Boverket

Myndigheten för samhällsplanering, byggande och boende

REPORT 2020:28

# Regulation on climate declarations for buildings

## proposal for a roadmap and limit values

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**Boverket**

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# Foreword

In the summer of 2019, the government commissioned the National Board of Housing Building and Planning (Boverket) to initiate preparations for facilitating the introduction of regulation for a climate declaration when constructing new buildings. Part of the commission was to propose a plan for the continued expansion of regulation on climate declarations covering the entire life cycle as well as including limit values on climate impact. This report is an english translation of the plan sent to the government in june 2020.

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Karlskrona, november 2020

Anders Sjelvgren
Director General

# Contents

# Concepts, abbreviations and terms

Net heated area = The area of all floors, including attics and basements, of temperature-regulated spaces intended to be heated to above 10° C within the building envelope. Area comprising interior walls and wells for stairs, shafts etc are included. Areas of garages, within the building in residential buildings or non-residential buildings other than garages, are not included.

BBR = Boverkets byggregler, or Boverket's construction regulations – mandatory provisions and general recommendations, BFS 2011:6.

Referens study period = When greenhouse gas emissions are calculated for the use stage (modules in stage B), a calculation period needs to be set – this is called the reference study or analysis period. The reference study period is the delimited period of time for which the calculations are made.

Biogenic carbon = Carbon dervied from biomass.

Gross floor area (GFA) = The sum of the areas of all floors, measured from the outside of the exterior walls. Calculated as specified in SS 21054:2009 until 17 March 2020, and thereafter as specified in SS 21054:2020.

Construction Products Regulation = Regulation (EU) No 305/2011 of the European Parliament and of the European Council laying down harmonised conditions for the marketing of construction products.

Construction stage = product stage (module A1–A3), construction process stage (module A4–A5), see also the term Life cycle stage.

Ds 2020:4 Climate Declaration for buildings = Memorandum from the Government Offices, the Ministry of Finance. The memorandum proposes a new law and ordinance on climate declarations for buildings. It also includes a proposal for an amendment to the Planning and Building Act.

EKS = Boverket's mandatory provisions and general recommendations on the application of European construction standards (Eurocodes), BFS 2011:10.

SS-EN15804 = SS-EN 15804:2012+A1:2013 Sustainability of construction works – Environmental product declarations – Core regulations for the product category of construction products.

SS-EN 15978 = SS-EN 15978:2011 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method.

EPD = Environmental Product Declaration for a specific product or group of products. In this report EPD refers to declarations that follow the calculation rules in SS-EN 15804. Also referred to as product specific data.

GWP = Global Warming Potential, a characterization factor describing the radiative forcin impact of one massbased unit of a given greenhouse gas relative to that of carbon dioxid over a given preriod om time.

Generic data = Climate data representative of a particular material or type of component. Such representative data are usually based on average values for different construction products in a particular group of products.

Limit value = Used in this report to denote a maximum climate impact level for a building that can be specified as a requirement in the regulations relating to climate declarations for buildings.

LCA = Life cycle analysis. Environmental assessment covering the entire life cycle of a product or service.

Carbon dioxide equivalent = Unit for comparing the radiative forcing of greenhouse gas to that of carbon dixid. Usually abbreviated $CO_2e$.

Level(s) = The European Commission's assessment and reporting framework for the sustainability performance of buildings. It is a voluntary system for improving buildings' sustainability. Using existing European standards, Level(s) is intended to provide a common EU method for assessing environmental performance in the built environment.

Life cycle stage = Used in this report for a building's life cycle stages as specified in the SS-EN 15978 standard: product stage (module A1–A3), construction process stage (module A4–A5), use stage (module B1–B7), end of life stage (module C1–C4).

Module = Used in this report to elucidate details of parts of different life cycle stages according to the SS-EN 15978 standard – for example, transports to the construction site (module A4) as a part of the construction process stage.

Target value = Used in this report to indicate a maximum climate impact level for a building, which can be seen as a long-term target for requirements in the regulatory framework for climate declarations of buildings.

The national climate database = Used in this report to denote the database with generic climate data, representative of Swedish conditions, which is currently being developed and is intended to be used when producing a climate declaration in accordance with the regulations.

National scenarios = Scenarios are collection of assumtions and information concerning an expected sequence of possible future events. The specification “national” means that they have to be representative of Swedish conditions.

Net-zero emissions = Achieved when human emissions of greenhouse gases into the atmosphere are balanced by human negative emissions over a specified period of time; net-negative emissions are achieved when the negative emissions exceed the emissions. However, Sweden applies special definitions as zero-net emissions targets stipulate that:

- Sweden’s territorial emissions must be reduced by at least 85 per cent by 2045
- The remaining maximum 15 per cent may be covered by “supplementary measures”.

Known supplementary measures include:

- Increased net removal in what is known in climate reporting as the Land Use, Land-Use Change and Forestry (LULUCF) sector
- Negative emissions processes such as capture and storage of biogenic $CO_2$ (bio-CCS)
- verified emissions reductions in other countries

PBL= Plan- och bygglagen, the Planning and Building Act (2010:900).

PBF= Plan- och byggförordningen, the Planning and Building Ordinance (2011:338).

PCR = Product Category Rules. Refers in this report to product specific calculation rules, either for entire building works (specification of the SS-EN 15978 standard) or for various product groups (specification of the SS-EN 15804 standard). Specified calculation rules for the relevant

product group are used to draw up an Environmental Product Declaration (EPD) in accordance with SS-EN 15804.

Bill of resources = Used in this report to denote the summary of quantities of material and energy-consumingprocesses that constitutes the basis for producing a climate declaration for a building.

Default values = Used in this report to denote data that can be used to facilitate climate impact calculations in some parts of the declaration. Default values thus correspond to representative values in kilos of $CO_2$ equivalents/$m^2$ for those parts.

Specific data = Used in the report above all to denote product specific climate data (EPD) that apply to a certain product or group of products from a particular supplier, as opposed to generic data.

See also terminology regarding e g modules and stages in SS-EN 15978 and SS-EN 15804:
https://www.sis.se/standardutveckling/tksidor/tk200299/sistk209/

# Summary

A proposal for legislation on climate declarations for buildings, intended to be introduced in January 2022, is presented in the government's memorandum Ds 2020:4, "Klimatdeklaration för byggnader" (Climate declarations for buildings). The proposal in Ds 2020:4 amounts to a requirement that all new construction of buildings be accompanied by a report on the climate impact of the building in question, in a climate declaration. The purpose with regulation on climate declarations is to improve knowledge and to reduce the climate impact of buildings. The government's proposed law limits this requirement to the construction stage, such that emissions have to be reported from the completed building and for specific building elements.

Boverket – the Swedish National Board of Housing, Building and Planning – has been commissioned to propose a plan for the further development of the regulations on climate declarations so that they encompass the buildings entire life cycle, as well as limit values. The aim of the proposal is to make subsequent regulations clear and transparent for the construction industry and to give it ample time to make preparations in terms of building up skills, and product and business development. An additional aim is to identify and highlight the need for further actions towards developing the regulations. In this report, Boverket presents proposals for new regulations on limit values for climate emissions from buildings (administrative instrument). The report also includes a proposal for extending reporting requirements on the climate impact of a building under construction, compared with the draft regulations that would be in force from 2022 (informational instrument).

Memorandum Ds 2020:4 was issued for public consultation during the spring. A memorandum is an early step in the legislative process, followed by several other steps. The government prepares the legislative proposal and presents it to, the Council on Legislation, in what is known as a legislation council referral. Following this, the government revises the proposal as it deems necessary before submitting it to the parlament. Parliamentary committees in the parlament are invited to present opinions on the legislative proposal, in what are known as committee reports. The parlament then decides on the adoption of the new law. As we are still at an early stage of the legislative process, changes may occur. Any such changes may influence the considerations made in this report on the development of climate declarations.

## Introduction of limit values proposed for 2027

In order to promote the application of climate improving measures during project design and construction, the proposal in this report is that limit values for climate emissions from buildings be introduced in 2027. The limit value should cover the construction stage, i e modules A1–A5 (raw materials supply at the product stage, transport at the product stage, manufacturing at the product stage, transport at the construction process stage, and the construction and installation process at the construction process stage), as well as additional building elements compared with the 2022 legislative proposal. Limit values also means creating the conditions needed for a transition towards net-zero climate impact construction, which will be necessary for achieving the 2045 national climate target. Boverket proposes that the limit value be gradually lowered in 2035 and in 2043. Each regulatory change should be preceded by a thorough **evaluation**, begun about three years before the changes to the regulatory framework. This will enable a preview of the **effects and consequences** of the regulations as well as the need for changes and reductions to limit values. Although several major actors will have experience and expertise in carrying out similar calculations before 2027, as well as an understanding of how results should be interpreted, Boverket regards it as reasonable to wait with the introduction of limit values until then since the requirement will apply for **almost all buildings being constructed** – since small and medium-sized companies will also have to comply to the requirements.

Limit values could possibly be introduced earlier, but the proposal is rather to await the development of skills and capacity for carrying out calculations **with quality**, thus creating **better conditions** for the introduction of limit values. When limit values are introduced, their fulfilment should require some form of climate-improving measures in construction (read more about limit values below). Boverket's assessment is that access to data for installations will be sufficiently good by 2027 – and by also adding the other parts of the building, declarations are expected to be of a more even and comparable quality, which creates better conditions. Boverket's further assesses that by 2027 digitalisation will have advanced to a point that should make it easier to carry out calculations with a higher level of precision than currently, even when essentially all building elements in the building are included.

Simplicity has been a priority in Boverket's roadmap, which means avoiding to frequent regulatory changes in order to facilitate for the construction industry. The timetable was drawn up to correspond with the national climate target and with the construction sector's roadmap. The

major change to the regulatory framework is proposed for 2027, with subsequent changes mainly involving further reductions of limit values and adjustments to the method as and if necessary.

One of the measures implicit in the proposed roadmap is the need for the addition of more data to Boverket's climate database.

## Increased reporting in climate declarations

Boverket's proposal is that climate declarations for buildings in 2027 comprise reporting on climate emissions for more life cycle stages and modules than the climate declarations will include from 2022 under the current legislative proposal. Additional modules, based on the European SS-EN 15978 (environmental performance of buildings) standard, would be:

- maintenance (B2), replacement (B4) and operational energy use (B6) at the use stage,
- de-construction, demolition (C1), transport (C2) waste processing (C3) and disposal (C4) at the end of life stage,
- supplymentary environmental information about biogenic carbon storage and net exports of locally produced electricity.

These additional modules were selected on the following grounds. In order to cover an entire life cycle, modules based on SS-EN 15978 (environmental performance of buildings) are included from the use stage as well as the end of life stage. For the use stage, priority modules are those that normally represent a major share of the climate impact in similar life cycle analyses: replacement (module B4) and operational energy use (module B6). The distinction between replacement (module B4) and maintenance (module B2) is not clear from the EU standard, for which reason Boverket suggests that planned periodic maintenance (module B2) also to be included. These are also the modules included in similar methods in the Nordic and other European countries. The proposal includes the entire end of life stage (modules C1–C4) as this may lead to some extent towards the use of more advanced methods of recycling and reuse, i e promote circular construction methods. Calculation of these additional parts is not expected to be particularly time-consuming if Boverket provides the scenario data to be used. Again, this follows the procedure in other Nordic countries.

Boverket further proposes that a separate declaration of biogenic carbon storage in wood-based products be made mandatory as part of

supplymentary environmental information. This will effectively be a report on the building's positive climate impact. Similarly, net exports of locally produced electricity to the network should also be declared as supplementary environmental information.

### Referens study period of 50 years

When calculating greenhouse gas emissions for the use stage (modules in stage B), a calculation period needs to be assigned – this is sometimes also called the reference study or analysis period. It is important to underline that the reference study period is precisely the delimited period of time for which the calculations are made. This is not the same thing as the expected technical servicelife of the building. Boverket proposes that the referens study period be set at 50 years, which would harmonise with what most Nordic and other European countries use as well as with what the European Commission's Level(s) reporting framework is currently expected to implement. Limiting the referens study period to 50–60 years is common practice, reflecting the consideration that scenarios about emissions linked to production methods that far into the future are inevitably very uncertain.

There was earlier a major concern that setting such a relatively short referens study period could perhaps discourage the use of construction products with long service life. However, there are no documented studies showing that the application of LCA in project design has had any such consequences. A referens study period of 50 years also takes account of the fact that buildings normally require fairly extensive renovation after that period of time.

### Choice of additional building elements

Boverket proposes that climate declarations be expanded in 2027 to cover additional building elements, so that installations, interior surface finishes and fitments are also included. This means that from 2027 a climate declaration will constitute a more complete representation of a building. Boverket also proposes that there should be default data for interior surface finishes and fitments.

The assessment is that by adding more building elements to climate declarations, a more comparable quality will be obtained for climate declarations overall. This creates better conditions for the introduction of limit values.

Recent LCA studies indicate that installations can represent a considerable share of a building's climate impact, ranging from 18 to 46

per cent, where a higher climate impact applies above all to net-zero or net-positive energy buildings with a large number of solar cells. The general trend is for increasing numbers of installations in buildings, so this is seen as an important part to add. The inclusion of installations is also expected to increase the focus on recycling in this area. Finally, it also constitutes a harmonisation with how the issue is managed through similar methods in the other Nordic countries.

## Method for limit values

The importance of benchmarking in this area as a way of driving design and construction towards low environmental impacts has been discussed for a long time. It is only now that a simplified life cycle analysis has started to be introduced in practice, however, that the importance of reference values and requirement levels has begun to be discussed in e g procurement criteria. Still, as limit values begin to be defined, it is also important to bear in mind that no country so far has legislation with stringent requirements in place, i e where climate improving measures are required in order to achieve the limit value, or where there has been time to evaluate how limit values for climate impact can influence and drive the construction and design of buildings.

Boverket proposes that from 2027 limit values on climate emissions during the construction stage (modules A1–A5) include a more complete building than when climate declaration requirements are introduced in 2022. Limit values are to be set differently for single-family houses, multi-dwelling blocks, and non-residential premises. Limit values should be stringent from the outset when they are introduced in 2027, so that some form of climate improving measures are needed in order to meet the requirements. Boverket proposes that the limit value for climate emissions be 20–30 per cent lower than a reference value obtained through a study of climate calculations for buildings. This reference value will be matched against registered climate declarations. Making limit values introduced in 2027 more stringent than in current regular construction is in keeping with the construction and civil engineering sector’s roadmap, whose signed organisations have committed themselves to a 50 per cent reduction of the climate impact from the construction stage between 2015 and 2030. Additionally, the concrete industry’s roadmap envisions a 50 per cent reduction in the climate impact of concrete already by 2023. There are also studies in Sweden that indicate it may already be possible to lower the climate impact of new buildings by 15–30 per cent using existing technology.

The proposal for limit values is to be lowered in 2035 and 2043, with at a linear rate from the 2027 limit value – with a 40 per cent reduction until 2035 and an 80 per cent reduction until 2043. Evaluations should be carried out well before planned reductions, to ensure that limit values do not drive developments in an undesirable way.

A limit value that comprehends the construction stage imply for a more focused steering towards reducing greenhouse gas emissions occurring today – while not regarding them as equivalent to potential emissions that lie several decades into the future, whose impact is more **difficult to assess**. The former can also be verified, which is not the case with calculations about future emissions. Finally, emissions during the construction stage currently represent a large share of total climate-impacting emissions when considered across the life cycle of a building.

Taking the national climate target into account, as well as the ambitions of the construction sector, it might be reasonable to set the limit value for climate emissions at zero in 2045. However, this is what is known as a net-zero target, which has not so far been defined in greater detail. The suggestion here is therefore that limit values for climate emissions should concern impact, and that it is this that has to be reduced, without taking any compensation measures into consideration. It is impossible to determine today what a reasonable target value will be around 2045, but the suggestion is that the interim aim should be for a 2043 target level that is 80 per cent lower than the baseline value set for limit values in 2027.

## Climate declarations for refurbishments

A further question that has been examined within the scope of the commission is whether the next step should include mandatory climate declarations formajor refurbishment works as well. Such works also involve the removal and use of large amounts of material, causing relatively large climate impacts which would, of course, be beneficial to reduce. An overriding reason for requiring climate declarations, or rather climate calculations, prior to refurbishment works would be the importance of promoting the efficient use of existing buildings for as long as possible. Boverket has determined that this issue needs to be examined in greater depth, for which reason this report does not present a final proposal in the matter.

## Other factors to consider before implementation of the plan

Many actors have pointed out that the ongoing process of digitalisation will facilitate implementation and improve the quality of climate declarations in the future. The upcoming review of European Construction Products Regulation may also influence Swedens possibilities of imposing requirements for environmental information on construction products, which is a central element if limit values are introduced.

### Developments within digitalisation in the construction sector

It is difficult to get a clear picture of how digitalisation is progressing within the construction sector, both nationally and internationally. Digitalisation of environmental information and climate calculations is under development in the construction sector, but the available technology is currently being used mainly by leading actors. Small and medium-sized companies, however, are sometimes finding it difficult to make use of digital tools due to limited resource and skills, which may in turn constitute an obstacle to the flow of digital information throughout the construction process. Requirements imposed by government agencies will drive the development of accessible and compatible digital tools and digital information about the climate impact of construction products. The implication is that more actors will have to embrace digital technology.

Some important conclusions that can be drawn from this are that the digitalisation of the construction sector is a prerequisite of high-quality climate declarations, produced in a resource-efficient way. Public funds should continue to be used to support research that contributes to the development of digitalisation in the construction sector.

### Construction products are harmonised at the EU level

Specific environmental information about construction products in the market would be advantageous as developers could make well-informed choices. Under EU law, however, it is currently not possible for public actors to require this from the manufacturers. Construction products are harmonised at the EU level in the Construction Products Regulation.

The work for describing the environmental impacts of construction products has been carried out under the mandate of the European Commission. This has resulted in the SS-EN 15804 standard, which is used to make Environmental Product Declarations, EPDs, for construction products. So far there is no legal connection between an

EPD under SS-EN 15804 and the harmonised construction product standards. Thus, the fact that requirements by public actors and the connection between SS-EN 15804 and the harmonised standards are still lacking means that it is not yet possible to impose requirements for the use of product specific EPDs for harmonised construction products. This is one of the reasons why the state will provide a database of generic data for construction products, to be used in climate declarations if generic data is used. However, these data can be substituted with product specific data (EPD), if such exist for the selected construction products.

An important conclusion is that in Sweden we want to have the possability to require that specific climate data or product specific data for construction products be used in the final climate declaration, but that this is not possible according to EU legislation. It is therefore very important to follow and influence the EU revision of the Construction Products Regulation so that it becomes possible to require specific climate data/environmental data for construction products if and when limit values are introduced in Sweden, and that the Environmental Product Declaration for construction products follows the European SS-EN 15804 standard and indirectly SS-EN 15978. It is also important to coordinate standardisation efforts of environmental product declarations with ongoing efforts within Europe regarding digital formats for information about construction products.

## Impact assessment

Essentially, Boverket's proposal in the roadmap gives rise to consequences for three reasons: because the proposal includes limit values; because it envisages further modules in the life cycle, in addition to the construction stage; and because it expands the number of building elements to be calculated at the construction stage beyond the building elements that will become mandatory from 1 January 2022.

The proposal will affect the environment, principally through limit values that lead to emission reductions. The proposal will also affect the government and developers. We can additionally expect construction product manufacturers to be affected by the roadmap, primarily if we impose requirements for product specific climate data and if stringent limit values are set. However, the long-time horizons involved make such analyses very uncertain. The roadmap therefore also includes regularly recurring evaluations of likely effects on different actors.

### Socio-economic benefit

Given that climate declarations are the instrument for achieving a reduced climate impact from new production in the Swedish construction sector, limit values are the main tool at our disposal. At the later stages of the roadmap, developers' possibilities of achieving these limit values will depend on technological developments. Such technological developments can in turn be influenced to some extent by policy measures. Policy decisions can stimulate research and development, thereby speeding up the transition to new, climate-friendly technology that is cheaper than the current technology. Another consequence may be increased investment in climate-friendly technology, which in turn would increase experience and knowledge in the area. This will lead to increased productivity, thus reducing the costs of the policy pursued.

A rough estimate of the climate benefit that a limit value could bring can be obtained by taking current climate emissions from new construction and then reducing annual emissions by 20 per cent from 2027 to 2034. This reduction would be in keeping with the roadmap for the proposed 2027 limit value, and the annual emissions reduction during the period can the be estimated at approximately 820,000 tonnes in $CO_2$ equivalents.

The annual economic benefit of limit values for climate emissions from buildings amounts to a 20 per cent reduction in climate emissions and can be calculated, using the rough estimate method above, at between SEK 1 and 6 billion.

If the number of new buildings is 10,000 per year, the total declaration cost of climate declarations can be estimated to SEK 500 million per year. This cost can be compared to the economic benefit of climate declarations, estimated above at between SEK 1 and 6 billion annually.

### Consequences for the government

Boverket's proposal for a roadmap will have consequences for the government principally as a result of the evaluations that are included in the proposal. In addition to costs arising in connection with evaluations, the roadmap also brings consequences due to changes in the supervision of climate declarations, an expanded climate database, the development of IT support for the climate declaration register, and information measures.

### Consequences for developers

The cost increase for developers is small when we add further modules in addition to A1–A5 in the calculation of the data on which the climate

declaration is based. We can therefore assume that the new mandatory modules to be accounted for at the use and end of life stages will only increase declaration costs to a limited degree.

Boverket has made five calculations for existing buildings in order to obtain an estimate of the cost of carrying out a climate declaration. These cost calculations, which were based on time studies for the various steps of the process, indicate that the cost of carrying out a climate declaration will be lower than previous calculations presented by Boverket.

Boverket has also had an interview study made with construction companies of various sizes. The results of this study can be taken to indicate that support and information measures should focus on smaller companies. The study notes that smaller companies that are not specialised in wooden buildings are more concerned about the proposed law (to apply from 1 January 2022) than bigger companies and companies specialised in wooden buildings are.

### Consequences for construction product manufacturers

It is above all if limit values are introduced requiring some form of climate-improving measures to be fulfilled, and if requirements are included that product specific climate data must be used in the final climate declaration, that there will be consequences for manufacturers of construction products. It is Boverket's hope that it will be possible to impose requirements from 2027 stipulating that climate declarations must be based on specific climate data for the chosen products. This would imply that manufacturers would be required to provide environmental product declarations, EPDs.

According to information from the trade association of Swedish construction product manufacturers (Byggmaterialindustrierna), it costs a manufacturer SEK 50,000–200,000 to draft a new EPD. There are also registration fees and annual fees to pay to the program operator selected by the manufacturer. The total cost of drafting an EPD depends on several different factors, such as the characteristics of the manufacturer (large/small, many/few construction products, few/many production facilities, geographical location, access to internal skills). It also depends on how complex the product is and to what extent a notified body must be consulted to carry out a third-party audit of the product and/or the manufacturing process.

For smaller construction product manufacturers, drafting an EPD can imply a sizeable cost. In industries with many small manufacturers (10–15 employees) in particular, this cost can be very high. In the future new

small companies working with alternative materials may also emerge. Such companies could become strategically important if their products have a markedly lower climate impact. It may become necessary with some form of support system to allow these smaller construction product manufacturers to draw up EPDs – not least if limit values are introduced.

If limit values are lowered by 40 per cent in 2035, more transformative changes (rapid and far-reaching changes) will be needed for the major bulk materials in buildings if limit values are to be met.

In a dissertation from 2015 the conditions and consequences is examined for three of the most emissions-intensive industries within the EU and the Nordic countries (except Iceland). The following conclusions can be drawn from its findings:

1. The combined effect of currently available reduction measures and proven best process technologies is not sufficient to contribute to sharp emissions reductions in the medium term (until 2030) or the long term (until 2050).

2. Unless production levels are significantly reduced, only ambitious implementation of carbon capture and storage will allow emissions reductions to match the climate targets. This concerns CCS (Carbon Capture and Storage) technology, in which carbon dioxide is separated and stored at the bottom of the sea instead of being released into the atmosphere. Additionally, technology for replacing coal with hydrogen gas in steel production will be required.

### Consequences for building owners

Boverket sees a risk that an increased focus on the climate impact of buildings could lead to negative effects for other important functions of the building when measures are undertaken to reduce the climate impact in construction – unless this is monitored carefully. This applies primarily to technical features such as fire protection, damp proofing, noise protection, and durability, which should be given special consideration. Issues that need to be explored include what might happen when we replace a certain material with a more climate-friendly alternative. An example of this would be if we switch to concrete with a lower climate impact. New materials can lead to construction defects if they have not been sufficiently tested, which in turn can have negative effects on other technical features in the building. Each structure material has its own advantages and disadvantages.

In a report from 2011 Boverket accounted for damp and mould problems in the existing building stock. The report showed that there is damp and mould damage in approximately 751,000 buildings, which make up about 36 per cent of the building stock. Much of the damp damage was caused by construction solutions that were put into large-scale production before having been adequately tested.

## Where to place regulations on limit values

According to Boverketit is reasonable to include regulations on limit values for climate emissions from buildings in the regulatory system for climate declarations. Limit values need to be based on the proposed act on climate declarations for buildings. Including limit values in the regulatory system for climate declarations makes for a coherent regulation. It would not be appropriate to include limit value regulations in the Planning and Building Act.

There is a political will for a Nordic harmonisation of building regulations regarding climate issues. Ministers of housing and construction in the Nordic countries have declared that they would like to see a Nordic harmonisation on carbon neutrality. Such harmonisation presents a challenge, as the various Nordic countries are in very different phases of development of regulations. So far only Sweden has produced a regulatory proposal.

## Discussion and conclusions

The proposal in this report would imply that climate declarations cover the major part of buildings' climate impact from a life cycle perspective. Considering that the Nordic ministers of housing and construction in the Nordic Council of Ministers want to see a harmonisation of regulatory frameworks, it would be a natural measure to include additional parts of the life cycle in the next step, in line with the other Nordic countries. It would also be a natural way to proceed with gradually improving learning, knowledge and solutions around how future greenhouse gas emissions from buildings can be limited through sensible design choices.

Still, it needs to be pointed out that the mandatory inclusion of additional parts of a building's life cycle does not automatically mean that the regulatory framework for climate declarations will lead to further reductions in buildings' climate impact. The reason for this is that scenarios are needed in order to be able to calculate future climate impacts. Scenarios need to be clearly defined in order to make sure the method is sufficiently robust.

The proposal to introduce limit values in 2027 that only comprehend modules A1–A5 means focusing on **steering towards a reduction in climate impacts occurring today when new buildings are constructed, and which can be measured and verified** and are not regulated by any other means, e g in building regulations.

# Introduction

Boverket has been commissioned to propose a plan for the development of regulations on climate declarations that includes limit values. This commission is part of a larger commission – see Annex 1 for a full description of the commission. The commission on developing climate declarations is described as follows in the government decision[1]:

- Boverket will propose a plan for the continued development of climate declarations to include the entire life cycle and comprehend limit values for the climate impact of buildings. In carrying out the commission, Boverket needto consider, wherever feasible, the ambition for expanding Nordic cooperation with respect to procedures, methods, data and tools for carbon neutrality in the built environment, as stated in Reykjavik at the October 2019 meeting of Nordic ministers for construction and housing. A proposal for a plan for the continued development of climate declarations must be presented to the government (Ministry of Finance) by 12 June 2020.

## Implementation

A working group made up of engineers, lawyers, economists, experts and investigators have collaborated in producing this report. LCA experts Docent Tove Malmqvist Stigell and doctoral student Nicolas Francart at KTH Royal Institute of Technology, and senior researcher Martin Erlandsson at IVL Swedish Environmental Research Institute was comissioned for basis to the report.

A draft of the plan for the next step in introducing regulations on climate declarations was discussed at a hearing organised by Boverket in Stockholm on 22 January 2020. Participants were given the opportunity to contribute with comments spoken or written. Of the approximately 120 participants at the hearing, around 90 provided written opinions. Some of these were joint opinions from several actors. In the work with the roadmap, comments were also obtained on the government's referral regarding Boverket's report[2] with a proposal for a law on climate declarations. A considerable part of the plan is based on material from

[1] Government decision Fi2020/00758/BB, Fi2020/00941/BB.
[2] Rapport Klimatdeklaration av byggnader. Förslag på metod och regler. Slutrapport, rapport nr 2018:23, Boverket (Report no 2018:23, final report, climate declarations for buildings – proposal for a method and regulations).

