CONCERTED ACTION
ENERGY PERFORMANCE OF BUILDINGS

(CCT1) Technical Elements

Status in 2022

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1. Introduction

Many of the aspects dealt with in the CA EPBD are closely interlinked with one another and may refer to both new and existing buildings, as well as to both inspection and certification. This is particularly true for technical aspects, such as the calculation methodologies, and how to include the efficiency of technical systems or how to integrate renewable energy within them. The CA EPBD central team 'Technical Elements' deals with issues of a technical nature, which are common to new and existing buildings, and/or with minimum demands, certification and inspection.

The central team 'Technical Elements' leads work and reports progress on the following articles of the Energy Performance of Buildings Directive (Directive (EU) 2018/844 amending Directive 2010/31/EU):

- Article 3 on adoption of methodology;
- Article 5 on calculation of cost-optimal levels of minimum energy performance requirements;
- Article 8 on electro-mobility;
- Implementation and use of CEN EPB standards in regulation in Member States;
- Annex I on Common general framework for the calculation of energy performance of buildings; and
- Annex III on Comparative methodology framework to identify cost-optimal levels of energy performance requirements for buildings and building elements.

In future, new technical elements of interest might be identified based on the needs arising from the discussions in the CA EPBD meetings focusing on new buildings, existing buildings, certification and inspection. Significant interaction is expected between these areas, as well as interaction with the Concerted Action for the Renewable Energy Directive (Directive 2009/28/EC, amended by Directive

2018/2001/EU) (RESD) and Concerted Action for the Energy Efficiency Directive (Directive 2012/27/EU and amending Directive 2018/2002/EU) (EED).

A new topic in the EPBD (Article 8, paragraphs 2-7) is the implementation of regulations for electrical vehicle charging points in national legislation. Under the Alternative Fuels Infrastructure Directive (Directive 2014/94/EU) (AFID), it is apparent that a large portion of electric charging takes place in the private domain. Hence, the key requirements under the EPBD are for recharging points and ducting infrastructure for such buildings. Therefore, ducting infrastructure is defined in the EPBD; to support pre-installation of ducting and cabling required to ensure that the cost of deploying charging points will be significantly lower in the future.

2. Objectives

The key topics covered by the Technical Elements team were:

- Further development and implementation of new CEN EPB standards (version 2 and possible improvements);
- Support for the development of standard and default values, which support the implementation of energy performance calculation standards;
- Further development and implementation of cost-optimality;
- Handling of technical systems in calculations;
- Member States implementation of electro-mobility requirements into building regulations;
- Handling of integrated renewable energy for calculation and requirements of Nearly Zero Energy Buildings;
- Handling of innovative technologies;
- Implementation of Life Cycle Assessment calculations;
- Experiences from realised Nearly Zero Energy Buildings.

3. Analysis of Insights

The Technical Elements analysis dealt specifically with issues of technical implementation that are common to new and existing buildings, as well as with minimum requirements, certification, or inspection.

Some of these topics were discussed in a wider context within the CA EPBD, and further descriptions of these topics may also be found elsewhere in these descriptions of the work of the CA EPBD.

3.1 Calculation of energy performance

3.1.1 Use of new EPB Standards in national calculation methodologies

The amending EPBD (Directive (EU) 2018/844) asks Member States to describe and report to the European Commission (EC) their national calculation methodology following Annex A of the overarching standards, namely ISO 52000-1 (Overarching EPB assessment), 52003-1 (Indicators, requirements, ratings and certificates), 52010-1 (External climatic conditions), 52016-1 (Energy needs for heating and cooling), and 52018-1 (Indicators for partial EPB requirements). The deadline for the reporting to the EC was by the transposition date of 10 March 2020.

The evaluation of status as of May 2019 showed that:

- Most Member States had either not started the process of reporting or only begun planning the reporting process;
- Member States intended to report in various ways, with certain countries planning to fill in Annex A, and others using Annex A as a template;
- Most Member States intended to report only to the EC instead of making reports publicly available.

Member States also noted that differences in implementation across Member States mean that reporting cannot obviously not be the same for all. For example, one Member State judged that 39% of the total number of values in Annex A were not relevant to their national calculation methodology.

To account for these challenges in Member States, the EC developed measures to ensure the process is as flexible as possible. This includes a support contract[1] and a Frequently Asked Questions (FAQs) document, which will include questions from other Member States and their responses. Recommendations from the CA EPBD V have been valuable input for revision of the EC guidance.

The changes to Annex I, introduced in Directive (EU) 2018/844, aimed to improve transparency and consistency between Member States whilst allowing the freedom and flexibility to adapt to local and climatic conditions. It also focuses more on health, indoor air quality and comfort levels and looks at primary energy factors and the treatment of on- and off-site renewables. Regarding requirements, Member States discussed whether performance should be based on calculated or actual energy use for end uses such as space heating, space cooling, domestic hot water, and lighting. It was understood that each Member State is free to decide if additional metrics should be used.

The energy performance of a building must be expressed in primary energy use per square meter per year. Additional indicators such as GHG emissions may also be reported. There is also a need to account for the positive influence of factors such as local solar conditions and district heating. Member States were required to implement these changes through revisions to their building codes by the transposition date of 10 March 2020. Member States were also required to report to the EC their national calculation methodology following Annex A of the overarching standard ((EN) ISO 52000-1). The EC initiated a project to support Member States through the reporting process. FAQs and case studies were made available. It was noted that this is to support Member States rather than to control the process.

There was discussion of more detailed changes such as the calculation of primary energy factors. The method for calculation is left to each Member State to decide, and, for example the possibility of using national/local or annual/monthly factors is left open. Renewable energy systems may be included in the calculation of primary energy factors, but in a non-discriminatory way. Therefore, if systems are equivalent, then they must be treated the same way, e.g., on- and off-site wind turbines or wind turbines under different ownership.

3.1.2 Cost-optimality – results from the 2nd round of calculations

The deadline for Member States to submit their second cost-optimal reports was 31 March 2018. Only 10 Member States submitted their reports by this deadline. Therefore, on 7 May 2018, EU Pilots[2] were launched for 18 Member States to facilitate reporting to the EC, with a deadline of 16 July 2018 to reply.

Initial evaluation (by November 2018) of the conformity and plausibility of the reports from 14 Member States was conducted by the Joint Research Centre (JRC). The evaluation process was lengthy because the reports themselves are long and some needed to be translated from national languages. Based on the results of JRC's evaluation and the EC's own assessment, the EC examined the conformity and completeness of the reports according to Article 5 of the EPBD, the Delegated Regulation 244/2012 and the accompanying guidelines. If the notified report was not complete or inconsistent with the EPBD and the Regulation, the EC could launch an EU Pilot (if more clarity is needed) or an infringement procedure (if there is a perceived clear breach) for non-conformity.

The JRC evaluation was based on the different stages in the reports. In most cases, the results of the conformity evaluation were sufficient, but in some cases the EC needed to ask Member States for further information in order for JRC to update its evaluation.

There were some recurrent gaps in the evaluated reports from the 14 Member States. Some had gaps in scope: some reports did not cover all building types (especially for non-residential buildings), or both new and existing buildings, or all minimum requirements. Despite the identification of such gaps, reports did not always provide a clear or identifiable plan to address the gap.

In most cases, there was only one non-residential building type and there was a lack of disaggregation according to size, age, construction materials, use patterns, and climatic zones. Even if the reference buildings might have been sufficient to cover the entire building stock, the required justification was not provided. Since this might just have been an issue of clarity in certain cases, the EC used EU Pilots to clarify. In some cases, there were no statistics or references provided for the definition of existing reference buildings, and where these were provided, the references often required translation. In the future, it would useful if Member States could provide a summary of such references.

Another recurring gap was in the identification of energy efficiency and renewable energy supply (RES) measures. Certain technologies were not taken into account; this included measures for Nearly Zero-Energy Buildings (NZEBs), RES measures, passive technologies, cogeneration and cooling for some reference buildings. In some cases, there were few variants analysed and without any justification provided.

On the calculation of primary energy, most Member States needed to provide more information. In some cases, information was provided in linked documents that were not accessible to the EC. Missing information included the calculation method (monthly vs. hourly, stationary vs. dynamic), the climate conditions applied, comfort conditions applied, the energy needs to be covered, how the energy performance is expressed (total vs. non-renewable primary energy demand), the starting year of the calculation, and the primary energy factors used. In some cases, these gaps may have just been an issue of clarity.

Other missing information included the calculation of global costs such as investment, maintenance, replacement, disposal etc., lifetime of building elements, discount rates, real interest rate(s) (for financial and societal, i.e., macro-economic perspectives), energy prices and their evolution (and the relevant sources), and CO_2 prices and their evolution. In some cases, it was not clear whether the financial or macro-economic approach was chosen.

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The sensitivity analysis was developed in order to determine whether results were reasonable. Some reports provided no information on the sensitivity analysis and others provided an incomplete analysis. Incomplete analyses lacked, for example, consideration of all building types (e.g., only new buildings), sensitivity of energy prices, sufficient analysis of discount rate variants, definition of real interest rate(s) and discount rate(s) for each scenario, as well as failure to consider sensitivity of macro-economic discount rates. In some cases, no results or comments were found.

The results used for deriving cost-optimal levels were not always clear and in some cases a cost-optimal range was not defined. Reporting of (average) gaps was often non-transparent, untraceable and misleading. Many reports lacked focus on cost-optimal levels for building elements (U-values etc.)

In many cases, plans and/or timelines to reduce the gap were not plausible or ambitious. The legal status and timeline of the plans were also unclear: plans need to be concrete, not just ideas. In some cases, the interpretation was wrong and there was no plan for correction. Where no plan was required because the gap was insignificant, this needed to be justified. Some reports were missing an analysis of the gap between cost-optimal levels and 2020 NZEB requirements.

