	In force since January 2022	In force since 2018	In force (climate declaration) since 2022 Proposed (limit values)
Applicability	All new buildings Limit values only apply to new buildings over 1,000 m2	All new buildings, except single-family houses (low carbon practice already widespread)	New residential, office and educational buildings	New residential and office buildings over 100m2	All new buildings with exemptions for some public buildings and private developers
LCA modules	A1-3 B4, B6, C3-4, D (separate)	A1-3, A4-5, B4, C1-4, D	A1-3, A4-5, B1-5, B6, B7, C1-4, D	A1-3, A4-5, B1-4, C1-4, D	A1-A3, A4-A5
Building components	Substructure, superstructure, internal finishes and building services	Alignment with building information available at building permit stage in BIM models – Proxy values for technical systems	All components described in the building permit request	Substructure, superstructure, installations	Substructure and superstructure
LCA method particularities	Detailed LCA Buildings in which special functional requirements impact material use can be compensated and allowed to exceed the limit values by a calculated amount specific to the project.	Detailed LCA "Carbon handprint" also required, which quantifies climate benefits (e.g. benefits from D or carbon storage). No limit values set for handprint.	Dynamic LCA calculation accounting for biogenic carbon storage Penalising factor if using default values rather than specific EPDs	Detailed LCA Includes a list of 11 environmental impact categories	Simplified LCA with limited scope of LCA modules and building components Default values are calculated with a 25% conservativeness factor

8. https://im.dk/nyheder/nyhedsarkiv/2021/mar/ny-aftale-sikrer-baeredygtigt-byggeri
9. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161796/YM_2019_23_Method_for_the_whole_life_carbon_assessment_of_buildings.pdf?sequence=1&isAllowed=y
10. https://www.legifrance.gouv.fr/loda/id/JORFTEXT000043877196/2022-09-21/
11. https://www.rvo.nl/onderwerpen/wetten-en-regels-gebouwen/milieuprestatie-gebouwen-mpg
12. https://www.boverket.se/sv/klimatdeklaration/

	Denmark	Finland	France	Netherlands	Sweden
Performance framework and metric	Mandatory limit values for WLC in one metric	Planned mandatory limit values for WLC in one metric	Mandatory limit values as separate metrics for EC and OC (energy use) Limit value calculated for each building individually	Mandatory limit values are expressed as a monetary value (environmental shadow price of building materials)	Mandatory limit values to be developed Currently only requirement for climate declaration
Current legal limit values	From 2023 to 2025: 12 kgCO2/m2/year (Revision by 2025)	Under development	Current limit values for embodied impacts: 640 kgCO2/m2 (SFH) 740 kgCO2/m2 (MFH)	Residential: 0.8 EUR/m2/year Offices: 1 EUR/m2/year	To be developed before 2027
Implementation	Details not yet decided Calculated and reported after building completion	Submitted to local authority Reporting required for building construction permit	Submitted to local authority Calculation capacity described in permit request; confirmation of compliance required after completion	Submitted to local authority Reporting required for request of environmental permit	Submitted to central authority Reporting required for use permit at building completion
LCA data governance	Under development	Under development, alignment sought with digitalisation initiatives for BIM-based reporting	No further access to mandatory LCA data The centralised database for WLC/LCA reporting of E+C- programme remains publicly available in anonymised form	No central collection or public database of LCA results	Centralised collection of data for analysis by national agency Data not systematically available, only on specific request

The performance requirement in the form of legal limit values is the key element to reducing WLC. Their implementation reflects the choices made in the points discussed above. While Denmark and the Netherlands have a fixed legal limit value that represents the maximum emissions allowed, France has taken a different approach. In the French model, the limit values vary depending on the properties of the building project. The local climate, planned underground parking spaces, works to connect the building with the local networks, and the use of default values instead of product-specific values all shape the maximum allowed emissions. This leads to varying thresholds that reflect many specificities of a building but reduce the ability to compare the legal limit between buildings. Sweden and Finland have not yet defined limit values.

The system for collection of LCAs offers variations concerning timing, responsibility and checks. One option is to require a submission based on the building design in the building permit process. This approach is foreseen in Finland and offers a means to correct exceedances of the legal limit value before a permit is granted and a building is completed. As a trade-off, some building elements like installations and interior materials are usually not defined in detail at this point. Denmark and France will require the full LCA calculation only after completion of the building. This creates better information on materials used but needs a system to penalise or correct limit value exceedances. This detail has not yet been determined. In all countries except Sweden, the LCA calculations need to be submitted to the local authority (typically a municipality) that processes the building permit request. In Sweden, a national authority checks the submissions, a step that only needs to be proven to the municipality before receiving the final use permit. Generally, spot checks of the correctness and completeness of the detailed calculations are the only feasible option to ensure compliance. This type of process is mentioned in all countries for which information could be collected.

None of the countries collects building LCA data in a publicly accessible database. This was the case in France under the E+C- pilot programme, which resulted in a dataset of more than 1,000 anonymised buildings, which can be accessed online. However, this has not been retained as part of the legal obligation under RE2020. As mentioned, Sweden currently collects climate declarations at national level, but only shares individual LCAs based on a request to the authority. Therefore, a transparent assessment of countries' or the EU's status on reducing WLC emissions remains impossible and an opportunity to expand the evidence base is lost.