KTH. The starting points as described below were also included in the commission to KTH.

## Limitations and starting points

The instructions for the commission from the government specify that the continued development of climate declarations is to encompass the entire life cycle and include limit values for the climate impact of buildings. Boverket's interpretation is that a **limit value** for the climate impact of buildings need not to necessarily comprehend the full life cycle of the building. By contrast, a **climate declaration** for a building should include the entire building's life cycle. Boverket's interpretation is further that all life cycle stages should be included, but that all modules need not necessarily be included in the climate declaration for a building.

This report includes a proposal for new regulations on limit values for climate emissions from buildings (administrative instrument) as well as a a proposal for increasing reporting requirements on the climate impact of a building under construction, compared with the draft regulations that is planned to come into force in 2022 (informational instrument). The term **limit value** is used primarily to denote the maximum allowable climate emissions, and the term **climate declaration** is used to denote mandatory reporting of climate impacts.

Boverket has had the following starting points in the investigation:

- The method shall complement to the government's proposal for a law and ordinance intended to enter into force on 1 January 2022.
- The method must, wherever feasible, be harmonised with the other Nordic countries' methods for climate calculations for buildings from a life cycle perspective.
- If possible, the method should be compatible with the proposal in the European Commission's Levels(s) reporting framework for the sustainability of buildings, where relevant.
- The method for calculation and reporting of the climate impact of buildings must comprehend the construction stage, the use stage, the end of life stage and possibly additional information in accordance with the European SS-EN 15978 standard on the environmental performance of buildings.
- A proposal for limit values for climate emissions from buildings must be included.

- A proposal for a suitable timetable for limit values must be included and be conceived such that the regulations have a timely effect, i e lead to reduced emissions of greenhouse gases from the construction sector in the construction of buildings, and contribute to the achievement of Sweden's climate target of no net emissions of greenhouse gases by 2045.
- Examine whether buildings as carbon sinks and groundworks should be included.
- Examine what is required in order to be able to set a limit value.

## How to read this report

This is a fairly extensive report which describes a roadmap as well as the method for calculating and reporting the climate impact of buildings. It therefore includes a rather detailed summary to describe important parts of the report.

The section **Background to the regulations on climate declarations** provides a description of regulations on climate declarations for buildings, to be introduced in 2022.

The section **Timetable for the introduction of limit values** presents a proposal for a timetable for when limit values can be introduced, as well as activities and measures that are required for the proposal to be implemented.

The section **Additional modules in climate declarations from 2027** describes the method for calculating and reporting the climate impact of buildings for additional modules and building elements, which in Boverket's proposal are to be added in the next step in climate declaration regulations. A more detailed description of the method can be found in Annex 2.

The section **Method for limit values** presents proposals concerning system boundaries and the formulation of limit values related to the climate declaration, as well as the principal grounds and tradeoffs involved. It also describes what measures are expected to be required in order to be able to introduce limit values.

# Background to the regulations on climate declarations

This section provides an overall description of requirements for climate declarations for buildings in construction, which are planned to be introduced on 1 January 2022[3]. The next step in regulations on climate declaration for buildings will complement the regulations that are planned to be introduced in January 2022.

## Why regulations on climate declarations for buildings

The new Climate Act (2017:720), which came into force on 1 January 2018, contains comprehensive provisions on the government's climate policy efforts. Under the Climate Act, the government must work towards reducing greenhouse gas emissions. Climate policy must be based on the long-term emissions target adopted by the parlament, which is that Sweden will have zero net emissions of greenhouse gases into the atmosphere by 2045. However, the Climate Act also stipulates that climate policy must be implemented in such a way that budget policy goals can also be achieved[4]. Sweden has the intention of being a leader in global efforts to realise the ambitious goals of the Paris Agreement[5]. The parlament therefore adopted a long-term emissions target for greenhouse gases which reads as follows:

> By 2045 Sweden will have zero net emissions of greenhouse gases into the atmosphere, after which negative emissions will be achieved. Supplementary methods may be included in order to achieve this. Emissions from activities carried out within Swedish territory must be at least 85 per cent lower than emissions in 1990.

The principal economic climate policy instruments that affect the construction stage are carbon taxes and the EU's system for trading in emissions rights, EU ETS. Both of these instruments are applied directly at the source of the emissions. There are also a number of other instruments that directly or indirectly affect climate emissions during a building's life cycle. Some of these instruments are presented in figure 1.

[3] In memorandum Ds 2020:4 the government proposed a new regulatory system for climate declarations, with a new law and ordinance on climate declarations for buildings. The memorandum is an early stage of the legislation process.
[4] Sections 1–3 of the Climate Act (2017:720) and Govt Bill 2016/17:146 A climate policy framework for Sweden.
[5] Govt Bill 2016/17:146.

Figure 1. Examples of policy instruments that directly or indirectly affect different modules in the life cycle stages of a building.

| MODULES | EXAMPLES OF POLICY INSTRUMENTS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CO2 tax | ETS EU emissions trading | Energy tax | Building and construction regulations | Building regulations section 9 | Building regulations section 6.6 | Building regulations section 6.7 | Alteration regulations PBL/ PBF/BBR | Energy declarations | Maintenance regulations in PBL | Extraction permit | Landfill tax | Planning and Building Act | Environmental Code |
| A1 Raw material supply | ● | | ● | | | | | | | | ● | | | |
| A2 Transport | ● | | ● | | | | | | | | | | | |
| A3 Manufacturing | ● | ● | ● | | | | | | | | | ● | | |
| A4 Transport | ● | | ● | | | | | | | | | | | |
| A5 Construction-installation process | ● | ● | ● | ● | | | | | | | | ● | | |
| B1 Use | | | | | | | ● | | | | | | | |
| B2 Maintenance | ● | | ● | | | | | | | (●) | | | | |
| B3 Repair | ● | ● | ● | | | | | ● | | | | ● | | |
| B4 Replacement | ● | ● | ● | | | | | ● | | | | ● | | |
| B5 Refurbishment | ● | ● | ● | | | | ● | ● | | | | ● | | |
| B6 Operational energy use | | ● | ● | | ● | | | | ● | | | | | |
| B7 Operational water use | | | | | | ● | | | | | | | | |
| C1 Deconstruction, demolition | | | | | | | | | | | | | | |
| C2 Transport | ● | | ● | | | | | | | | | | | |
| C3 Waste processing | | | | | | | | | | | | | | |
| C4 Disposal | | | | | | | | | | | | ● | | |
| D Benefits and loads | | | | | | | | | | | | | | |

All sectors, including the construction and real estate sector, have to contribute to the fulfilment of the long-term national emissions target for greenhouse gases. The construction and real estate sector's domestic emissions of greenhouse gases amount to approximately 12 million tonnes of $CO_2$ equivalents, and represent about one fifth of the Swedish climate impact. About a third of these emissions come from the

construction of new buildings and the demolition of old buildings. See figure 2 below.

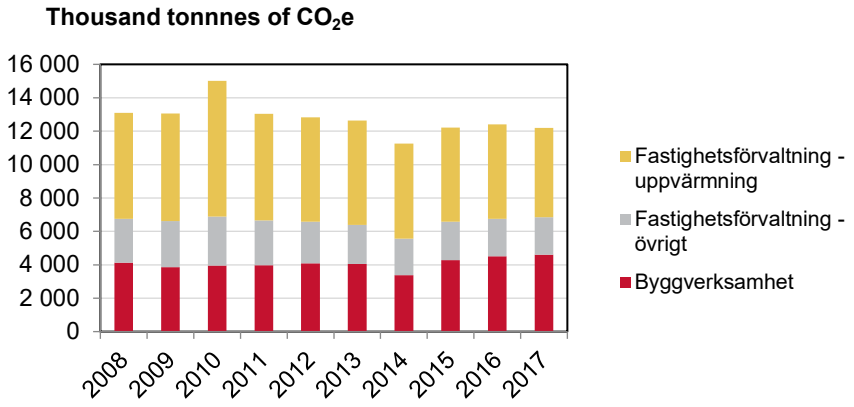


Figure 2. Domestic emissions of greenhouse gases from the construction and real estate sector, excluding imports. Climate declarations are steering above all towards reducing emissions from the construction of new buildings and from demolition (Byggverksamhet). Source: Boverket.

The biggest climate impact from buildings comes from material use in construction (modules A1–A3) and from operational energy use (module B6) in a life cycle perspective. See figure 3 below for an example of a life cycle analysis of climate impact.

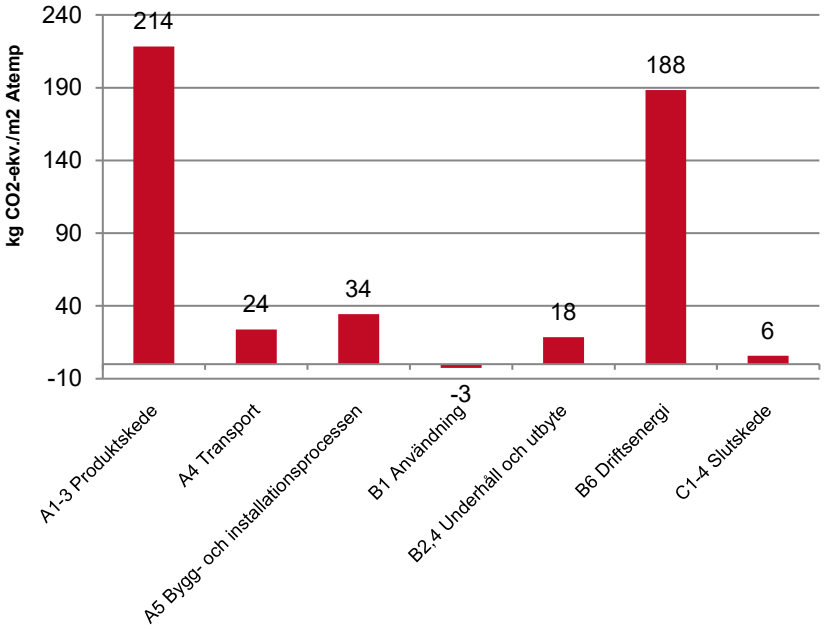


Figure 3. Example of a life cycle analysis of climate impact. Source: Malmqvist, T, Erlandsson, M, Francart, N, Kellner, J. (2018). Minskad klimatpåverkan från flerbostadshus – LCA av fem byggsystem. Source: IVL Report C 344. Stockholm: Sveriges Byggindustrier.

The construction of buildings impacts the climate to a considerable extent, and a faster transition towards lower emissions is required if Sweden's climate target is going to be met. Regulations on climate declarations are needed in order to accelerate the transition towards lower emissions from material use at the construction stage.

## Summary of regulations to be introduced in 2022

Introduction of a completely new regulatory system is planned for 2022, see figure 4. In parallel, work is in progress to draw up regulations at the various regulatory levels. The broader and more decisive regulations are placed at the statutory act level, governing e g who has to make the declaration, when it has to be made, and rules on registers. The government draws up the proposal for a statutory act and the parlament decides on its adoption.

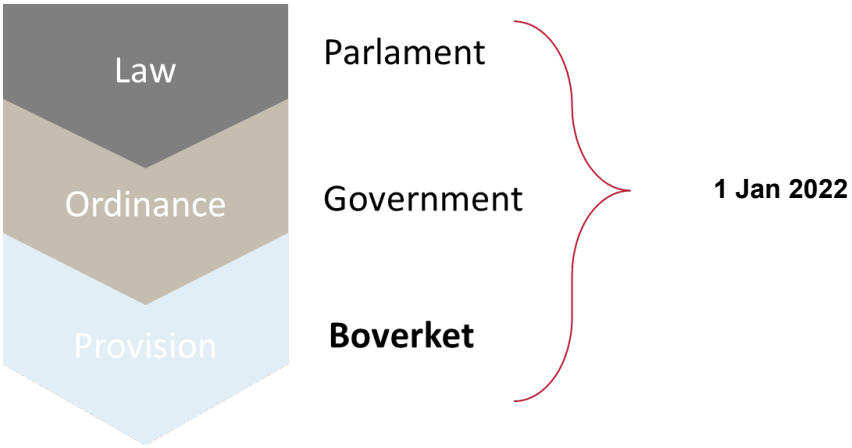


Figure 4. Introduction of a completely new regulatory system is planned for 1 January 2022.

An ordinance contains more detailed regulations, e g on which parts of the building are subject to the climate declaration requirement and which parts of the life cycle must be included in the climate declaration. The government decides on the adoption of proposed ordinances. Boverket can then issue even more detailed regulations in its provisions, e g which climate data is to be used when calculating climate impact. Boverket is empowered to decide on provisions that supplement the statutory act and ordinance.

Additionally, an amendment to Chapter 10, Section 34 of the Planning and Building Act (PBL) has been proposed. This would make a climate

declaration conditional before final clearance. If a developer has not submitted a climate declaration in connection with final clearance, the municipality can issue an interim final clearance until the declaration has been submitted to Boverket.

The government's proposed legislation in memorandum Ds 2020:4 Climate Declarations for Buildings means that when a new building is constructed its climate impact must be reported in a climate declaration. The purpose of the climate declaration is to reduce climate impacts in the construction of buildings by highlighting those impacts. The government's proposed law on climate declarations for buildings limits reporting on emissions to the construction stage, i e until the building is completed, see figure 6. The building elements proposed to be included in the report are load-bearing structures, the building envelope and interior walls. It is a limited part of a complete LCA, but it is still a major change for the construction sector to begin reporting these emissions.


Figure 6. The government's proposed law on climate declarations for buildings limits reporting on emissions to the construction stage, i e until the building is completed. See figure 9 for a more detailed description.

**The legislative proposal in brief:**

- A new law on climate declarations for buildings in construction is proposed to enter into force on 1 January 2022.
- The requirement for a climate declaration will apply for those seeking building permits on or after 1 January 2022.
- Certain buildings will be exempt from the climate declaration requirement[6].
- The developer is responsible for registering a climate declaration with Boverket and for presenting proof of this to the Building Committee before final clearance may be issued.
- The legislative proposal is based on the European SS-EN 15978 standard for the assessment of environmental performance of buildings.
- Climate impacts are to be calculated in kg of $CO_2$ equivalents per $m^2$ gross floor area.
- The developer must save the supporting documentation for the climate declaration for 5 years.
- Supervisory responsibility will be shared between the relevant municipality and Boverket.

### How things will work in 2022

The developer is proposed to assume responsibility for making and registering a climate declaration before final clearance can be issued by the municipality, see figure 7.

In order to draft a climate declaration, a summary of the materials and the energy and fuel use required to construct the building is needed. This is usually referred to as a bill of resources. The bill of resources should ideally be drawn up in connection with the financial calculation for the project. At the early stages of a project, approximate key indicators and experience-based values are sometimes used to estimate the amount of material needed, but often there is a construction cost calculation that

[6] Exempt buildings include temporary buildings intended to be used for a maximum of two years; industrial facilities and workshops; outbuildings in agriculture, forestry or similar; buildings with a gross floor area of less than 50 square metres. A developer who is a natural person and who constructs a building extraneous to their business activity will also be exempt from the requirement to make a climate declaration.

provides a useful summary of the resources intended to be used in the project.

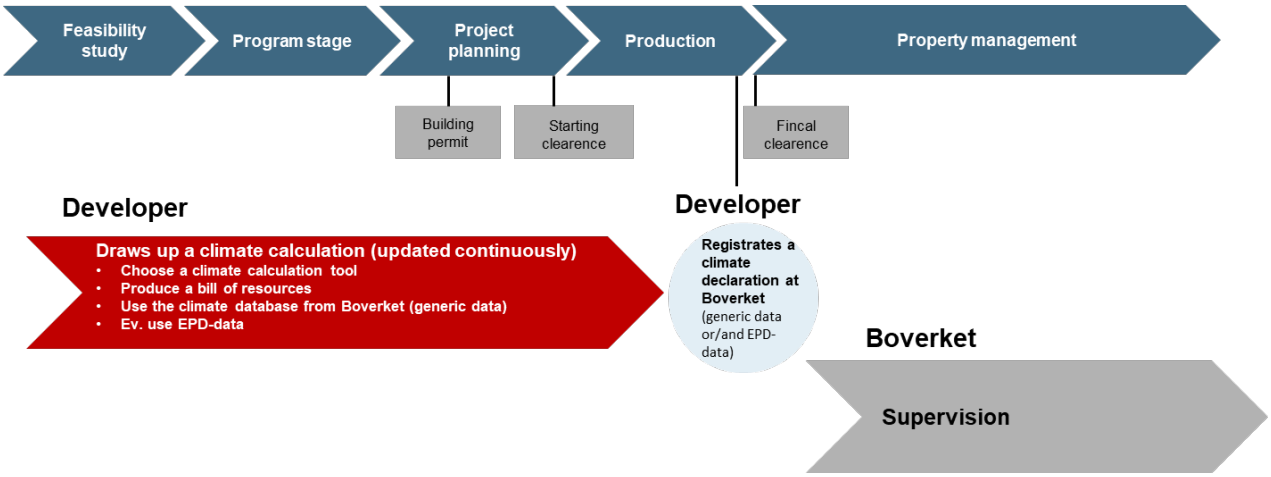


Figure 7. Flow chart describing the process for making a climate declaration and the actors responsible. The developer has responsibility for making and registering a climate declaration before final clearance can be issued by the municipality. Work on a climate declaration begins long before its registration, however – it is appropriate for a climate declaration to be made at an early stage of a construction project.

If the construction cost calculation program used does not automatically convert amounts to climate impacts for the different building elements, this will need to be done using a different tool capable of converting volumes of construction products into what are known as generic resources.

Once the bill of resources (energy and products specified in kg or kWh) is complete, the resources are then linked to various climate data so that the building's climate impact can be calculated by making a climate calculation. Climate data can be product specific or generic. In the early stages of a construction project it is not yet known what products will be included in the construction. The best option then is to use what is known as generic data, which means average figures. The generic data used must be representative of construction products in the Swedish market. Boverket will provide access to a database which is to be used if generic data are used in the climate declaration. At a later stage of the construction process, when it is known what products will be used, product specific data (Environmental Product Declarations, or EPDs) can be substituted for the generic data. This makes the climate impact calculation for the project in question more representative of the actual

building. If product specific data is not available for the selected construction products, generic data may be used in the final, registered climate declaration as well.

## Boverket's climate database

Boverket is in the process of developing a national climate database, the use of which Boverket proposes be made mandatory for climate declarations when generic data are used. The database is expected to be ready to use in the spring of 2021. It will be a database with generic climate data for construction products and energy, representative of Swedish conditions. The information in the database will be easily accessible and will be published in a digital format adapted to the needs of the industry. The database will contain the generic climate data needed to make a climate declaration.

# Timetable for the introduction of limit values

In this section a proposal for a timetable is presented for when limit values for climate emissions from buildings can be introduced. The proposal is based on the goal of stricter reductions on climate emissions contributing to the achievement of Sweden's climate targets. Activities and measures deemed necessary for implementing the proposal are also described. Overall grounds and considerations regarding times and the principal parts of the timetable are dealt with in this section, while more detailed considerations are dealt with in the sections "Additional modules in climate declarations from 2027" and "Method for limit values".

## Proposal for a timetable

Boverket proposes that limit values for climate emissions from buildings be introduced in 2027 for the construction stage (modules A1–A5) and then be lowered in two phases, until 2035 and 2043. The introduction of limit values and their subsequent lowering should be preceded by a thorough evaluation.

Changes to the climate declaration regulations concerning limit values are proposed for 2027, 2035 and 2043. Each regulatory change needs to be preceded by a thorough evaluation on which changes to the regulatory framework and lowering of limit values must be based. Evaluations should begin about three years before each regulatory change. See figure 8 below.

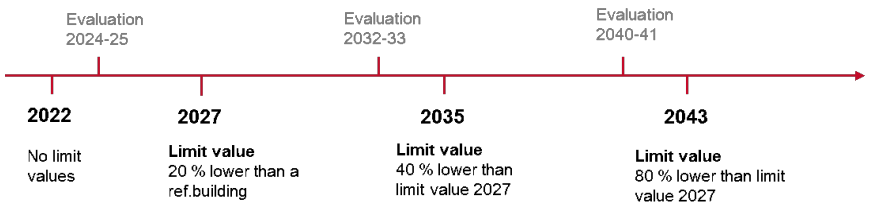


Figure 8. An appropriate date for the introduction of limit values is deemed 2027, followed by a downward adjustment of limit values in 2035 and 2043. Emission levels on which to base the 2027 limit values will be established using reference buildings. Read more in the section "Method for limit values".

## Grounds for the dates chosen for limit values

Limit values for climate emission for buildings are proposed to be introduced in 2027, for the construction stage (modules A1–A5) and for more building elements than in the proposed law to be introduced in 2022 – this in order to push further for the adoption of climate improving actions in design and construction. Another reason is to create the conditions for a shift towards construction with a net-zero climate impact, which will be necessary if Sweden's climate target is to be achieved. The proposal is to further lower the limit values in 2035 and again in 2043. Each regulatory changed should be preceded by a thorough evaluation, begun around three years before the projected changes. This will highlight effects and impacts as well as the need for changes and lowered limit values.

Simplicity has been a priority in Boverket's roadmap, which means avoiding overly frequent regulatory changes in order to facilitate matters for the construction industry. The timetable was drawn up to be in sync with the national climate target and with the construction sector's roadmap for climate neutrality[7]. The major change to the regulatory framework is proposed for 2027, with subsequent changes mainly involving further reductions and possible adjustments to limit values – and adjustments to the method if necessary.

### Introducing limit values in 2027 is reasonable

A reasonable date for introducing the next step in the regulation on climate declarations is deemed to be 2027. At that point the legislation will have been in place for five years and should be known and implemented by many developers. At Boverket's hearing on climate declarations, in January 2020, most of those who provided written comments considered it reasonable to introduce the next step in regulations on climate declarations in 2027, as there is also time to carry out an evaluation before then.

However, several actors have saidthat limit values should be introduced earlier, not least due to the urgency of the climate issue. Many companies have already begun carrying out calculations in accordance with the proposal for climate declarations. Several development projects are also underway in which various actors have initiated development of skills. This in order to carry out climate calculations and to find ways of using them for learning purposes at the design stage and in formulating requirements. In its roadmap for climate neutrality[8] the construction and

[7] https://byggforetagen.se/fardplan-2045/
[8] https://byggforetagen.se/fardplan-2045/

civil engineering sector has undertaken to declare the climate impact, from a life cycle perspective, of all buildings and constructions constructed from 2020 onward. This undertaking indicates that the sector has the ambition of developing skills and carrying out quality calculations in preparation for the introduction of climate declaration regulations in 2022. Considering, therefore, that future regulations are already having an effect in practice, and that leading companies have every possibility of anticipating events, Boverket's assessment is that the regulatory framework can be developed by 2027. It needs to be borne in mind, however, that these initiatives so far mainly involve knowledge development regarding the calculation methodology. Boverket's assessment is that additional measures are needed to encourage the implementation of climate improving measures and ensure that they really start being applied – and for that reason it is important to introduce limit values in the next step. In comments to Boverket's report with a proposal for legislation on climate declarations[9] as well as at Boverket's hearing in Stockholm in January 2020, there was broad agreement that limit values should be linked to climate declarations in order to make the regulatory framework a more powerful instrument.

Although several major actors will have experience of and expertise for carrying out similar calculations before 2027, as well as an understanding of how results should be interpreted, Boverket regards it as reasonable to wait with the introduction of limit values until then since the requirement will apply for **almost all buildings being constructed**. It would in principle be possible to introduce limit values earlier, but the proposal is rather to await the development of skills and capacity for carrying out calculations with **quality**, thus creating **better conditions** for the introduction of limit values. When limit values are introduced, their fulfilment should require some form of climate-improving measures in construction. Boverket's assessment is that access to data for installations will be sufficiently good by 2027 – and by also adding the other parts of the building, declarations are expected to be of a more even and comparable quality, which gives better conditions for the introduction of limit values. Boverket's assessment is also that by 2027 digitalisation will have advanced to a point that should make it easier to carry out calculations with a higher level of precision than is currently possible, even when essentially all building elements in the building are included.

[9] Report on Climate Declarations for Buildings. Proposal for a method and regulations. The final report, 2018:23, which the government sent for public consultation.

## Measures needed before limit values are introduced

Certain measure needs to be undertaken before regulations regarding limit values are introduced. This section describes those measures in general terms. Many of the measures will likely need to be undertaken by Boverket, which is already tasked with facilitating the introduction of requirements for climate declarations from 2022. Boverket has also been commissioned to develop and manage a climate database, produce information and guidance, and draw up provisions for the legislation due to come into force in 2022.

### Method review

A review and potential adjustment of the method presented in this report will be necessary for calculations of the additional life cycle stages, the building, and other information which the proposal would make mandatory in 2027. This is necessary for the updating of the law, ordinance and provisions before that time, and in this connection adjustments should also be made, if possible, towards further harmonisation with other Nordic regulatory frameworks, the European Commission's Level(s) framework, and the European SS-EN 15978 standard for the environmental performance of buildings.

### Further data needs to be added to the database

The "Background" section describes Boverket's commission to develop a climate database in preparation for the climate declaration regulations proposed for 2022. On the basis of the proposal in this report, Boverket's climate database will need to be augmented with additional data as the entire life cycle will be included in climate declarations as well as additional building elements. Development of the database comprises generic data as well as scenarios and default data. These are described in brief below.

#### Development of additional generic data

- Generic data for materials and components for **additional mandatory building element**s from 2027 need to be produced and added to the national climate database.
- Data on **biogenic carbon storage** (measured as GWP-GHG) in wood-based materials and products included in the national climate database need to be collected and made available in the climate database.

#### Develoment of national scenarios

To allow for climate declarations to be made in a consistent manner and with similar assumptions, a series of national scenarios need to be

developed. These are needed in order for developers of climate calculation programs to be able to include calculations of the use stage (the B modules) and the end of life stage (the C modules). Scenarios that need to be made available in the national climate database include:

- Scenarios for technical service life and maintenance intervals for the materials and components included in the national climate database, which are needed for calculations of maintenance (module B2) and replacement (module B4).
- Climate data on future emissions of greenhouse gases from district heating, electricity and any other relevant energy vectors are needed for calculation of operational energy use (module B6). Such climate data must be based on a national scenario for the development of Sweden's energy system in line with the national climate target (similar to what has been done in Finland and Denmark).
- Scenarios in the form of climate data on different methods of processing waste products as currently done, which are needed for calculations of waste processing (module C3) and disposal (module C4).
- Scenarios for how the materials/components included in the national climate database are handled in current practice regarding waste management in the industry (i e categorising them according to the different waste processing methods above), which are needed for calculations of waste processing (module C3) and disposal (module C4).

#### Development of default values

In order to facilitate calculations of additional building elements beginning in 2027, it is recommended that a number of default values be developed. The following should be made available in the national climate database:

- a default value that covers the entire "Interior surface finishes and room fittings"
- depending on the availability of data, possibly also one or two default values to cover the entire building element
- default values for calculation of de-construction, demolition (module C1) and transport (module C2) should be reviewed and updated as necessary.

### Evaluation prior to introduction of limit values

The first evaluation, proposed for 2024–2025, needs to consider a number of important questions, such as:

- Has method practice reached a stage of maturity where declarations can be based on actual purchased products and quantities?
- Is the calculation basis, which has to e presented in the event of a random check sufficient to check quality, or should it be a full cost calculation in order to ensure the quality of climate impact calculations?
- How effective and qualitative are digitalised calculations? Is it administratively feasible to expand requirements for mandatory parts in climate declarations?
- What quality deficiencies do submitted declarations have? Are they of sufficient quality? Or does the introduction of requirements for certified declaration experts – or some other means of ensuring that declarations are of sufficient quality – need to be considered?
- Is there are need for adjustments to the regulatory framework for climate declarations due to EU law (the Construction Products Regulation, the Energy Performance of Buildings Directive) or possible revisions of the European standards on which the climate declaration methodology is based (SS-EN 15978 and SS-EN 15804), or the European Commission's Level(s) framework?