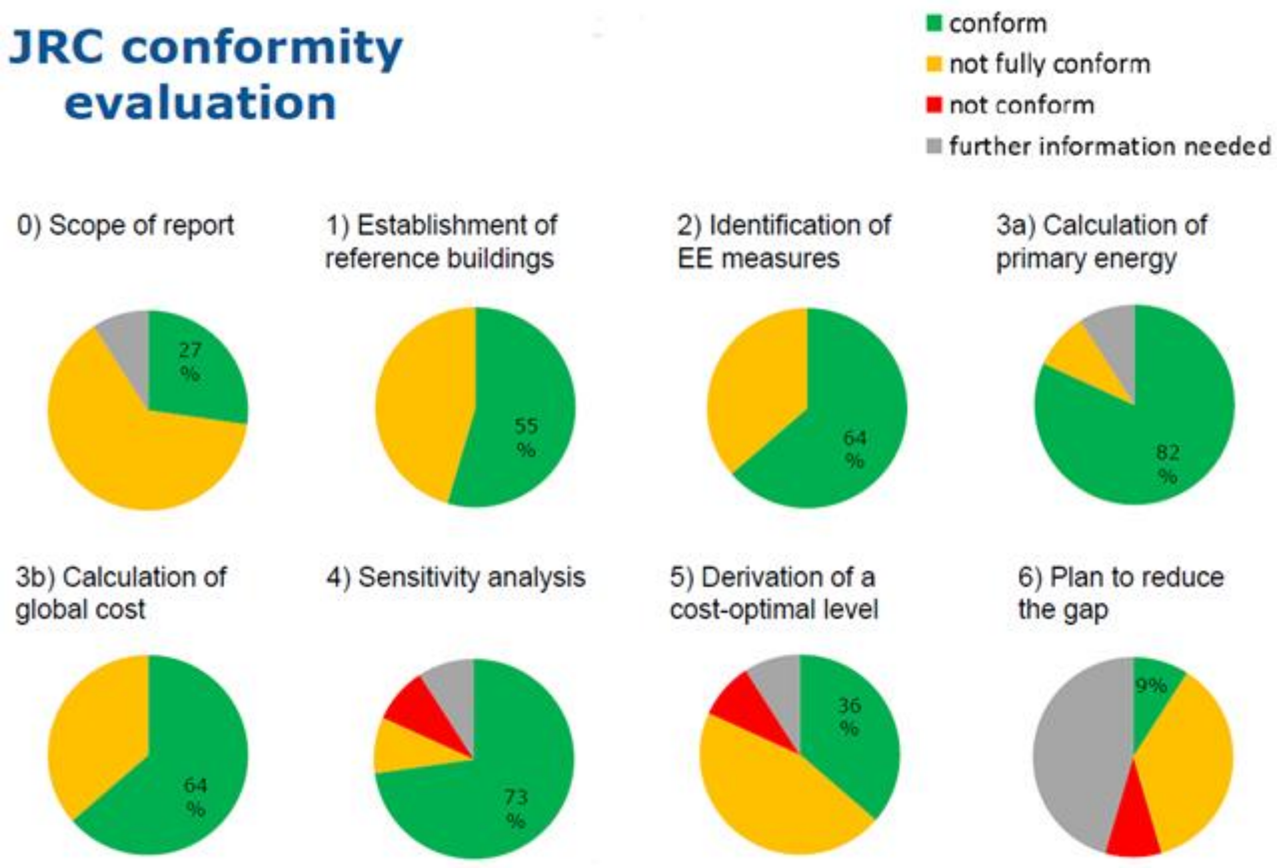

Figure 1. Overview of conformity found by JRC in the first 14 cost-optimality reports submitted by MS by November 2018.

Member States exchanged knowledge about the do's and don'ts in the process of calculations and highlighted some of the difficulties and implications that Member States experienced during preparation of their second cost-optimal reports. Results were presented and discussed. Some of the lessons learned were:

- Model inputs should be technically and functionally feasible;
- It is easy to produce technical (engineering) models, but costs are very important and hard to estimate;
- Photovoltaics out-perform other technologies and are always in the cost-optimal range if included in the analysis;
- Because other renewable energies may not be cost-optimal, it is useful to have a specific renewable energy requirement;
- The discount rate is the most important factor and the societal rate should be used instead of the financial rate;
- The 2018 calculation used the same calculation set-up, reference buildings, geometry, etc.; only the requirements, the cost of work and energy prices have changed;
- For some new buildings, the cost-optimal level varies depending on the building heat supply (i.e., whether district heating is available).

The lessons learned provided valuable input for the revision of the Guidance document.

3.1.3 Primary energy factors

Primary energy factors (PEFs), or weighting factors for electricity and district heating must be expected to evolve over time as the energy carrier fuel mix changes, e.g., with renewable energy sources increasingly replacing fossil fuels in electricity generation. In this process, the factors may use historical and forecasted information. The cost-optimal reports[3] from Member States are a useful source to inform the decisions on current and future primary energy factors in national calculations. In the calculation of the PEF for the energy performance of buildings, Member States may take into account RES supplied through the energy carrier, and RES that are generated and used on-site, provided they are used on a non-discriminatory basis. The impact of current and future primary energy factor calculations needs to be evaluated by Member States.

The choice of PEF values to calculate the primary energy content of energy delivered by different energy carriers is at the discretion of Member States. From a physical perspective, some differences between PEF values in different Member States for certain energy sources are inevitable because of differences in local conditions, e.g., electricity. In addition, there are several different internationally recognised conventions for the primary energy content of electricity from renewable or nuclear sources. Review of the published PEF values and enquiries to Member States reveal that reported PEF values do indeed vary by more than the purely physical differences. The reliability of primary energy savings (or consumption) in buildings and the consistency between cost-optimisation of national regulations and definitions of NZEB depends on the quality and transparency of the PEF calculations.

The choice of values for PEFs to calculate the primary energy content of energy delivered by different energy carriers is at the discretion of individual Member States. These parameters influence the calculation of EPCs: they can be calculated on a cost optimal basis, following CO_2 emission criteria; they can vary depending on national, regional, or local specificities; they may be based on annual, seasonal, or monthly weighted averages and on other more specific information.

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In many Member States, PEF are only reviewed to see if updates are necessary. However, Member States reported that PEF values do indeed vary greatly and identified a variety of reasons:

- For conventional energy carriers such as fossil fuels, the variations in PEFs are moderate (between 1-1.2) whereas for less established and centralised carriers such as biomass and biofuels much greater variations are observed (between 0.0-1.3).
- Electricity presents large variations (between 0.0-3.0) that are expected to vary even more as RES become more prevalent.
- PEFs for District Heating are dependent on local factors and vary significantly (0.0-1.6) across Member States as they are influenced by parameters such as cogeneration, type of source (renewable or not or waste incineration), or waste heating from processes.
- Most Member States base their PEF on national standards (21 out of 24).
- 14 out of 24 Member States use different PEF or weighting factors for individual district heating systems.

This topic has been reviewed along with CT1 New Nearly Zero Energy Buildings and CT2 Building Codes and more detailed descriptions can be seen in the reports from those core themes.

Highlights of 3.1	The status of reporting on the national calculation methodology following Annex A of the 'new' CEN overarching standard in May 2019 was that some Member States intended to fill in Annex A and some were using Annex A as a template. Even though the calculation of cost-optimal requirement levels was the second calculation of this kind, some Member States faced challenges in timely delivery and adequately reporting to the EC. In some cases, this was due to a reporting scheme that did not accommodate all national calculation procedures. CA EPBD has given input to improvements of the Guidance document and reporting template. The reliability of primary energy savings (or consumption) in buildings and the consistency between cost-optimisation of national regulations and definitions of Nearly Zero Energy Buildings depended strongly on the quality and transparency of the PEF calculations. The CA EPBD will continue discussing this topic.

Main Outcomes of 3.1
It is important in the future for Member States to follow the adaptation of the new set of EPB standards in national compliance checking of cost-optimality calculations and energy certification procedures. The CA EPBD has established a common understanding among national experts on how to use the EPB standards. More transparency and continued discussions among experts are still needed. Additionally, reporting to the EC needs further streamlining to ensure a smooth process that accommodates all the different approaches taken in the different Member States.

Main Outcomes of 3.1

There will need to be greater focus on this topic as the deadline approaches for the 3rd round of delivering cost-optimal levels calculations to the EC in 2023. Further analysis of how Member States set their PEF need to be carried out in the future.

3.2 Electro-mobility

E-mobility is a new topic under Article 8 of the EPBD, and Member States have started transposing the requirements into national legislation. These requirements are based on the Alternative Fuels Infrastructure Directive (AFID) (2014/94/EU), which indicates that a large portion of charging takes place in the private domain. Electro-mobility is therefore mentioned in the EPBD in seven paragraphs in connection to the domestic charging points that are required for use of electric vehicles. Key requirements are recharging points and ducting infrastructure. Recharging points are defined in the AFID, including the distinction between normal (transfer less than or equal to 22 kW) and high-powered (transfer greater than 22 kW) charging points. Ducting infrastructure is defined in the EPBD, however. By pre-installing ducting, the cost of deploying charging points will be up to nine times lower in the future.

Member States are required to transpose the relevant EPBD requirements, which apply to new buildings with more than ten parking spaces as well as to significantly renovated buildings, by 10 March 2020. For non-residential buildings (Article 8(2)), the requirement is that at least one recharging point and ducting for one in five parking spaces must be provided. For residential buildings (Article 8(5)), ducting must be provided for every parking space. Member States may decide to add additional requirements.

In addition, Member States are required to lay down requirements in national legislation for the installation of a minimum number of charging points for all existing non-residential buildings (Article 8(3)) that have car parks with more than 20 parking spaces. The requirements are to be laid down by 10 March 2020 and must be implemented by 2025.

Requirements in the EPBD are the minimum and Member States can go further. Additionally, national requirements may include a minimum charging capacity (normal or high-power), additional specifications for ducting infrastructure, specifications for fire safety, specifications for electric bicycles and vehicles for people with reduced mobility, requirements related to smart charging, and requirements/specifications for vehicle-to-grid energy transfer. Experience and lessons learned from additional requirements could discussed in future CA EPBD meetings.

Scope		**MS obligation**
New** buildings* **AND** *Buildings undergoing **major renovation	**Non-residential** buildings with more than 10 parking spaces	Ensure the installation of **at least 1 recharging point** and Ensure the installation of **ducting infrastructure for at least 1 in 5 parking spaces (10/3/2020)**
	Residential buildings with more than 10 parking spaces	Ensure the installation of **ducting infrastructure for every parking space (10/3/2020)**
***Existing** buildings*	**Non-residential** buildings with more than 20 parking spaces	Lay down requirements for the **installation of a minimum number of recharging points** - applicable from 2025

Figure 2. Overview of minimum obligations and deadlines for electro-mobility for Member States to implement in national legislation.

The electro mobility requirements were discussed in various sessions during the CA EPBD V and there is an inventory of information on the current status in Member States.

3.2.1 Electro-mobility - existing experiences

In a questionnaire in October 2018, Member States provided an overview on the status of implementing national requirements for electro mobility. Among the 17 responses, 10 Member States reported previous experience with electro-mobility as part of the 'Deployment of Alternative Fuels Infrastructure Directive' (AFID - 2014/94//EU), and the other seven (7) states did not report previous experience (Figure 3).

Those Member States with previous experience with the AFID were asked to describe what measures for building recharging points had been implemented, and if these could be implemented into the national EPBD regulation.