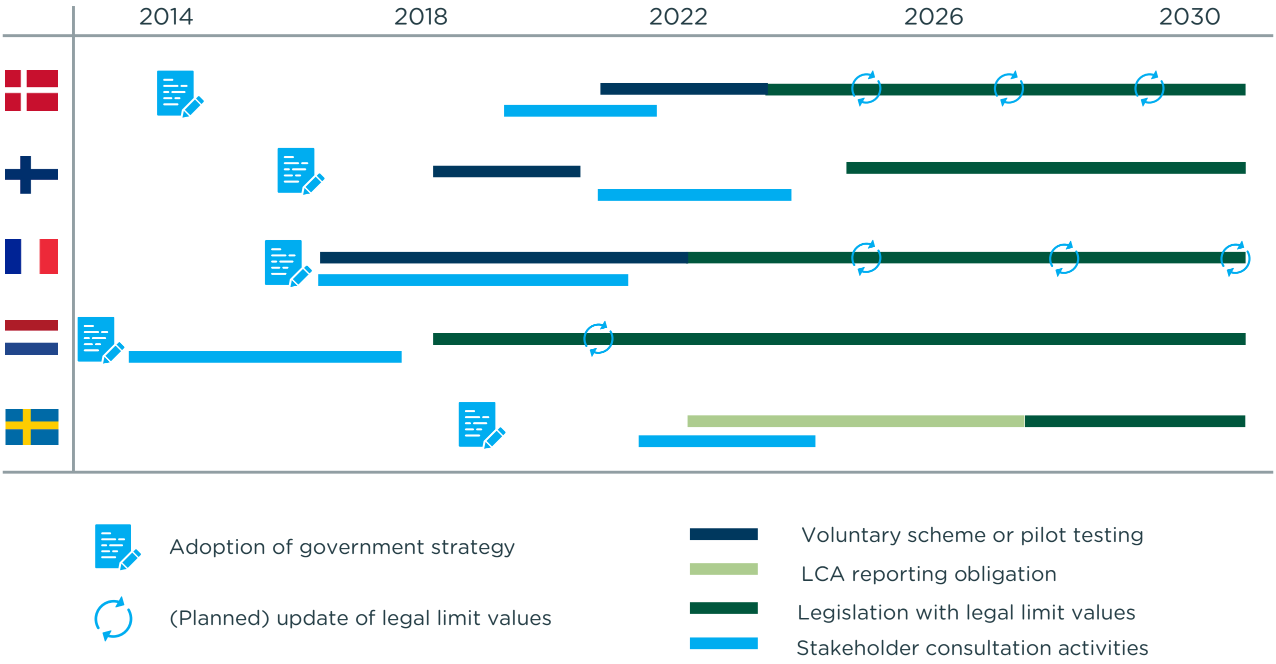
3.2 Comparison of the development processes leading to legislation

Aside from the specifics of how legislation is set up and how data is calculated, the comparison of development processes leads to some highly relevant insights as well.

While the initiative and development of the first steps were taken by policymakers, the private sector has also developed into a key driver. In the five countries, but also across Europe and internationally, the construction and real-estate sector – from investors to materials producers – has developed decarbonisation roadmaps and frameworks to reduce WLC. A robust and long-term decarbonisation policy framework plays an important role in the investment decisions of developers. WLC legislation that builds on the support from the industry therefore minimises the risk of stranded assets caused by non-compliant climate performance, in addition to advancing the urgently needed decarbonisation of the built environment.

Each of the countries in this comparison has taken a distinct but comparable path towards the creation of current legislation and the upcoming or completed introduction of legal limit values. Figure 4 illustrates the process and timelines.

Figure 3: Status of LCA and WLC legislation in Europe. Source: own research and BPIE 2021.



The most important aspect that emerges from the analysis is the need for a**wareness of the need to reduce WLC,** as well as **capacities and skills to perform LCAs and design low-carbon buildings.** The introduction of comprehensive and complex calculation requirements and legal limit values creates challenges for the industry if it is not prepared. Therefore, it is common in all countries to roll out the legislation in a gradual manner. This can take different forms:

- A **voluntary scheme** of LCA calculations to obtain sustainability certification, as was found with the E+C- programme in France and the voluntary sustainability class in Denmark.
- A **later starting date** for mandatory limit values, following the introduction of a reporting obligation, as is currently the process in Sweden.
- **Small subsidies** to participating companies, such as in the Level(s) pilot phase, during which the Finnish government offered financial support. This helped build the necessary capacity among industry actors to comply with WLC legislation more easily.

In all countries, an intensive process of stakeholder engagement and knowledge exchange has also driven the development. Commonly, the initiative was taken by policymakers at ministerial level. However, in the development of the methodologies, databases and performance requirements, research institutes and stakeholder platforms played an important role. Research institutes and national agencies play a key role in preparing and defining methodologies, such as the BUILD institute at Aalborg University in Denmark, the Scientific Centre for Technology and Buildings (CSTB) in France, and national agencies (mainly Boverket) in Sweden. Industry engagement has proven essential for the buy-in of the private sector. Institutionalised groups have often been used. For instance, in Denmark, France and the Netherlands, one or more permanent stakeholder platforms were established in what were called climate sector partnerships (Denmark), concerted groups (France), or policy committee (Netherlands).

Also in Sweden and Finland, industry dialogues have played an important role, albeit in a less structured way.

A third element which influences the development process and shapes the resulting policy model is coherence with other (pre-existing) national policies, tools and practices. This increases both acceptance and efficiency in the private and public sector. In France and the Netherlands, for example, the respective approaches of building-specific factors and the shadow costs of products have been used for energy efficiency in buildings before (France), or are required for other products as well (Netherlands).

In Finland, alignment with material use reporting that is currently in preparation ensures minimising calculation burdens for companies and allows efficient plausibility checks by the authorities. Also, the practice of using BIM or sustainability certification such as DGNB/BNB, HQE or LEED are described as important considerations for the alignment of the level of required detail. These certification schemes have often shaped national practice. Therefore, a close alignment with such initiatives is important and has been undertaken in all countries where specific initiatives are widespread.