### Evaluation of the effect of limit values

Evaluations should be carried out before the limit value reductions as proposed in the timetable. This involves evaluating the effect of the regulatory framework and the possibility of lowering the limit values according to the proposed timetable. The following aspects are particularly important before the first proposed reduction, in 2035:

- As the proposal is only to include the construction stage (modules A1–A5) from 2027, it is important to evaluate – before the limit value reduction in 2035 – whether a differentiation of limit values may be necessary. This particularly in order not to disadvantage net-zero and energy-plus buildings or flexible/adaptive design strategies.
- Future reductions in limit values should be preceded by evaluations of consequences and undesired effects such as conflicts with other performance requirements in building regulations.

# Additional modules in climate declarations from 2027

This section describes the method for calculating and reporting the climate impact of buildings for the additional modules and building elements that Boverket's proposal would include in the next step of the development of climate declaration regulations. These are modules beyond the construction stage A1–A5, which has already been described in the government's legislative proposal[10] and Boverket's report[11]. A more detailed description can be found in Annex 2. For a summary of the system boundaries for climate declarations of buildings and limit values, see Table 1 below.

Table 1. Summary of system boundaries in climate according to the government's proposal for regulations to be introduced in 2022 and Boverket's proposal for the next regulatory step, in 2027.

| **Year** | **2022** | **2027** |
|---|---|---|
| **Limit value** | No limit value | Limit value covering A1–A5 |
| **Modules to be declared** | A1–A5 | A1–A5, B2, B4, B6, C1–4, supplementary environmental information – biogenic carbon storage and net export of locally produced electricity |
| **Building elements** | • Load-bearing structures<br>• Building envelope<br>• Interior walls | • Load-bearing structures<br>• Building envelope<br>• Interior walls<br>• Installations<br>• Interior surface finishes<br>• Room fittings |
| **Referens study period** | – | 50 years |

[10] In Ds 2020:4 the government proposed a new regulatory system for climate declarations – a new law and ordinance on climate declarations for buildings.
[11] The report Climate Declarations for Buildings. Proposal for a method and regulations. The final report, 2018:23, Boverket.

## Proposal of additional modules in a building's life cycle

Boverket proposes that the additional modules in a building's life cycle to become mandatory in declarations from 2027 should be modules B2, B4 and B6 at the use stage, C1–C4 at the end of life stage, as well as supplymentary environmental information, biogenic carbon storage, and net exports of locally produced electricity. See figure 9 below.

| Building Life Cycle Information | | | | | | | | | | | | | | | Supplymentary information |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A 1–3 Product stage | | | A 4–5 Construction process stage | | B 1–7 Use stage | | | | | | | C 1–4 End of life stage | | | | Supplementary environmental info |
| A1 – Raw material supply | A2 – Transport | A3 – Manufacturing | A4 – Transport | A5 – Construction-installation process | B1 – Use | B2 – Maintenance | B3 – Repair | B4 – Replacement | B5 – Refurbishment | B6 – Operational energy use | B7 – Operational water use | C1 – De-construction, demolition | C2 – Transport | C3 – Waste processing | C4 – Disposal | Biogenic carbon storage<br>Net exports of locally produced electricity |

Figure 9. Proposal for which additional modules in the life cycle should be made mandatory in the next step, if development of the instrument proceeds in accordance with the proposal in this report. Green indicates modules that are included in the regulations from 2022. Orange indicates modules suggested for inclusion in the regulations from 2027.

### Grounds for the choice of additional modules

These additional modules were selected on the following grounds. In order to cover an entire life cycle, modules based on SS-EN 15978 are included from the use stage as well as the end of life stage. For the use stage, priority modules are those that normally represent a major share of the climate impact in similar life cycle analyses: replacement (module B4) and operational energy use (module B6). The distinction between replacement (module B4) and maintenance (module B2) is not clear from the EU standard, for which reason Boverket suggests that planned periodic maintenance (module B2) also be included. These are also the modules included in similar methods in the Nordic and other European countries, and for which there are also fairly established and robust methods for drawing up scenarios in the calculations. The proposal

includes the entire end of life stage (modules C1–C4) as this may lead to some extent towards the use of more advanced methods of recycling and reuse, i e the promotion of circular construction methods. Calculation of these additional parts is not expected to be particularly time-consuming if Boverket provides the scenario data to be used. Again, this follows the approach of planned regulations in Finland and Denmark, for example. When greenhouse gas emissions are calculated for the use stage, a referens study period needs to be assigned. Boverket proposes that the referens study period be set at 50 years, which would harmonise with most Nordic and other European countries as well as with what looks likely to be implemented in the European Commission's Level(s)[12] framework.

Boverket further proposes that a separate declaration of biogenic carbon storage in wood-based products be made mandatory as part of supplymentary environmental information. This will then effectively be a report on the building's positive climate impact and is also deemed potentially to provide valuable statistical information to be used in connection with follow-ups of the national climate target. Similarly, net exports of locally produced electricity to the grid should also be declared as supplementary environmental information.

### More about the use stage (modules B1–B7)

The distinctions between what is meant to be included in modules B2–B5 are not clear in the SS-EN 15978 standard, which allows for many different interpretations of the individual modules in LCA studies and methods from different countries. It is important, therefore, that a methodology description for climate declarations provides clearer detail about what is to be included. It is possible that a future revision of SS-EN 15978 will make the distinctions clearer, but at the current time the proposal is for modules B2 and B4 to be included – and how they are to be calculated therefore needs to specified in greater detail.

Repair (module B3) includes repair of damaged components in order to restore them to their expected performance level (e g replacing a windowpane in a broken window). This is easily confused with maintenance in module B2 and is very difficult to draw up realistic scenarios for as this involves tricky predictions. Including repair (module B3) would require more detailed construction damage statistics than what is currently available. This means that the calculation methods for this

[12] The European Commission's reporting framework for sustainability indicators for buildings.

module are not robust enough to justify its inclusion in the regulatory framework.

Refurbishment (module B5) includes major changes in the form of renovation and refurbishment, e g of the design, building envelope, or technical systems that lead to a change in the building's performance or function. With a long reference study period (over 50 years at least) it is usually argued that refurbishments should be included in life cycle analyses[13]. With a referens study period of 50 years, which is common, and which is proposed here, Boverket assumes that a major performance-enhancing refurbishment will occur after the referens study period period. The climate impact of such a refurbishment can then be seen as initiating the building's "next life cycle". It is very difficult to judge the need for refurbishments for other reasons when the building is constructed. SS-EN 15978 recommends that operational energy use (module B6) have a system boundary that matches the Energy Performance of Buildings Directive (EPBD) and its national implementation. This means that the system boundary should match the definitions used in a member state's energy requirements for construction. The energy management requirements in PBL would thus be the basis on which climate emissions were determined. Operational water use (module B7) is assessed not to be relevant.

Use (module B1) concerns the environmental impact connected with the use of the building. This might involve climate emissions as a result of the use of refrigerants in various installations in the building, or emissions from painted surfaces. So far practice in academia and in the industry is limited in terms of including this in building LCAs. For structures in concrete the effect of carbonatation of concrete during the use stage can also be included here, which has been done in some studies in Sweden (e g Erlandssson et al, 2018[14]). In buildings this positive effect is typically very small, and Boverket's hearing in January this year yielded no strongly expressed wishes that this be included in the next step of climate declarations. Nor has the concrete industry insisted that including this in climate calculations should be a priority.

[13] Häkkinen, T. (2017). Sustainability and performance assessment and benchmarking of buildings. Final report. https://www.vtt.fi/inf/pdf/technology/2012/T72.pdf

[14] Erlandsson, M., Malmqvist, T., Francart, N., & Kellner, J. (2018). Minskad klimatpåverkan från nybyggda flerbostadshus – LCA av fem byggsystem. Decision guidance report. https://www.ivl.se/download/18.72aeb1b0166c003cd0d1d5/1542035270063/C350.pdf

### More about the end of life stage (modules C1–C4)

The end of life stage (stage C) usually represents a relatively small share of a building's climate impact over its life cycle, despite calculations taking current techniques of e g transport and waste processing into account. Exclusion of the end of life stage could be considered, but it can also be seen as a way of drawing some attention to increased circularity in construction and also constitutes a harmonisation with other Nordic countries and developments in Europe. The proposal is therefore to include the end of life stage from 2027.

### More about Benefits and loads beyond system boundaries (module D)

Module D, **Benefits and loads beyond system boundaries** is included as additional information in the European standard for environmental performance of buildings, SS-EN 15978. Calculated values in module D cannot, and should not, be compared with or added to modules A–C. Module D can provide information that is of interest for future circular construction, as it indicates which recycling option is most beneficial for different materials as they are removed from the building as waste. For example, module D can be used to calculate what the positive effects are of energy recovery from wood as a fuel, depending on what fuel it is assumed to be replacing. In the same way, the climate benefit of recycled metals can be calculated, which depends on how much primary material the recycling is assumed to replace, and where the outcome depends on what manufacturing process was chosen for the replaced metal. In general, calculations in module D produce the same recommendations as in following the EU's waste hierarchy. Experience also show that requiring such calculations can be a driver of costs. Requiring these calculations therefore risks increasing the cost of the declaration without adding much in the way of decision guidance.

However, in Finland[15] an **expanded** version of additional information has been proposed. This is known as a "carbon handprint" and consists of module D (including periodisation of the remaining service life of components with remaining life after the reference study), biogenic carbon storage, and net surplus

of locally produced energy. The purpose is also for this "handprint" to provide the opportunity to declare positive effects (not just negative climate impacts as in the rest of the declaration). Boverket proposes the introduction of a similar approach in 2027 by means of a mandatory

[15] Finnish Ministry of the Environment. (2019). Method for the whole life carbon assessment of buildings. https://julkaisut.valtioneuvosto.fi/handle/10024/161796

declaration of biogenic carbon storage and net exports of locally produced electricity.

## Proposed referens study period

Boverket proposes a 50-year referens study period for the climate calculation, which harmonises with most Nordic and other European countries as well as with what looks likely to be applied in the European Commission's Level(s) framework.

### Grounds for the referens study period

When calculating greenhouse gas emissions for the use stage (modules in stage B), a calculation period needs to be set – this is sometimes also called the reference study period or analysis period. It is important to underline that the reference study period is precisely the delimited period of time for which the calculations are made. This is not the same thing as the expected technical service life of the building. As buildings often have long service life compared with other consumer products, for instance, scenarios need to be developed that describes a very distant future. In the development of LCA methodology for buildings, e g within the context of certification systems, a practice has therefore gradually developed in academia and the industry that usually sets the referens study period at 50–60 years. This reference study period is used precisely to estimate climate impacts related to maintenance measures, replacement of building elements, and operational energy use. The fact that such a relatively fixed reference study period of 50–60 years is common practice is partly a reflection of the consideration that scenarios about emissions linked to production methods that far into the future are inevitably very uncertain, and that they become increasingly uncertain the longer the reference study period is. It is also the horizon that existing regulatory frameworks for durability requirements are based on, i e those that apply for the design and load dimensioning of building elements that cannot be replaced.

### Does a 50-year referens study period involve risks

There was earlier a major concern that setting such a relatively short referens study period might risk disadvantaging the use of construction products with long service life. However, there are no documented studies showing that the application of LCA in design has had any such consequences. Durability and dimensioning requirements included in Boverket's building and construction regulations counteract any such risk. A referens study period of 50 years also takes account of the fact that buildings normally require fairly extensive refurbishment after that

period of time. The 50-year timespan can then be seen as a representative period, corresponding to the length of time until a building undergoes a more comprehensive and performance-enhancing refurbishment. A longer period would reasonably require that the methodology also include resource use in relation to factors that are not part of normal operation and maintenance, such as rebar corrosion and biodegradation of the frame. At present there are no established methods for including this in regular life cycle calculations for buildings.

### Experiences from longer referens study periods

The European standard for environmental performance of buildings, SS-EN 15978, does not set a fixed referens study period, suggesting instead the use of expected service life in calculations, which the client will set. That was the suggestion that Denmark tried to follow in drawing up the country's adaptation of the German DGNB (the German abbreviation for the German Sustainable Building Council) system, where reference study periods of up to 80 or even 120 years had previously been permitted. However, the Danish experience provides clear examples of other complications when using a longer reference study period. Some construction products, such as solar cells and windows, will then represent a disproportionately large share of the calculated climate impact over the life cycle because they need to be replaced several times. Considering the rate of technological development of construction products such as solar cells, it is unreasonable to factor in current climate impacts from production of materials 60 years into the future, which remains current practice in academia and the industry for such analyses. Boverket's assessment is that it is not appropriate to have reference study period that goes beyond 50 years.

## Choice of additional building elements and processes

Boverket proposes that climate declarations be expanded in 2027 to cover additional building elements, such that installations, interior surface finishes and fitments are also included. This means that from 2027 a climate declaration will constitute a more complete representation of a building. Boverket also proposes that there should be default data for interior surface finishes and fitments.

#### Grounds for additional building elements

The assessment is that by adding more building elements to climate declarations, a more comparable quality will be obtained for climate declarations overall. This creates better conditions for the introduction of

limit values. Boverket's assessment is further that access to climate data for installations will be good enough by 2027, and that digitalisation will have reached a point where calculations can be carried out easily as essentially all building elements in the building will be included. Boverket also proposes that a default value be available for interior surface finishes and fitments to facilitate matters for smaller actors.

Installations can represent a considerable share of a building's climate impact. Birgisdottir et al (2017)[16] indicate that this share ranges from 18 to 46 per cent, where higher climate impacts apply above all to net-zero or net-positive energy buildings with a large number of solar cells. The general trend is for increasing numbers of installations in buildings, so this is seen as an important part to add – as advocated by many participants at Boverket's hearing in January 2020 and in public consultations. Including installations is also expected to increase the focus on recycling in this area. Finally, it also constitutes a harmonisation with how the issue is managed through similar methods in the other Nordic countries.

#### Building elements need to be specified

Due to the fact that installations, interior surface finishes and fitments should be included in declarations in 2027, the term "installations" should be defined more precisely, as the term is vague and likely to be interpreted in different ways in different methods and LCAs. At a minimum, installations must include heating, water, sanitations, electricity, lifts, and installations for local production of electricity (such as solar cells). Heat pumps should be included if district heating substations are also included.

#### Risk of certain installations being disadvantaged over time

Boverket's assessment is that it is important to include installations for local electricity production as it is important to highlight that such production has a relatively large climate impact. However, this means that such installations will potentially be disadvantaged as the proposal only imposes limit values – at least initially – on modules A1–A5. This is a minor problem until 2035, when the proposal is to lower limit values, but this potential steering effect should be taken into account. The alternative is to exclude installations for local electricity production from the calculation, but this would also imply the exclusion of local electricity

[16] Birgisdottir, H., Moncaster, A., Wiberg, A. H., Chae, C., Yokoyama, K., Balouktsi, M., … Malmqvist, T. (2017). IEA EBC annex 57 evaluation of embodied energy and CO2eq for building construction. Energy and Buildings, 154, 72–80. https://doi.org/10.1016/j.enbuild.2017.08.030

production from mandatory declarations of operational energy use (module B6). If operational energy use were not be included in the mandatory declaration, then climate impacts of energy producing units on the building should not be included in modules A1–A5 either. But even if this is done, façade and roof-integrated solar cells will already be included in climate declarations from 2022 and could then be disadvantaged. This is not particularly common thus far, but could of course increase in the future.

#### Climate data on installations is needed

In the past installations have often been overlooked in LCAs of buildings, due to a shortage of data. Generic climate data for various types of installations need to be developed and made available in the national climate database. Generic data will likely only be used in the short term, but the aim is to encourage the development and use of specific data on installations in the future in order to provide a stimulus for climate improving measures in this area. Another possibility to consider is the development of a default value in the form of an overall value in kilograms of carbon dioxide equivalents per square metre of gross floor area (kg $CO_2e/m^2$ GFA) for all installations. The same applies for interior surface finishes and room fittings. It is seen as important to be able to provide a reasonably conservative default value in order not to increase the time required to make the declaration, even if this should not imply any large amount of extra work considering the digitalised calculations which are expected to dominate by 2027.

#### Should groundworks be included in climate declarations?

Boverket has also looked at whether groundworks should be added to the regulations about climate declarations for buildings. Under some circumstances, groundworks can represent a considerable share of the climate impact at construction stage, and for this reason it could be argued that they should be included in order to encourage improvements and developments in technology and working methods in these areas.

One reason for not including groundworks in climate declarations is that this would facilitate matters for producers of single-family houses. The climate impact of groundworks is determined by where the buildings are located. Another important aspect to consider, if groundworks are going to be included, is whether this can discourage construction in certain areas – such as former industrial estates – where groundworks could contribute to significant climate emissions, but where construction might be advantageous for other reasons.

The distinction between what constitutes groundworks and what does not is sometimes difficult to make. Other Nordic countries and France include groundworks in their assessments, but so far do not include them in limit values. The most likely outcome is that they will not be included in future limit values, and it appears as if this will also be the case in the Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö[17]. Both groundworks and garages have to do with urban planning, and it might be a good idea to be consistent and deal with these two in the same way in declarations. What, in terms of groundworks, it is appropriate to deal with in the planning process and in the construction process, respectively, is something that needs to be examined in greater detail. Are climate declarations for buildings the right instrument for driving developments towards reduced climate impacts from groundworks? Any negative consequences for housing construction need to be weighed against the magnitude of emissions reductions that may be possible to achieve. Boverket has not had time to compile sufficient documentation to be able to make a proposal; instead it is noted that this needs to be examined further.

[17] Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö. www.lmf30.se

# Method for limit values

This section presents proposals concerning system boundaries and the setting of limit values for greenhouse gas emissions in connection with climate declarations. It also describes principal grounds for the introduction of limit values, considerations and actions judged to be required in order to be able to realise their introduction. The introduction of limit values puts higher demands on the methodology for climate calculations than if the instrument were purely informational, i e a climate declaration. For limit values the method must provide comparable and replicable results with an acceptable level of uncertainty, considering the fact that sanctions will be linked to the requirement.

Boverket proposes that:

- Limit values for climate emission for buildings be included for the construction stage (modules A1–A5) from 2027.
- Limit values comprehend more complete buildings from 2027 compared with when the declaration requirement is introduced in 2022. Additional building elements to be included are installations, interior surface finishes and room fittings.
- Limit values be differentiated for single-family houses, multi-dwelling blocks and non-residential premises.
- The level for limit values in 2027 be set to achieve 20–30 per cent 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 be made in 2035 and 2043, with the aim that they be 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.

In the public consultation on Boverket's report[18] as well as at Boverket's hearing in Stockholm in January 2020 there was broad agreement that limit values should be linked to climate declarations in order to make the regulatory framework a more powerful instrument. The importance of benchmarking has long been discussed in this area, in order to drive design and construction towards low climate impacts. But it has not been until now, when a simplified life cycle analysis has begun to be introduced in practice, that the importance of reference values and requirement levels has begun to be discussed in the context of procurement criteria, for example.

Reference values have been used for several years in the German environmental certification system for buildings, DGNB[19]. Switzerland was also early in adopting similar values in its roadmap, the SIA Efficiency Path[20]. And the Netherlands introduced limit values connected with requirements for LCAs as early as in 2018. In France, whose regulatory framework is currently being revised, limit values have been part of a pilot phase for the new framework. Still, it is important to note that there is currently no single country whose legislation has more stringent requirements, or where an evaluation has yet been made of how limit values for climate impacts can influence and drive the construction and design of buildings.

The following section presents the individual proposals as well as the grounds they are based on and a discussion.

## System boundaries for limit values

### The limit value comprehends the construction stage, modules A1–A5

Boverket proposes that limit values for climate emissions from buildings in 2027 comprehend climate impacts from the construction stage (modules A1–A5).

Before a reduction of limit values in 2035, an evaluation should identify any negative consequences of the boundaries for limit values. If there are

[18] Rapport Klimatdeklaration av byggnader. Förslag på metod och regler. Slutrapport, rapport nr 2018:23, Boverket (Report no 2018:23, final report, climate declarations for buildings – proposal for a method and regulations).
[19] https://www.dgnb.de/en/
[20] https://www.amstein-walthert.ch/en/services/2000-watt-society/sia-energy-efficiency-path-sia-2040/

compelling reasons, a revision of the system boundaries for limit values may be carried out.

**Grounds for restricting limit values to A1−A5**

There are a number of reasons for restricting limit values to the construction stage (modules A1–A5). Judging from comments on Boverket's report[21] and comments expressed at Boverket's hearing in January 2020, the proposal for climate declarations to be introduced 2022 appears to have been positivly received. Many participants at the hearing commented that it may be reasonable to have limit values only for the construction stage, at least initially. Several people pointed at the importance of evaluation of the effects and consequences progressively. Focusing on the construction stage, i e modules A1–A5 (raw material supply at the product stage, transport at the product stage, manufacturing at the product stage, transport at the construction process stage, the construction and installation process at the construction process stage), means a more tightly focused steering towards reducing greenhouse gas emissions occurring today. It is also possible to verify these emissions, as opposed to calculations of future emissions. What this means is that it focuses on reducing current emissions and not on rating these as equivalent to potential emissions that lie several decades into the future and are harder to evaluate. Finally, emissions at the construction stage currently represent a large share of climate impacting emissions across a building's life cycle.

The way calculation methods for life cycle analyses currently work does not mean that including additional parts of the life cycle in the limit value is guaranteed to drive developments towards increased measures to reduce climate change. The reason for this is that the scenarios for future emissions used in the calculation must be made in a regulated and standardised way. This in order to ensure that buildings do not meet limit values simply because of subjective scenarios, which are impossible to verify and costly for a supervisory authority to oversee. Moreover, if scenarios for the use and end of life stages are stringently regulated, potential climate-improving project design choices made will not be clearly visible in the calculation. The approach in some of the other Nordic countries, however, is to have a limit value that covers the entire life cycle. But this does not lead to the same focused steering to reduce current emissions as limit value only for the construction stage does. The

[21] Rapport Klimatdeklaration av byggnader. Förslag på metod och regler. Slutrapport, rapport nr 2018:23, Boverket (Report no 2018:23, final report, climate declarations for buildings – proposal for a method and regulations).

more parts of the life cycle that are included in the calculation, the more "diluted" the calculation becomes, as pointed out by Hollberg (2019)[22], for example. What this means is that if a limit value is set for the entire life cycle, in kilograms of carbon dioxide equivalents per square metre of gross floor area (kg $CO_2e/m^2$ BTA), the steering is lower towards measures to reduce climate impact in modules A1–A5, for example, it will become less "visible" in the calculation outcome.This is the reason why several methods that include limit or reference values have several values rather than a single value – usually one value related to material flows (embodied environmental impact) and a separate value for operational energy use (module B6). In the Swedish context, if a "dynamic" scenario for operational energy use (module B6) is applied – as is suggested here – operational energy use (module B6) will generally not dominate climate impacts over the course of the building's life cycle. This has historically been the case in similar LCA calculations and is still the case in many other countries in Europe.

#### Is there are risk of sub-optimisation

What is often cited as the main purpose of including the entire life cycle in the limit value is the avoidance of sub-optimisations in construction. This is mainly about whether a singular focus on the climate impact of the construction stage risks leading to noactions that could lead to future reductions in climate impact and resource use. One example is local energy production (solar cells) that reduces the need for purchased energy; another is design and component/product choices that go further than the performance and durability requirements for buildings laid down in building legislation. The risk of sub-optimisation is currently judged to be fairly low, as there are other regulatory frameworks that govern these issues, but future reductions of limit values should be preceded by evaluations of possible negative consequences of restricting limit values to parts of the life cycle, and any necessary adjustments can be made in 2035.

At the present time it is not possible to foresee consequences of proposed future reductions to limit values in terms of other qualities and functions that are essential for buildings. There are also other regulatory frameworks that govern these matters, but it is of course very important

[22] Hollberg, A, Lützkendorf, T, Habert, G. (2019). Top-down or bottom-up? – How environmental benchmarks can support the design process. Building and Environment 153 (2019) 148–157. https://doi.org/10.1016/j.buildenv.2019.02.026

to continuously evaluate consequences and any undesired driving effects of making regulations more stringent.

#### How to deal with the possibility of some measures being disadvantaged

Simplicity in the regulatory framework has been a goal, and the proposal is for the same system boundaries to apply in future regulatory changes. Depending on the state of knowledge and what the evaluation prior to lowering limit values in 2035 shows, a differentiation of limit values may be considered in order to reduce the risk that the system boundaries of the limit values (module A1–A5) lead towards a disadvantaging of solar cells as well as flexible and adaptive design strategies. The risk that a limit value restricted to modules A1–A5 would discourage a development towards low-energy and passive houses is considered to be low as additional climate impacts of materials in the building envelope are assessed to be low compared with building according to existing energy requirements in BBR (see Erlandsson and Peterson, 2015).

### Special considerations regarding operational energy use (module B6)

Boverket proposes that limit values in 2027 do not include operational energy use (module B6), but that reporting climate emissions from operational energy use be made mandatory in the climate declaration (see also the section "Additional modules in the climate declaration from 2027").

#### Grounds for not including operational energy use (module B6) in the limit value

The product stage (modules A1–A3) and operational energy use (module B6) cause the biggest emissions of greenhouse gases during the life cycle of a building (see figure 3 in the section "Background to the regulations on climate declarations"). For that reason Boverket has devoted special consideration to whether operational energy use at the use stage should in fact be included in the requirement for a maximum permissible climate impact when a limit value is introduced. There are arguments both for and against this.

Arguments **against** adding operational energy use include the fact that energy management requirements in the Planning and Building Act (abbreviated PBL in Swedish) already steer, albeit indirectly, towards reduced climate impacts[23]. There are also other instruments that limit

[23]Chapter 8, Section 4, item 6 of the Planning and Building Act (2010:900), PBL; Chapter 3, Section 14 of the Planning and Building Ordinance (2011:338), PBF; and section 9

emissions from energy use, including financial instruments such as energy tax and the EU's emissions trading system. This makes it possible not to include this module in the limit value and thus simplify the regulatory framework for climate declarations, which may be advantageous to developers. Also, if operational energy use is included in the limit value, climate declarations and the energy management requirements in PBL would have different approaches regarding the developer's choice of heating systems. If the emissions factors used for different energy carriers to calculate climate emissions from module B6 in the climate declaration differ from each other, this could influence the developer's choice of heating system, e g the choice between district heating and various heat pump solutions. In proposals for changes to the energy management requirements, the basis is instead that the requirements should contribute to technology neutrality between sustainable heating systems – in other words, the ambition is to minimise the steering of the developer's choice of heating system, unless it is fossil fuel-based[24]. The emissions factors used in climate declarations would additionally need to be based on uncertain scenarios about future emissions. A further point to add is that scenarios about the future can also be calculated in different ways.

Arguments **for** adding operational energy use in the limit value include, as mentioned earlier, the fact that module B6 – along with modules A1–A3 at the product stage – causes the biggest emissions of greenhouse gases during the life cycle of a building. Including operational energy use would also highlight the benefit of measures such as heat insulation and local production of energy, which reduce operational energy use but which at the same time cause increased emissions at the construction stage. If operational energy use is not included, only the emissions they

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Energy Management in Boverket's building regulations (2011:6) – provisions and general recommendations, BBR.

[24] Changes to the energy management requirements in PBF and BBR are planned for the autumn of 2020. See the government's memorandum *Byggnaders energiprestanda – förslag på ändringar i plan- och byggförordningen, som redogör för de ändringar i PBF (2011:338) som följde av ställningstagandena i regeringens skrivelse Byggnaders energiprestanda* (Communication 2018/19:152). See also Boverket's public consultation: https://www.boverket.se/sv/lag--ratt/boverkets-remisser/aldre-remisser/remiss-forslag-till-andring-av-boverkets-byggregler-20116--foreskrifter-och-allmanna-rad-bfs-2020xx/. Among the proposed changes is a shift from calculating energy performance expressed as primary energy in what are known as weighting factors instead of primary energy factors. The weighting factors are intended to contribute to technology neutrality between sustainable heating systems not based on fossil fuels. The proposal means that heating systems such as district heating, downhole heat exchangers and biomass fired boilers will be made equivalent to a high degree, in the sense that choosing one or the other will lead to equivalent energy performance in a building.

cause at the construction stage are considered in the calculation. The developer's possibilities of weighing up measures directed at the construction stage against measures at the use stage, in order to effectively achieve low total climate emissions over the life cycle, become less evident. However, the risk that buildings with more energy-efficient building envelopes than those stipulated in the energy management requirements in BBR would be disadvantaged is considered to be relatively low[25]. Instead it is above all extensive installation of solar cells, which can cause an increased climate impact at the construction stage (and in module B4 Replacement), whose positive effect for module B6 will then not be evident[26]. It is also important that the methodology in climate declarations matches, to the extent it is possible, developments in the other Nordic countries[27] and also within the EU. The other Nordic countries currently take the approach of including module B6 in their methods. In the voluntary framework for reporting on the sustainability of buildings currently being developed by the European Commission, Level(s), module B6 is also included in the indicator for greenhouse gas emissions during a building's life cycle[28].