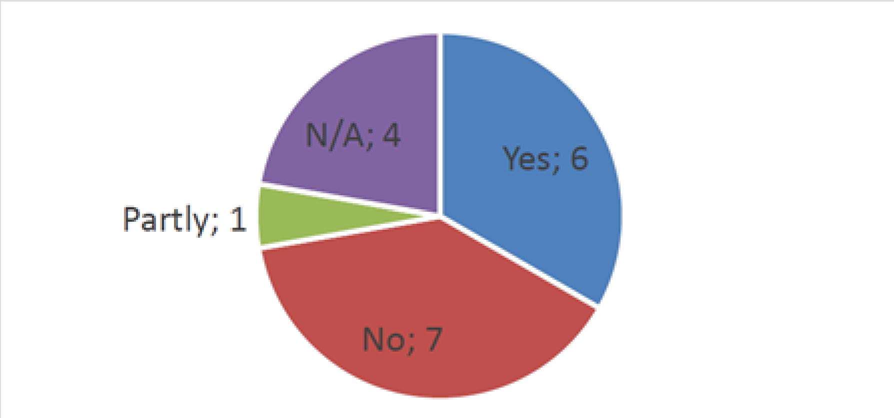


Figure 3. Member States' possibility to implement previous experiences from AFID into the national EPBD regulation.

Ten Member States answered that implementation of electro-mobility requirements into the EPBD regulation were 'in process', and seven answered 'not started yet' as of October 2018.

In December 2018, all Member States had already adopted a national policy framework under the AFID. Some, such as Austria, France, Italy and Spain, have further defined specific requirements in legislation. In countries such as Ireland, Finland and Portugal, consultation on national implementation was still ongoing in 2018.

3.2.2 Member States' implementation of electro-mobility requirements into building regulations

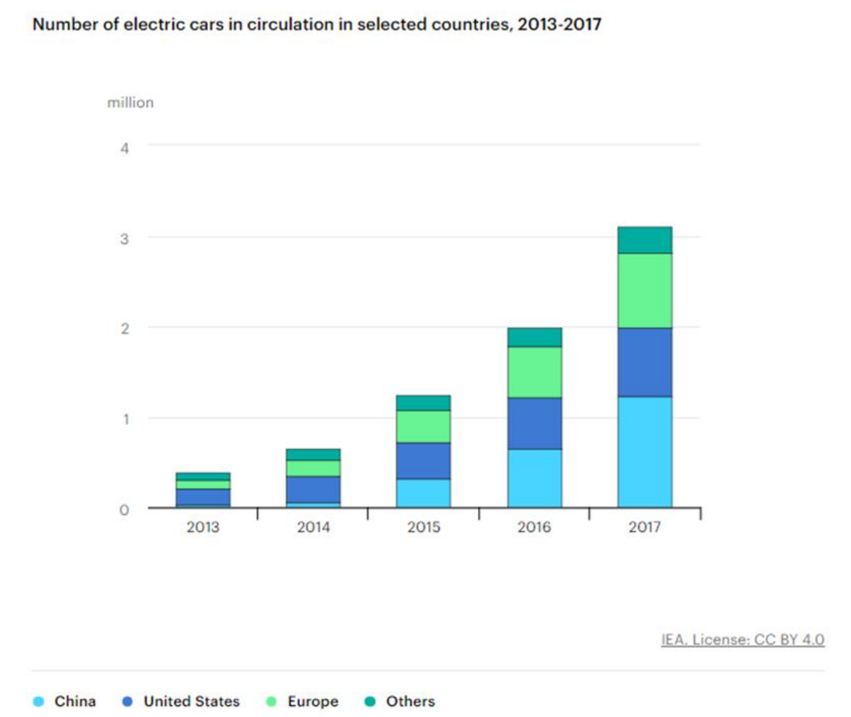
The EC published a guidance document addressing some of the concerns and questions about implementation of electro-mobility requirements into the EPBD regulation. From discussions on the guidance document and experiences from advanced Member States, it was found that local conditions and requirements needed to be considered when setting requirements and milestones. For example, where Electric Vehicle (EV) adoption is already high and charging infrastructure is well established (e.g., Norway) the goal is to continue this progress whilst ensuring that the sources of electricity remain clean. In other Member States, there must be a greater push on installing the necessary infrastructure. This has to be done according to needs, while respecting the minimum requirements in the EPBD. By ensuring the adoption is appropriate to the needs of the Member States, it is likely to find a solution that is cost-effective. However, some Member States have explored whether infrastructure should meet either the minimum EPBD requirements, the current needs, or the targets of the future. Cost implications of this decision must also be considered.

New EPBD requirements for EV charging infrastructure raise questions for Member States. These include:

- How to determine the number of charging points to be set out in national regulations – should it be based on the EPBD minimum requirements or based or the targets/needs of the country?
- How to handle situations where the owner and user of the charging infrastructure are different?
- How to handle situations where the building and the charging infrastructure are not connected?

EVs see record sales again in 2017

Over 1 million electric cars were sold in 2017 – a new record – with more than half of global sales in China. The total number of electric cars on the road surpassed 3 million worldwide, an expansion of over 50% from 2016.



Only a handful of countries have significant market share

In terms of share, Norway remains the world's most advanced market for electric car sales, with over 39% of new sales in 2017. Iceland follows at 11.7%, then Sweden at 6.3%.

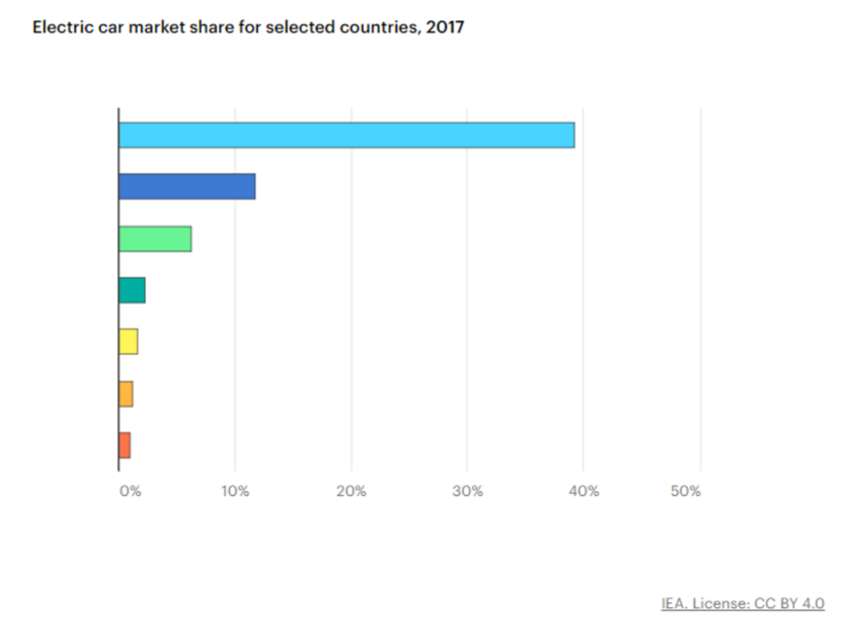


Figure 4. Electric cars, market share from IEA – Global EV Outlook 2018, https://www.iea.org/gevo2018.

Member States have discussed implementation and related issues and have made progress in finding solutions. For example, Norway has a long history of promoting and subsidising EVs, meaning that the infrastructure that many Member States are working on is already in place. Conversely, in Slovakia, there are very few EVs, so minimum EPBD requirements have been adopted. Ireland's experience has shown that the EPBD can be flexible and that that best solutions for the individual needs of the country can be found by building upon EPBD requirements. Denmark has explored whether infrastructure should meet today's needs or the needs of the future. The number of charging points strongly depends on the ambition and whether Member States want to actively promote the use of electric vehicles. It is hoped that by combining experiences with the guidance document, Member States will arrive at the best solution.

3.2.3 Implementation in national EPBD legislation

By March 2020, all Member States are expected to have implemented national legislation for charging infrastructure for electric vehicles in new and existing buildings undergoing major renovation. This information was collected and prepared for discussion in November 2020.

Using data from questionnaires and feedback from Member States, the implementation in 2020 of Article 8 was further explored. The results from the questionnaires showed that Member States have chosen to follow the EPBD's minimum requirements quite closely. In some Member States it was found, that the minimum requirement would not be adequate in the near future. However, there are areas where several Member States chose to interpret various parts of Article 8 differently.

The main findings were:

- Most Member States define 'major renovation' as in the EPBD, i.e., '*a renovation of a building where more than 25% of the surface of the building's envelope undergoes renovation or the renovation cost exceeds 25% of the building value.'*

- Most Member States had adapted the EPBD minimum requirements. A few, however, have defined their own stricter requirements, based on their own analysis of the local electro-mobility market.

- The minimum implementation of charging points will not be enough in the future as indicated in Figure 5. It is the hope that based on local demand more than the minimum number of charging points will be installed.

- Many Member States (Figure 6) provided additional initiatives for the use of EVs, such as tax exemptions, procurement support and funding of charging points.

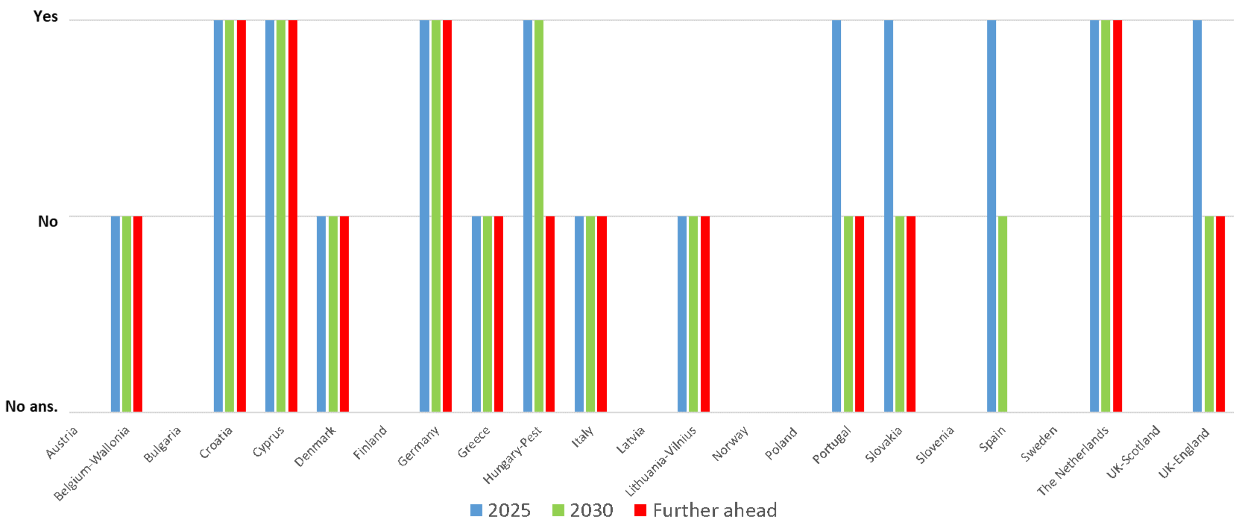


Figure 5. Will minimum implementation of charging points be sufficient for the demand of the market?