4. Conclusions

All five countries are regulating embodied carbon in addition to operational carbon with the objective of reducing WLC emissions. The approaches chosen differ from each other but show **that legislation on regulating WLC is feasible** in a diversity of contexts. As a result, an ambitious WLC component in the EPBD revision is possible and should be pursued by EU policymakers.

The comparison revealed a **list of features that need to be developed** and defined in the process. This includes the scope, LCA calculation method, definition of legal limit values, and data transparency.

The comparison also shows that all **existing or proposed policy models differ in at least some of the key features.** The pre-existing national practices around sustainable buildings, climate impact quantification and regulation of new construction greatly shape the WLC legislation.

These differences result in varying performance in relation to aspects such as comprehensiveness, specificity, circularity, and ambition.

- **An overall political strategy or decarbonisation roadmap is important** to highlight the role of WLC legislation as a contribution to climate efforts and simultaneously linking it with the broader framework of sustainable construction policies.
- **The more buildings fall within the scope of the legislation, the higher the impact on the sector.** A high number of construction projects that require a new process, means that almost all actors in the value chain need to adjust. France requires compliance with the legal limit for residential, office and educational buildings with only a few exceptions. Such comprehensiveness is not achieved so far in the other countries, which focus primarily on larger buildings.
- **Incentives for the use of specific data on the WLC impact of materials create an advantage for using low-carbon building materials rather than using standard materials** and calculating with default values for certain materials. This strongly supports the decarbonisation of the construction and real-estate sectors. Sweden and France have both introduced measures to make the use of default values less attractive, which represent best practices in this aspect.
- **Including the end-of-life stage of the building (LCA module C) as well as the benefits beyond the life cycle (module D) creates incentives for circularity** in building design and material choice. France, Finland and the Netherlands include these modules and can be used as reference points for the circularity aspect of WLC legislation.

- Given the many different calculation methods, a **comparison of the ambition of each of the approaches is difficult.** The comparison of LCAs for specific buildings across countries is even more challenging[17] . At the minimum, transparency on the data sources used and calculation method is needed through project documentation to make a comparative analysis possible.
- Furthermore, **LCA data of new buildings is not commonly registered in a central database.** This limits transparency and the possibility to steer future policy development processes based on a comprehensive evidence base. France's E+ C- database creates a good example but it would need to be reintroduced in the context of legal limit values to fully track the decarbonisation progress in the construction sector.
- A concerted effort from policymakers and various other actors of the value chain is needed. For this awareness raising and capacity building through voluntary pilot programmes can play an important role. The crucial role of triple helix cooperation between policymakers, industry and academia and non-for-profits was also highlighted in a previous report[18].
- Finally, in order to **incentivise the use of low-carbon materials not only for new construction but also for refurbishment projects,** the scope of WLC legislation across Europe should progressively widen to include building renovation projects as well. Currently, none of the countries can serve as a best practice in this respect, but updates or new legislation may address this gap. Further research should be dedicated to how best to include refurbishment in WLC legislation.

To increase the speed of decarbonisation across all of Europe, policy instruments at EU level could be useful. Such a step could strengthen the harmonisation of approaches across different countries to ensure comparable decarbonisation efforts. However, the high context dependence of existing national approaches means that there will be trade-offs between the harmonisation and aligning with common national practices. Possible pathways for an EU-level initiative are explored in the second work package of this project, with the aim of proposing possible approaches for the EU.

17. For the results of such a harmonisation exercise, see also: Röck, M., Sørensen, A., Tozan, B., Steinmann, J., Horup, L. H., Le Den, X., & Birgisdottir, H. (2022). Towards embodied carbon benchmarks for buildings in Europe - #2 Setting the baseline: A bottom-up approach. https://doi.org/10.5281/zenodo.5895051.

18. Röck M, Sørensen A, Steinmann J, Le Den X, Lynge K, Horup L H,, Tozan B, Birgisdottir H. (2022) Towards Embodied Carbon Benchmarks for Buildings in Europe – #1 Facing the data challenge. https://doi.org/10.5281/zenodo.6120522.

Appendix 1: Country sheets and tables

Denmark

Regulatory framework, governance and development

In 2021, the Danish government adopted a widely supported national strategy for sustainable construction. Central measure of this strategy will be a requirement in the building regulation to calculate buildings' climate footprints and comply with WLC limit values.

The legislation is foreseen to take the form of a government ordinance to supplement the building regulation and to enter into force in January 2023. The new Danish regulation for the mandatory calculation of the climate impact of new buildings will apply to all building types which are covered by the existing energy regulation. However, buildings above 1000 m2 must comply to limit values (see below). Buildings below 1000 m2 must still conduct the calculation but do not need to comply with the limit values.

In practice, the carbon footprint calculation will be performed alongside all project stages and finalised after completion of the building, when consolidated material quantities are available. The results will have to be submitted to the local municipality and may undergo a check on a random sample basis. Consequences for the exceedance of limit values have not been decided yet and might differ between municipalities.

The development of the mandatory legislation has been taking place since 2014 when the ambition to have sustainability classes was formulated by the national government. Previously, the Danish GBC had created a national version of DNGB certification that started the practice of LCA calculations.

The national authority in charge of buildings and construction and the BUILD institute of Aalborg University started developing the elements for a voluntary sustainability class. One component was the creation of LCAbyg, as a calculation tool, and accompanying guidance on how to conduct LCAs for buildings.

In 2019 and 2020, a sector round table for sustainability and a BUILD study on 60 LCA cases helped further shape the policy model, build awareness and acceptance, and determine a feasible level for limit values. These elements led to the formulation of the national strategy for sustainable construction and the development of the regulatory measure.