#### Considerations

If we want to introduce limit values that are based more on life cycle analysis methodology, it would be natural also to add a calculation of climate impacts from future energy use. The specific choices that can be highlighted in calculating operational energy use (module B6) are energy-efficient solutions, local production of energy, and the choice of energy carrier. In past life cycle analyses of Swedish buildings, the energy carrier has always had considerable significance for the outcome. In these analyses the use of fossil fuels has a major impact, which module B6 can highlight. In the present situation in Sweden, fossil fuels are no longer an option as energy carrier for new buildings (aside from remaining use in

[25] Erlandsson and Peterson (2015) were able to show that in a Swedish context, buildings that are better insulated than the norm stipulates contribute to only a relatively small increase in the (calculated) climate impact at the construction stage.

[26] Birgisdottir et al (2017) show that installations can represent a considerable share of the climate impact, ranging from 18 to 46 per cent in more recent LCAs, where higher climate impacts apply above all to net-zero or net-positive energy buildings with a large number of solar cells. In Norwegian case studies from the Zero Emission Building Centre, solar cells typically represent 30 per cent of the embodied climate impact (modules A1–A3+B4); their impact is particularly large in module B4 as it is assumed they will be replaced after 20 years.

[27] https://www.norden.org/en/declaration/nordic-declaration-low-carbon-construction-and-circular-principles-construction-sector

[28] Dodd et al (2017). Level(s) – A common EU framework of core sustainability indicators for office and residential buildings.

district heating and electricity production). In practice, the choice of energy carrier today is essentially one between district heating and electricity (heat pumps) and whether to install solar cells or not, and this is not just highlighted in module B6 but is also affected by calculations at the product stage (modules A1–A3).

Boverket's assessment, based on the above and on the arguments described in the section "The limit value comprehends the construction stage, modules A1–A5", is that it is appropriate for operational energy use (module B6) not to be included in the initial phase when a limit value is introduced, but that reporting the climate impact of operational energy use should nonetheless be mandatory in climate declarations. This means that the proposal takes efforts at Nordic harmonisation into consideration, and also contributes to highlighting energy-efficient solutions while at the same time making clear that the focus of the regulatory framework is not to steer the choice of energy carriers/heating systems. Finally, at the present time energy calculations and construction solutions/choices of material are usually managed by different entities/competencies. This may be another reason to include it in climate declarations, in order to encourage greater interaction around making climate-smart choices, both in terms of future energy use and building-related climate impacts.

Annex 2 describes additional considerations which have been made regarding operational energy use.

## Building elements comprehended by the limit value

Boverket proposes that limit values for climate emissions from buildings comprehend those building elements that are included in the declaration from 2027. This will amount to a more "complete" building in comparison with the regulations from 2022 regarding the building elements and components in modules A1–A5 which will then be subject to climate calculations.

### Grounds for expanding the number of building elements included in climate declarations

The expansion is in line with many foreign methods and should guarantee that declarations achieve a higher quality in the sense that they will be more comparable in terms of the scope of the construction products included in the calculation. Boverket's assessment is that this will be important for enabling the introduction of limit values for climate emissions from buildings. However, Boverket proposes that the option be given to use a default value for the entire item "interior surface finishes and room fittings" in order to facilitate calculations going forward as

well. The system boundary for the building means that any subterranean garage must be subject to calculation and must "be included" in the limit value – this is further discussed below, in the section "Establishing levels for limit values".

### What building types are comprehended

Finally, Boverket proposes that the building types to be comprehended by limit values be the same as those in the 2022 regulations. However, as noted in the government's memorandum **Climate declarations for buildings Ds 2020:4**, an additional consideration should be whether certain types of simpler and comparable industrial facilities, such as warehouses, should eventually be comprehended by climate declarations. But any decision on this needs to be preceded by a more detailed analysis of what types of industrial buildings should be included.

## Establishing levels for limit values

This section discusses in greater detail how levels for 2027 limit values might be established and how the roadmap for further reductions to limit values might look.

### Different limit values for three different building types

Boverket proposes that limit values for climate emissions from buildings be set differently for single-family houses, multi-dwelling blocks and non-residential premises, which is also in line with the differentiation of energy requirements in BBR.

#### Grounds for different limit values for different building types

In general, the climate impact at the construction stage varies for different types of buildings[29], for which reason Boverket proposes a differentiation of the limit value for climate emissions from buildings of three distinct types – single-family houses, multi-dwelling blocks and non-residential premises. This kind of differentiation is common in methods in other countries – e g France, Switzerland and also in regulations likely to be introduced in Denmark. The European Commission's Level(s) framework so far does not include any suggested reference or limit values. Some form of differentiation based on different building types was also advocated by a majority of the participants at Boverket's hearing in January 2020. The voluntary initiative Local Roadmap for a Climate-

[29] Erlandsson, M. (2019). Modell för bedömning av svenska byggnaders klimatpåverkan. IVL Rapport C 433.
https://www.ivl.se/download/18.2299af4c16c6c7485d0185f/1568901945660/C433.pdf

Neutral Construction and Civil Engineering Sector in Malmö[30] is also considering using differentiated limit values for single-family houses, multi-dwelling blocks and non-residential premises.

Limit values could be differentiated even more, and this may be especially important to consider if different performance requirements are made on buildings. This applies above all to various types of non-residential premises, such as a hospital compared with a multi-storey car park. However, there is little knowledge about the extent to which this could produce significant differences in climate impacts for modules A1–A5. It should be possible to have one limit value for all types of non-residential premises. When reference buildings are selected to establish levels for limit values, therefore, the possibility and benefits of further differentiation should be examined.

#### The impact of garages on the limit value

Different buildings may include different performances that can influence the calculation outcome and thus the possibility of meeting the limit value. The clearest example of this is whether a building includes a garage or not. The government's proposal[31] is that garages be included in the calculation if they are present. Still, garages have a different function than the creation of accommodation and residential space for people. This was the main reason for introducing the reference unit gross floor area instead of net heated area in Boverket's proposal[32] – as a way of evening out the differences between buildings with and without garages. The best area to use in a limit value is something that needs to be analysed in more detail. Still, buildings with subterranean garages will typically have a higher load per unit of gross floor area without savings measures. For now, however, the proposal is that the limit value for buildings with garages not to be differentiated from 2027. The reason for this is that garages can often cause a fairly large climate impact, and it is important to work on reducing these impacts. It could also be argued that garages should be excluded from the limit value with the justification that they are more of an urban planning issue. This question needs to be examined further.

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[30] Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö. www.lmf30.se

[31] In Ds 2020:4 the government proposed a new regulatory system for climate declarations – a new act and ordinance on climate declarations for buildings.

[32] Boverket. (2018). Klimatdeklaration av byggnader. Förslag på metod och regler. Slutrapport, rapport nr 2018:23. Karlskrona: Boverket (Climate declarations for buildings. Proposal for a method and regulations, final report, Report no 2018:23).

#### Need for an evaluation before reducing limit values in 2035

As mentioned in the section "System boundaries for limit values", another question is whether further differentiation is also needed because only modules A1–A5 are included in the limit value. This question comes up in particular if a construction project is "better" than the requirements in Boverket's building and construction regulations, and when climate impacts of installations for local electricity production are included in modules A1–A5. The risk of this problem occurring is judged to be smaller for the levels on limit values to be introduced in 2027, but prior to the reduction of limit values in 2035 it is appropriate to make an evaluation of any negative consequences of restricting the application of limit values, and they can then be adjusted in 2035 if this is deemed necessary. One possible differentiation route to take is to allow an increase in the limit value if the energy class is better than current requirements in BBR, and if a specified number of strategies for flexibility or adaptability are being applied. This could be based on the checklist for these things in the European Commission's Level(s) framework[33].

#### Countries without differentiated limit values

In conclusion it can be added that there are also examples of non-differentiated limit values. So far this seems to have been the approach in the Netherlands, and in the German DGNB certification system the only separate reference values are for logistics buildings. One way of seeing it is that single-family houses generally have a lower climate impact per unit of gross floor area, and that such houses can generally be allowed to meet limit values more easily. Correspondingly, it can be seen as more important to make a bigger effort to limit the climate impact of non-residential premises, whose climate impact is generally greater. In the case of these buildings, it may be especially important that there are also resources for making more climate-smart choices.

### Levels for limit values in 2027, 2035 and 2043

Boverket proposes that the level for limit values for climate emissions from buildings in 2027 be set stringently, with a suggested 20–30 per cent improvement on reference buildings.

Reductions to limit values are proposed for 2035 and 2043, with the aim that they be reduced at a linear rate from the 2027 limit values, or a 40 per cent reduction until 2035 and an 80 per cent reduction until 2043, in

[33] Dodd, N., Cordella, M., Traverso, M., & Donatello, S. (2017). Level(s) – A common EU framework of core sustainability indicators for office and residential buildings.

order to move decisively towards the 2045 national climate target. Evaluations should be carried out well before the reductions of the limit values, in order to make a more in-depth analysis of the effects of the 2027 limit values and of whether a linear-rate reduction is the right way to proceed in view of its consequences.

#### Grounds for limit values from 2027

An important underlying assumption for developing the regulatory framework for climate declarations is that this contributes to achieving the national climate target. In other words, the initial level as well as future reductions need to be based on policy goals. Considering that the climate impact of construction has not decreased since 1990[34], limit values should be set such that climate-improving actions in construction are required right from their introduction in 2027. As a general target, therefore, Boverket proposes that 2027 limit values could correspond to 20–30 per cent lower climate emissions than the reference values which we suggest be established for each building type in a study of climate calculations. An impact analysis of 20 per cent lower and 30 per cent lower climate emissions, respectively, should be made before the right level for the limit value can be established – this is the reason Boverket's proposal for limit values is a range rather than a fixed figure.

#### Emissions can already be lowered by 20 per cent today

A study from 2018 of five different existing systems for constructing multi-dwelling blocks showed that a 15–20 per cent improvement in climate impacts from modules A1–A5 could be achieved for all five systems even when only two or three measures with the greatest potential for each system were undertaken[35]. For the BRF Viva multi-dwelling block in Gothenburg, a 30 per cent reduction in climate impact from modules A1–A3 was demonstrated by comparing how it had been built with the impact the building would have if it had been built using a more conventional concrete mixture and virgin rebars [36]. A Danish study of 60

[34] Boverket. (2020). Miljöindikatorer 2019. https://www.boverket.se/contentassets/b9aca218a3584da88ac43db6f5dbab1b/miljoindikatorer-2019.pdf

[35] Erlandsson, M., Malmqvist, T., Francart, N., & Kellner, J. (2018). Minskad klimatpåverkan från nybyggda flerbostadshus – LCA av fem byggsystem. Decision guidance report.

[36] Kurkinen, E-L, Al-Ayish, N, Brick, K, Rönneblad, A, Brunklaus, B, During, O, Larsson Ivanov, O. (2018). Kriterier för resurssnålt byggande i praktiken. Swedish Energy Agency & IQ Samhällsbyggnad (The Swedish Centre for Innovation and Quality in the Built Environment). https://www.e2b2.se/library/4301/slutrapport_kriterier_for_resurssnalt_byggande_i_praktiken.pdf

buildings, using the same calculation method for all of them, showed that there is a very considerable climate impact variation even within various building categories, and that this is not due to functional differences. The authors' view is therefore that a large under-utilised potential exists for reducing the climate impact of construction[37].

#### The construction industry's own targets

In Sweden, sector-related work on roadmaps within Fossilfritt Sverige (Fossil-free Sweden)[38] means that the construction industry has also made commitments and defined targets, which it´s reasonable to see reflected in limit values for climate emissions. The signatories of the construction and civil engineering sector's roadmap for climate neutrality[39], for example, have committed themselves to the following targets for the sector:

- 2025: Emissions of greenhouse gases show an unequivocally decreasing trend.
- 2030: 50 per cent reduction in greenhouse gas emissions (compared with 2015).
- 2040: 75 per cent reduction in greenhouse gas emissions (compared with 2015).
- 2045: Net-zero emissions of greenhouse gases.

The concrete industry's corresponding roadmap[40] contains commitments to being able to halve the climate impact from concrete already by 2023; to having "climate-neutral concrete" on the market by 2030; and to being able to make all concrete climate neutral by 2045. What these roadmaps show is that far-reaching targets set today are not just policy goals but also ambitions expressed by the business community. Taken together, this means that there should be a considerable possibility of emissions reductions in construction, provided the industry lives up to its own commitments.

[37] Kjaer Zimmerman, R, Ernst Andersen, C, Kanafani, K, Birgisdottir, H. (2020). Klimapåvirkning fra 60 bygninger. Muligheder for udformning af referencevaerdier til LCA for bygninger. SBI 2020:04. https://sbi.dk/Assets/Klimapaavirkning-fra-60-bygninger/SBi-2020-04.pdf
[38] http://fossilfritt-sverige.se/
[39] https://byggforetagen.se/fardplan-2045/
[40] http://fossilfritt-sverige.se/fardplaner-for-fossilfri-konkurrenskraft/fardplaner-for-fossilfri-konkurrenskraft-betongbranschen/

**Reasonable to have more stringent requirements from 2027**

As there are still quite a few years to go before 2027, it seems reasonable to require limit values with reductions by 20–30 per cent compared to construction today, with some adjustment based on how representative different construction solutions are assessed to be for current construction within each type. A verification should also be carried out against submitted declarations before limit values are set, to make clear that limit values will be possible to reach for e g buildings with different framing materials.

**In line with EU targets**

The commitments described above match visions and policy goals in other contexts. In 2011 the EU was already discussing the need for the construction sector to reduce its climate impacting emissions by 90 per cent between 1990 and 2050[41]. In Germany targets have been formulated for the construction sector to reduce its emissions by 67 per cent from 1990 to 2030[42], and the World Green Building Council[43] has expressed a vision that net-zero climate impact buildings be possible to build in 2050.

**Target level in 2043**

Taking the 2045 national climate target and the construction sector's ambitions into account, it might be reasonable to set the limit value for climate emissions from buildings at zero in 2045. Still, these targets are for what is called a net-zero level, and this has so far not been defined in greater detail for the construction sector. Boverket therefore proposes that limit values for climate emissions deal with impacts, and that these should be what have to be reduced, without consideration of any compensatory measures. What level would be reasonable as a target level around 2045 is impossible to determine today, but for now Boverket proposes that the aim should be that the target level in 2043 be around 80 per cent lower than the baseline level set for limit values in 2027. For 2035, then, the proposal is that limit values be reduced by 40 per cent compared with the same baseline level.

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[41] European Commission. (2011). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Roadmap for Moving to a Competitive Low Carbon Economy in 2050. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF

[42] German federal environment agency. (2013). Background paper Germany 2050 a greenhouse gas neutral country. Federal Environment agency, Dessau-Rosslau, Germany. https://www.umweltbundesamt.de/sites/default/files/medien/376/publikationen/germany_2050_a_greenhouse_gas_neutral_country_langfassung.pdf .

[43] https://www.worldgbc.org/embodied-carbon.

It is not possible to say unequivocally that this proposal follows the ambitions of the national climate target, since that target has not been expressed in concrete terms for the construction sector. There is no reduction target (in percentage points since 1990) which is specific for the construction and real estate sector and which can be used a starting point for setting target values in 2043. An important question in this connection is whether the construction and real estate sector needs to make a reduction that is the same as this national target, or greater or smaller than it. The proposal for limit values is in line with the other ambitions of the national climate target as well as of the construction sector. It constitutes a radical reduction compared with today, and as Boverket's environmental indicator for greenhouse gas emissions shows that construction activity has not decreased since 1993[44], it´s reasonable that considerable reductions need to be made to this particular part of the construction and real estate sector's climate impact going forward.

Even if the proposal here makes clear the aim of the projected future development of climate declarations and their limit values, continuous follow-ups and evaluations will be required of the possibilities of achieving limit values as well as any undesired consequences of the levels set for limit values in 2027 and 2035. This may lead to adjustments in both limit values and methodology, if they are judged to be necessary. The main point for discussion, however, is whether it is appropriate to set the limit values proposed above for 2043. They imply a far-reaching (but necessary), innovative technology development beyond what we can see today. In order to reduce the climate impact from the construction and real estate sector to the extent required to contribute to the national climate target, many other strategies also need to be developed and implemented[45]. If the climate impact from construction (in total or per capita, instead of per newly constructed square metre) is to decrease, a greater focus is needed on better use and reuse of existing buildings and built structures. There should be a gradual shift towards measuring the climate impact of buildings also in relation to how they are used, not just per square metre. The rate of construction will also have to be included in the assessment of what limit value levels are appropriate going forward, and the formulation of limit values may also need to be adjusted in order to consider the effects of changes to the European emissions trading

[44] Boverket. (2020). Miljöindikatorer 2019. https://www.boverket.se/contentassets/b9aca218a3584da88ac43db6f5dbab1b/miljoindikatorer-2019.pdf

[45] Francart, N., Malmqvist, T., & Hagbert, P. (2018). Climate target fulfilment in scenarios for a sustainable Swedish built environment beyond growth. Futures, 98, 1–18. https://doi.org/10.1016/j.futures.2017.12.001

system (EU ETS). These issues will need to be studied more closely once limit values have been introduced in climate declarations.

## Basis for setting limit values for 2027

Boverket proposes that limit values for climate emissions from buildings be based on reference values from a study of climate declarations for single-family houses, multi-dwelling blocks and non-residential premises as well as of data in the climate declaration register.

### Development of reference buildings

The proposal for limit value levels from 2027 is to be based on a study of climate declarations for a number of buildings. The study should comprise at least around ten buildings of three different types (single-family homes, multi-dwelling blocks, non-residential premises). The buildings should also represent a variation in terms of the materials used in load-bearing structures, in the number of floors, in whether they have garages or not, etc. Calculations should be made in accordance with the proposed regulations for 2027 and using data from the climate database. Another consideration should be whether calculations using different climate calculation tools should be carried out in order to ensure that the tool does not give rise to considerable differences. An adaptation of the levels should be based on how representative various construction solutions are judged to be of current construction practice for each building type.

As yet there are no properly developed reference or limit values for climate emissions during the construction stage of new buildings in Sweden which fully reflect the method for climate declarations, but a compilation of approximate levels for different building types is included in Erlandsson (2019)[46], which could be used. It is based partly on a thorough case study of multi-dwelling blocks (e g Liljenström et al[47],

[46] Erlandsson, M. (2019). Modell för bedömning av svenska byggnaders klimatpåverkan. IVL Rapport C 433. https://www.ivl.se/download/18.2299af4c16c6c7485d0185f/1568901945660/C433.pdf

[47] Liljenström, C., Malmqvist, T., Erlandsson, M., Fredén, J., Larsson, G., & Brogren, M. (2015). Byggandets klimatpåverkan - Livscykelberäkning av klimatpåverkan och energianvändning för ett nyproducerat energieffektivt flerbostadshus i betong. Retrieved from https://www.ivl.se/download/18.2aa2697816097278807f384/1525081550712/B2217.pdf

Larsson et al[48], Erlandsson et al, 2018[49], Ylmén et al, 2019[50], etc). More and more developers and contractors are currently carrying out similar calculations, in particular for multi-dwelling blocks, which by and large follow the method for climate declarations. The number of studies of single-family houses and non-residential premises in Sweden is so far lower. A thorough calculation has also been made for the Hoppet preschool and a newly built office block, both in Gothenburg (Ylmén et al, 2019, etc). A number of degree projects have also been done on single-family homes, but for both single-family homes and non-residential premises reference buildings should be compiled and more systematically subjected to calculations in order to draw up limit values. However, there is a lot of interesting work going on which should be able to supplement the study so that a good basis of reference buildings for Swedish conditions can be produced. Ongoing work to develop the Sweden Green Building Council's (SGBC) certification system, NollCO2, the Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö, and Public Housing Sweden's climate requirements at a reasonable cost also include proposing limit values adapted to Swedish conditions, from which lessons can be learned. In the study possible steering effects of limit valuescan be studied, e g whether garages should be excluded from or included in a limit value.

In order to be able to analyse differences between buildings and designs that may be significant when developing limit values, it would be appropriate for the following information to be obtained and analysed for the buildings included in the study:

- the use of the building and, if it has different uses (offices, homes), their distribution in terms of area
- the gross floor area and net heated area (and ideally information about what is included in the gross floor area and is not part of the net heated area)

[48] Larsson, M., Erlandsson, M., Malmqvist, T., & Kellner, J. (2016). Byggandets klimatpåverkan - Livscykelberäkning av klimatpåverkan för ett nyproducerat energieffektivt flerbostadshus med massiv stomme av trä. IVL Rapport B 2260. https://www.ivl.se/download/18.29aef808155c0d7f05063/1467900250997/B2260.pdf

[49] Erlandsson, M., Malmqvist, T., Francart, N., & Kellner, J. (2018). Minskad klimatpåverkan från nybyggda flerbostadshus – LCA av fem byggsystem. https://www.ivl.se/download/18.72aeb1b0166c003cd0d1d5/1542035270063/C350.pdf

[50] Ylmén, P., Peñaloza, D., & Mjörnell, K. (2019). Life cycle assessment of an office building based on site-specific data. Energies, 12(13), 1–11. https://doi.org/10.3390/en12132588

- residential area (abbreviated BOA in Swedish), non-residential area (LOA), and ancillary area (BIA)
- the form factor, i e envelope area/heated area
- whether there is a garage/parking area/basement/attic and how much of those are included in the calculation
- principal material(s) in at least the load-bearing structures and the building envelope
- energy performance, noise requirements, accessibility requirements and any other significant performance requirements
- principal room height
- number of floors
- climate zone
- description of any climate-improving measures undertaken
- description of any measures for future flexibility and adaptability (e g with the help of the Level(s) list)
- window-to-wall ratio
- foundation method
- division of calculation results not just into life cycle modules, but also by building elements and materials
- description of in which parts of the calculation specific generic data and default values, respectively, were used
- references to any EPDs that were used in the calculation.

In March 2020 the National Agency for Public Procurement and Boverket were given a joint government commission[51] to develop and supplement the former's sustainability requirements and other guidance in order to cost-effectively promote reduced climate impacts throughout the life cycle in the construction, civil engineering and real estate sectors. Guidance has to be provided for choice of methods, reference values and follow-ups of the requirements, among other things. Boverket hopes that this work will provide supporting documentation on which to base reference values for buildings. A challenge in this connection is that Boverket's climate database will come online in January 2021.

[51] Government decision Fi2019/01139/BB, Fi2020/01192/BB.

**Verification against statistics in the climate declaration register**

It would be useful if the climate declaration register could increasingly be used to follow up the development of climate impacts from newly added buildings from 2022. A few years before 2027, the proposed levels for limit values could then be verified against statistics from the climate declaration register in order to determine whether the levels are reasonable. Since climate declarations that will be submitted from 2022 will not have the scope in terms of building elements as those proposed from 2027 will have, the default values established for those additional elements – as is also proposed – could be used to verify levels.

The advantage of comparing with climate declarations in the climate declaration register is that they have all used similar calculation methods. This body of declarations will thus be a reflection of actual construction and the variations inherent in it. In order to base limit values on such statistics, however, they need to be of sufficient quality, which is harder to assess than if a more controlled study of reference buildings is carried out. This still brings the advantage that a study of actual buildings can demonstrate the natural variation in construction. It also provides the possibility of being able to establish reference values for limit values well ahead of 2027. Similar studies have been the basis of e g developing reference values in Denmark[52], Norway[53] and France[54].

Another possible approach would be to model theoretical standard buildings on which currently cost-optimal measures could also be evaluated. Modelling of standard buildings was used e g to establish reference values for DGNB[55] and other certification systems, and also appears to be used in the regulatory framework in France.

[52] Nygaard Rasmussen, F, Ganassali, S, Kjær Zimmermann, R, Lavagna, M, Campioli, A, Birgisdóttir, H. (2019). LCA benchmarks for residential buildings in Northern Italy and Denmark – learnings from comparing two different contexts. Building Research & Information. https://doi.org/10.1080/09613218.2019.1613883

[53] Wiik, M, Fufa, S M, Kristjansdottir, T, Andresen, I. (2018). Lessons learnt from embodied GHG emission calculations in zero emission buildings (ZEBs) from the Norwegian ZEB research centre. Energy & Buildings 165 (2018) 25–34.

[54] Lasvaux, S, Lebert, A, Achim, F, Grannec, F, Hoxha, E, Nibel, S, Schiopu, N, Chevalier, J. (2017). Towards guidance values for the environmental performance of buildings: application to the statistical analysis of 40 low-energy single family houses' LCA in France. Int J Life Cycle Assess (2017) 22:657–674. https//doi.org/10.1007/s11367-016-1253-z

[55] König, H and De Cristofaro, M. L. (2012). Benchmarks for life cycle costs and life cycle assessment of residential buildings. Building Research & Information, 40(5), 558–580. https://doi.org/10.1080/09613218.2012.702017

# Requirement for climate declarations for refurbishments

Another question which has been examined within the scope of the commission is whether climate declarations should be expanded in the next step to become mandatory for major refurbishments. In refurbishments there occurs removal of a lot of material and use of large amounts of material, which causes a relatively large climate impact that it may also be important to reduce. The question of whether there are reasons to require climate declarations for refurbishments was asked to the participants at Boverket's hearing in January 2020. A small majority of those who answered the question were in favour of making climate declarations for refurbishments as well, while a number of larger real estate representatives were not in favour of doing so.

Reasons for requiring climate declarations, or rather climate calculations, prior to major refurbishments include the importance of promoting the efficient use of existing buildings for as long as possible. This means that in general it is always better to make a major refurbishment than to demolish the building and construct a new one. One way of drawing attention to this issue could be to introduce a mandatory climate calculation before a refurbishment when limit values are introduced in 2027, or in 2035 when the limit values are reduced. A general requirement could be introduced under which a developer must be able to show what measures have been taken to limit emissions, and to provide evidence of this by means of a climate calculation of various alternative solutions. That would potentially send a steering signal against demolitions and new construction.

The reason not to require climate calculations for refurbishments is that there is still a considerable need for improving the energy efficiency of the existing building stock. This development is only happening slowly, requiring mandatory climate calculations for refurbishments can be seen as an increased administrative cost in this context. Moreover, a simplification of the regulatory framework for refurbishments is a priority issue in the final report from the Committee for Modernised Building Regulations[56]. As climate declarations are expected to be able to drive

[56] Kommittén för modernare byggregler. (2019). Modernare byggregler– förutsägbart, flexibelt och förenklat (The Committee for Modernised Building Regulations. Modernised building regulations – predictable, flexible and simplified). http://modernarebyggregler.se/wp-content/uploads/2019/12/sou-2019_68_slutlig.pdf

developments decisively towards a reduction in the climate impact of materials and products, this will also gradually reduce the climate impact of refurbishments – with respect to those building elements that are included in the declaration.

One option would be to specify which types of refurbishments should be subject to climate calculations. Today extensive refurbishments occur relatively frequently due to what are known as tenant adaptations, particularly in office blocks. A requirement for a climate calculation for that type of refurbishment could drive developments towards more flexible solutions in new construction as well as highlight the unsustainability of removing large amounts of material that is nowhere near the end of its technical service life.

An alternative to regulations on climate declarations for refurbishments would be for the government to carry out special guidance initiatives on climate considerations prior to refurbishments or demolitions.

Boverket sees a need to examine this issue further, for which reason no final proposal on climate declarations for refurbishments is provided in this report.