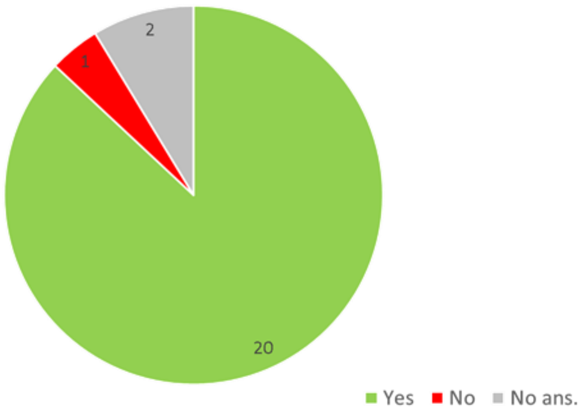


Figure 6. Have any additional initiatives been made to promote the use of EV's?

Some of the additional initiatives are:

- tax exemption/reduction for EVs;
- procurement support;
- free parking in public areas, free municipal charging stations, free access to limited traffic areas, use of shuttle lanes;
- charging points integrated with photovoltaic and metering system;
- roll out of highway chargers;
- support for installation of charging point to residential owners;
- public funding of private and public charging points.

The Netherlands followed the EPBD directive for the most part, but chose not to implement the SME exception since the government believes SMEs should play a role in green mobility. Denmark, however, felt the SME exemption should be used for existing buildings but not new buildings, largely because of the difficulty in confirming the type of ownership. Most Member States have followed the requirements stated in Article 8 for non-residential buildings. Finland, however, chose quite a different method of implementation, allowing EV chargers to be either high powered or multiple normal power chargers depending on the number of parking spaces.

Highlights of 3.2	In November 2018, only a few Member States assessed that it was possible to implement the previous AFID experiences and regulation into national EPBD legislation. AFID includes charging infrastructure beyond the limits of EPBD and so cannot be directly implemented in the EPBD. In Norway, deployment of electric vehicle charging stations occurred without EPBD legislation due to the early development of infrastructure and an ambitious subsidy scheme for electric vehicles, thus establishing ordinary market demand.

Main Outcomes of 3.2
Member States are working hard to meet the deadlines for implementing regulations for charging infrastructure in new and existing buildings undergoing major renovation. It is important to establish a comparable overview of the implementation status in the future and let Member States learn from each other to encourage further deployment of electric vehicles in all Member States. Many Member States offered additional initiatives for the use of EVs, such as tax exemptions, procurement support and funding of charging points.

3.3 Member States' Regulations

This section describes various initiatives in Member States to update national legislation. These are collected under individual headings, indicating to which part of the legislation it relates.

3.3.1 Definition of 'functionally, technically and economically feasible' in building renovation

In the context of renovation, the term 'functionally, technically and economically feasible' ensures that the EPBD requirements are not excessive and only apply when cost-effective. The notion of feasibility applies to EPBD Article 7 as well as Articles 8, 14 and 15. These articles cover the major renovation of buildings and building elements, Technical Building Systems (TBS), Self-Regulating Devices (SRD), and Building Automation and Control Systems (BACS).

Discussions focussed on how the condition of feasibility is currently applied in national legislation and what types of exemption are accepted. A pre-session questionnaire indicated that the methods of implementing EPBD Articles 7 and 8 vary considerably, with most Member States yet to define 'technically, functionally and economically feasible'.

The EC issued recommendations on how to apply the notion of feasibility in relation to EPBD Articles 8, 14 and 15. Economic feasibility considers the proportionality of the costs of a planned intervention to the benefits. There should also be an assessment of whether the technical characteristics of the system prevent the requirements from being applied or whether the changes would impair the operation of the system, or the usage of the building.

The EC has provided specific recommendations for what 'feasibility' implies in relation to Articles 8, 14 and 15. Article 8 deals with the technical building systems that could be affected in a renovation. Member States must define the cases where feasibility cannot be ensured and how this is assessed. The different elements of a feasibility assessment include:

- Technical feasibility – do the technical characteristics of the system prevent the requirements from being applied?
- Economic feasibility – are the costs of the application of requirements proportionate to the costs of the planned intervention and/or do expected benefits outweigh these costs?
- Functional feasibility – would the changes impair the operation of the system, or the usage of the building considered, taking into account the characteristics of the system or building, and the constraints that may apply?

It is up to public authorities in Member States to detail the cases for which feasibility cannot be ensured; feasibility must be assessed under clear guidelines and established procedures. Interpretation of the terms must not be left to the owner or system installer as this could lead to confusion and lack of consistency in application.

For self-regulating devices, technical feasibility would not be met in cases where the room has no heating/cooling or the heating system of an existing building makes it impossible to install such devices. For building automation and control, technical feasibility may not be met in existing buildings where the building system cannot be controlled without substantial alterations. For both, economic feasibility may not be met if the investment cannot be sufficiently recovered; however, this would be a rather rare situation.

Denmark published a guideline to help the national building industry find good and effective solutions for building renovation. It is available in Danish at https://bygningsreglementet.dk/-/media/Br/Kap_11_Energi/Vejledninger_Energi/Vejledning-Ofte-rentable-konstruktioner_BR18_januar21.pdf.

Figure 7. Guideline 'Normally financially viable constructions from Denmark'.

3.3.2 Ventilation and airtight buildings

A survey was undertaken in the autumn of 2020 among national CA EPBD experts to identify the range of building standards currently applied in Member States for airtightness, ventilation, and overheating. The results are summarised below under three topics:

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1. Member States having minimum airtightness requirements for new buildings and for major renovations;
2. Member States having minimum ventilation requirements and if they adapt their requirements for particularly airtight buildings; and
3. Member States having requirements to avoid overheating problems in new dwellings, in buildings other than dwellings and for major renovation of both.

To achieve advanced airtightness requirements, mechanical ventilation seems to be important for adequate ventilation. It was also recognised that it is necessary to independently validate ventilation systems to guarantee their good functioning and design. It was also agreed that occupants should be able to maintain and control their ventilation systems to a certain extent.

- Most Member States do not have set airtightness requirements. Instead, they give default values which effectively encourage building owners to have their buildings pressure tested.

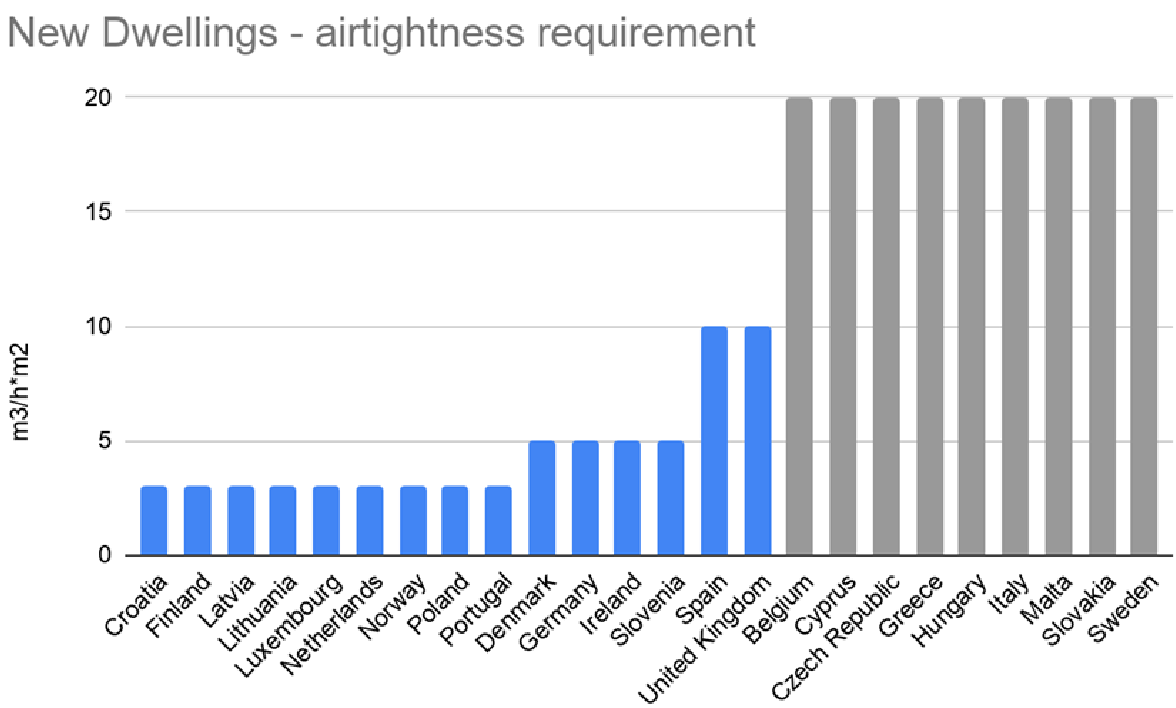

Figure 8. Airtightness requirements for new buildings.

For new dwellings, 13 out of 24 Member States that responded require an airtightness level of 5 $m^3/(h.m^2)$, or less, while nine (9) have no specific airtightness requirement (Figure 8).

- It was concluded that not all dwellings necessarily need mechanical ventilation: some dwellings can meet airtightness targets by using natural ventilation. But these buildings need to be carefully designed.

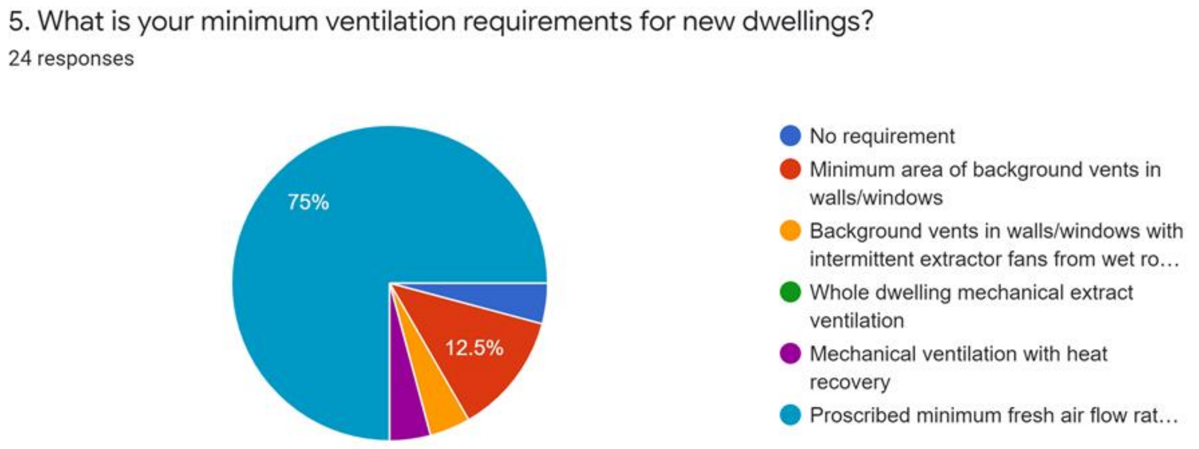

Figure 9. Minimum ventilation requirements for new buildings.