LCA calculation requirements

Life cycle scope	A1-A3, B4, B6, C3, C4, D (D is mandatory to calculate but not included in the sum that is compared to the limit values)
Building component scope	See table below
Climate impact assessment	The climate impact assessment follows EN15978 and reports results on GWP.
Reference study period	50 years

LCA calculation requirements	
Square meter definition	Gross floor area as defined in § 455 of the Danish building code including all basement area and with the following modifications: 1) All basement areas, waste rooms at ground level and security rooms are included. 2) External ramps, stairs, fire escapes and balconies are only included with 25 per cent. 3) Integrated garages for single-family houses and terraced houses and the like are only included with 50 per cent. 4) Integrated carports, outbuildings, roofs, sheds and the like are only included with 25 per cent. 5) Secondary buildings are not included.
Environmental data sources	The authorities provide a database of datasets that must be used for the calculation. The database is based on generic Ökobau data and industry EPDs representative of the Danish industry. Specific product EPDs which are not included in the database can also be used.
LCA calculation tool	There is no mandatory tool nor is there a tool provided by the authorities. As long as the calculation method follows the referred standard and guidelines, any tool can be used. The Danish "LCAbyg" tool developed by BUILD is accepted as a possible tool to use for compliance – and it will be updated with a schematic and database customized to follow the building regulation. OneClickLCA has been accepted for calculation of LCA for the DGNB-DK certification in Denmark by the DK-GBC. It is expected that this will be true for the regulations as well.
Reporting metrics	kg CO2/m2/year

Case collection, controls, and transparency	
Collection of LCAs	Under development
Compliance check	Under development
Database	Under development
Accessibility	Under development

Performance framework

The legislation formulates limit values that relate to the WLC of a building expressed in $kgCO_2/m^2/year$. Therefore, both embodied and operational carbon emissions are included in the same limit value.

There is no differentiation by building type. For building types with specific needs or other situations out of the ordinary which result in extra CO_2-emissions from materials e.g., extra foundations due to soil properties, the limit value can be exceeded by a calculated amount specific to the project using a defined calculation method.

When entering into force, the limit value will be of 12 kg $CO_2/m^2/year$. A voluntary level is set by the low emission class for which 8 kg $CO_2/m^2/year$ may be emitted. After this, the limit and low emission class are foreseen to reduce every two years until 2029:

- In 2025: 10.5 kg $CO_2/m^2/year$ limit, 7 kg $CO_2/m^2/year$ low emission class
- In 2027: 9 kg $CO_2/m^2/year$ limit, 6 kg $CO_2/m^2/year$ low emission class
- In 2029: 7.5 kg $CO_2/m^2/year$ limit, 5 kg $CO_2/m^2/year$ low emission class

These limit values have been established using bottom-up methods based on the report "KLIMAPÅVIRKNING FRA 60 BYGNINGER" (Climate impact from 60 buildings) published by BUILD. These numbers, however, may be adjusted based on the lessons and developments during the first two-year period and each subsequent step.

For each two-year period, the LCA method and underlying database remain frozen to avoid changing methodologies. At the step from one limit value to another, however, the method and data may be updated to reflect developments in standards and other external factors.

Sources:

Government documents and websites:
Press release: Ny aftale sikrer bæredygtigt byggeri
National Strategy for Sustainable Construction
Aftale om National strategi for bæredygtigt byggeri

LCA byg:
LCA byg

Interview:
Harpa Birgisdottir (BUILD Institute at Aalborg University)

Table 3. Level(s) building elements and WLC reporting requirements in Denmark, showing elements that have to be assessed explicitly (RE), via proxy values (RP), or not at all (-).

Section	Building Parts	Elements	Reporting
Shell (substructure and superstructure)	Foundation Substructure	Piles Basements Retaining walls	RE RE RE
	Load-bearing structural frame	Frame (beams, columns and slabs) Upper floors External walls Balconies	RE RE RE RE
	Non load bearing elements	Ground floor slab Internal walls, partitions and doors Stairs and ramps	RE RE RE
	Facades	External wall systems, cladding and shading devices Façade openings (including windows and external doors) External paints, coatings and renders	RE RE RE
	Roof	Structure Weatherproofing	RE RE
	Parking facilities	Above ground Underground	RE, if part of the floor area def. RE

Section	Building Parts	Elements	Reporting
Core (fittings, furnishes and services)	Fittings and furnishings	Sanitary fittings	RE/RP
		Cupboards, wardrobes and worktops	-
		Ceilings	RE
		Wall and ceiling finishes	RE
		Floor coverings and finishes	RE
	In built lighting system	Light fittings	RE/RP
		Control systems and sensors	-
	Energy system	Heating plant and distribution	RE/RP
		Cooling plant and distribution	RE/RP
		Electricity generation and distribution	RE/RP
	Ventilation system	Air handling units	RE/RP
		Ductwork and distribution	RE/RP
	Sanitary systems	Cold water distribution	RE/RP
		Hot water distribution	RE/RP
		Water treatment systems	RE/RP
		Drainage system	RE/RP
	Other systems	Lifts and escalators	RE/RP
		Firefighting installations	RE/RP
		Communication and security installations	-
		Telecoms and data installations	-
External Works	Utilities	Connections and diversions	-
		Substations and equipment	-
	Landscaping	Paving and other hard surfacing	RE
		Fencing, railings and walls	partially
		Drainage systems	RE

Finland

Regulatory framework, governance and development

Finland aims to be carbon neutral by 2035 and carbon negative by 2040. The building's climate declaration ("Ilmastoselvitys") and the low-carbon assessment method are a key part of the future regulatory control of the building's low carbon footprint. A substantial update of the Planning and Construction law is aimed to come into force in 2025, which follows the principles defined in the industry's roadmap since 2016.

The obligation for climate declarations including WLC calculations will affect all new buildings for which a building permit is needed excluding detached single-family houses, buildings with wide refurbishments to be done, or "almost zero energy buildings" (e.g. farm buildings for non-residential use). These exemptions were chosen to reduce the administrative burden from projects that are generally low-impact buildings based on timber (SFH, zero energy buildings) and desirable projects (refurbishments).