# Other things to consider in the roadmap

This section describes other relevant work that should be considered before implementing the roadmap. Many actors have highlighted how ongoing digitalisation will facilitate its implementation and improve the quality of climate declarations in the future. The pending review of the Construction Products Regulation will potentially affect Sweden's possibilities of requiring environmental information for construction products, which is a central factor if limit values are introduced. The proposal for introducing limit values will also affect Boverket's supervision of climate declarations. All three areas are described briefly below, as well as how this could influence the implementation of the roadmap for developing climate declarations. The distinction between energy declarations and climate declarations is also commented in this section.

## Developments in digitalisation

It is difficult to get a clear picture of the situation of the digital development in the construction sector, both nationally and internationally. An overall description will be attempted in this section.

The construction sector does not use digital methods to any significant extent, even if some changes are in the making[57]. The strategic development programme Smart Built Environment[58] makes the assessment that there is a potential for reducing climate impacts by 40 per cent if the opportunities that digitalisation offers are used. Climate declarations as an instrument will probably drive the digitalisation of environmental information about construction products and climate calculations.

Several research and development programmes to promote digitalisation in the construction sector are ongoing. Examples of initiatives that embrace digitalisation to varying degrees include the strategic innovation

[57] Byggbranschen och digitalisering, AB Svensk Byggtjänst, 2017.

[58] The strategic innovation programme Smart Built Environment supports the built environment sector's joint digitalisation efforts – through research, development and innovation – with the aim of helping enable construction that is cheaper, faster and more sustainable. It is coordinated by IQ Samhällsbyggnad (the Swedish Centre for Innovation and Quality in the Built Environment) and financed by e g Vinnova, Formas and the Swedish Energy Agency.

programme Smart Built Environment, the international forum buildingSMART[59], Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö (LMF30)[60] and the Development Fund of the Swedish Construction Industry (SBUF)[61].

Digitalisation of environmental information and climate calculations is underway in the construction sector, but the full use of the available technology is limited principally to the sector's leading actors. Small and medium-sized companies, however, can find it hard to make use of digital tools due to resource and skills constraints, which may in turn constitute an obstacle to the flow of digital information throughout the construction process.

Requirements imposed by public agencies will drive the development of accessible and compatible digital tools and digital information about the climate impact from construction products. Procurement criteria are also an important instrument that can potentially drive development. The implication is that more actors will have to embrace digital technology.

All in all, requirements by the Government and by clients have the potential to accelerate development and bring about climate declarations of a higher quality that can be made in a more cost-effective way.

### Digital climate calculations of buildings

A climate calculation can be made with the help of various digital tools. As digital information grows in volume and also becomes more accessible and increasingly in demand, the need for integration with digital climate calculation tools will also increase.

The Government does not intend to regulate which climate calculation tools are to be used for the calculations in climate declarations. Many tools have been developed to facilitate life cycle analyses (LCAs). They can either be rather simple, so that no significant amount of knowledge

[59] buildingSMART is an independent international forum whose work includes initiating and developing open digital standards (IFC) for Building Information Modelling, BIM.
[60] Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö, LFM2030, a local initiative to speed up the construction and civil engineering sector's climate transition. The initiative is actor-driven and supported by the Swedish Construction Federation, Fossil Free Sweden and the City of Malmö. Also supported by Informationscentrum för hållbart byggande, the Information Centre for Sustainable Construction.
[61] Svenska Byggbranschens Utvecklingsfond, the Swedish Construction Industry's Development Fund, finances and disseminates research and development for the construction sector.

about LCA is necessary to make the calculations, or more advanced and thus require a certain amount of prior knowledge. Several LCA tools have been developed specifically for the construction sector. So far LCA tools for the construction sector have been separate programs, but new LCA modules for existing cost calculation programs are also beginning to appear.

One decisive factor for the outcome of a climate calculation is the quality of the Bill of resources. Climate declarations have to be based on a complete bill of resources, and from 2027 the proposal is for additional building elements and modules to be included, which may mean that the declaration contains several thousand calculation items. This will make manual calculation very onerous and perhaps not even possible. The purchasing process should be digitalised in the future so that actual purchased amounts, wastage measurements, discarded material and additional packaging material that is included with the product are documented digitally. No digital solution of this kind currently exists.

Today it is above all major consultancy businesses that make LCAs on order from the developers. Depending on the form of contract, the provider – the contractor – has the option of replacing the products that were included in the LCA. It is often the case that smaller actors in the form of subcontractors are the providers and therefore place the definitive order for construction products. By developing simple tools that are free of charge, the threshold for all actors could be lowered, which could also facilitate following the prescribed products from the early project design stages to final execution.

#### Digital Building Information Modelling, BIM

Digital Building Information Modelling, BIM, are tools that facilitate the management of digital information[62]. BIM has existed in Sweden for around 30 years but is still only used to a limited extent. It provides possibilities for virtual analyses and simulations that can save time, money, energy and the environment, as well as improve quality.

The idea behind BIM is that information about a building can be transferred between different parties and thus be further processed and improved throughout the life cycle of the building. Standardised format for information exchange is a prerequisite for reaching the goal of increased digitalisation. Today there is still a lack of, for example, shared

[62] Digital models of buildings are called building information models, and the method for making them is called building information modelling. Both terms are abbreviated BIM.

ways of managing product information for building elements or construction products.

One area of use for BIM is to produce the basis of good-quality climate declarations in a resource-efficient manner. BIM can also be used to calculate the climate impact of different choices of material and design proposals from the early stages to the finished product. Yet another advantage of BIM is that bill of resources can easily be made effectively and with greater precision as they are generated digitally and can use the same source material.

### Digitalised climate data on construction products

The aim of developing Boverket's climate database is to have a format that allows input and output data to be readable digitally[63]. The structure and content of the climate database will be continuously updated and developed in line with the pace of digital development.

Environmental information about construction products is going through a phase of rapid development based on LCA methodology, in what are known as EPDs (Environmental Product Declarations)[64]. The aim in the roadmap for developing climate declarations is that only specific climate data will be used in the final climate declaration. This assumes, among other things, that CE marking of construction products includes an environmental declaration (read more in the section "Construction products are harmonised at the EU level") and the information is made available digitally. An industry initiative for developing digital product information for CE-marked products is Smart CE marking, a standardisation concept by CEN.

Construction material manufacturers currently provide information about their products to various information systems owners[65], who in turn sell the information on to the buyers of construction products. Development of digital product data sheets is ongoing and will make the information transfer more efficient for both construction material manufacturers and buyers[66]. A digital format for product specific LCA data, adapted to BIM,

[63] API - Application Program Interface.
[64] According to the SS-EN 15804 standard.
[65] Databases with e g logistical data, price information, images, documentation, environmental declarations, and product characteristics for construction products.
[66] Standardisation of digital product data templates and product datasheets is carried out by the CEN TC 442 technical committee in collaboration with BuildingSMART and ISO 19650.

is expected to be ready in 2020[67]. The **Digital Supply Chain** project, which is being carried out within the strategic development programme Smart Built Environment, aims to define a construction sector-wide vision for ownership and management of standardised construction product data.

### Conclusions

- The digitalisation of the construction sector is a prerequisite for producing good-quality climate declarations in a resource-efficient way. The construction industry has not reached as far in terms of digitalisation as many other industries have, but developments are accelerating.
- Open, standardised formats for information exchange between tools and platforms as well as digital inputting of bill of resources in LCA tools are important elements of digitalisation.
- Criteria in public procurement to reduce climate impacts from the construction and real estate sector can serve to promote digitalisation in the construction sector, as can the requirements for climate declarations. Official directives that publicly owned developers – real estate managing agencies as well as government enterprises – have to reduce the climate impact of their construction activities can also contribute to this development.
- The Government should continue to support research that contributes to the digitalisation of the construction sector. Further needs for government support should be analysed.
- The Government should coordinate, quality assure and make available public data about buildings in, for example, the Geodata Portal being developed by Lantmäteriet (the Swedish mapping, cadastral and land registration authority).
- To support digitalisation of the construction sector, the government should provide a freely accessible climate database which is developed to be compatible with the calculation tools on the market.
- Boverket's climate declarations register should be developed to facilitate digital information transfer.

[67] ISO 22057 Enabling use of Environmental Product Declarations (EPD) at construction works level using building information modelling (BIM).

## Construction products are harmonised at the EU level

The purpose of climate declarations is to reduce the climate impact of new construction in the first instance. In order for developers to be able to make informed choices, the most effective tool would be access to specific information about construction products on the market. Under current EU law, however, it is not possible for public actors to require this from manufacturers. Construction products are harmonised at the EU level under the Construction Products Regulation (EU) No 305/2011. This regulation stipulates that the characteristics of construction products must be assessed and described using the same methods across the EU in order to facilitate matters for actors on the internal market. The methods to be used are laid down in harmonised product standards.

### Current EU regulations for construction products

European efforts to facilitate the free movement of construction products in the internal market have been going on for 30 years. An important part of these efforts has been to establish harmonised standards for the products. Such standards have thus been developed over a long period of time based on the regulatory needs of the member states, i e member states' legislation related to construction products. This meant that if member states required a certain characteristic for construction products, a European method that would apply in all member states was devised for testing this characteristic. As harmonised standards began to be established 30 years ago, when few member states had environmental requirements in their building legislation, environmental considerations are also often lacking in the harmonised standards.

Since it is the manufacturer who makes the performance declaration and the CE marking of the construction product, and these are about in-process supervision to a great extent, they cannot be carried out afterwards, e g for a used construction product. Even if a used construction product was CE marked to begin with, there is no way of being certain that the product characteristics described in the original product documentation are still present. During its period of use – which is often numerous years – a construction product will have been subjected to e g loads, climate, light and sometimes chemicals, all of which may have affected its characteristics.

### Limits to requirements by public actors

Under the Construction Products Regulation, the characteristics of construction products have to be described according to the harmonised

system. The European Commission noted early on that Germany required descriptions of more characteristics than what the harmonised standards specified. A judgment was issued by the Court of Justice of the European Union in 2014 stating that the EU regulations with the harmonised standards are exhaustive and that member states are therefore not permitted to supplement additional requirements for descriptions of the essential characteristics of construction products. If a member state is not satisfied with the scope of the standards it can present a formal objection to them[68].

In 2015 Germany presented formal objections to a number of harmonised standards. The German view was that the standards in question did not include methods for assessing certain essential characteristics such as the emission of hazardous substances. With respect to emission of hazardous substances, the standards specified that national methods could be used for the time being. Germany's interpretation was that this went against judgment C-100/13 and demanded that the European Commission rectify the incorrect standards. The European Commission did not change the standards but issued a decision to the effect that in the absence of harmonised assessment methods, the clauses in harmonised standards that refer to national methods were invalid.

Germany appealed the European Commission's decision in 2017, demanding that the references to the standards in question be withdrawn, i e that the affected products would no longer be eligible for CE markings. This would imply that member states could use national assessment methods to assess the products. The second court of the Court of Justice of the European Union[69] ruled in 2019 that a member state must refrain from unilateral national measures that limit the free movement of these harmonised inferior construction products, even if the member state considers a current harmonised standard to be incomplete. The appeal was therefore rejected[70].

[68] Judgment C-100/13 in the Curia case law database: http://curia.europa.eu/juris/liste.jsf?num=C-100/13&language=SV
[69] The General Court.
[70] Judgment T-229/17 in the Curia case law database: http://curia.europa.eu/juris/liste.jsf?language=en&num=T-229/17

### Environmental product declarations for harmonised construction products

The European Commission is working on describing the environmental footprint of products using a method abbreviated PEF[71]. This method has been applied in many product areas.

In the area of construction products, efforts to describe the environmental impact of such products have followed a parallel path, also at the behest of the European Commission. As early as in 2004 the European Commission asked the European Committee for Standardization, CEN, to draw up standards for describing the environmental impact of construction products. This led to the development of the SS-EN 15804 standard which is used to produce environmental product declarations, EPDs, for construction products. The committee has begun work to adapt the SS-EN 15804 standard so that it becomes more similar to the PEF system, but so far the two standardisation efforts are being pursued in parallel.

The European Commission has begun discussions with member states and the industry about using PEF instead of environmental product declarations according to SS-EN 15804, but it has not gained support for this approach. The construction products industry, CEN and member states have been working on preparing and implementing SS-EN 15804 since 2004, and the proposal for climate declarations for buildings is based on the environmental impact of construction products being reported in accordance with SS-EN 15804.

So far, however, there is no legal connection between EPD according to SS-EN 15804 and the harmonised construction product standards, as this is not covered by current construction product standards. In light of the legal cases described above, the harmonised construction product standards need to be revised so that they refer to SS-EN 15804 in order for everything to be legally correct. In many cases this change will mean that the instructions for standardisation also need to be revised to include the instruction that references to SS-EN 15804 have to be made in the product standards.

The fact that requirements by public actors and that the connection between SS-EN 15804 and the harmonised standards is still lacking means that it is not as yet possible to require the use of product specific

[71] The Swedish Environmental Protection Agency's information in Swedish about environmental footprints/PEF: https://www.naturvardsverket.se/Miljoarbete-i-samhallet/EU-och-internationellt/EUs-miljooarbete/EU-och-resurseffektivitet-EU-2020/Fardplan-for-ett-resurseffektivt-Europa/Miljoavtryck/

environmental product declarations for harmonised construction products in legislation. This is one of the reasons that Boverket has proposed a database with generic data on construction products. It is possible for manufacturers to produce voluntary environmental product declarations, and if they have done so, these data can be used in the final climate declaration instead of the data in the generic database.

### Development of the Construction Products Regulation

There are forces that favour a change in order to bring about the legal connection between the harmonised construction product standards and SS-EN 15804. The new European Commission that took office at the end of 2019 has a clear environmental focus, as presented in what is known as the European Green Deal[72]. In March 2020 the Commission also presented an action plan for a circular economy in which environmental data on construction products was highlighted as an important factor for future progress towards the EU's climate targets[73]. Several member states are interested in having the ability to require environmental product declarations of construction products. France, for example, is already requiring environmental product declarations, while Germany has a more cautious approach and is awaiting developments at the EU level. Still, many manufacturers are already making voluntary environmental product declarations.

Earlier in 2020 the European Commission began to work on a revision of the Construction Products Regulation. The Commission's stated ambition is to have a new version of the regulation ready before the next elections to the European Parliament in 2024. In addition to the revision of the Construction Products Regulation itself, a review of the system of harmonised standards has also been initiated. This means that new legislation could come into force before 2027. Since there are more countries than Sweden that want to have access to specific environmental information about construction products, it is likely that this possibility will be included in the amended legislation.

The three main points that Sweden's Government Offices have so far contributed to these efforts at the EU level are the following:

[72] The Commission's information about the European Green Deal: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en.
[73] The Commission's 2020 action plan for a circular economy: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

- that we get specific environmental information about the climate impact of construction products, which is needed under our pending legislation, and that this information preferably be in the form of environmental product declarations in accordance with SS-EN 15804
- that the information can be made available in digital format
- that we are able to get information about the chemical content of construction products to a greater extent than what is possible today.

### Conclusions

- In Sweden we want to have the possibility of requiring that specific climate data or product specific data for construction products are used in the final climate declaration, but this is not possible under EU law.
- It is very important to follow and influence the EU's work on revising the Construction Products Regulation so that it becomes possible to require specific climate data/environmental data on construction products if and when limit values are introduced in Sweden.
- It is important to influence the EU's work so that the methods for environmental product declarations for construction products follow the European SS-EN 15804 standard (indirectly SS-EN 15978).
- It is important to coordinate standardisation efforts of environmental product declarations with ongoing European efforts to introduce digital formats for information about construction products.

## Need for changes of the supervision for climate declarations

This section deals with Boverket's supervision methods; the scope of supervision and its execution; sanctions and interventions, and in conclusion with the instituting of a new supervisory function.

According to the government's proposal, responsibility for supervision will be shared between municipalities and Boverket. In a building application with the municipality, the developer must make and submit a climate declaration to Boverket's climate declaration register. This submission is a condition for the developer's receipt of final clearance from the municipality. The municipality will verify that the climate declaration has in fact been made and registered.

Once the climate declaration is registered, Boverket's supervisory role takes over. This should occur as soon as possible after the developer has

received final clearance. But it should also be possible to initiate a supervisory matter in response to an individual who reports to Boverket that a climate declaration contains errors. The latter type of supervisory matter will likely be fewer in number than Boverket's own supervisory actions.

## Methods of supervision

This section deals with how supervision can be carried out by means of validity checks and random checks. A parallel is drawn with how supervision is carried out in Boverket's other supervisory activity with respect to energy declarations and market surveillance of construction products.

### Validity checks and random checks

Validity checks involve verifying, at a comprehensive level, the plausibility of what is being measured. The purpose of a validity check in this context is to provide an overall picture of the quality of the system's input data and results, and use this as a basis for possible decisions on changes to the system. The outcome of a validity check can also be the basis for an inspection and a more in-depth examination of input data, e g in an energy or climate declaration. Boverket should carry out an annual validity check of the climate declarations completed over an operating year. The outcome of the validity check can then be the basis for random checks of different climate declarations. Random checks examine the contents of a declaration and whether its information is plausible.

The proposal is that the supervisory responsibility for the contents and quality of climate declarations lie with Boverket. Boverket already has supervisory responsibility for energy declarations. One difference is that Boverket does not inspect the contents of energy declarations and does not need to request any underlying documentation in order to verify the accuracy of the declaration. Boverket's supervision of energy declarations involves validity checks of a more general nature. The energy declaration system has a built-in quality guarantee in that energy declarations are made by an independent, certified energy expert. Boverket exercises supervision over energy declarations, but not over the specialist knowledge of the energy expert. Under the system for energy declarations, the energy expert's specialist knowledge must be guaranteed by means of certification from a certification body with SWEDAC accreditation for its task.

There is no corresponding system with certified climate calculation experts for supervision of climate declarations - this in order not to make

the administrative burden for developers too big. Instead, under the government's proposal, it is the developer who has to make and register the climate declaration. Boverket is thereafter to carry out supervision and quality verification of the declaration. Using random checks, Boverket is to check that the information and calculations in the climate declarations are accurate. How this work is to be organised can be compared with Boverket's market surveillance of construction products. Market surveillance includes documentation checks, among other measures. This involves requesting documentation for a particular construction product from the companies that market the product. The quality and accuracy of the documentation is then checked in order to assess whether the construction product meets current requirements. This can be likened to the random checks that are part of the supervision of climate declarations.

## The scope of supervision

This section deals with how supervision might be done during the 2022–2027 period as well as after limit values are introduced in 2027. The focus of supervision will initially be on making comparisons with reference buildings and will then shift to limit values. The scope of supervision is still being studied, and needs may change.

#### Supervision of climate declarations 2022–2027

In order for Boverket to be able to carry out supervision of climate declarations, documentation verifying the information in the climate declaration needs to be provided by the developer.

The elements of this documentation that are significant for the verification are primarily the bill of resource and the financial calculation. The bill of resources is verified with documentation – a list of purchases or resources is appropriate - and this verifies the information in the climate declaration. The developer is obliged to keep this documentation for five years. Boverket also needs information about which of the resources have been calculated with the help of Boverket's climate database (generic data) and which have been calculated using specific data (EPDs). This forms the basis of the verification calculation Boverket has to carry out. Boverket further needs access to a calculation tool in order to compare the climate impact computed by the developer and the climate impact computed by Boverket.

If Boverket's supervisory calculation produces a value for the climate impact that materially deviates from the information declared by the

developer, Boverket must give the developer the opportunity, within a specified period of time, to present an explanation for the deviation.

Before limit values are introduced, Boverket needs to obtain reference values that show LCA data for different types of buildings in new construction and extension. This is in order to be able to determine whether a certain type of building has reasonable values in relation to the climate declaration made. Read more about reference buildings in the section “Establishing levels for limit values”.

#### Supervision of climate declarations from 2027 onwards

The proposal is for limit values for climate emissions from buildings to be introduced for the construction stage (modules A1–A5) in 2027, in order to drive climate-improving measures in project design and construction. The proposal is also for changes to regulatory framework with respect to the calculation method and limit values to be made in 2035 and 2043. This means that Boverket’s supervision will also need to change.

The focus for supervision will now shift to verifying that the limit value is not exceeded. The assumption is that the developer will declare a value that is lower than the limit value. This supervision will therefore mainly involve random checks. In connection with these Boverket may request the bill of resources from the developer. In those cases where Boverket suspects that the climate declaration is inaccurate, and a more detailed examination is required, the authority will make its own calculations. In other cases, it may be sufficient for Boverket simply to request documentation that verifies the accuracy of the climate calculations.

### Interventions and sanctions

According to the government’s proposal, Boverket’s supervision will include the possibility of verifying the calculation in the developer’s climate declaration in order to check that the value is accurate. If the calculation produces a value that materially deviates from the information declared by the developer, the opportunity will be given for the developer to present, within a specified period of time, an explanation for the deviation. If the developer is unable to present a reasonable explanation, a sanction fee may be imposed for the violation. Boverket will also have the option of imposing the obligation on the developer of rectifying the error by making an accurate climate declaration.

Under Section 18 of the proposed Act on Climate Declarations, Boverket will be able to impose a sanction fee if a verification calculation has been carried out which shows that an inaccurate value was declared and there

are special reasons to impose a sanction fee. Such reasons might be that the developer, without explanation, has provided inaccurate information about e g the principal materials used in the building, transports carried out, or other technical matters which have resulted in the building's climate impact materially deviating from Boverket's calculation. This option should be exercised restrictively and only in the event of significant deviations.

Under Section 13 of the proposed Ordinance on Climate Declarations, the sanction fee must be linked to the size of the building in question and be calculated using the official price base amount. In order to facilitate the application of this provision, the same floor area concept should be used as in the Planning and Building Act and Ordinance.

### New supervisory function

Accordning to the background of what has been described above, Boverket needs to set up a new supervisory function. Boverket regards its supervisory function as not just a matter of inspection, but also as providing guidance and support. This means that the actual supervision will include processing of cases. The supervisory function may assume responsibility for an online handbook, supervision guidance, IT support and other information initiatives linked to the future provisions on climate declarations. Additionally, a supervision plan must be drawn up annually. The supervision plan must include information about the priorities, focus and scope of supervision, and about resources for supervision.

Boverket therefore sees a need for additional resources in order to be able to carry out its supervisory activities. In this connection, a comparison has been made with Boverket's current supervisory activities and the actual resources that exist today within these areas. The need for resources is described in terms of annual working units, and a comparison is made with Boverket's supervision of energy declarations and market surveillance of construction products. The employees making up these resources have different skills and include administrators, researchers, lawyers, economists, administration managers and civil engineers.

When the Act on Climate Declarations comes into force in 2022, Boverket's estimate is that five annual working units will be needed to carry out supervision of climate declarations. A further two annual working units are also estimated to be needed to manage the climate declaration register. A variety of skills will be needed, as is the case in Boverket's existing supervisory functions, but there may also be the need

for specialists. When limit values are introduced in 2027, the need in terms of annual working units are expected to be the same or slightly greater. Employment of seven annual working units in total will imply an annual cost of SEK 9.52 million.

### Conclusions

Boverket's assessment is that there will not be any greater changes to the implementation of supervision if limit values are introduced in 2027. Supervision will be of more or less the same size and scope. The focus needs to be shifted to checking that the declared value in fact does not exceed limit values. This will place greater demands on Boverket's supervision and on the scope of random checks, which needs to be examined further in order to ensure thorough and effective supervision. As described above, Boverket will need to set up a new supervisory function with new resources on the basis of the government's proposal. The current assessment is that the resources needed in 2022, when the requirement for climate declarations is introduced, will also be sufficient in 2027.

## Connection to energy declarations

The energy declaration (energy performance certificate) is an informational policy instrument with a clear consumer perspective[74]. The purpose is to promote increased energy efficiency, particularly in the existing building stock. It is therefore directed first and foremost at building owners and consumers, i e prospective buyers and tenants. Increased energy efficiency is promoted primarily by highlighting and providing information about a building's energy performance by means of energy classification from A to G[75]. At the same time, it is also required that a developer must produce an energy declaration for new construction in much the same way as for climate declarations. Boverket's assessment is that there is reason to inform about climate declarations in these energy declarations that are made for new construction, as this may contribute to a raised consumer awareness of

[74] An energy declaration has to be made for new building that are constructed, for buildings that are sold or leased, and for buildings that have a total usable floor area of more than 250 $m^2$ and are frequently visited by the general public. In new construction this requirement must be met by the developer; for existing buildings, by the building owner.

[75] The energy classification makes it easier for consumers to assess whether a building is better or worse in terms of energy use and allows for comparisons between buildings. It helps make energy performance a valued characteristic – a building with a better energy performance can attain a higher value in the real estate market. This creates an incentive for building owners to carry out measures to improve their buildings' energy efficiency.

climate emissions from construction[76]. However, consideration is needed in this connection of how extensive such information should be and in what way it should be provided. The information could consist of a notification that a climate declaration exists and where it can be found. This type of supplementary information is already being provided today about e g mandatory ventilation controls and whether radon measurements have been made. It could also consist of a report on the result of a climate declaration.

### Information about the climate declaration in the energy declarations

For the consumer, the information value of energy declarations is greatest when buying or selling buildings. It may be assumed to be most significant in ownership transfers between private individuals, i e above all regarding single-family houses, as the level of knowledge about energy use is generally lower in this group than among larger real estate owners. For this reason, it is important for the information to be easily accessible. The focus in energy declarations is on operational energy. This means that climate declarations and energy declarations have different system boundaries. In order for consumers to be able to evaluate the calculation outcome in a climate declaration, it is important that it is presented along with reference values. In the absence of reference values, a numerical value for climate emissions would be of limited value to the consumer and would also risk to complicate the information in energy declarations.

Considering that the energy declaration is a policy instrument that comprehends operational energy use at the use stage, an option might be to only inform about climate emissions from module B6. That could potentially contribute to an increased demand for new buildings with low climate emissions from operational energy use. It is also conceivable that the information would strengthen the building owner's incentive to carry out further measures for increased energy efficiency or, for example, consider heating options with even lower climate emissions. Still, this effect is likely to be limited as new buildings are already energy efficient and generally have heating systems that can be considered sustainable. Also, the energy classification in the energy declaration already highlights the possibility of trying to achieve better energy classifications

[76] As the proposal is for climate declarations to be made in connection with final clearance, and energy declarations are typically made at a later stage, they can be linked together by means of information about the climate declaration being provided in the energy declaration.

(classes A and B) than the energy classification that corresponds to requirements for new construction (class C).

There are also certain obstacles to reporting climate emissions from module B6. The proposal is for climate declarations to be made pending final clearance, which means that the emissions values will be based on a calculation. The main rule for the energy declaration, by contrast, is that it should be based on actual energy use, i e measured values. That is the reason why energy declarations for new buildings are produced within two years of completed construction. The actual measured energy use may differ from the calculated that was used as a basis for calculating emissions in the climate declaration. This suggests that if we particularly want to provide information about climate emissions from operational energy use in energy declarations, it would be better instead to use the results of the energy declaration itself. However, that would in turn lead to a discrepancy, in most cases, between the reported climate impact of operational energy use in the two declarations.

### Conclusions

- Boverket's assessment is that information about climate declarations should be provided in energy declarations produced for new construction as this may contribute to a raised consumer awareness of climate emissions from construction.
- Initially the information should consist of a notification that a climate declaration exists and where it can be found. If, and if so how, this information should be expanded needs to be evaluated in greater detail going forward.

# Impact assessment

This section describes the consequences for various stakeholders and actors that may be expected as an effect of the roadmap. The ambition is to present advantages, disadvantages and consequences for various actors such as developers, contractors, construction product manufacturers, smaller companies, the government and municipalities. The ambition is also to present costs, but the long-time horizon means that in many cases it is only possible to indicate where costs will arise – not how high they may be.

Essentially these consequences will arise for three reasons (compared with the climate declaration regulations planned to be introduced in 2022):

- Because the proposal includes limit values.
- Because it adds further modules in the life cycle, in addition to the construction stage A1–A5. The proposal adds reporting of modules B2, B4, B6, C1–C4 and D.
- Because it expands the number of building elements to be calculated for A1–A5. The proposal envisages declaration of installations, interior surface finishes and room fittings (interior surface finishes and fitments in the form of white goods, sanitary ware, fitted cabinets and similar).