All Member States in the survey had a minimum ventilation requirement for new dwellings (Figure 9). Most countries rely on a stated minimum design airflow target, with two countries relying on free area calculation for background ventilators.

- It was agreed that overheating should be assessed, but the current calculations still need refining.

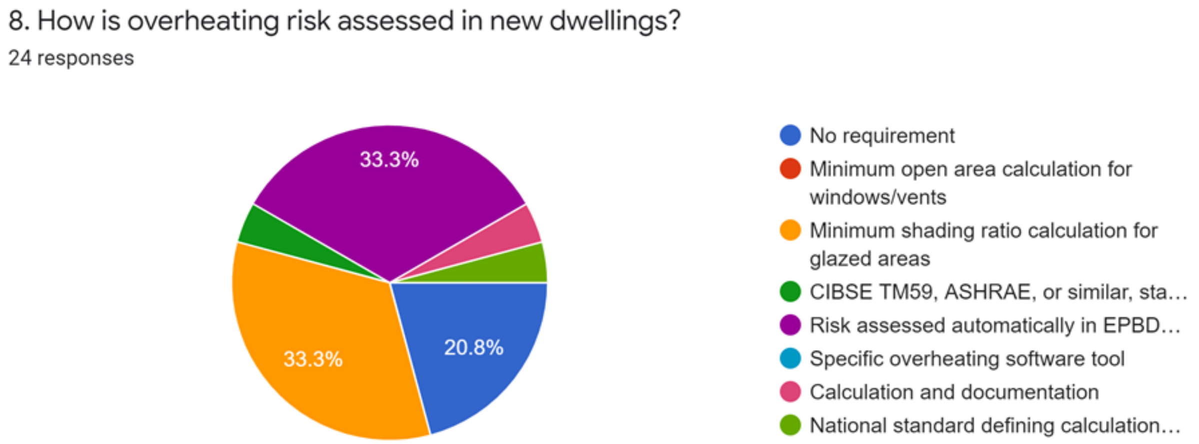

Figure 10. Overheating risk assessed in new dwellings.

The survey found that 46% of respondents reported a requirement for a specific overheating calculation based on a shading ratio for glazed elements and/or a glazing ratio to floor area. 33% reported that the overheating calculation was included in the national energy calculation methodology.

Three (3) Member States (Denmark, Ireland and Portugal) presented their requirements regarding airtightness, ventilation and overheating and their methods for assessing compliance. Some key points were:

- Denmark has ventilation practices with specific requirements in place to ensure high air quality;
- Ireland achieved an average airtightness improvement of 70% by introducing new requirements and providing financial incentives;
- Portugal reported dealing with overheating issues by limiting the solar heat gain coefficient (SHGC).

3.3.3 From smart buildings to smart districts and beyond

There is no fixed definition of 'smart districts' but there is a consensus that the pillars are: sharing of infrastructure, use of ICT, energy storage available, and an integrated approach. The better the integration, the more costs can be reduced.

In the past, the optimisation of energy performance of the built environment was generally limited to the optimisation of each building as an independent entity. A broader approach brings many benefits. There has been widespread introduction of renewables. The difficulty in deploying sufficient renewable energy technologies at specific locations (e.g., on many individual buildings) has been helped by more optimal deployment at the district or city levels. At the same time, greater digitalisation helps the deployment of electrical or thermal storage and the introduction of e-mobility.

REScoopVPP is a Horizon 2020 project to set up community driven virtual power plants that can provide flexible services to the grid and contribute to a 100% share of RES into the grid. REScoopVPP has an objective of creating the most advanced open smart building ecosystem for energy communities. EnergieID, one of the partners of REScoopVPP, is a cooperative platform that collects, analyses, and compares energy, water, waste, and transport data. The concept for future energy services is that demand follows generation as opposed to the current system of generation following demand.

One key to success was that the inhabitants and workers participating in the project should be involved in the process to optimise it. The second key message was that investment in smart districts should be a combination of public and private finance and the exchange of international knowledge and inspiring cases remain a must.

This topic has been reviewed along with CA EPBD Central Team topic Smart Buildings (CT6) and more detailed descriptions can be seen in the report from this core theme.

3.3.4 NZEBs in cold climates, examples and technical solutions

The EPBD states that from January 2021, all new buildings should reach the target status of NZEB as defined at the national level. However, there is a notable lack of technical knowledge and a limited budget across Member States. To achieve this target, it will therefore be crucial to maintain a database of NZEB examples.

A Nordic-Baltic collaboration project shared experiences of NZEB in comparable cold climates, reviewed energy performance requirements, as well as good NZEB examples and available technical solutions. A survey asked whether NZEB examples accompany the NZEB requirements in national legislation. Among the 23 Member States who answered, 17 stated that no example cases accompanied the national NZEB requirements, and six (6) confirmed that they had examples (Figure 11). The survey also asked whether national NZEB requirements in the building code follow the recommendations in EN16798-1:2019. Here, 13 Member States stated that their national NZEB requirements follow the recommendations, and eight (8) said that they did not (Figure 12).

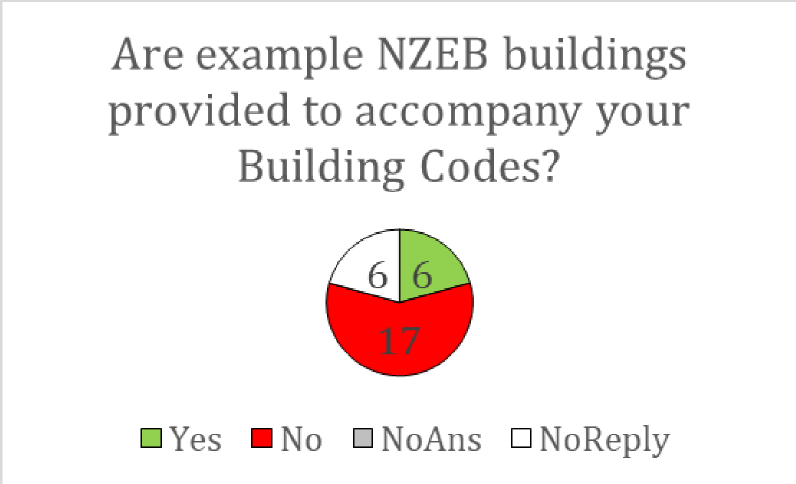

Figure 11. Question 1 from the pre-session questionnaire. 'NoAns' is a no-answer amongst those who returned the questionnaire, whilst 'NoReply' shows the number of questionnaires that were not returned.

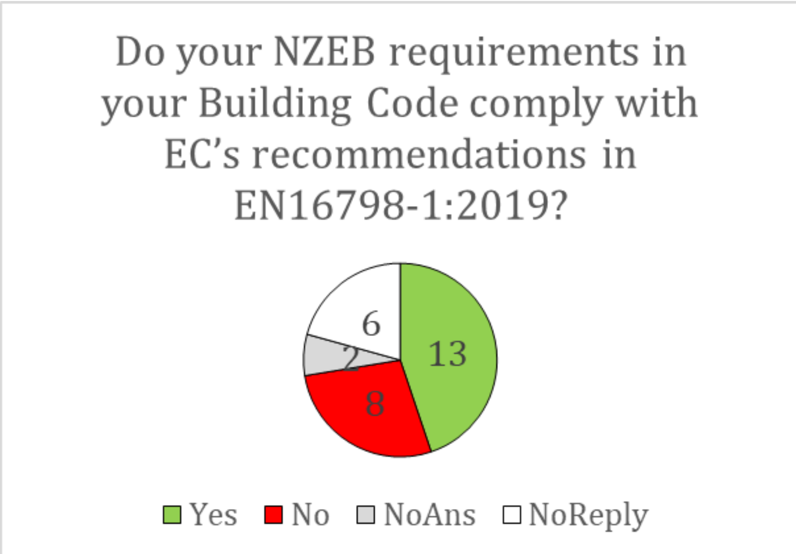

Figure 12. Question 2 from the pre-session questionnaire. 'NoAns' is a no-answer amongst those who returned the questionnaire, whilst 'NoReply' shows the number of questionnaires not returned.

Raimo Simson (Tallinn University of Technology) presented an overview of a Nordic-Baltic Project to collect NZEB examples, compare the requirements and performances of the buildings, and develop a catalogue with good technical solutions for NZEB. The objectives of the project were to:

- compare the calculation methodology for residential NZEB;
- analyse energy performance requirements and strictness of EC recommendations;
- focus on Oceanic and Nordic climate zone countries: Denmark, Estonia, and Finland.

In the Nordic-Baltic Project, different calculation methodologies and energy performance requirements for NZEB were compared and the differences between Member States and the EC recommendations were reviewed. The EC recommendations are set out in EN16798-1:2019. The recommendations divide Europe into four climatic regions: Mediterranean, Oceanic, Continental and Nordic. Recommendations are provided for each of the different regions. For the Nordic region, the net primary energy use ranges from 40-65 kWh/(m².year) for new residential houses. Two nearly zero energy reference buildings were presented, from Denmark and Estonia. In order to compare results, the performance of these buildings was calculated using both the national methodology from Denmark, Estonia and Finland, and the standardised methodology. The local renewable energy production was adjusted where needed to meet specific requirements. The selected Danish building was a single-family house, whilst the Estonian building was a 5-storey apartment building. Both buildings were well insulated, with good technical systems and built to a nearly zero energy standard in their respective countries. To accurately model the buildings, dynamic simulations were produced using IDA-ICE software.

The study showed that, when using national calculations to compare the energy demand for space cooling, supply air heating, and space heating, Estonia and Finland achieved very similar results. On the other hand, the Danish case had much lower energy demand for all items. When utilising the standardised input data from the EPBD, results from all scenarios were similar to the national calculations. The only notable difference was that Finland had a slightly higher energy demand. Following the results of the project, it was concluded that Member States should set requirements both with and without inclusion of renewable production for ease of comparison. The Oceanic zone EC recommendations for primary energy appeared to require relatively higher energy performance (at least for the northern part of the Oceanic zone) compared to the Nordic zone recommendations, and recommendations are typically met with ground source heat pump and extensive photovoltaic installation.