In addition, a carbon handprint quantifying climate benefits is part of the climate declaration. This includes benefits from LCA module D, surplus energy generated onsite, long-time storage of carbon, and trees planted onsite. For this, a specific methodology is still under development.

Structurally, the Ministry of Environment prepares the decree which sets a framework for climate assessment. The climate declaration is tied to building permission, which is controlled by each county's building permission authority. A valid climate declaration would be needed for the building permit. However, likely only spot checks will be possible to assess the accuracy. A foreseen legislation on material declarations will enable a better, possibly automated, plausibility check. The details of this are not yet defined.

The development of the legislation started in 2016. The Finnish government in form of the Ministry of the Environment and its strong links to research as well as actions by the Finnish GBC have laid the ground for the initiation of the legislative process. Voluntary sustainability certificates have been used widely even before especially with newer buildings, while older buildings have only mandatory energy certificates. A lot of capacity in the sector was built through the Level(s) pilot, during which the Level(s)-method was tested widely in Finland in cooperation with the JRC. At this stage, small support funds were made available by the Finnish government to new companies who used the method and reported according to it. This included LCA calculation and thereby laid the foundation of knowledge and awareness in the industry to be prepared for a mandatory climate declaration.

A further supporting factor to the development, according to the Ministry, was the sandbox philosophy that was adopted and supported by policymakers, researchers, industry and non-profit organisations. Additionally, open exchange with neighbouring countries (Denmark, Sweden, Estonia) was described as helpful to explore options and develop the priorities of the Finnish government.

LCA calculation requirements

Life cycle scope	A1-3, A4-5, B4, C1-C4, D
Building component scope	See table below
Climate impact assessment	A "carbon handprint" will also be required which accounts for benefits from LCA module D, surplus energy generated onsite, long-time storage of carbon (e.g. biogenic) and other environmental benefits.
Reference study period	50 years
Square meter definition	Net heated floor area

LCA calculation requirements	
Environmental data sources	Various sources of environmental data possible
LCA calculation tool	No mandatory tool but certain tools with high popularity (e.g., OneClickLCA).
Reporting metrics	To be defined, most likely kgCO2eq/m2/year

Case collection, controls, and transparency	
Collection of LCAs	Under development
Compliance check	Under development
Database	Under development
Accessibility	Under development

Performance framework
Reference or limit values have not been established yet. According to the proposal, the carbon footprint of a new building should not exceed the limit value determined by the use category as proposed in a separate government decree. The level of ambition for these limit values would be conservatively ambitious to ensure acceptance from the industry. The concept of these limit values has been specified through various investigations so that according to current planning, limit values for new buildings would be defined by 2025. The current planning is to adopt a single limit value that comprises all elements of WLC in order to keep the process simple. The reference values would be developed in accordance with material statement regulation and be based on the data collected during previous stages of Level(s) testing. No limit values will be introduced for the carbon handprint at this stage.

Sources:

Government documents:
Method for the whole life carbon assessment of buildings (2019)
Ilmastoselvitys – summary of decree status
Summary of stakeholder consultation

Interview:
Matti Kuittinen (Ministry of the Environment)

Table 4. Level(s) building elements and WLC reporting requirements in Finland, showing elements that have to be assessed explicitly (RE), via proxy values (RP), or not at all (-).

Section	Building Parts	Elements	Reporting
Shell (substructure and superstructure)	Foundation Substructure	Piles	RE
		Basements	RE
		Retaining walls	RE
	Load-bearing structural frame	Frame (beams, columns and slabs)	RE
		Upper floors	RE
		External walls	RE
		Balconies	RE
	Non load bearing elements	Ground floor slab	RE
		Internal walls, partitions and doors	RE
		Stairs and ramps	RE
	Facades	External wall systems, cladding and shading devices	RE
		Façade openings (including windows and external doors)	RE
		External paints, coatings and renders	RE
	Roof	Structure	RE
		Weatherproofing	RE
	Parking facilities	Above ground	RE
		Underground	RE

Section	Building Parts	Elements	Reporting
Core (fittings, furnishes and services)	Fittings and furnishings	Sanitary fittings	RE/RP
		Cupboards, wardrobes and worktops	-
		Ceilings	RE
		Wall and ceiling finishes	RE
		Floor coverings and finishes	RE
	In built lighting system	Light fittings	RE/RP
		Control systems and sensors	-
	Energy system	Heating plant and distribution	RE/RP
		Cooling plant and distribution	RE/RP
		Electricity generation and distribution	RE/RP
	Ventilation system	Air handling units	RE/RP
		Ductwork and distribution	RE/RP
	Sanitary systems	Cold water distribution	RE/RP
		Hot water distribution	RE/RP
		Water treatment systems	RE/RP
		Drainage system	RE/RP
	Other systems	Lifts and escalators	RE/RP
		Firefighting installations	RE/RP
		Communication and security installations	-
		Telecoms and data installations	-
External Works	Utilities	Connections and diversions	-
		Substations and equipment	-
	Landscaping	Paving and other hard surfacing	RE
		Fencing, railings and walls	partially
		Drainage systems	RE

France

Regulatory framework, governance and development

The French WLC regulation in the national law Réglementation environnementale (RE2020) aims at reducing the overall impact of new construction. A contribution of WLC reduction to national targets is not quantified. This is only the case for operational energy use according to EU legislation (primarily EPBD).

RE2020 applies to new construction of residential buildings, office buildings and education buildings (primary and secondary education). An extension to other building types is foreseen to follow in the future.

RE2020 represents a national law that is applicable directly to new buildings and those designing and developing the projects. It was adopted in 2021 and is in force since January 2022.