The proposal will affect the environment, principally through limit values that lead to emission reductions. The proposal will also affect the government and developers. We can also expect construction product manufacturers to be affected by the roadmap, primarily if we impose requirements for product specific climate data and limit values. However, the long-time horizons involved make such analyses very uncertain. The roadmap therefore also includes regularly recurring evaluations of likely effects on different actors.

## The reference alternative – if no changes are made

New production of buildings impacts the climate to a great extent, which has been shown earlier in the report. A rapid transition to low climate emissions is required if Sweden’s climate targets are to be achieved. The assessment is that regulations on climate declarations are needed to reduce emissions from materials use at the construction stage, which

represents a large share of the climate impact of buildings, seen from a life cycle perspective.

The act on climate declarations that is proposed to come into force on 1 January 2022 is intended to deal with the information imbalance that exists between developers and construction product manufacturers. It is unlikely that the proposed law by itself will lead to large enough reductions in climate emissions from the new production of buildings for the construction sector to fulfil its share of achieving the climate target by 2045. It is true that climate declarations in the form proposed for introduction in 2022 would contribute to some reduction in climate emissions, but more forceful measures would be required to achieve the long-term climate target.

## The change alternative – limit values for climate emissions

Given that climate declarations are the chosen instrument for achieving a reduced climate impact of new buildings in the Swedish construction sector, limit values are the main tool at our disposal. At the later stages of the roadmap, developers' possibilities of achieving these limit values will depend on technological developments. Such technological developments can in turn be influenced to some extent by policy measures. Policy decisions can stimulate research and development, thereby speeding up the transition to new, climate-friendly technology that is cheaper than the current technology. Another consequence may be to attract increased investment in climate-friendly technology, which in turn would increase experience and knowledge in the area. This will lead to increased productivity, thus reducing the costs of the policy pursued.

There are nevertheless uncertainties about climate declaration regulations as a climate policy instrument. These have to do partly with how the instrument will affect emissions, and partly with the climate declarations themselves – will it be possible to determine limit values, and later the outcome of climate emissions, with sufficient precision in the declarations so that the system is seen to be legally certain by developers?

These uncertainties have led to a strategy that to some extent is "wait and see", the implication being that we learn more before undertaking costly measures. For example, can we expect that new and cheap technology will be available in 2035? Evaluations in 2024–2025 and 2032–2033 will most likely provide us with better answers to this question than we have today.

However, provided that limit values and the associated outcomes can be determined with sufficient precision, there are reasons to be optimistic about the possibilities of achieving our climate target with limit values. Still, this may be conditional on imposing severe sanctions on those developers who exceed the limit value. This is a conclusion that can be drawn from economic studies in the area of quantitative regulations and environmental emissions[77].

Let us assume that there are many sources of emissions which are not identical[78]. A cost-effective removal would then require that the marginal cost of removal be the same for all emissions sources. In the climate context, the term marginal cost means something like “the cost reducing carbon dioxide emissions by an additional kilo”. If the marginal cost of reducing carbon dioxide emissions is going to be the same for all emissions sources, the upshot is that all emissions sources get an individual emission quota. Those sources of emissions that have a high removal cost will get a higher emission quota than those sources that have low removal costs.

Assume, for example, that carbon dioxide emissions from car traffic have to be reduced by 25 per cent. One way of resolving this dilemma would be to give every car owner a rationing card that corresponds to 75 per cent of the original fuel consumption. The problem in this case is that some car owners would be more adversely affected than others because they have to take their car to work or elsewhere, which means shifting to driving shorter distances is associated with high costs for them. If we introduce a regulatory system with an equal reduction for all car owners, the marginal cost will not be the same for all of them, which means that the system will not be cost-effective.

So does this mean that quantitative regulations are always a bad idea in the environmental context? No, it does not: a quantitative regulation, e g limit values, has the benefit of always attaining the environmental target, provided that:

[77] Brännlund & Kriström (2015).

[78] Two different types of cases can be identified in the environmental economy theory of quantitative regulations and environmental emissions: (1) when there is only a single emissions source (or several emissions sources which are identical), and (2) when there are several emissions sources which are not identical. (1) can be interpreted as there only being one company that produces all the environmental emissions, while (2) means that there are several companies that produce the emissions. For our purposes, the situation resembles (2).

- we have a good control system, which is to say we have good supervision
- severe sanctions befall those who violate the rules.

If a deviation from the environmental target implies great costs for society, it may be the case that a quantitative regulation is more effective overall than any other conceivable instrument.

A rough calculation example of the potential climate benefit of a limit value can be obtained by taking current climate emissions from new production of buildings and then reducing annual emissions by 20 per cent from 2027 to 2034[79]. This emissions reduction would be sticking to the roadmap in terms of the limit value proposed for 2027. The annual emissions reduction during this period can then be estimated at approximately 820,000 tonnes of carbon dioxide equivalents.

This can be compared with the emissions trading right in the EU ETS system[80]. What would it cost to annul 820,000 emission rights every year?[81] Assume that the price of one emission right is 20 euros[82], or about SEK 215. The annual cost of annulling 820,000 emission rights at a price of 20 euros/tonne would be SEK 176 million.

It is also possible to make an estimate of the economic benefit of this annual climate gain. The economic benefit of the climate declaration is

[79] According to Boverket's environmental indicators, domestic emissions from construction during the period 2008–2017 was 4,083,000 tons of carbon dioxide equivalents per year, on average. Emissions vary with the state of the economy: the more construction, the higher the emissions if construction uses the same methods over time. It should be noted that construction includes demolitions of existing buildings, if they occur, and groundworks that are required for the building to be erected. A better estimate of the annual reduction in emissions is likely obtained if an assumption is made about what share of emissions can be linked to demolitions and preparatory groundworks, and this share is then subtracted from the total before the estimate is made, since those emissions are not affected by Boverket's proposal for limit values. Still, it is also important to remember that the environmental indicators themselves are estimates.
[80] The EU Emissions Trading System (EU ETS) began in 2005. Today the system comprises around 13,000 European facilities, of which about 750 are in Sweden. Many of these facilities are in energy-intensive industries and energy production. Since 2012 the system also includes airlines operating within the EU. The ETS aims to reduce emissions in the most cost-effective way possible. Trading in emissions rights is intended to allow for reductions to be made in the country and the sector where the cost is lowest. Emissions trading is based on a ceiling being set for total emissions. One emission right corresponds to 1 tonne of carbon dioxide or carbon dioxide equivalents. Source: Swedish Environmental Protection Agency.
[81] Annulling emission rights means buying them up. Compare this with what is referred to as the "emissions brake".
[82] See e g https://www.di.se/hallbart-naringsliv/priset-pa-utslappsratter-rasar-ingen-anledning-till-oro/

defined as the reduction in the environmental damage cost that is achieved through the reduction in climate emissions[83]. According to reports, the price to be used in calculating national effects of carbon dioxide emissions is SEK 7/kg $CO_2e$[84]. This carbon dioxide price will be available in the Swedish Environmental Protection Agency's price database, but at the time of writing no such change to the carbon dioxide price had been made in the database[85]. The accepted price for calculating carbon dioxide emissions is SEK 1.14/kg $CO_2e$, which comes to SEK 1.16/kg $CO_2e$[86] when adjusted to current price levels. It may therefore be appropriate to calculate a range of values for the climate benefit, from a carbon dioxide price of SEK 1.16/kg $CO_2e$ to the price of SEK 7/kg $CO_2e$.

The annual economic benefit of limit values for climate emissions from buildings that bring a 20 per cent reduction in climate emissions can thus be valued – using this rough calculation method – at between SEK 1 and 6 billion. This is the annual national benefit that the cost of climate declarations should be compared against.

With respect to the possibility of determining limit values for the construction stage (modules A1–A5), however, some practical issues remain to be resolved. For example, results of climate declarations that have been carried out indicate that climate emissions from similar new buildings can differ greatly, depending on how many construction products are reported for the calculation. One problem that has been highlighted is, in other words, that the "exemplary" developer risks being disadvantaged because a careful climate calculation which includes a large number of construction products will indicate higher climate emissions for the building. This issue should be explored further.

## Consequences for the government

The roadmap will have consequences for the government principally as a result of the evaluations that are included in the proposal. Several stakeholders have pointed to the importance of recurring evaluations of effects and consequences. Evaluations will be required at the times

[83] Boverket (2018). Klimatdeklaration av byggnader (Climate declarations for buildings).
[84] See e g https://www.di.se/ledare/klimatet-har-fatt-nytt-pris/
[85] The Swedish Environmental Protection Agency's price database is updated when a decision has been made by the Swedish Transport Administration and ASEK has been updated, which normally occurs in April every year.
[86] Swedish Transport Administration (2018). Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 6.1 (Analysis method and economic calculation values for the transport sector). Chapter 12 includes a discussion of how the price can be adjusted upwards.

indicated below, and resources will have to be allocated to these evaluations.

| | |
|---|---|
| **2024–2025** | **Evaluation of the introduction of the regulatory framework. Effects/consequences for different actors, quality of declarations, administrative costs, etc to be studied.** |

| | |
|---|---|
| **2032–2033** | **Evaluation of the effects and consequences of introducing limit values, and of the prospects for carrying out the planned reduction in 2035.** |

| | |
|---|---|
| **2040–2041** | **Evaluation of the effects and consequences of reduced limit values, and of the prospects for carrying out the planned reduction in 2043, or if the regulatory framework needs to be reprioritised based on the status of climate impacts from different parts of the construction and real estate sector.** |

This shows that realisation of the roadmap will hinge to a great extent on government action. Changes to the calculation method and limit values are proposed for 2027, 2035 and 2043. These changes need to be preceded by evaluations, initiated three years before each regulatory framework change, which are capable of highlighting the effects and consequences of the regulatory framework as well as the need for changes and reductions to limit values. The proposal is for climate declarations to be changed above all in 2027 by the introduction of limit values for modules A1–A5 in order to drive climate-improving measures in project design and construction. Additional parts of the life cycle and the building will be introduced as mandatory elements of the declaration in order to gradually increase knowledge about which measures are important for reducing the climate impact of buildings from a life cycle perspective, as well as to create the conditions for a shift towards

construction with a net-zero climate impact, which will be necessary if the national climate target is to be achieved.

In addition to costs arising in connection with evaluations, the roadmap also brings consequences due to:

- changes in supervision of climate declarations (expansion of the system of control)
- an expanded climate database
- development of IT support for the climate declaration register
- further information measures.

Climate declarations will gradually be expanded according to the proposal. Generic data for materials and components for additional mandatory building elements from 2027 need to be produced and added to the national climate database. Data on biogenic carbon storage in wood-based materials and products included in the national climate database need to be collected and made available in the climate database

To allow for climate declarations to be made in a consistent manner, with similar assumptions, a series of national scenarios need to be developed in order for LCA-program developers to be able to include calculations of modules in stages B and C. These need to be made available in the national climate database.

One issue that will come up when limit values, according to the proposal, are introduced in 2027 is the need to examine in greater detail whether requirements are needed for certified declaration experts, or some other type of control – beyond the regular supervision carried out by Boverket – that declarations are of sufficient quality. If limit values are introduced as legalrequirements, greater demands need to be placed on the robustness and consistency of the calculation method and on ensuring that it produces results of sufficient quality. Lessons from the studies Boverket commissioned include how decisive and important the procedure and method are, and how difficult it is to predict whether the method will generate equivalent results independently of who carries out the calculations[87]. Some of the elements that were identified as critical in the studies commissioned by Boverket include choice of products, unit conversion, and calculation of transport distances.

[87] Flink & Joelsson (2019).

The regulations proposed from 2027 will also mean the the information and training initiatives by the government will be necessarybeyond. In preparation for the proposed law on 1 January 2022, Boverket has had an interview study done with companies of various sizes[88]. The results of this study can be taken to indicate that support and information measures should focus on smaller companies.

Finally, the issue of Nordic harmonisation of regulations and climate emissions from buildings from a life cycle perspective may imply costs for the government. A working group and a forum for dialogue have been set up to support Nordic collaboration in the area. The Swedish Life Cycle Center has been tasked with coordinating this work, and Boverket will initially be coordinating its work on climate declarations with the working group. Coordination of the working group will rotate between the different Nordic building authorities. In the autumn of 2020 Sweden will cede responsibility for coordinating the working group to Finland.

## Consequences for municipalities

This section describes consequences for municipalities in their role in the construction process under the Planning and Building Act, PBL.

According to the proposal, the big change for municipalities is set for 1 January 2022, when climate declarations become a legal requirement and developers will need to provide proof of having submitted a climate declaration to Boverket in order to receive final clearance. This means that municipalities will share supervisory responsibility over climate declarations with Boverket. A consequence of this will be an increased administrative burden for municipalities, albeit to a limited extent.

The proposal will further oblige municipalities, from 2022, to ensure that a climate declaration has been made pending final clearance. In practical terms the proposal will also make municipalities responsible for assessing whether a possible exemption from mandatory declarations is applicable.

From 1 January 2022 municipalities will not be tasked with verifying the contents of climate declarations and, from 2027, for verifying that the limit value for climate emissions from buildings is not exceeded. These tasks will fall to Boverket.

In its current form the roadmap does not imply any further consequences for municipalities. However, if groundworks become included in the regulations on climate declarations, which cannot be ruled out since

[88] Ljung & Iveroth (2020).

groundworks can contribute to considerable climate impacts, this may mean that municipalities will have to take this into account in some other way in planning. A large share of the land that may be built on in Sweden is owned by municipalities. Land transfers from municipalities are done via what are known as land allocations. The question of whether groundworks should be included in climate declarations needs to be examined further.

## Consequences for developers and contractors

What Boverket has found is that the cost increase is small when modules in addition to A1–A5 are included in the calculation of the data underlying the climate declaration[89]. We can therefore assume that the new mandatory modules that have to be reported at the use and end of life stages will only moderately increase the declaration cost.

Boverket has had five calculations made for existing buildings in order to obtain an estimate of the cost of carrying out a climate declaration[90]. These cost calculations, which were based on time reports for the various steps of the process, indicate that the cost of carrying out a climate declaration will be lower than previous calculations presented by Boverket[91]. The calculations made are shown below.

| | |
|---|---|
| Mass-produced single-family house, 150 $m^2$ | SEK 40,000 – 60,000 |
| Multi-dwelling block, 3,825 $m^2$ | SEK 20,000 – 30,000 |
| Non-residential premises, 60,000 $m^2$ | SEK 60,000 – 90,000 |
| Digital non-residential premises, 60,000 $m^2$ | SEK 30,000 – 45,000 |
| School, 7,426 $m^2$ | SEK 30,000 – 45,000 |

Assume that the cost per climate declaration is SEK 50,000 on average. How many new buildings are constructed each year and will be subject to the requirement to make a climate declaration? The number of newly constructed ordinary multi-dwelling blocks is about 400 a year, according

[89] The cost increase was 13 per cent for the school that was studied. Source: Flink & Joelsson (2020).
[90] Flink & Joelsson (2019), Flink & Joelsson (2020).
[91] Boverket (2018). Klimatdeklaration av byggnader (Climate declarations for buildings). In the report, where calculations were based on an number of large and medium-sized construction projects for multi-dwelling blocks, the cost of making a climate declaration ranged from SEK 120,000 and SEK 241,000.

to Statistics Sweden[92]. In addition to multi-dwelling blocks there are single-family houses and non-residential premises. Probably the best way to estimate the number of new buildings per year is to look at statistics on building permits. These include all new buildings granted a building permit. In 2019, according to these statistics, 13,550 buildings (homes/second homes/non-residential premises) obtained a building permit[93]. Let us further assume that 10,000 of these buildings were comprehended by the requirement to make a climate declaration, and that they were indeed built. If the number of new buildings is 10,000 per year, the total cost of making climate declarations for them can be estimated at SEK 500 million per year. This cost can be compared with the economic benefit of climate declarations, which was previously calculated to be somewhere between SEK 1 and 6 billion per year.

Boverket has also found that the difference in costs is not primarily linked to the type or size of the building, but to the format of input data. In other words, how the input data is structured has a very considerable effect on time and cost when making a climate declaration. It is likely that in most cases it takes longer to make a calculation for a multi-dwelling block than for a single-family house, but it depends on how detailed the input data/documentation is from the project. In Boverket's calculations of actual buildings it turned out to be more expensive to make a climate declaration for a mass-produced single-family house than for a multi-dwelling block. The reason was that quantities for the single-family house were not specified in cubic metres, kilograms or square metres ($m^3$, kg or $m^2$). This meant that the quantity of each product in the house needed to be calculated before it could be input into the LCA program. By contrast, the quantities for the multi-dwelling block were all measured in the correct units and could immediately be input into the program.

One suggestion for facilitating the work on climate declarations is to produce a template for input data. This would mean that the developer and the contractor know what the LCA expert is asking for in order to make the climate calculation. Important points to include in such a template would be a specification of the type of material used in the

[92] The objects consist of construction projects that can include one or more houses. Source: SCB. http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BO__BO0201__BO0201E/AreorPerLghRegFHn/

[93] https://www.scb.se/hitta-statistik/statistik-efter-amne/boende-byggande-och-bebyggelse/bygglovsstatistik-for-bostader-och-lokaler/bygglovsstatistik-for-bostader-och-lokaler/pong/tabell-och-diagram/bygglovsstatistik-for-bostader-och-lokaler-oversiktstabell-preliminara-siffror/

building, units of measurement of the material ($m^3$, kg, $m^2$), information about what material belongs to each structural element, and possible references to product data sheets for the material. Information about suppliers should also be included, if available, or otherwise about the retailer. Compilation of data can be much quicker if it is done in connection with project design and if there are clear and detailed instructions for what has to be reported.

As long as it is done manually, work on climate declarations will probably be divided between at least two people with different skills. The compilation of quantities will be done by the contractor and the climate calculation by the LCA expert. If the procedure is digital, however, it is easier for the LCA expert to get access to the BIM data, meaning that they themselves can export the correct material quantities to the LCA tool. The cost of making climate declarations in the future will depend on how digitalisation develops. It will be cheaper if BIM is used more and digital product information becomes available. It is likely that the cost will fall over time.

In an interview study[94] commissioned by Boverket, construction companies that were interviewed emphasise the importance of clear boundaries for what building elements have to be included in a climate declaration. Boverket has previously proposed that the building envelope, load-bearing structures and non-load bearing interior walls to be included in climate declarations from 1 January 2022. According to the construction companies that emphasised the importance of clear boundaries, the term “load-bearing structures” is unambiguous. These companies fear that different companies will calculate the climate impact of their buildings differently, which could lead to a number of problems.

According to the proposed law, everything is to be included in the indicated building elements. Boverket will issue guidance on what is included, which means that it will not be possible to exclude emissions-driving construction elements.

Examples of problems that could otherwise arise, and which the companies point to, include differences between those who make maximum and those who make minimum calculations, and distorted competition in procurements. Unclear distinctions regarding what is to be included in a climate declaration could also, according to the construction companies, cause some companies to sub-optimise their buildings in order to guarantee minimum emissions levels according to the climate

[94] Ljung & Iveroth (2020).

declaration, while other emissions-driving construction elements are left out. This could eventually lead to increased or unchanged climate emissions, despite climate declarations.

Along the same line of reasoning, a number of the interviewed companies highlight the importance of industry standards and transparency regarding how climate emissions are to be reported. Unless clear and robust industry standards are introduced, the risk is considerable that companies will calculate and/or report their climate emissions differently, which will lead to difficulties in comparing different materials and buildings. Besides minimising the risk of foul play in the calculation and reporting of climate emissions, industry standards are also important for the digitalisation of climate declarations. The risk is otherwise that suppliers, developers, contractors etc will use different units, which makes digitalised climate declarations harder to achieve.

Other consequences that the companies in Boverket's interview study expect climate declarations to bring include:

- increased transparency in the industry
- more rapid innovation of more climate-friendly alternatives, e g plaster and concrete
- higher demands on suppliers regarding both sustainability and transparency
- higher house prices for the end customer
- new forms of procurement and land allocation competitions that specify maximum permissible emissions.

A majority of the interviewed companies consider that a well-functioning LCA tool is of the utmost importance for making climate declarations feasible. Most of them also believe that a well-functioning, purchased LCA tool is the solution that will allow them to manage their climate declarations.

A common attitude among the interviewed companies is to wait until the requirement becomes a reality before dealing with its consequences. This means that they are not making any particular preparations but will deal with the requirement when it becomes imperative.

## Consequences for building owners

In future evaluations of the roadmap its suitable to examine what the proposal implies for buildings and their owners. Does it imply that new

construction solutions are being used that may increase the risk of damage? Does the proposal also affect the design of buildings?

Issues that need to be examined include what might happen to other important characteristics of the building when we replace a certain material with a more climate-friendly alternative. One example is if we switch to concrete with a lower climate impact. New materials can lead to construction defects which can have negative effects on the building's technical characteristics[95]. Each framing material has its own advantages and disadvantages.

An interview survey carried out by Boverket showed that many of the potential problem areas mentioned by the construction industry as future risks are connected with the development of new materials and products[96]. Boverket's view is that the implementation of new products in the construction industry is often too easy and quick, which causes defects, deficiencies and damage to arise. Problems can also arise when a product that is part of a system is replaced with a new product that appears to have the same characteristics, but when it is actually put to use in the system, some defect occurs. This use becomes a form of full-scale test carried out live, as advance testing has only been carried out on the individual product. Boverket's opinion is therefore that there needs to be impartial research into systems and overall solutions, instead of allowing the market more or less to steer research towards individual products.

Previous experience shows that the introduction of new or alternative materials with a lower climate impact brings a risk of construction defects or that odd product choices are made in connection with construction – in other words, that new methods are introduced and products chosen that, in practice, are not up to the task. In a report from Boverket the damp and mould problems are decribed in the existing building stock[97]. The report is a more detailed exploration of results that were presented to the government in 2009 and describes the health problems that damp and mould damage can cause. An increased risk of respiratory problems and asthma has been established for people who live in buildings with that type of damage. The results show that there is damp and mould damage

[95] Boverket (2018). Hållbart byggande med minskad klimatpåverkan (Sustainable construction with a reduced climate impact).
[96] Boverket (2018). Kartläggning av fel, brister och skador inom byggsektorn (Mapping of defects, deficiencies and damage in the construction sector).
[97] Boverket (2011). God bebyggd miljö – förslag till nytt delmål för fukt och mögel. Resultat om byggnaders fuktskador från projektet BETSI (Good built environment – proposal for a new intermediate target for damp and mould. Results on damp damage in buildings, from the BETSI project).

in approximately 751,000 buildings, which corresponds to about 38 per cent of the building stock. According to the report, damp damage is present in about 38 per cent of single-family houses, about 13 per cent of multi-dwelling blocks, and in about 11 per cent of non-residential premises. To a large degree, the causes of the damage can be attributed to building structures that were put into large-scale production before they had been sufficiently tested. From the 1960s and 1970s, these include shallow foundations and internally insulated basements. From 1990–2000 they include plastered, single-layer sealed timber stud walls. The report also notes that damp damage has increased in single-family houses and that damage is also present in traditionally designed constructions with outside air ventilation, such as crawl spaces and non-insulated attics.

Boverket sees a risk in that an increased focus on the climate impact of buildings could mean that other important functions are negatively affected when measures are taken to reduce the climate impact in construction, unless this is closely monitored. This applies primarily to technical features such as fire protection, damp proofing, noise protection and durability, which should be given special consideration.

## Consequences for manufacturers of single-family houses

From the perspective of single-family house manufacturers, the proposal could mean that customers choose a slightly more expensive house design, but one whose components have a longer service life and therefore bring both economic and climate benefits.

As mentioned earlier, operational energy use (module B6) is not included in the limit value. This means that the positive effects of solar cells in B6 (i e the use stage) are not highlighted. However, climate emissions from solar cells are included at the construction stage A1–A5. This can become a disadvantage primarily for single-family houses, as solar cells may represent a large share of total electricity use in this type of house.

According groundworks, the proposal is for these not to be part of the roadmap. This facilitates climate declarations for single-family houses as groundworks depend on the location of the building. As mentioned earlier, however, the question of whether groundworks should be included in climate declarations needs to be examined further.

## Consequences for construction product manufacturers

The official report of the Swedish Government "Plats för fler som bygger mer" ("Make space for more builders to build more") noted that construction material costs had increased more than other construction costs and more than other industrial goods manufactured in Sweden[98]. The Swedish Competition Authority has also noted that market concentration is high in some parts of the construction product industry, a situation that construction companies have drawn attention to[99].

It is above all if limit values are introduced, with requirements that product specific data be used in the final climate declaration, that there may be consequences for construction product manufacturers. It is Boverket's hope that it will be possible to require, from 2027, that climate declarations be based on specific climate data for the chosen products. This would mean that manufacturers have to provide Environmental Product Declarations (EPDs).

Under current EU law it is not possible to require construction product manufacturers to provide EPDs for their products, even if it would be desirable for developers to use product specific EPDs for the chosen construction products. The responsibility for future environmental information requirements lies with the European Commission, on the basis of what is feasible under the Construction Products Regulation. The environmental impact of a product depends on where it was manufactured, which means that two identical products manufactured by the same company in two different factories can have different environmental impacts. Currently product documentation has to be specific for each product type[100]. If EPDs become a part of the CE marking system, the definition of the term "product type" may have to be changed to also include the place of manufacture.

Drawing up an EPD implies a cost for the construction product manufacturer. This cost will of course vary from case to case. It is one thing to produce a completely new EPD; it is another thing if there are

[98] SOU 2015:105.
[99] Konkurrensverket 2018:7. A high market concentration indicates that a small number of companies dominate the industry.
[100] The Construction Product Regulation's definition of product type, Article 2.9: the set of representative performance levels or classes of a construction product, in relation to its essential characteristics, produced using a given combination of raw materials or other elements in a specific production process.

similar products, meaning that an existing EPD can be used with minor changes – or perhaps even in its original form.

According to information from Byggmaterialindustrierna, an association of Swedish construction product manufacturers, it costs a manufacturer SEK 50,000–200,000 to produce a new EPD. There are also registration fees and annual fees to pay to the program operator selected by the manufacturer[101]. The total cost of producing an EPD depends on several different factors, such as the characteristics of the manufacturer (large/small, many/few construction products, few/many production facilities, geographical location, access to internal skills). It also depends on how complex the product is and to what extent a notified body must be consulted to carry out a third-party audit of the product and/or the manufacturing process.

One problem which has been highlighted is that construction projects that certain manufacturers participate in are often unique. It is rare for "mass production" of products to occur. One question to ask in this connection is if it is reasonable to require that the construction product manufacturer produce an EPD for each unique product.

The proposal in this report is that limit values for maximum climate emissions from buildings from the construction stage be introduced in 2027 and that this limit constitute an improvement compared with a reference value to be obtained in a study of climate calculations of buildings. This would mean, generally speaking, that it will be easier for buildings with timber framing (at least if the timber was produced in Sweden) to meet the emissions requirement without making improvements than for those with concrete framing (unless climate-improved concrete is used). There are studies of Swedish buildings which show that a 15 to 30 per cent improvement is possible with current technology, regardless of the choice of framing material[102] [103]. A Danish study of 60 buildings also indicates a very broad range of climate impacts for buildings of the same type, and that this is not only due to e g the choice of timber framing. The current cost price of what is known as climate-improved concrete, which will likely have to be used to a greater extent by 2027 to avoid exceeding limit values, is not much higher than

[101] See e g https://www.environdec.com/Creating-EPDs/Costs-and-fees/
[102] Erlandsson, M., Malmqvist, T., Francart, N., & Kellner, J. (2018). Minskad klimatpåverkan från nybyggda flerbostadshus – LCA av fem byggsystem. Decision guidance report.
[103] Kurkinen, E-L, Al-Ayish, N, Brick, K, Rönneblad, A, Brunklaus, B, During, O, Larsson Ivanov, O. (2018). Kriterier för resurssnålt byggande i praktiken. Energimyndigheten & IQ Samhällsbyggnad.

the price of conventional concrete. However, longer drying times are currently recommended for climate-improved concrete, which of course can prolong the construction time, with associated cost increases. Still, there should also be the potential for reducing costs by means of improved optimisation of material quantities and also by being more careful to use materials optimised for a specific use. A more efficient logistical chain could also lead to reduced material use and less wastage at the site, which in turn should lead to reduced costs associated with materials. This applies particularly to the potential for more careful quantity estimates, which lead to more precise deliveries of loose goods such as timber by the metre, ready-mixed concrete, reinforcement bars and sheet metal. This should be less of a problem with piece goods which have not been specially ordered and material with a long shelf life, where the focus should be on using the materials in future projects. Regarding loose goods such as concrete and timber products in particular, a careful analysis should be made to ensure that the right material is used in the right place – for example by avoiding treated (impregnated, pre-painted systems with a high climate impact) timber unless absolutely necessary, or the use of sheet metal and surface finishes with a high climate impact. To reduce climate impacts where concrete is used, the focus currently is on using substitute products such as fly ash and blast furnace slag in the recipes. Fly ash from coal combustion is becoming scarcer as coal burning plants are being closed down. Blast furnace slag could also be in short supply if adaptations are made to the steel industry going forward.