Based on the study, Raimo Simson provided the following conclusions:

- Having two sets of requirements, with and without renewable production inclusion, is helpful for comparison purposes;
- The Oceanic zone EC recommendations for primary energy appeared to require relatively higher energy performance compared to the Nordic zone recommendations;
- Recommendations are typically met with the provision of ground source heat pumps and extensive photovoltaic installation;
- Estonian requirements complied closely with EC Nordic NZEB recommendations;
- Finnish requirements were less strict and did not fulfil the EC Nordic NZEB recommendations.

There are a number of difficulties when comparing the energy performance requirements amongst Member States. Although it may not yet be possible to compare solutions directly across the climate zones, some solutions can serve as inspiration to create new combinations of solutions in other Member States.

3.3.5 Transposition of the EPBD requirements on BACS (Articles 14 & 15) and compliance checking

With the 2018 revision of the EPBD, Member States are now required to equip non-residential buildings with BACS where the effective rated output of heating, air-conditioning, ventilation, or combined systems exceeds 290 kW. This should be completed by 2025. A review in late 2021 explored how Member States had transposed these requirements and discussed practical implementation, how to identify gaps, and guidance for implementation as well as checking compliance.

One analysis showed that, for the most part, Member States do not have a clear idea of how many buildings fall within the scope of the requirements. Results also showed that Member States have directly transposed the new requirements, and most had conducted stakeholder consultations as part of the transposition phase. The standard EN15232-1 was generally viewed as a helpful supporting document for the transposition. However, most Member States were still at the planning stage of compliance checking and, in most cases, stakeholder consultations were not yet planned for this purpose.

Certain standards are helpful to map a building's capabilities to BACS functions and classes. As part of the translation of Articles 14(4) and 15(4), some countries said they provided references to EN 15232-1 in general, or to Class A or Class B as defined in EN 15232-1.

CA EPBD experts received a presentation by the building automation industry association, eu.bac, on an EPBD BACS Compliance Verification package they developed. They shared three important eu.bac documents related to EPBD implementation:

1. Guidelines for implementation on all BACS related articles in the revised EPBD. It also includes a review of how to interpret economic/technical feasibility of BACS requirements. It includes suggestions on how to implement technical building system optimisation.

2. A study of the impact of the revision of the EPBD on energy savings from the use of BACS. The report showed that BACS measures can provide significant savings.

3. An EPBD BACS Compliance Verification checklist which offered a view on the BACS capabilities required under Articles 14 and 15 and that can help simplify work undertaken by market surveillance authorities.

Denmark and Portugal explained how they transposed the requirements. The Danish transposition closely follows the EPBD requirements, although they added a requirement to check the installation and correct operation of the BACS if necessary. This function check includes:

- sensors;
- time controls;
- set points;
- alarms;
- presentation of data;
- verification whether the system meets expectations.

Guidance was made available with more explicit descriptions of how to fulfil the requirements. Denmark has requirements for individual rooms as well as for the whole building.

Portugal had transposed the EPBD BACS requirements, and a manual was published with guidance on the methodology.

With about 180,000 non-residential buildings that already have EPCs, a broad understanding of the building stock was possible: most buildings are over 100 m², and around 90% are privately owned. The validity of the EPCs lasts eight years.

(CCT1) Technical Elements

The requirements for new buildings in Portugal are:

- Buildings with an installed technical building system power over 100 kW need to have technical management but not (necessarily) BACS;
- Since 2019, when buildings have an installed power for technical building systems that exceeds 250 kW, it is mandatory for them to have a label B in terms of BACS classes.
- By 2025, buildings with an installed power for technical building systems over 290 kW will need to be class A and a roadmap is established for building owners to understand what they will need to do to achieve the 2025 requirements.

For existing buildings:

- Buildings with an installed power for technical building systems exceeding 290 kW (around 1,800 buildings) will be required to install BACS by the end of 2025, and label B will be the minimum requirement.

The installation and maintenance of BACS must be performed by qualified technicians, and all maintenance records must be kept on the EPC registry. Buildings with systems of 70 kW or more must have a mandatory inspection regarding BACS.

When calculating the energy performance of the building, the effect of BACS can be considered using the F_{bacs} factor, determined in accordance with standard EN15232-1. However, the real impact of BACS on consumption has not yet been measured.

There are some technical constraints for installing BACS, for example the lack of space for, e.g., technical equipment and cables that are not yet accounted for. The current regulation only accounts for economic constraints.

This topic has been reviewed along with CA EPBD Central Team topic Smart Buildings (CT6) and more detailed descriptions can be seen in the report from this core theme.

Highlights of 3.3	’Functionally, technically and economically feasible’ is a concept used in the EPBD to determine whether energy upgrading is mandatory when a building undergoes renovation. This concept also applies for technical building systems. The definition is up to the individual Member State. For example, one Member State reported that everything is functionally and technically possible, it is just a question of economy and therefore only the economically feasible applies. There are significant differences on how Member States set requirements for airtightness of new and high-performance buildings. Some do not set specific requirements, but exercise indirect control by requiring a pressurisation test and the use of results in the energy performance compliance calculation. All Member States have a minimum ventilation rate for new buildings. Even though buildings constructed today will remain for decades and will be subject to the impact of a changing climate, not all Member States (especially northern countries) require an overheating assessment.

	EU recommendations for minimum energy performance in the northern part of the Oceanic climate zone seems to be too tight. Member States should strive for the integration of public and private finance to invest in smart districts. Further exchange of international knowledge and inspiring cases remain a must. There are some technical constraints for installing BACS, such as the lack of space for technical boards and cables that are not yet accounted for. The current regulation only accounts for economic constraints.

Main Outcomes of 3.3
’Functionally, technically and economically feasible’ also applies to technical building systems when a building undergoes major renovation. However, there are large differences among Member States on defining the concept. Ventilation requirements for new and high-performance buildings differ significantly among Member States. However, some states exercise indirect control by allowing actual values used in compliance calculations. New buildings and buildings undergoing major renovation will be subject to the impact of the changing climate, but not all Member States are requesting an overheating assessment of these buildings. Concerning recommendations for NZEB in the Nordic zone it can be concluded that having two sets of requirements, with and without the inclusion of renewable production, is helpful for comparison purposes. The Oceanic zone EC recommendations for primary energy appeared to require relatively higher energy performance compared to the Nordic zone recommendations. Recommendations are typically met with the provision of ground source heat pump and extensive photovoltaic installation. There are several difficulties when comparing the energy performance requirements across Member States.

3.4 Life Cycle Assessment (LCA) methods and status

In March 2020, the EPBD, as amended by Directive (EU) 2018/844 (EPBD), set a deadline of 2050 for Member States to implement national Long Term Renovation Strategies (LTRS), setting the path, policy measures and mobilising financing needed to decarbonise their existing building stock. This has led to lower energy demands in the operational phase. However, energy is used not only in the operational phase, but also during construction. It will therefore be important to evaluate a building’s energy use over its entire lifetime to get a more accurate depiction of overall energy consumption.

3.4.1 LCA and embodied energy in future energy performance requirements

In mid-2021, Member States had a first opportunity to exchange information about how the Life Cycle Assessment (LCA) approach is to be implemented and to review how far Member States have analysed and/or discussed the inclusion of LCA in energy performance requirements or whether they are planning to do so in the future.

(CCT1) Technical Elements

DG ENER stated that the first step is to develop a 2050 whole life-cycle performance roadmap. In March 2020, the EC laid the foundations for an industrial strategy that would support the twin transition to a green and digital economy. The strategy outlines 14 different ecosystems, one of which is construction. The strategy encompasses the whole supply chain, including installers, product developers, manufacturers, and suppliers. The second action outlined in the Renovation Wave is the review of the Construction Product Regulation. The third action, the Green Public Procurement Levels, is to be completed by the end of 2022. The procurement levels only cover office buildings, but there is potential to increase the scope to schools and residential buildings. The fourth action is the update of the national training roadmaps which will include LCAs and embodied energy. The fifth action includes an ongoing review of material recovery targets and the support of the internal market for secondary raw materials. The market for secondary raw materials is relevant to LCA/embodied energy. Finally, the last action is the new European Bauhaus Platform. This platform looks at both the 'circularity' and LCA of buildings.

There are also other actions important to LCA and embodied energy. The first is EU Taxonomy (https://ec.europa.eu/info/law/sustainablefinance-taxonomy-regulation-eu-2020-852_en). For buildings over 5,000 m^2, the embodied energy and carbon of the building must be disclosed according to the standards and levels. Other important actions include the research programmes for Horizon Europe and LIFE, particularly the Work Programme and Built4People partnership. These actions are supported by EC's Level(s), the European framework for sustainable buildings (https://ec.europa.eu/environment/topics/circular-economy/levels_en), a new approach to assessing and reporting on the sustainability performance of buildings throughout the building's lifecycle.

In Belgium, a study was conducted, to test different levels of renovations for their embodied energy and material impact. Approximately one-fifth of the total GHG emissions were the result of materials, with half of it relating directly to construction materials. Previously, the analysis of buildings with a low impact was focused on the energy consumption of buildings, also known as the operational energy phase. To account for the impacts embodied in production of a material, it is important to consider construction processes, replacements, maintenance, end of life and demolition, and the impact of materials. The LCA is a technique to quantify the environmental impact of a product or building for its entire life cycle. This includes not only its operational phase, but also the production of the materials, the construction phase, maintenance, and end of life. European standards (EN 15643-1-5 and EN 15978) have been developed that specify which environmental indicators should be considered when performing an LCA, and these indicators can then be combined into a single score. The Product Environmental Footprints scheme outlines such an approach.

For Switzerland, a '7 Mile Steps' scheme was formed, which outlines the requirement to build in accordance with the Minergie-ECO scheme and the SIA Energy Efficiency Path. These schemes calculate the LCA impacts of a building and compare them against set thresholds. In Finland, the Climate Declaration, currently in the process of being written, will look at a building's carbon footprint, accounting for the emissions caused by the building over its lifecycle, and the 'carbon handprint', a term for a group of different standard-based ways of presenting potential climate benefits.

This topic has been reviewed along with CA EPBD Central Team topic Renovation Strategies (CT4) and more detailed descriptions can be seen in the report from this core theme.

3.4.2 LCA and embodied energy, tools, and guidance for implementation

Member States are starting to take LCAs and embodied energy into consideration for future building regulations. But many issues still need to be addressed. For example, it is unclear how much the additional LCA requirements will result in added effort for building planners and the impact on construction practices.