It constitutes an evolution of the Réglementation thermique (RT2012), which implemented the previous version of the EPBD that sets thermal energy standards and performance levels for the use stage. No parameters for the embodied carbon impact were measured. In a major revision of the legislation, to introduce RE2020, the existing indicators have been adjusted as well as the underlying floor area definition, and new indicators with limit values have been introduced.

At the request of the construction permit, the developer has to provide an initial assessment of the embodied carbon impact and describe how the compliance with the legislation will be ensured. After finalisation of the building, as part of a document to request final approval, the calculation and respect of the limit values has to be submitted. The local authority is responsible for the assessment.

To prepare for the development of the RE2020, an experimental phase was conducted starting in 2016. It allowed developers to calculate the whole life carbon footprint of new building projects and offered a low carbon label in return. This phase helped build a database for recent building projects and test the data collection method in practice. The experimental phase has yielded data on more than 1000 cases. This contributed to building knowledge about WLC assessment methods and informed the policymaking.

The voluntary experimentation phase was led by a state-owned research centre (CSTB) which was supported by a steering committee and a technical advisory group. Both these groups had members from public agencies, industry, NGOs and the French GBC.

LCA calculation requirements

Life cycle scope	A-D
Building component scope	All elements permanently linked to the building, including potential parking and network connections, see table below.
Climate impact assessment	RE2020 relies on a dynamic LCA with an assessment of the impact of biogenic carbon storage . This is chosen because it emphasises the immediate and short-term carbon impacts of materials and aligns with the national legislation ELAN.
Reference study period	50 years
Square meter definition	Net floor area: liveable surface (residential) or usable surface (office), excluding walls, garages, areas kept at outdoor temperatures, ceiling heights below 1.80m
Environmental data sources	INIES database (including specific EPDs complemented by generic datasets)

LCA calculation requirements	
LCA calculation tool	No standardised calculation tool is in place, but a list of compliant tools existed under the E+C- programme. Architects, certifiers, and construction engineering companies have developed tools as services to developers.
Reporting metrics	kgCO2/m2

Case collection, controls, and transparency	
Collection of LCAs	LCAs are not centrally collected, but only submitted to local authorities.
Compliance check	Comparison between initial and final compliance declarations. Visual spot checks for the plausibility of data are possible.
Database	With the introduction of a legal obligation, the collection of LCA cases in a database was ended. A centralised database was in place since the E+ C- pilot programme. This database is hosted by the ministry and the public agency ADEME.
Accessibility	The entries in the E+C- database remain publicly and freely accessible in an anonymised manner. RE2020 data is not accessible.

Performance framework

RE2020 sets mandatory limit values of GHG emissions separated by operational (OC) and embodied carbon (EC). A WLC impact is voluntary and calculated for information purposes only.

- OC values for reference points and building results are expressed in kWh/m2/year and kgCO2eq/m2
- EC values for reference points and building results are expressed in kgCO2eq/m2
- Further values for the heating and cooling needs, non-renewable energy use and energy balance (considering on-site generation) are calculated.

The limit values are not set at a standardised level. Only a base value is defined that is adjusted to every specific building according to a set of coefficients. These coefficients relate to the geographic location (Migéo), the underground structure (Miinfra), the availability of infrastructure an utilities (Mivrd), and the use of environmental generic data (Mided). The formula is: Icconstruction_max = Icconstruction_maxmoyen × (1 + Micombles + Misurf) + Migéo + Miinfra + Mivrd + Mided

The overall reference point (Icconstruction_maxmoyen) and the coefficients reduce at different rates over time:

	Single-family homes	Multi-family homes
2022-2024	640 kgCO2/m2	740 kgCO2/m2
2022-2024	530 kgCO2/m2	650 kgCO2/m2
2028-2030	475 kgCO2/m2	580 kgCO2/m2
From 2031	415 kgCO2/m2	490 kgCO2/m2

This change over time is set in three-year intervals to allow for experiences to be gathered before a new value is applicable. The required reduction is steeper at the beginning with a 17% drop in 2025 compared to a 10% reduction in 2028. The initial limit values were set to enable relatively easy compliance for building projects, with increasing ambition over time. A further adjustment of values is not planned at the moment. This was done to allow the building industry to develop long-term strategies and enable the transition step by step.

Expert groups determined the methods and coefficients taking into account the expectations of stakeholders, technical feasibility and economic impacts.

This is informed by the cases in the E+C- experimentation and observatory database and the discussion with experts and stakeholders. The underlying approach can therefore be described as bottom-up.

Sources:

Legal document:
Décret no 2021-1004 du 29 juillet 2021 relatif aux exigences de performance énergétique et environnementale des constructions de bâtiments en France métropolitaine

Government materials:
Guide RE2020
Summary report of the concertation committee on the ambition level

E+C- Website:
Website Energie Positive & Reduction Carbone
Méthode d'évaluation de la performance énergétique et environnementale des bâtiments neufs (2017)

INIES database:
INIES database

Table 5. Level(s) building elements and WLC reporting requirements in France, showing elements that have to be assessed explicitly (RE), via proxy values (RP), or not at all (-).