If limit values are reduced by 40 per cent in 2035, more transformative changes (rapid and far-reaching changes) will be needed for the major bulk materials in buildings if limit values are not to be exceeded. Still, the proposed limit values are on the low side considering the commitments in e g the construction and civil engineering sector's roadmap for climate neutrality[104]. If limit values are reduced sharply, they can put pressure on the affected sectors to take such transformative technological steps. Scenario studies are beginning to be published that look at the possibilities of achieving the ambitions of the Paris Agreement, with the focus precisely on the construction sector and the biggest groups of

[104] https://byggforetagen.se/fardplan-2045/

materials by quantity[105] [106] [107]. Overall, they all show that it will be possible, but in some cases challenging, to meet the targets, and that there are different and complementary strategies to follow. The studies also show that certain difficult decisions about investments need to be made in some sectors. The EU ETS can also push matters in this direction, even if that system does not quite as clearly target the material sectors that produce bulk materials for the construction sector. The concrete industry's roadmap for a fossil-free future contains commitments to being able to halve the climate impact from concrete by 2023; to having "climate-neutral concrete" on the market by 2030; and to being able to make all concrete "climate neutral" by 2045[108].

In his thesis from 2015, Rootzén examines the conditions and consequences for three of the most emissions-intensive industries in the EU and the Nordic countries (except Iceland)[109]. The three industries are oil refining, iron and steel production, and cement production, jointly labelled "the carbon-intensive industry". The thesis consists of six studies and is based on a bottom-up approach to current technology and new techniques and processes. Based on these studies, the following conclusions can be drawn:

1) The combined effects of all currently available reduction actions and tried and tested best process technologies are insufficient for contributing to sharp emissions reductions in the medium term (until 2030) or the long term (until 2050).

2) Unless production levels are significantly reduced it will only be with an ambitious implementation of carbon dioxide capture and storage that emissions reductions will match the climate targets. This applies to CCS (Carbon Capture and Storage) technology in which carbon dioxide is separated and stored at the bottom of the sea instead of being released

[105] Francart, N., Malmqvist, T., & Hagbert, P. (2018). Climate target fulfilment in scenarios for a sustainable Swedish built environment beyond growth. Futures, 98, 1–18. https://doi.org/10.1016/j.futures.2017.12.001
[106] Karlsson, I., Rootzén, J, Johnsson, F. (2020). Reaching net-zero carbon emissions in construction supply chains – Analysis of a Swedish road construction project. Renewable and Sustainable Energy Reviews, 120. https://doi.org/10.1016/j.rser.2019.109651
[107] Favier, A., Scrivener, K, Habert, G. (2019). Decarbonizing the cement and concrete sector: integration of the full value chain to reach net zero emissions in Europe. IOP Conf series: Earth and environmental science 225 (2019). https://doi.org/10.1088/1755-1315/225/1/012009
[108] http://fossilfritt-sverige.se/fardplaner-for-fossilfri-konkurrenskraft/fardplaner-for-fossilfri-konkurrenskraft-betongbranschen/
[109] Rootzén (2015). Pathways to deep decarbonisation of carbon-intensive industry in the European Union - Techno-economic assessments of key technologies and measures.

into the atmosphere. Additionally, technology for substituting hydrogen gas for coal in steel production is needed.

The thesis also shows that progress in overcoming the technical and financial obstacles to using alternative low-carbon technologies has so far been slow. The low price of emissions rights in the EU ETS has been far below the levels required in order to stimulate investment in manufacturing processes with low carbon emissions.

Rootzén's research also indicates that the investments required will only contribute to a marginal cost increase of about 0.5–1 percent of the end products (where the materials are used)[110]. The size of the investments needed to store carbon underneath the sea bed amount to a 25–70 per cent increase in production costs, with a corresponding increase in price, where 25 per cent refers to the price increase of steel and 70 per cent to the price increase of cement[111]. Introducing CCS technologies thus requires big investments. It may be reasonable for the state to contribute financing and to share the risk in this area.

In the roadmap it´s proposed that climate declarations comprehend further two building elements:

- installations
- surface finishes and room fittings.

This means the materials used in these building elements may also become subject to changed choices. This would particularly be the case for metals used in installations and fitments, ceramic tiles etc, and as this concerns metals it is likely that the regulatory framework could be a stimulus above all for the increased use of recycled and reusable components in products, to replace virgin raw materials. The proposal also means that manufacturers of all kinds of construction products can be given increased incentives to provide product specific information about the products' climate impact.

Similarly, should maintenance (module B2) and replacement (module B4) be added as mandatory elements of the declaration, it is above all bigger components that need to changed once or several times during the use stage that will contribute to climate impacts in these modules. These are typically various types of installations, windows, and roof and façade

[110] https://www.ingenjoren.se/2015/10/29/teknikskifte-kravs-for-nollutslapp/. Rootzén, J. & Johnsson, F. (2017). Managing the costs of CO2 abatement in the cement industry. Climate Policy, Volume 17, Issue 6, 781-800.
[111] https://www.ingenjoren.se/2015/10/29/teknikskifte-kravs-for-nollutslapp/

finishes (where, again, metals above all are prominent). Essentially it is particularly those products that have a long service life and/or a construction design that reduces their exposure to the elements which may important for the strategy to reduce this climate impact. At the same time, possibilities for allowing a freer setting of scenarios in the calculations currently appear limited, as this would lead to considerable variation in the calculations. The consequence could be difficulties in changing choices of material more than what is already being done based on climate calculations for modules A1–A5.

For modules B2 and B4 the proposal is for it to be possible to use the service life as specified in a third partycertified EPD to be possible to use in calculating the climate declaration. That means that this information needs to be provided by the construction product manufacturer in the EPD.

The end of life stage (stage C) may indicate a need for changes to choices of material based on differences in greenhouse gas emissions of different waste management processes. Normally stage C represents a relatively low climate impact in climate calculations in Sweden, for which reason there has hitherto been little discussion about changing choices of material based on possible differences in climate impact related to stage C.

It should be mentioned that in LCAs for buildings in e g Germany and Denmark, storage of biogenic carbon is included in modules A1–A3, and this is then released at stage C when the products are assumed to be burned. In these cases the climate impact of stage C will be considerable (but may actually mean that declarations for modules A1–A3 present negative emissions of greenhouse gases). For climate declarations the proposal is that biogenic carbon storage only be reported separately, meaning that it should not be included in modules A1–A3 nor be highlighted as an emission at stage C, as long as the wood products come from “sustainable” forest management with a higher rate of growth than extraction. Otherwise a notable load could be seen at stage C for wood products.

When parts of the use stage are added in the next step of the climate declaration, a referens study period needs to be assigned (the suggestion is 50 years). Some construction product manufacturers state that they would prefer a longer period, and the question is whether more durable materials would be disadvantaged with a period of 50 years. This issue has been analysed for 60 Danish buildings, where the buildings with the lowest and the highest climate impacts were the same regardless of

whether the reference study period was set at 50 or 80 years – in other words, the study showed no clear differences that were due to differences in choice of materials in "large" building elements[112]. It is primarily installations such as solar cells, with a service life of e g 30 years, that emerge as clearer contributors to the climate impact if the reference study period is extended. As explained above, not including operational energy use (module B6) in the limit value may have consequences for the installation of solar cells and solar panels. This is important to bear in mind when drawing up the climate declaration, particularly in view of the current trend towards more locally produced electricity.

Inclusion of biogenic carbon storage in climate declarations (i e if it is included in the limit value) would favour wood-based products. This has not been proposed, however – only the separate reporting of biogenic carbon dioxide content. Therefore, this should not, in the current situation, contribute to changes in choices of material; instead it amounts, in a way, to an extra reporting task for manufacturers of wood-based products.

## Consequences for architects

For architects the proposal will most likely not have any major consequences in 2027[113]. But if limit values begin to become more stringent from 2035, this may have consequences for how architects design buildings in order to achieve a lower climate impact. This will depend on how limit values are formulated and will also mean that architects need to acquire new skills in making climate calculations and using new tools.

It may be appropriate, therefore – around the time of the evaluation planned for 2032–33 if not before – to ask the question of what happens to the design of buildings if architects strive to build with the lowest possible climate impact[114].

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[112] Kjaer Zimmerman, R, Ernst Andersen, C, Kanafani, K, Birgisdottir, H. (2020). Klimapåvirkning fra 60 bygninger. Muligheder for udformning af referencevaerdier til LCA for bygninger. SBI 2020:04. https://sbi.dk/Assets/Klimapaavirkning-fra-60-bygninger/SBi-2020-04.pdf

[113] Provided that all types of buildings can just as easily lower their climate impact by 20 per cent without major design issues.

[114] This issue, and related issues, should begin to be studied already in 2024–25. Will construction become more uniform? How will it affect the possibilities of building a socially sustainable built environment, with areas that people appreciate spending time in? What will be the effect on designing façades, entrances, bays, arcades, roofs, skylights, "towers and pinnacles" etc?

## Consequences for small companies

This section deals with the consequences for small companies. “Small” here refers to size measured by sales or number of employees relative to other companies in the industry.

Boverket commissioned an interview study involving construction companies of different sizes[115]. The results of this study can be taken to indicate that support and information measures should focus on smaller companies. The study notes that smaller companies that are not specialised in wooden buildings are more concerned about the proposed law (to apply from 1 January 2022) than bigger companies and companies specialised in wooden buildings.

Among smaller construction companies there is a fear that the proposed law may mean that they need to hire additional employees and pay for consultancy services, and eventually deal with higher prices. Several smaller companies refer to the paradox that the construction sector on the one hand is accused of building homes that are too expensive, and on the other will be forced to carry out administrative measures due to climate declarations, which will push costs even higher.

Smaller companies do not consider themselves to have either the capacity or the skills to carry out climate declarations. Instead they see their main options as being – if the capacity exists – to train their current staff or, in most cases, to hire consultants to handle the task. If well-functioning and easy-to-use tools are available, such as climate modules for existing spreadsheet programs, these companies believe that they could manage the added administration to a greater extent without resorting to outside help. Irrespective of which solution the companies choose, they see administration as a problem as it implies increased costs associated with the construction process.

When other building elements of buildings are added to climate declarations in 2027, Boverket’s assessment is that the comparability and quality of climate declarations will be improved. This will in turn create improved conditions for introducing limit values. To facilitate matters for smaller actors, however, the proposal allows for the use of a default value for interior surface finishes and fitments.

Consequences for construction product manufacturers have been described under a separate heading above. For smaller construction

[115] Ljung & Iveroth (2020).

product manufacturers, producing an EPD may imply a big cost. Particularly in industries with many small manufacturers, with perhaps 10–15 employees each, producing an EPD for a construction product can imply a very considerable cost. Also, new, smaller companies that use alternative materials may appear in the future. These companies may become strategically important if their products have a substantially lower climate impact[116]. Producing an EPD for a construction product will probably constitute a major cost for such companies as well. For all of these smaller companies within the materials industry, some form of support system for producing EPDs may be necessary – not least if limit values are introduced.

## Other consequences

The requirement that building contractors provide documentation for the developer's climate declaration applies for Swedish as well as foreign contractors. Foreign contractors need to familiarise themselves with the Swedish regulatory framework, just as they need to familiarise themselves with the other requirements in the Swedish regulatory framework for construction, as building regulations are national.

The introduction of climate declarations will increase the demand for LCA consultants, and there will initially be a shortage of such consultants. This is also favourable for skills development and training companies. The consultancy business will thereby develop new skills.

New calculation tools for LCAs will need to be developed. From 2027, calculation tools used for climate declarations will need to be able to handle all the life cycle stages. This will be a boon to software developers.

The proposed law on climate declarations in 2022 will spur the development of EPDs, and an expansion of climate declarations in 2027 to include limit values will mean that EPDs become fundamentally necessary. This will favour program operators (where EDPs are registered), of which there are currently few to choose from for construction product manufacturers.

[116] This applies even for a product with same climate impact as today, but which brings other forms of added value.

# Proposal for regulation

This section describes where it would be appropriate to include regulations on limit values for climate emissions from buildings. It also discusses what are referred to as local limit values. Further, it describes the situation in the Nordic countries regarding the development of regulations with requirements on buildings to reduce climate emissions. Finally, it highlights the challenges to Nordic harmonisation related to the differences between the countries in terms how far they have progressed in adopting regulations in this area.

## Where to include regulations on limit values

Boverket's view is that it is reasonable to include regulations on limit values in the regulatory system for climate declarations as well. Limit values need to be based on the proposed act on climate declarations for buildings. Including limit values in the regulatory system for climate declarations makes for a coherent regulation.

It would not be appropriate to include limit value regulations in the Planning and Building Act (PBL). If limit values were regulated in PBL this would realistically be in the form of a requirement for technical characteristics of the building (Ch 8, Section 4 of PBL). But there would nevertheless be a considerable difference between such a requirement and requirements for other technical characteristics. As an example, there is a considerable difference between the technical characteristic requirement that the building be safe in the event of a fire, and a requirement specifying the amount of greenhouse gases that are allowed to be emitted during the building's construction stage.

There should be a sanction – a financial penalty – if limit values are exceeded. This financial penalty should not be insignificant. The amount should be high enough that it constitutes a clear disincentive for new construction to exceed the limit values. Sanctions are already included in the separate regulatory system for climate declarations, which would then be possible to expand with sanctions for exceeding limit values. Sanctions need to be regulated in a act/ordinance.

Supervision of climate declarations should be maintained unchanged when limit values have been introduced, so that Boverket's supervision also covers limit values. Supervision at the municipal level should continue to only cover verification that climate declarations are submitted

for buildings. Municipalities are not to assess whether a limit value for climate emissions from buildings has been exceeded.

## Local guideline values

Many actors in the society want to drive the issue of reduced climate impacts further. A number of actors in the construction industry have expressed their desire to do so. Initiatives for establishing local limit values have already been taken.

Under civil law, which concerns the relationship between individuals, it is permitted to set your own limit values between parties. The set value does not need to have statutory support, but it cannot be unreasonable. This referred to below as a guideline value. Under public law, which concerns the relationship between public entities and individuals, statutory support is needed for municipalities to impose a requirement involving a limit value. This is referred to below as a limit value.

Regulations on climate declarations is proposed to come into force on 1 January 2022. These regulations will not include any limit value on climate emissions from buildings. But the fact that the regulations come into force will not prevent e g a construction company from setting its own requirements regarding maximum climate emissions for what it constructs. Another example is if the municipality, in the role of developer, sets maximum climate emissions requirements in connection with public procurement of construction contracts. The government has commissioned the National Agency for Public Procurement and Boverket to promote reduced climate impacts through public procurement. This includes formulating sustainability requirements and other means for public procurement to enable reduced climate impacts in construction from a life cycle perspective. The agencies have to provide support in method selection and regarding reference values, among other things. As the issue of climate impacts will receive increasing attention when the new law is introduced, local guideline values are likely to be increasingly imposed from 2022.

When limit values are added to the regulations on climate declarations after a number of years, it is therefore likely that there will already be established local guideline values that have been used by actors in the construction industry – but these values may differ. It can be seen as a disadvantage if there are various local guideline values in operation because this can lead to a fragmented construction market. Still, local guideline values can also build valuable experience before limit values

are laid down in the regulations on climate declarations. It is probably a good idea to begin on a small scale and then evaluate the consequences.

All actors will be obliged to comply with the specified limit value for climate emissions from buildings in the regulations on climate declarations. However, some actors will have higher ambitions and use more stringent requirements, or lower values. If an actor sets stricter limit values than the national limit value, it is important that this does not have the consequence that e g requirements for technical characteristics are negatively affected such that they no longer meet Boverket's building regulations, BBR.

## Nordic harmonisation

As mentioned earlier in this report, the political will exists for a Nordic harmonisation of building regulations regarding climate issues. Ministers of housing and construction from the Nordic countries have declared that they would like to see a Nordic harmonisation on carbon neutrality[117].

Nordic harmonisation presents a challenge, as the various Nordic countries are in very different phases of drawing up regulations. Only in Sweden has a regulatory proposal been produced. It is a challenge for the first country that draws up regulations to adapt when regulations have not been formulated in the other Nordic countries.

Regulations have to formulated in exact terms. There is a big difference between considering drawing up regulations and actually formulating proposals for regulations which are then examined by various referral bodies. Receiving referral opinions is an important step in drawing up regulations.

Below Boverket has summarised the situation in the other Nordic countries regarding plans for introducing regulations with requirements for buildings to reduce climate emissions. The summary is based on information from the Nordic construction authorities.

### Norway

Norway has plans to introduce regulations with requirements for reduced climate emissions from buildings from a life cycle perspective. There is no detailed timetable for this. It is uncertain when such regulations might be expected to be in place andthe content of such regulations. However,

[117] https://www.norden.org/en/declaration/nordic-declaration-low-carbon-construction-and-circular-principles-construction-sector.

the following points have been mentioned as potential conditions for possible regulations.

Requirements to make climate declarations for construction of new buildings and of extensive alterations to existing buildings. Such declarations would have to be made before the building is commissioned for use. Single-family houses would be exempt from the climate declaration requirement. The modules that the declaration would cover are A1–A3, B4 and B5. The building elements in the declaration would be the building envelope, excluding subterranean foundations. If a limit value is to be included, it would be of a voluntary nature.

### Denmark

Denmark does not have plans, over the next few years, to introduce regulations with requirements for reduced climate emissions from buildings from a life cycle perspective. In May 2020 guidelines were published in Denmark on a voluntary sustainability classification. This classification includes criteria on climate impact. The classification system is going to be tested and developed over two years, after which the authorities will have a better basis on which to determine whether requirements associated with climate impact are going to be introduced into building regulations or not. This will then be a policy decision.

The voluntary classification applies for construction of new buildings and for refurbishment of buildings. It applies for all types of buildings. The declaration has to be made in connection with the application for a building permit as well as before the building is commissioned for use. Declarations will cover modules A1, A2, A3, A4, A5, B4, B6, C3, C4 and stage D, but results from stage D are to be presented separately from the other modules. All building elements of the building are to be included in the declaration – areas outside of the building as well. There will be no limit values.

### Iceland

Iceland has no plans, over the next few years, to introduce regulations with requirements for reduced climate emissions from buildings from a life cycle perspective. Since 2012 Iceland has building regulations that include recommendations for LCAs. These recommendations apply to all buildings that require a building permit and apply both for construction of new buildings and for alterations to a building. They apply for all building elements of the buildings and for modules in all stages from A to C4. The recommendations say nothing about limit values. Since 2012 building regulations also include a requirement for drawing up a plan for

management of construction waste. This applies for most buildings that require a building permit and applies for construction of buildings and for all building elements. Module A5 is included. There is no limit value. In connection with a review of Iceland's climate action plan the possibility is being explored of further energy exchanges with respect to machinery and equipment used in construction projects.

### Finland

Finland has plans to introduce regulations with requirements for reduced climate emissions from buildings from a life cycle perspective. This involves changes to the country's land use and building act as well as an ordinance on climate declarations for buildings. The law is expected to enter the referral process by the end of 2020 at the earliest, while the ordinance is expected to enter the referral process during the latter part of 2021. The land use and building act is expected to enter into force in 2022. The ordinance on climate declarations for buildings is expected to enter into force before 2025.

Preliminary boundaries for the regulations are as follows. The regulations will comprehend all construction projects that require a building permit. Declarations will be required prior to the issuing of building permits. Declarations will not be required for buildings that do not have to meet energy efficiency regulations. The modules included in the declaration will be all modules in stage A, B3–B4, B6, all modules in stage C and all of D. Which building elements are to be covered by the regulations will be based on the classification system in use in Finland. Briefly, this includes load-bearing elements, the building envelope, interior walls and some installations. The regulations will include limit values.

### Summary

- Regulations on limit values should be included in the regulatory system for climate declarations.
- Local guideline values for climate impacts already exist, and will exist in parallel when limit values are added to climate declaration regulations. But once limit values are introduced, all actors must comply at least with the specified limit value.
- Sweden is the first among the Nordic countries to have drawn up a proposal for regulations on climate declarations. Nordic harmonisation is made more difficult by the fact that the various countries are in very different phases of establishing regulations for climate impacts.

# Discussion and conclusions

The proposal in this report would mean that climate declarations cover the greater part of climate impacts from a life cycle perspective. In the public consultation on Boverket's proposed law on climate declarations[118] as well as at Boverket's hearing in Stockholm in January 2020, it emerged that many actors are of the opinion that climate declarations should gradually be made to include more parts of the life cycle. Considering the fact that Nordic construction and housing ministers on the Nordic Council of Ministers[119] want to see a harmonisation of regulatory frameworks, this is also the natural route to take, as at the time of writing Sweden is the only Nordic country to have begun by limiting the life cycle to modules A1–A5. Including additional parts of the life cycle at the next step also amounts to a natural way to proceed with the gradual development of learning, knowledge and solutions about how future greenhouse gas emissions from buildings might potentially be limited through sensible project design choices, by highlighting potential future climate impacts. In other words, to increase awareness and learning, which has been the main purpose of the regulatory framework from the outset.

It needs to be pointed out, however, that the proposal to expand mandatory declarations to include essentially the entire life cycle should be considered in relation to other instruments for limiting the climate impact, from a life cycle perspective, of the building stock as a whole. Making additional parts of buildings' life cycles mandatory in the declaration does not automatically mean that the regulatory framework for climate declarations will lead to further reductions in climate impact. This is because scenarios are needed in order to be able to calculate future climate impacts. Scenarios need to be clearly defined in order to make sure the method is sufficiently robust. The core question is therefore which steering effects this regulatory framework should be focused on.

An alternative proposal could have been not to add further parts of the life cycle in 2027 and instead have the requirement for climate declarations continue to focus solely on climate impacts from construction itself (the construction stage). But that would not have

[118] Rapport 2018:23, Boverket.
[119] Declaration adopted at the Nordic Council of Ministers' meeting of construction and housing ministers in Reykjavik in October 2019. https://www.norden.org/en/declaration/nordic-declaration-low-carbon-construction-and-circular-principles-construction-sector.

fulfilled the commission to include the entire life cycle in regulations on climate declarations for buildings.

That the proposal for limit values from climate emissions from buildings, to be introduced in 2027, only comprehends modules A1–A5 means that the focus is on **driving a reduction of the climate impact that occurs today when new buildings are constructed, which can be measured and verified,** and which is not regulated in any other way, e g in building regulations.

Boverket has discussed whether it would be possible to introduce limit values earlier than 2027, as many actors in the construction sector have advocated this. Our assessment is that the earliest date they could be introduced would be 2026, but there are very many things that have to be in place before then. It is important to have time to evaluate the consequences of stringently set limit values, i e that some form of climate-improving actions is required in order not to exceed them. It is also important that the construction sector has had time to adapt and has started implementing improvement actions to reduce climate emissions related to design and product choices – it is important, for example, that sufficient numbers of appropriate construction products are available in the market. It is also of central significance that the construction sector has had time to adapt so that all the information needed for a climate declaration can be obtained without imposing an unreasonable administrative burden, and that it is of good quality. This means that digitalisation has to have taken off and that digital tools for climate calculations are in place and are used. Bill of resources need to be complete and easy to obtain. Access will also be needed to specific climate data for construction products from manufacturers. Another crucial factor is that it is possible to require the use of specific climate data in the final climate declaration. It will of course be important to have time to establish reference values before then. The evaluation carried out before the introduction of limit values should have the capacity to address all of these concerns.

In order to be able to make use of the potential inherent in digital building and construction product information, small and medium-sized companies will need to have access to simple and easy-to-use tools for climate calculations. Public building information such as the Geodata portal (currently being developed by Lantmäteriet) should be comprehensive, quality-assured and accessible for other public authorities. This would make the collection of building information for the climate declaration register more efficient and would reduce the

administrative burden for developers. The government can contribute to the development of open-source digital solutions by financing research in the area, defining criteria for public procurement, and ensuring that public building information is provided by all municipalities.

## In-depth discussion about modules in stages B, C and D

The proposals made in this report for additional elements in climate declarations from 2027 set out from the assumption that this will help increase awareness of the future climate impact of buildings, and that this can lead to proactive design choices. The additional elements proposed here also match proposals for future regulatory frameworks in e g Finland, Denmark and France, and are in line with the European Commission's Level(s) framework. As discussed earlier, the calculations will above all highlight potential future climate impacts expected during the use and end of life stages. It would be preferable, however, if the mandatory declaration could also clearly contribute to steering towards project and design choices that also clearly reduce climate impacts during stages B and C. Examples of such choices, which a life cycle analysis of a building would ideally be able to encourage, include:

- choosing design solutions and construction products that last a long time and/or are easy to repair
- choosing solutions with low maintenance needs
- designing and choosing solutions that create the conditions for giving the building a very long service life, i e solutions for flexibility and adaptability
- designing and choosing solutions that create the conditions for easy de-construction of building elements in the future, so that materials can be re-used.

All of these choices are essentially about laying the groundwork for minimising the long-term climate impact of a building (and future buildings) already at the project design stage. Above all, a high climate impact price can be paid during the use stage if large/important components need to be replaced often, either because they have short service life or because they are difficult to repair. Providing guidance on choosing solutions with low maintenance needs is another issue. However, maintenance such as regular repainting does not usually come with a high climate impact; rather, it is a cost consideration of some interest.

Another, more long-term issue is that it is essential from a climate perspective that existing buildings and built structures can be used for as long as possible before needing to be demolished and replaced by new buildings. What this means is that it must be possible to avoid removing large quantities of materials and replacing them with new materials when a building's use needs to be changed or performance-improving measures need to be taken e g due to more stringent regulations. An adaptable building, e g with tall ceilings and with building elements and components that can easily be replaced, reduces the future risk of premature demolition and costly renovations with a high rate of material replacement.

A further issue related to this is the promotion of future re-use of materials in new buildings and built structures, by means of designing for de-constructibility – which is to say, the idea that our buildings are our future materials bank.

In the best case, a more complete life cycle calculation might provide good guidance on important project design choices that have to do with these issues. In a regulatory framework such as this one, where a declaration must be made by all developers, the calculation should be facilitated and also be based on assumptions that are as similar as possible. The proposal is therefore for scenarios and calculation methodology to be rigorously defined. This is judged to be feasible today, as described in the report. What this means, however, is that specific solutions as itemised above will not be possible to highlight in declarations, other than to a limited extent. This in turn means that declaration of these elements will not necessarily drive such solutions. Still, increased learning about these matters may nonetheless be stimulated by introducing mandatory declarations, as this will highlight climate impacts and enable increased discussion of these issues.

As a future strategy for reducing the total climate impact of construction will need to be about using existing buildings more efficiently and extending their service life, the inclusion of some form of declaration about design solutions precisely for flexibility and adaptability could be considered. The European Commission's Level(s) framework has a checklist (for level 1 in "Macro-objective 2: Resource efficient and circular material life cycles") that could be used as voluntary information in the declaration in order to illustrate such design choices in the building and to stimulate this type of consideration. However, it is likely to be more effective to stimulate such design choices, including designing for de-constructibility and re-use, through other targeted policy instruments.