Regarding NZEB, the EPBD describes how the implementation of Directive 2010/31/EU could simultaneously ensure the transformation of the building stock and shift to a more sustainable energy supply, whilst also supporting the heating and cooling strategy. To ensure appropriate implementation takes place, the general framework for the calculation of the energy performance of buildings needs to be updated. Additionally, an improved performance of the building envelope should be encouraged with the support of the work elaborated by CEN, under Commission mandate M/480. Member States can also choose to add further supplementary measures by providing additional numerical indicators, such as those for the overall energy use of the entire building or greenhouse gas emissions.

This topic is to provide an overview of the integration of whole-life carbon (WLC) considerations in the EU policy framework, considering how the EPBD may include requirements for an assessment of the environmental impact of buildings.

The European Green Deal serves as a blueprint to address the climate objectives of the EU. It also increases the EU climate ambition goals to set an objective of climate neutrality by 2050, and a cut in GHG emissions by at least 55% by 2030 from the 1990 baseline. The 2030 objective is based on strategies with four pillars: energy efficiency, energy saving, electrification, and innovation. In response, the EC proposed the Renovation Wave, the Fit for 55 packages, as well as proposed revisions to the Renewable Energy Directive, the EED and the Emissions Trading System (EU ETS). The second part of this response was the Clean Energy for all Europeans package in 2019 (the so-called winter package), which includes the 2018 revision of the EPBD.

The building sector is responsible for more than one-third of the EU's energy-related GHG emissions and there is significant potential for emissions reductions. Only about 1% of buildings undergo an energy renovation every year, meaning that roughly 75% of the building stock is in need of improved energy performance. This is an alarming percentage, as 85-95% of today’s buildings will still be in use in 2050. The Renovation Wave was published as an action plan to improve these figures, with the ambition to double renovation rates in the next 10 years and ensure that renovations lead to a higher overall energy performance. Although energy efficiency is the horizontal guiding principle, the affordability of renovations also plays a key role by protecting people’s right to obtain affordable housing. The EC announced its intention to incorporate lifecycle thinking and circularity into the Renovation Wave from now on. This will include revising the EED and EPBD, developing a 2050 whole life-cycle performance roadmap to reduce carbon emissions from buildings, and advancing national benchmarking, developing green public procurement criteria related to life cycle and climate resilience, and setting up the European Bauhaus platform to combine sustainability with art and design.

To meet the EU’s climate and energy targets for 2030 and reach the objectives of the European Green Deal, it is vital for investments to be directed towards sustainable projects. The EU Taxonomy is at the core of the Sustainable Finance Action Plan and will help create a classification system for environmental and sustainable economic activities. This will act as a common language for investors when investing in climate positive projects. The Taxonomy Regulation, published in June 2020, develops technical screening criteria for the construction and renovation of buildings, sale and ownership, installation of energy efficient equipment, and for manufacturing in the supply chain. It says that buildings larger than 5,000 m^2 must calculate the life-cycle Global Warming Potential (GWP) resulting from construction at each life cycle stage and disclose this information to investors and clients.

The revision of the EED and EPBD will be instrumental in future iterations of the Renovation Wave. The EED will set a more ambitious binding annual target for reducing energy use, including a renovation rate of 3% of public buildings per year and using these public buildings to build increased awareness of circular economy and WLC. The revised EPBD will aim to reduce a building's GHG emissions and contribute towards the primary climate ambition with a long-term vision for buildings.

Level(s) is a European framework to assess and report on the sustainability performance of buildings throughout the whole lifecycle. The framework provides six macro-objectives and correlating indicators for projects to report against (Figure 13).

Macro Objectives	Indicators			
1. Greenhouse gas emissions throughout building life cycle	1.1 Use stage energy performance (kWh/m2/yr)	1.2 Life cycle Global Warming Potential (CO2 eq./m2/yr)		
2. Resource efficient and circular material life cycles	2.1 Bill of quantities, materials and lifespan	2.2 Construction and Demolition waste	2.3 Design for adaptability and renovation	2.4 Design for deconstruction
3. Efficient use of water resources	3.1 Use stage water consumption (m3/occupant/yr)			
4. Healthy and comfortable spaces	4.1 Indoor air quality	4.2 Time out of thermal comfort range	*4.3 Lighting*	*4.4 Acoustics*
5. Adaption and resilience to climate change	5.1 Life cycle tools: scenarios for projected future climatic conditions	*5.2 Increased risk of extreme weather*	*5.3 Sustainable drainage*	
6. Optimised life cycle cost and value	6.1 Life cycle costs (€/m²/yr)	*6.2 Value creation and risk factors*		

Figure 13. The six macro-objectives defined in Level(s) and the corresponding indicators.

Based on the full lifecycle of a building, the building sector is responsible for: 50% of all extracted materials; 50% of the total energy consumption; a third of water consumption; and a third of total waste generation. As a result, the sector is under pressure to increase resource efficiency and reduce carbon emissions. Figure 14 depicts the carbon emissions during a building's lifecycle with embodied carbon spiking at completion, then at the replacement and maintenance stages, and then finally at end of life. A typical energy renovated building today will need to be used for 40-50 years before the embodied carbon used to make it energy efficient is balanced by the lower operational emissions.

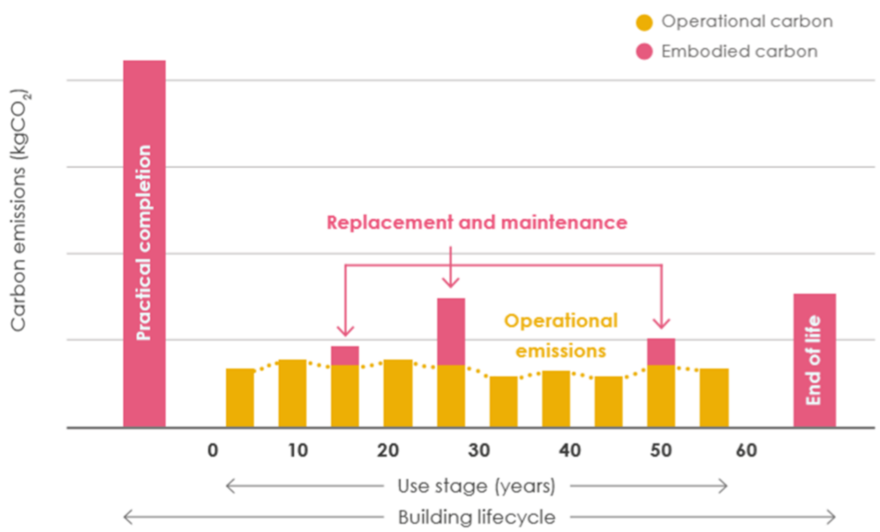

Figure 14. The interaction between operational and embodied carbon throughout the lifetime of a building. LETI Climate Emergency Design Guide.

The Green Public Procurement (GPP) criteria are being developed to facilitate the inclusion of green requirements in public tender documents. To date, GPP criteria for 20 different product groups have been developed. It was noted that there are many different LCA tools and databases available, and Level(s) provides an indicative list of those which are compliant.

Moving forward, the many upcoming revisions to policies, regulations, and guidance, such as the revisions to the EPBD and EED, will need to be monitored by Member States to ensure that national policy is being updated in parallel to reflect these changes.

3.4.3 LCA and embodied energy - Status, plans and databases for implementation in Member States

In late 2021, experts shared experiences about their national plans for implementation of LCA in future building regulations. Some Member States have well developed plans for the implementation of LCAs in future legislation, while others have not considered this issue to date.

In Denmark, LCA requirements will be enforced in 2023, with a tightening of limit values every two years. Denmark currently does not have its own LCA database, but instead utilises a German database called 'OEKOBAUDAT'.

In addition to the mandatory sustainability level, Denmark has nine requirements that are being considered beyond the typical building code. These requirements are called the 'voluntary sustainability class'. They are currently in the process of being tested, expected to finish by 2023. To make sure that building regulations set more sustainable targets, these requirements will address LCA, resource use on construction sites, Life Cycle Costing (LCC), etc. Figure 15 shows these requirements and how they will be implemented into the Danish building code. These requirements align closely with Level(s).

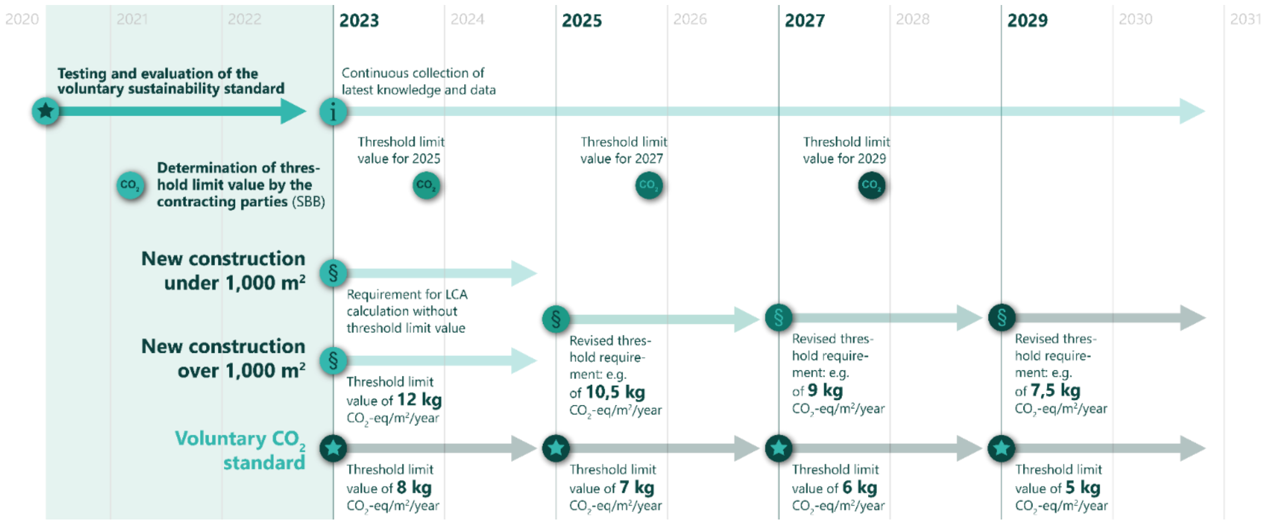

Figure 15 Staged phasing and tightening of the CO_2-criteria in Denmark.

By 2018, the Netherlands had introduced the first mandatory LCA limit values, using their own LCA database (the '*Nationale Milieu Database*'). The Netherlands has separate public and private aspects to their database. The system is divided because the public side addresses political discussions about policy and regulation, whilst the private side of the system is for technical discussions about assessment methods. The assessment method has historically been privately owned.