Section	Building Parts	Elements	Reporting
Shell (substructure and superstructure)	Foundation Substructure	Piles	RE
		Basements	RE
		Retaining walls	RE
	Load-bearing structural frame	Frame (beams, columns and slabs)	RE
		Upper floors	RE
		External walls	RE
		Balconies	RE
	Non load bearing elements	Ground floor slab	RE
		Internal walls, partitions and doors	RE
		Stairs and ramps	RE
	Facades	External wall systems, cladding and shading devices	RE
		Façade openings (including windows and external doors)	RE
		External paints, coatings and renders	RE
	Roof	Structure	RE
		Weatherproofing	RE
	Parking facilities	Above ground	RE
		Underground	RE

Section	Building Parts	Elements	Reporting
Core (fittings, furnishes and services)	Fittings and furnishings	Sanitary fittings	RE
		Cupboards, wardrobes and worktops	-
		Ceilings	RE
		Wall and ceiling finishes	RE
		Floor coverings and finishes	RE
	In built lighting system	Light fittings	RE
		Control systems and sensors	partially
	Energy system	Heating plant and distribution	RE
		Cooling plant and distribution	RE
		Electricity generation and distribution	RE
	Ventilation system	Air handling units	RE
		Ductwork and distribution	RE
	Sanitary systems	Cold water distribution	RE
		Hot water distribution	RE
		Water treatment systems	RE
		Drainage system	RE
	Other systems	Lifts and escalators	RE
		Firefighting installations	RE
		Communication and security installations	RE
		Telecoms and data installations	RE
External Works	Utilities	Connections and diversions	RE
		Substations and equipment	RE
	Landscaping	Paving and other hard surfacing	RE
		Fencing, railings and walls	RE
		Drainage systems	RE

Netherlands

Regulatory framework, governance and development

In the Netherlands, calculating the Environmental Performance of Buildings (MPG, in Dutch) is mandatory for the construction of new residential buildings and office buildings larger than 100m2. A limit value quantified in EUR/m2/year applies to these buildings.

The legislation came into force in January 2018 and is strongly interlinked with the legislation on the Environmental Cost Indicator (MKI). The MKI is a nationally standardised calculation method in which the outcome of an LCA is translated into a monetary unit (EUR). This is done by assigning a monetary value to 11 environmental impact categories of the LCA (including GWP, ozone depletion potential, acidification, etc.). The cost factors for each impact category are determined from the damage costs of a certain type of emission. The cost indicator is also referred to as shadow costs of the building. For instance, 1 kgCO2eq has a shadow price of 0.05 EUR.

Buildings that fall into the scope need to obtain an environmental permit for construction. For this, the MPG has to be calculated and stay below the limit value. Data for the LCA calculation is available in the national environmental database NMD.

In 2013, a new Building Decree stipulated that every application for an environmental permit for the construction of residential, non-residential and office buildings must be accompanied by a calculation of the building's environmental performance. This was followed in 2018 by the introduction of limit values and an update of the methodology to align with EN15804 and EN15978.

The development process was accompanied by a stakeholder engagement platform in which public and private developers, the construction material industry, and building designers were represented. The technical development was also performed by the Building Quality Foundation (management of the NMD database), NIBE as a private consulting company, and the Dutch GBC.

LCA calculation requirements

Life cycle scope	A1-3, A4-5, B1-4, C1-4, D
Building component scope	As available at the design stage, particular focus on the load-bearing structure, shell and installations but also including non-loadbearing elements
Climate impact assessment	11 environmental impact categories monetized and calculated in one value. Therefore, the final value does not allow insights into WLC levels.
Reference study period	50 or 75 years
Square meter definition	Gross floor area defined as gross area (including walls) of all indoor spaces in a building
Environmental data sources	NMD database including generic and specific data
LCA calculation tool	Multiple calculation tools are available and accredited by the NMD
Reporting metrics	EUR/m2/year

Case collection, controls, and transparency	
Collection of LCAs	LCAs or MPGs are not centrally collected.
Compliance check	Checks of the MPG are undertaken based on the most contributing building elements (walls, floors, installations). For this, the final building is compared to the environmental declaration. Spot checks can be carried out for more detailed features. In this context, it is acknowledged that not all details are known at the design stage when applying for the environmental permit.
Database	No national database of collected LCAs exists. MPG calculations are submitted to the local municipality but not stored centrally.
Accessibility	It is not possible to access other MPG calculations in a systematic manner.

Performance framework

The MPG legislation includes one standardised maximum limit value for the building as a product. Only embodied carbon emissions are considered in this limit, while operational emissions are regulated through other policy measures.

At the time of the introduction in 2018, the limit value was at 1 EUR/m2/year. This limit value was set through the analysis of representative buildings which represents a bottom-up approach.

In 2021, the limit value was decreased for residential buildings to 0.8 EUR/m2/year, but remained the same for office buildings.

It is foreseen to tighten the limit value to 0.5 EUR/m2/year in 2030 and thereby halve the emissions caused by the buildings in scope of the MPG.

Sources:

Legal document:
Environment Performance Buildings - MPG

National environmental database:
Bepalingsmethode Milieuprestatie Bouwwerken
Database (NMD)
Rekeninstrumenten (NMD)

Environmental Shadowprice:
Environmental Cost Indicator (MKI) – Overview

Sweden

Regulatory framework, governance and development

In Sweden, legislation requiring mandatory climate declarations for buildings came into force in January 2022. The introduction of maximum limit values for these declarations is also proposed to apply at the latest from 2027 onwards. The objective of this stepwise approach is to increase knowledge of the climate impact of the construction of new buildings and start reducing their climate impact as a contribution to the national objective of climate neutrality in 2045.

The Swedish climate declaration limits the requirement to the construction stage, such that emissions have to be reported from the completed building and for specific building elements. The climate declaration covers new buildings that require building permits. However, exemptions apply for private individuals that develop a building without a business purpose, some industrial buildings such as agricultural (non-residential) buildings, and public building projects for defense or transport infrastructure. Additionally, the scope of the legislation is limited to buildings over 100 m2.

The climate declaration can be completed at any time before starting to use the building. It has to be submitted online to the National Board of Housing, Building and Planning, which checks the declaration. In order to receive final clearance to use the building according to the Planning and Building Act, the completion of the climate declaration has then to be demonstrated to the municipality. As there are currently no limit values in place, this is the only requirement at the moment.