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# Annex 1 Governmental assignment

| | | |
|---|---|---|
| **The Government** | **Government decision** | II 2 |
| | 2020-03-05<br>Fi2020/00758/BB<br>Fi2020/00941/BB | |
| **Ministry of Finance** | Boverket<br>Box 534<br>371 23 Karlskrona | |

## Assignment to take actions to facilitate the introduction of a requirement for climate declarations when constructing buildings

### The Government's decision

The Government instructs Boverket (the National Board of Housing, Building and Planning) to take actions, in 2020–20222, to facilitate the introduction of requirements for a climate declaration when constructing buildings. Boverket shall continue its preparatory work on

- developing an open database with relevant climate data to be used for the calculation of the climate impact of buildings from a life cycle perspective,
- developing a register for climate declarations,
- developing information and guidance material, and
- drafting a plan for the continued development of climate declarations, which shall include the entire life cycle and comprehend limit values for the climate impact of buildings.

Boverket shall also assist the Government Offices of Sweden (Ministry of Finance) in preparing necessary legislation for the introduction of a requirement for climate declarations.

A proposal for a plan for the continued development of climate declarations shall be presented to the Government (Ministry of Finance) no later than on 12 June 2020. The rest of the assignment, including

completed information and guidance actions, shall be finally presented to the Government no later than on 20 December 2022.

### Background

The construction and real estate sector represent around one-fifth of Sweden's domestic emissions of greenhouse gases. The construction of buildings greatly impacts the climate, and in order to achieve Sweden's climate target of having zero net greenhouse gas emissions into the atmosphere by the year 2045, and thereafter achieving negative emissions, a more rapid transition towards low emissions is required in the sector. Calculations of climate impact when constructing buildings are currently only carried out to a limited extent, and there is a need for increased awareness and information about the climate impact of buildings as well as about how various choices in the construction process impact the environment and the climate.

The Government intends to propose that a requirement on drawing up and submitting climate declarations when constructing buildings be introduced on 1 January 2022, which is comprehended by the January Agreement, a policy agreement between the Swedish Social Democratic Party, the Centre Party, the Liberals and the Green Party. Introducing a requirement for climate declarations will involve legislative amendments, which are currently being prepared by the Government Offices of Sweden. Certain preparatory actions must be taken to introduce the requirement for climate declarations in an effective and appropriate manner. The Government has previously commissioned Boverket to begin such work during 2019 (Fi2019/02439/BB).

Introducing a requirement for climate declarations entails new obligations for the industry's stakeholders, which is why it is important that the application of the provisions does not become too burdensome. To limit the costs and to facilitate the introduction of climate declarations, basic data for calculating the climate impact of buildings must be made available. This is especially important for small and medium-sized companies and foreign stakeholders. To ensure that climate declarations are of a high and consistent quality, it is important that the data used when calculating climate impact are transparent, quality assured and representative of the Swedish market. An open database with climate data is also of great significance for other climate calculations unconnected with the introduction of a requirement for climate declarations. Therefore, climate data that is not essential to producing climate declarations but of importance when assessing the climate impact of a building should also be included in the database.

The introduction of a requirement for a climate declaration when constructing a new building shall be considered part of the efforts to steer towards reducing climate impact from buildings from a life cycle perspective. A clear plan for the continued development of climate declarations should be prepared to provide the construction and real estate sector with long-term rules and planning conditions. Such declarations shall, in the long term, be used to set minimum requirements for construction from a life cycle perspective.

### Details about the assignment

When carrying out the assignment, Boverket shall, to the extent possible, consider the ambition established at the meeting in Reykjavik on 10 October 2019 between Nordic Ministers responsible for Construction and Housing: to increase the Nordic cooperation with respect to approach, methodology, data and tools for carbon neutrality in the built environment.

When developing the database with climate data, Boverket shall make appropriate use of the expertise and experience available on the subject within the Swedish Environmental Protection Agency and the Swedish Transport Administration. An open database with climate data and a climate declaration register shall be available for use by relevant stakeholders no later than on 1 January 2022, when the requirement for climate declarations is intended to come into force.

On behalf of the Government

[signature]

Per Bolund

[signature]

Roger Eriksson

# Annex 2 Specialised section

This annex provides a more detailed description of the calculation of additional modules in climate declarations, described in more general terms in the section “Additional modules in climate declarations from 2027”.

## Maintenance and replacement – module B2 and module B4

Calculation of modules B2 and B4 is proposed to include scheduled, periodic replacement and maintenance of all materials and components included in the climate declaration for modules A1–A3, with a shorter technical service life than the 50-year reference study period. Routine maintenance and unscheduled repairs are not included in the calculation. The climate impact of production of replaceable components and maintenance materials such as paint is included, as is transport to the construction site and waste management.

The number of replacements is proposed to be calculated without any rounding down or up, according to the formula:

Number of replacements = (reference study period / technical service life of the component/measure) -1

Calculations of modules B2 and B4 are added up and declared as a joint item.

### The method according to the SS-EN 15978 standard

According to SS-EN 15978, replacement (module B4) includes the environmental impact from production of materials in building components that have reached the end of life stage and therefore need to be replaced during the building’s reference study period. Module B4 also includes transportation of components and materials for the building, the impact of energy-intensive processes used when carrying out the replacement and waste management of the removed components. According to the SS-EN 15978 standard, maintenance (module B2) includes the environmental impact of processes used for maintaining the building’s technical performance and aesthetic qualities. This includes e g cleaning and painting of the building’s interior and exterior, maintenance of installations, and production and transportation of material required for these processes.

The climate impact of replacement (module B4) depends on four factors: the duration of the reference study period, which building elements and components are expected to be replaced, the climate impact of the production of these components, and how frequently they are replaced. The two main strategies for reducing climate impact in modules B2 and B4 are therefore to select components/materials/products with a longer technical service life and to design the building such that there is less need for replacing or maintaining different components. This means, for example, limiting sensitive building elements exposure to the weather and taking into account how different building elements are combined to enable various components to reach their full technical service life before needing to be replaced.

### Proposal and main purpose of calculations

The way of calculating the number of replacements means, for example, that a component with a technical service life of 20 years would be replaced 1.5 times during a 50-year reference study period. All components and materials with a service life longer than the reference study period are assumed to have 0 impact when calculating module B4.

Regarding the calculation method for the number of replacements, the alternative to the method proposed above is to round the number of replacements up or down; for example, that a component with a service life of 20 years is replaced twice over a 50-year period. Allowing a partial number of replacements, as proposed here, has several advantages. The calculation result will be less sensitive to threshold effects related to assumptions about technical service life. If you instead round up or down, two similar products with a service life of 24 and 25 years, respectively, would be replaced twice and once, respectively. In other words, a small difference in service life would effectively double the climate impact in module B4 for this product. With the proposed method, the first product would be replaced 1.08 times, which significantly reduces the difference.

The technical service life and maintenance intervals applied need to be standardised for Swedish conditions and should be included in the climate database. The scenarios can build on Erlandsson (2015[120]) and are needed to enable tool developers to include calculations of modules B2 and B4 for the climate declaration. This would not imply significant additional work in making the calculation. However, technical service

[120] Erlandsson (2015). Livslängdsdata samt återvinningsscenarion för mer transparenta och jämförbara livscykelberäkningar för byggnader. Rapport B2229. IVL Svenska Miljöinstitutet.
https://www.ivl.se/download/18.343dc99d14e8bb0f58b76ce/1445517742414/B2229.pdf

from an EPD would likely also be useful for the calculation if used to calculate modules A1–A3. This means that a component's technical service life is assumed to be independent of how and where it is installed and used. The only exception is components and materials embedded in more long-lived building elements that will clearly not be replaced during the reference study period, such as insulation under a concrete slab.

With respect to values for technical service life and maintenance intervals, the proposed approach is the same as in most other countries (e g France, Denmark). This considerably simplifies the calculation compared to making case-by-case assessments, which would be done according to the factor method in the ISO 15686[121] standard. The factor method considers all case-specific parameters that may influence the replacement intervals for different components but it is significantly more complicated and relies on several arbitrary estimations (7 different factors for each component), which risks leading to major variations in the calculation of module B4, if allowed.

The same data for climate impact for replaced parts and materials used for the calculation are used to calculate the equivalent material for modules A1–A3, meaning climate data that reflects the current production of material, either as generic data from the climate database or based on any EPD data used. This implies that the climate impact is assumed to remain the same as it is today, which is highly unlikely. However, there is currently no common practice within academia or the industry for using more dynamic emission scenarios to calculate module B4 (in the way proposed for module B6). This may change in the future if consensus is reached on how to set such future scenarios for climate impact of production of various building materials.

#### Detailed description with considerations and details regarding modules B2 and B4

One important methodological issue when calculating replacement and maintenance during the use stage is how to set replacement and maintenance intervals. EPDs and technical specifications for construction products usually contain a reference service life, but this value is not always appropriate to use as the conditions of use may vary. As previously mentioned, SS-EN 15978 refers to the ISO 15686[122] standard, which proposes the use of a factor method where the reference service

[121] International Standards Organization (2020) ISO 15686-1:2011 -Buildings and constructed assets — Service life planning. https://www.iso.org/standard/45798.html
[122] International Standards Organization (2020) ISO 15686-1:2011 -Buildings and constructed assets — Service life planning. https://www.iso.org/standard/45798.html

life for different building elements or components are multiplied by 7 different case-specific correction factors to represent material quality, design and execution, exposure to indoor and outdoor spaces, conditions of use, and intended maintenance of the components.

Another central methodological issue is which rule to use to set the scenario for how many times a component is replaced or maintained during the reference study period. The SS-EN 15978 standard is not entirely clear on how this is to be done, which is why it is done differently in different methods. Certain methods, for example the German DGNB system and PCR for buildings, follow the rule that the number of replacements is to be be rounded up or down. This means that if the reference study period is 50 years, a product with a technical service life of 20 years would be replaced twice in 50 years. The Finnish method[123] also mentions the possibility of rounding the number of replacements up or down depending on the case. PCR for buildings mentions the possibility of ignoring unlikely replacements, i e replacements or maintenance that would occur shortly before the end of the reference study period. It would be improbable, for example, to replace a component with a service life of 24 years after 48 years with a 50-year reference study period. Some methods instead use calculations with partial replacements. This means that a component with a 20-year technical service life is “assumed” to be replaced 1.5 times during a 50-year reference study period. This rule is applied in the French E + B method.

Here we propose the use of a 50-year reference study period. However, it is important to point out that this time horizon is not the same as the building’s service life. In order words, it is assumed that the building will not be disassembled and demolished after 50 years but will remain in use, likely following a refurbishment. In that case, it is important to avoid methods that exclude replacements or maintenance shortly before the end of this 50-year period. A component with a service life of 45 years will really be replaced, as it is most likely that the building will remain in use for longer than 50 years. Therefore, there are two possible approaches. Either the number of replacements/repairs is rounded up or stated as a decimal value representing partial replacements. The first approach represents emissions that will actually occur during a 50-year period (for example, a component with a service life of 20 years will be replaced twice). The second approach distributes the climate impact of production

[123] Finnish Ministry of the Environment. (2019). Method for the whole life carbon assessment of buildings. https://julkaisut.valtioneuvosto.fi/handle/10024/161796.

of the component across the remaining value by the end of the 50-year period (for example, a component with a service life of 20 years will be replaced 1.5 times, as the replaced component will have half of its remaining service life left after 50 years). This rule appears to be slightly less common but has the advantage that the calculation result becomes much less sensitive to threshold effects with respect to assumptions on technical service life, as previously mentioned.

## Operational energy use – module B6

The system boundary for operational energy use (module B6) should correspond with the definition of energy performance as specified in the Planning and Building Act (PBL).

The emission factors used to calculate greenhouse gas emissions should represent the annual average consumption mix in Sweden, both for district heating and electricity. The factors should be based on emission scenarios that describe a future development of the energy system in line with the national climate targets.

Boverket identifies a need for certain efforts before implementing the proposal regarding module B6. National emission scenarios for energy carriers need to be developed based upon which emission factors can be determined. Going forward, the handling of locally produced energy, especially solar cells, also needs to be investigated further.

### The method according to the SS-EN 15978 standard

As described in SS-EN 15978 Sustainability of construction works, operational energy use (module B6) includes "energy used by building-integrated technical systems during the operation of the building". This includes heating, hot water, ventilation, air conditioning, lighting, lifts, escalators, etc. Thus far, the standard has not been clear on whether electricity use that are not building-related are to be included or not, but this will likely be clarified in the ongoing review of the standard. The evaluation of the energy use itself according to the standard is in turn based on the EN 15603[124] standard.

According to SS-EN 15978, the system boundary for operational energy use should correspond to the energy performance directive and its national implementation, which means, among other things, that the

[124] Swedish Institute for standards. (2008). SS-EN 15603:2008 - Energy performance of buildings – Overall energy use and definition of energy ratings.

system boundary should be in accordance with the definitions used in a member state's energy requirements for construction.

The determination of climate emissions from operational energy use (module B6) is achieved by multiplying energy use by emission factors for greenhouse gas emissions for the different energy carriers used in the building.

### Proposal and main purpose

It is important that the methods used in the climate declaration and to calculate energy performance in BBR are uniform, both from a user perspective, as differences would add complexity, and because it creates opportunities for using the energy calculations made during planning as a basis for also determining climate emissions. Because the climate declaration must be submitted before final clearance, energy use cannot be based on measured values but must be calculated in compliance with the energy management regulations.

The definition of energy performance in PBF[125] is based on delivered energy, with the exception of energy from the sun, wind, ground, air or water generated in the building or on the buildings´ plot. This means that the definition in practice includes purchased energy. It corresponds to, and is specified through, the definition of the building's energy use in Section 9 Energy Management in BBR.[126] BBR clarifies that only locally produced energy used in the building may be credited, i e exported energy may not be credited. To be in accordance with the definitions in the energy management requirements, net export of locally produced electricity to the electric grid would therefore not give any advantage in module B6 but would need to be reported as separate information. When determining climate emissions from operational energy use (module B6), the starting point should thus be delivered, purchased energy (unweighted), which is then multiplied by emission factors for greenhouse gas emissions for the various energy carriers used in the building.

[125] Chapter 1, section 3 a § of the Planning and Building ordinance (2011:338).
[126] Boverkets construction regulations (2011:6) – mandatory provisions and general recommendations.

## Specialised section on operational energy use (module B6)

#### Emission scenarios for energy carriers should represent an annual average Swedish consumption mix

With respect to the method for climate data to be used in calculating operational energy use (module B6), it should be noted that Sweden's electricity market is divided into four lots as part of the Nordic electricity market Nordpool. For district heating, the actual energy production depends on the local grid, which differs between municipalities. However, a national average consumption mix (including import, export and losses) is proposed for both cases. The main reason is that it matches other, similar national methods in the Nordic countries and the method developed by the EU's Joint Research Centre.[127] Another reason is that the declaration is proposed to focus on the building's qualities rather than its location, meaning a building is not penalised if it is connected to a district heating network with higher emissions. Correspondingly, we propose that the declaration does not cover potential advantages of purchasing "green electricity" or electricity with an electricity disclosure (of guaranteed of origin). It is appropriate to use a consumption mix that accounts for import, export, and losses to represent the energy actually delivered to the building.

With respect to the time resolution of the energy mix, it is recommended that an annual average is used for the sake of simplicity. The use of, for example, an hourly value would significantly increase the amount of required data and the complexity of the calculations, and the variation in results is usually quite small.

#### The emission scenarios should represent the future development of the energy system

With respect to scenarios for the future development of climate impact from different energy carriers, it is important to use a future scenario to ensure that the climate data used corresponds to Sweden's climate targets for the development of the energy system. Using such "dynamic" climate data also complies with the methods now being developed for a future equivalent regulatory framework in e g Denmark and Finland. Such climate data needs to be produced for energy carriers for Swedish conditions and be based on a national scenario in line with the climate

[127] Moro, A., & Lonza, L. (2018). Electricity carbon intensity in European Member States: Impacts on GHG emissions of electric vehicles. Transportation Research Part D: Transport and Environment, 64(April 2017), 5–14. https://doi.org/10.1016/j.trd.2017.07.012

target. Erlandsson (2019)[128] has drafted a proposal for such a scenario based on long-term prognoses from the Swedish Energy Agency, the Danish Energy Agency, the Swedish Wind Energy Association and the Swedish Environmental Protection Agency.

There are not yet any such "official" emission factors in Sweden, meaning they would need to be developed. Because reporting is to be based on so-called accounting LCA, it is important that they are set in that way and do not incorporate an impact analysis for this particular part of the calculation. Boverket has started its work on producing values to include in the climate database for calculating module A5. Last year, Sweden Green Building Council (SGBC) completed a project and settled on a common method for their certification procedure. This is currently described in Citylab's manual for sustainable districts.[129] In parallel, the construction sector is also devising a shared calculation method as part of its roadmap efforts.

#### Need for investigation of locally produced energy, especially solar cells

As mentioned above, the consequence when operational energy use (module B6) is not included in the limit value is that the positive effect of e g solar cells in the use stage is not highlighted, although it causes increased emissions in the construction stage. How this is to be handled needs to be further investigated going forward.

It is primarily single-family houses that may see a clearer disadvantage, as solar cells may represent a greater share of total electricity use for this type of building (the ratio roof area/net heated area is generally higher). With a dynamic energy scenario for operational energy use (module B6), the advantages also become less visible compared to a static energy scenario, as greenhouse gas emissions should generally decrease in the energy system in the future.

One possible solution for getting around this problem when the limit value is limited to the construction stage (modules A1–A5) could be to exclude climate impact for energy producing units, such as solar cells and solar panels, in the construction stage (modules A1–A5) and also when calculating module B6. However, this would not comply with the energy performance definition in PBL. If you choose not to include module B6 as mandatory in the climate declaration, climate impact from energy producing units on the building should not be included in modules A1–

[128] Erlandsson, M. (2019). Modell för bedömning av svenska byggnaders klimatpåverkan. IVL Rapport C 433.
[129] Sweden Green Building Council. (2019). Citylab manual.

A5 either. However, the problem would remain in cases of roof or façade integrated installations as they are included in the façade and roof structural element.

## End of life stage – module C

Calculation of module C is proposed to include all modules (modules C1–4), i e processes for demolition and de-construction, transport of waste and materials, processing and removal of waste and materials, including climate impacts linked to processes for recycling, incineration and disposal).

Modules C1–C2 may be calculated based on default values. Modules C3–C4 are calculated using standardised scenarios in the form of climate impact values for different groups of materials that can be provided in the national climate database.

### The method according to the SS-EN 15978 standard

As described in SS-EN 15978, the end of life stage (module C) includes de-construction and demolition of the building and waste processing of embedded material when the building does not have any further use. Module C is divided into on-site demolition and de-construction processes (C1), transport of materials (C2), waste processing (C3) and final removal of waste including incineration and disposal (C4). Potential environmental benefits of recycled materials, energy recovery or landfill gas recovery are considered to occur outside the building's life cycle and are credited to module D.

Even though module C is proposed to be included, this does not mean that the method in any way recommends that buildings only shall be used for 50 years (due to the reference study period proposed in the method for the use stage). Naturally, buildings should be used for as long as possible, but at some point in the future, de-construction and demolition will occur and the related climate impact is then part of the building's impact across its life cycle, as demonstrated in module C.

### Proposal and main purpose

By including all sections of the end of life stage (module C), it is possible to provide a more complete picture of buildings' impact throughout their life cycle. The downside of relying on similar default values and standardised scenarios is that the declaration for the end of life stage might be viewed more as informative and thereby have a highly limited steering effect. Examples of things that may impact module C include

whether plastic products are used in the construction process to a greater extent than normal. Calculation of modules C1–C4 should not result in much additional work for those making the calculations, as long as default values and climate data for modules C3–C4 are provided by Boverket in the national climate database.

Calculation of modules C1–C2 is proposed to be based on default values. Climate impact in module C1 is based on energy use and the associated climate impact of machinery for de-construction and demolition using today's methods. It may be divided into a component depending on floor area, in kilogram carbon dioxide equivalents per gross floor area (kg $CO_2e/m^2$ GFA), and a component depending on total weight for different groups of materials, in kg $CO_2e$/kg. The value for module C2 may correspondingly be calculated based on an emission factor in kg $CO_2e$/kg, the same for all types of materials. For now, this default value is proposed to be based on an estimate of the average distance between buildings and waste treatment facilities in Sweden and current use of fuel per km in vehicles. Default values for C1 and C2 can be obtained by making new measurements in demolition projects, but values recorded in existing literature[130] may also be reused. Alternatively, their approach may be updated and refined.

To calculate climate impact from modules C3-4, we propose calculating climate impact per kg material for those materials with generic data in the national climate database, and to make it available in the climate database. For the time being, calculated values will reflect today's waste processing and removal process for how various types of materials are usually handled. This means that many materials in the database may be given the same values as they belong to the same group of materials. By having similar scenarios in the form of "estimated values" available, the effort to declare modules C3-C4 is reduced but also ensures a consistency in that all climate declarations are based on similar assumptions.

If specific data is used for certain materials in the declaration and these EPDs already contain a value for modules C3-C4, these values can be used instead of the scenarios provided by Boverket. The reason for this is

[130] Erlandsson M, Pettersson D. (2015). Klimatpåverkan för byggnader med olika energiprestanda. IVL Underlagsrapport till kontrollstation 2015. För Energimyndigheten och Boverket.
https://www.boverket.se/contentassets/1efdca0430b946e99d77527a93c24971/u5176-klimatpaverkan-for-byggnader-_mh_2_me_aw_me_bov-stem_16-april_clea...pdf

to enable a certain steering potential and that, in case of new innovative materials, established scenarios are not included in the database.

With respect to calculation of carbon uptake from carbonatation of concrete after decommissioning, this is discussed in the EN 16757[131] standard. According to the standard's appendix BB, it is up to each country to create a standardised calculation method, or else carbonatation is to be ignored. In Sweden so far, the work of Stripple (2013)[132] deals with this issue.

We propose that scenarios set for the entirety of stage C reflect current processes without considering potential future changes in waste management and technology. If such a scenario is developed in the future and harmonises with other approaches in the Nordic countries, it can be used instead of the current values.

#### Detailed description modules C1–C4

Module C is divided into on-site demolition and de-construction processes (C1), transport of material (C2), waste processing (C3) and final removal of waste including incineration and disposal (C4). In similar European methods, module C's system boundaries are handled in different ways. The DGNB system only includes modules C3–4, the European Commission's system Level(s) includes C1–C4 but also offers the option of a simplified calculation that only includes C3–C4. In France, "module C" is included but it is not clear whether all the constituent modules are included in the calculation. In Norway and Finland, all constituent modules in stage C are included, but in Finland it is possible to use default values in kg $CO_2$e /$m^2$ for modules C1, C2, and C3–4.

The climate declaration's module A includes declaring climate impact from the construction process stage (modules A4 and A5). While default values for e g transport distance are used for the majority of materials in module A4 or to calculate material spillage in module A5, it is still possible to use real, specific data and measure actual material spillage on the construction site. In module C, however, it is never possible to measure specific data for e g demolition and de-construction processes in

[131] Svenska Institutet för Standarder. (2017). SS-EN 16757:2017 Hållbarhet hos byggnadsverk - Miljödeklarationer - Produktspecifika regler för betong och förtillverkade betongprodukter. https://www.sis.se/produkter/byggnadsmaterial-och-byggnader/byggnadsmaterial/betong-och-betongprodukter/ss-en-167572017/

[132] Stripple, H. (2013). Greenhouse gas strategies for cement containing products. IVL Rapport B 2024. https://www.ivl.se/download/18.343dc99d14e8bb0f58b7619/1449742948292/B2024.pdf

module C1 and actual transport distances in module C2, as these processes take place in the future. It is therefore reasonable not to put time and resources into calculating these sections in module C, but instead to base the declaration of this part on default values multiplied by e g number of $m^2$ or amounts of different materials. At the same time, this means that there is no incentive in this section of the declaration to make specific planning choices that may reduce climate impact. However, the calculations are easy to implement and provide a more complete picture of the building's climate impact from a life cycle perspective.

Default values for climate impact from demolition and de-construction processes in Sweden have been calculated by Erlandsson & Pettersson (2015) [133] and have been used e g in Larsson et al (2016) [134] and in EPDs. To calculate module C2, a default value for transport distances between construction sites and waste disposal plants of e g 14 and 15 km has been used in studies conducted in Sweden.[135]

For modules C3 and C4, equivalent to waste management and removal processes, climate impact depends on types and amounts of demolition waste materials in various categories as well as which scenarios are assumed for processing and final removal of every type of material. Above all, it is impacted by assumptions on whether different materials and products will be reused, recycled, discharged or incinerated. As previously mentioned, the scenarios should, for the time being, be based on today's conditions and statistics on how demolition waste is processed, as there is no consensus on future scenarios that could otherwise be used for this purpose.

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[133] Erlandsson M, Pettersson D. (2015). Klimatpåverkan för byggnader med olika energiprestanda. IVL Underlagsrapport till kontrollstation 2015. För Energimyndigheten och Boverket. https://www.boverket.se/contentassets/1efdca0430b946e99d77527a93c24971/u5176-klimatpaverkan-for-byggnader-_mh_2_me_aw_me_bov-stem_16-april_clea...pdf

[134] Larsson, M., Erlandsson, M., Malmqvist, T., & Kellner, J. (2016). Byggandets klimatpåverkan - Livscykelberäkning av klimatpåverkan för ett nyproducerat energieffektivt flerbostadshus med massiv stomme av trä. IVL Rapport B 2260. https://www.ivl.se/download/18.29aef808155c0d7f05063/1467900250997/B2260.pdf

[135] Larsson et al (2016) enligt ovan, Liljenström, C., Malmqvist, T., Erlandsson, M., Fredén, J., Larsson, G., & Brogren, M. (2015). Byggandets klimatpåverkan - Livscykelberäkning av klimatpåverkan och energianvändning för ett nyproducerat energieffektivt flerbostadshus i betong. Retrieved from https://www.ivl.se/download/18.2aa2697816097278807f384/1525081550712/B2217.pdf Magnusson, N. (2013). Environmental Product Declaration Type III for Buildings Definition of the End-of-life Stage with Practical Application in a Case Study. Examensarbete. KTH: Stockholm. http://kth.diva-portal.org/smash/get/diva2:659809/FULLTEXT01.pdf

To calculate climate impact from modules C3–4, we propose calculating climate impact per kg material for those materials with generic data in the national climate database and to make it available in the climate database. This generic data for modules C3–C4 for each respective material must be based on what percentage of each type of material is presumed to be recycled, reused, incinerated and disposed. This should be done using available waste statistics. Calculated values also need to be based on climate impacts from today's processes for handling, sorting of different types of material, and processes for final removal through incineration or disposal.

## Supplementary environmental information

Finally, we propose introducing a mandatory, separate declaration for biogenic carbon storage in wood-based products. It will be an account of the positive environmental impact. This is potentially valuable statistical information to track in relation to follow-ups and reviews of the climate target. Correspondingly, we also propose to declare information on the net export of locally produced electricity to the electric grid as separate information. These declarations are also reported as supplementary environmental information.

### Motive for mandatory supplementary environmental information

Biogenic carbon storage and net export of locally produced electricity are today the current, primary "strategies" when working towards so-called "climate neutral" buildings. However, climate neutrality is not a well-defined term even though it is of interest to developers for the purpose of communication. Biogenic carbon storage is one of the so-called accompanying measures included in Sweden's official climate reporting as part of its work towards the net-zero goal for 2045. Therefore, it may be beneficial to provide conditions in the climate declaration for declaring biogenic carbon storage if the authorities wish to use this data for national climate reporting. In that case, this information is to be reported separately and should not be linked to the limit values, which focus on steering towards reduction in impacts. Correspondingly, it is consistent also to report net export of locally produced electricity separately if the climate impact of production of e g solar cells is included in the declaration's modules A1–A5 (which is the starting point for the proposal). There may be some value in keeping track of net export of locally produced electricity using the climate declaration.

Reporting of biogenic carbon storage should be done in units of GWP-GHG in kg $CO_2e$ and should not require additional work, as we propose making data on carbon storage in wood-based materials and products included in the national climate database available in the same location. We propose that biogenic carbon storage only applies to carbon stored in the final construction product, not in packaging material.

It is appropriate to coordinate and harmonise with Finland's development of their "carbon handprint", which is also proposed to contain a mandatory declaration of this information. Sweden Green Building Council's (SGBC) future certification procedure NollCO2 and the methodology created through the initiative Local Roadmap for a Climate-Neutral Construction and Civil Engineering Sector in Malmö also address these matters.

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