The development of the current legislation, as well as the future limit values, is driven by the Ministry with strong support from the National Board of Housing, Building and Planning (Boverket). The Board has developed a database with relevant climate data for standard materials that can be used for calculations for climate impacts from the construction of new buildings. However, in these default values include a 25% penalty to incentivise the use of specific data from EPDs. An online calculation tool is available through the Swedish Environment Agency (IVL). From here, data can directly be submitted to the National Board of Housing, Building and Planning. Furthermore, extensive information and guidance on how to calculate the climate impacts is available on their website.

The process started in 2019 when the government commissioned the National Board of Housing, Building and Planning to initiate preparations for facilitating the introduction of regulation for a climate declaration when constructing new buildings. In 2020, they presented a draft for the law on climate declaration for new buildings. The focus on upfront embodied emissions from the construction stage only, and the later introduction of limit values mean that the current legislation builds the capacity to lay the ground for stricter regulations of a more comprehensive life-cycle scope and mandatory limit values. Because of demands from the national construction and real-estate sector, the original timeline of introducing limit values in 2027 might be brought forward to create a reliable policy framework.

LCA calculation requirements

Life cycle scope	A1-3, A4-5, according to EN15978:2011
Building component scope	Building envelope, load-bearing structural elements and non-load-bearing internal walls
Reference study period	Normally 50 years but not applicable to the climate declaration, as only upfront embodied emissions are calculated
Square meter definition	Gross floor area (total space, including space not used for living or office use)
LCA calculation tool	A database of EPDs and generic data is available from the National Board of Housing, Building and Planning. Generic values are set about 25% higher than the average of the value calculated for the product group to discourage the use of default, generic data.

LCA calculation requirements	
LCA calculation tool	A calculation tool has been developed by the Swedish Environment Agency (IVL) through which LCAs can be submitted directly to the National Board of Housing, Building and Planning. However, this tools is not mandatory and other tools or forms can be used.
Reporting metrics	kgCO2/m2

Case collection, controls, and transparency	
Collection of LCAs	The National Board of Housing, Building and Planning compiles all climate declarations and will use them to determine the limit values for the future.
Compliance check	Submission and completeness are checked centrally by the National Board of Housing, Building and Planning. The system for checks of compliance with future limit values is still unclear.
Database	See above.
Accessibility	Specific entries can be requested from the national authority. The complete dataset or a searchable version is not made available to the public.

Performance framework

As there are no limit values proposed at the moment, the proposal for setting these values in the future gives the most relevant information:

- Limit values for climate emission for buildings should be included for the construction stage (modules A1–A5) from 2027, the extension to further LCA modules and information about biogenic carbon storage as well as net exports of locally produced electricity could be considered.
- Limit values should comprise a more complete building component scope from 2027 compared with the declaration requirement. Additional building elements foreseen to be included are installations, interior surface finishes and room fittings.
- Limit values should be differentiated for single-family houses, multi-dwelling blocks and non-residential premises.
- The level for limit values in 2027 should be set to achieve 20–30% lower climate emissions than a reference value to be established in a study of climate calculations of buildings. This reference value is to be checked against registered climate declarations.
- Reductions in limit values should be made in 2035 and 2043, with the aim that maximum values are lowered at a linear rate from the 2027 limit value, with a suggested 40 per cent reduction by 2035 and an 80 per cent reduction by 2043.
- Evaluations should be carried out well before planned reductions, to ensure that limit values do not drive developments in an undesirable way

Sources:

Boverket websites:
Regulation on climate declarations for buildings (boverket.se)
About the climate database from Boverket - Boverket
Syftet med att klimatdeklarera byggnader - Klimatdeklaration - Boverket
Meningen med att klimatdeklarera | Boverket.se (infab.io)
Questions and answers about climate declarations - Boverket

Government proposal 2020:
Klimatdeklaration för byggnader – DS2020:4

Other stakeholders:
"Klimatsmart byggande en konkurrensfördel" | Byggföretagen (byggforetagen.se)
Klimatdeklaration för byggnader | KTH

Interview:
Robin Marve (Ramboll Buildings Sweden)

Table 6. Level(s) building elements and WLC reporting requirements in Sweden, showing elements that have to be assessed explicitly (RE), via proxy values (RP), or not at all (-).

Section	Building Parts	Elements	Reporting
Shell (substructure and superstructure)	Foundation Substructure	Piles Basements Retaining walls	- RE -
	Load-bearing structural frame	Frame (beams, columns and slabs) Upper floors External walls Balconies	RE RE RE RE
	Non load bearing elements	Ground floor slab Internal walls, partitions and doors Stairs and ramps	RE RE RE
	Facades	External wall systems, cladding and shading devices Façade openings (including windows and external doors) External paints, coatings and renders	RE RE RE

Section	Building Parts	Elements	Reporting
	Roof	Structure Weatherproofing	RE RE
	Parking facilities	Above ground Underground	- RE
Core (fittings, furnishes and services)	Fittings and furnishings	Sanitary fittings Cupboards, wardrobes and worktops Ceilings Wall and ceiling finishes Floor coverings and finishes	- - RE - -
	In built lighting system	Light fittings Control systems and sensors	- -
	Energy system	Heating plant and distribution Cooling plant and distribution Electricity generation and distribution	- - -
	Ventilation system	Air handling units Ductwork and distribution	- -
	Sanitary systems	Cold water distribution Hot water distribution Water treatment systems Drainage system	- - - -
	Other systems	Lifts and escalators Firefighting installations Communication and security installations Telecoms and data installations	- - - -

Section	Building Parts	Elements	Reporting
External Works	Utilities	Connections and diversions	RE
		Substations and equipment	RE
	Landscaping	Paving and other hard surfacing	RE
		Fencing, railings and walls	RE
		Drainage systems	RE