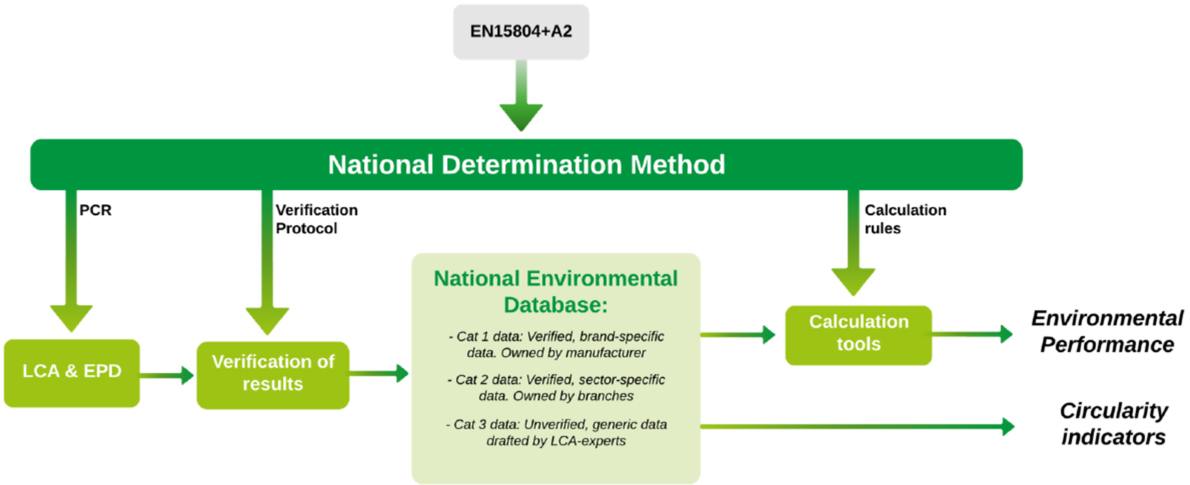

Figure 16 Overview of the assessment method in the Netherlands.

In France, several laws over the last 10 years have outlined the requirements for new and existing buildings for carbon impact, although implementing them was voluntary. The government published mandatory requirements in 2020, coming into force in 2022. France also has its own database, called '*Inies*'.

Highlights of 3.4
The Whole-life-cycle Performance Roadmap will include quantified targets with milestones to 2050. It will cover both embodied and operational carbon separately and together, be robust and relevant with regards to time and place, and will not simply be a list of policy recommendations. There is a need for a centralised database for the Environmental Product Declaration (EPD). EPDs are always available as PDFs, even though it is a difficult format to extract information to input into an LCA tool. Development towards machine readable EPDs would contribute to the creation of the centralised database. It is recommended that the number of LCA practitioners available should equal the number of energy assessors.

Main Outcomes of 3.4
There is a strong interest in LCAs. Developing information on the whole lifecycle will be an integral part of EU policies in the future. Green Procurement Plan criteria are still in the early stages of development. As Level(s) sets out a methodology only for measuring and without any benchmarks, such benchmarks will have to be determined by considering green building certification schemes, best practice examples, and taxonomy wherever relevant. The many upcoming revisions to policies, regulations, and guidance, such as the revisions to the EPBD and EED, will need to be monitored by Member States to ensure that national policy is being updated in parallel to reflect these changes. If LCAs are to be made mandatory in Member States, it is recommended that the requirements should be implemented on a voluntary basis first, prior to being fully integrated into the regulation.

4. Main Outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Use of new EPB standards in national calculation methodologies	Not all values requested in the reporting annexes are relevant for all Member States	Some Member States will complete Annex A; others will use the annex for guidance	It is important to monitor Member State implementation of the new set of EPB standards in the future
Cost-optimality – results from the second round of calculations	Member States had challenges in delivering adequate reporting to the EC	The reporting scheme is not flexible enough to accommodate all national calculation procedures	The topic needs follow-up before the third round of calculations
Primary energy factors	The reliability of primary energy savings and the consistency between cost-optimisation of national regulations and definitions of NZEB depend on the quality and transparency of PEF calculations in Member States	The Member States - reported PEF values vary greatly, e.g., electricity variations are between 0.0-3.0 as renewable energy sources become more prevalent	Further analysis on how Member States set their PEF is needed in the future
Electro-mobility – experiences	All Member States are working hard on meeting the deadline for national implementation	Some Member States see difficulties in implementing AFID into national EPBD regulation	It is important to establish an overview of the national implementation status
Definition of 'functionally, technically and economically feasible' in building renovation	There are large differences among Member States on how to define the concept for technical building systems	It is up to Member States' public authorities to detail the cases for which feasibility cannot be ensured	The EC is encouraged to provide more guidance on this topic
Ventilation in airtight buildings	There are significant differences on how Member States set requirements for airtightness of new and high-performance buildings. All Member States require a minimum	Some Member States do not set specific requirements, but exercise indirect control by requiring a pressurisation test and the use of results in the energy performance compliance calculation	The topic needs to be followed-up

(CCT1) Technical Elements

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
	ventilation rate in new buildings		
Overheating assessment	New buildings and buildings undergoing major renovation will be subject to the impact of the changing climate, but not all Member States require an overheating assessment of these buildings	Overheating should be assessed, but the current calculations still need refining.	The topic needs to be followed-up
From smart buildings to smart districts and beyond	Member States should strive for the integration of public and private finance to invest into the smart districts	Further exchange of international knowledge and best practice cases is essential	The topic needs to be followed-up
NZEBs in cold climates	In the cold regions of the Oceanic zone, EC recommendations for primary energy appear to require relatively higher energy performance compared to the Nordic zone recommendations	Concerning recommendations for NZEB in the Northern countries it can be concluded that having two sets of requirements, with and without renewable production inclusion, is helpful for comparison purposes	The EC is encouraged to update guidance on this topic
The EC is encouraged to update guidance on this topic	There are some technical constraints for installing BACS, for example the lack of space for technical boards and cables that are not yet accounted for	The current regulation only accounts for economical constraints	The topic needs to be followed-up
LCA and embodied energy in future energy performance requirements	The Whole-life-cycle Performance Roadmap will include quantified targets with milestones all the way to 2050	As Level(s) only sets out a methodology for measuring and does not provide any benchmarks, benchmarks will have to be determined by considering green building certification schemes, best practice	The topic needs to be followed-up

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
		examples, and taxonomy wherever relevant	
LCA and embodied energy, tools, and guidance for implementation	There is a need for a centralised database for EPDs. Because EPDs are always available as PDFs, development towards machine readable EPDs would contribute to the creation of the centralised database	The many upcoming revisions to policies, regulations, and guidance, such as the EPBD and EED, will need to be monitored by Member States to ensure that national policy is being updated to reflect these changes	The topic needs to be followed-up
LCA and embodied energy, status, plans and databases for implementation in Member States	It is recommended that the number of available LCA practitioners should equal the number of energy assessors	If LCAs are to be made mandatory in a Member State, it is recommended that the requirements be implemented on a voluntary basis first, prior to being made into regulation.	The topic needs to be followed-up

5. Lessons Learned and Recommendations

The EPBD asks Member States to describe and report to the EC their national calculation methodology following Annex A of the CEN overarching standards, namely ISO 52000-1 (Overarching **EPB assessment**), 52003-1 (Indicators, requirements, ratings and certificates), 52010-1 (External climatic conditions), 52016-1 (Energy needs for heating and cooling), and 52018-1 (Indicators for partial EPB requirements). The deadline for reporting to the EC was by the transposition date of 10 March 2020.

In May 2019, it was found that:

- Most Member States had either not started the process of reporting or had only begun planning;
- There was a mixed response on how Member States intended to report, with some planning to fill in Annex A and some using Annex A as guidance;
- Most Member States intend to only report to the EC, not to national bodies.

Member States remarked that due to differences across countries, the reporting could not be the same for all. One Member State estimated that 39% of the total number of values requested in Annex A are not relevant to their national calculation methodology.

To help Member States, the EC put in place measures to ensure the process is as flexible as possible and has issued guidance to help. This includes a model contract and a FAQs document, which includes questions from other Member States and the responses from the EC.

(CCT1) Technical Elements

The second round of **cost-optimality** calculation was due on 31 March 2018. By that deadline, only 10 Member States had delivered a report, increasing to 16 shortly after, with a further 10 under assessment. The JRC scrutinised Member States' reports in collaboration with the EC for conformity and completeness, and several recurrent gaps have been identified from the 14 Member States evaluated so far. Gaps in many cases related to scope, as some reports did not cover all building types (especially non-residential buildings), or both new and existing buildings, or all minimum requirements. Despite the identification of these gaps in some reports, a plan to reduce the gaps was not always included or identifiable.

In most Member States, there is only one non-residential building type and there is a lack of disaggregation according to size, age, construction materials, patterns of use and climatic zones. It is possible that the reference buildings included are sufficient to cover the entire building stock, but this requires justification, which was often not provided. Some reports lack an analysis of the gap between cost-optimal levels and upcoming NZEB requirements.

In November 2017, there was a new implementation of requirements for charging points for electric vehicles (EVs) in national building regulations. **Electro-mobility** was included in the revised EPBD because under the Alternative Fuels Infrastructure Directive (AFID), it has become apparent that a large portion of charging takes place in the private domain. Therefore, the key requirements are for charging points and ducting infrastructure. Recharging points are already defined in the AFID, including the distinction between normal (transfer of less than or equal to 22 kW) and high-powered (transfer of greater than 22 kW) charging points. By pre-installing ducting in new and renovated buildings, the cost of deploying charging points will be up to nine times lower in the future.

In November 2017, experience with implementation of EV charging requirements varied significantly among Member States. However, the most common barriers to the uptake of EVs have been a limited range and the lack of charging infrastructure.

EPBD Article 8(3) requires that Member States lay down requirements for the installation of a minimum number of recharging points for certain non-residential buildings with more than 20 parking spaces. However, it is left for Member States to determine the specifics of the requirements and whether they want to go beyond these based on local conditions.

To help Member States determine these factors, the EC published a guidance document addressing some of the concerns and questions raised.

In June 2019, it was suggested that Member States should consider local conditions and requirements when setting requirements and milestones for implementation. For example, in countries where EV adoption is already high and charging infrastructure is well established, the goal is to continue this progress whilst ensuring that the sources of electricity remain clean. In other cases, there needs to be a greater push for installing the necessary infrastructure, although this needs to be done in a measured way. With adoption that is appropriate to the needs of the country, a cost-effective solution is possible. However, it is an open question whether to install infrastructure that meets current needs or the needs of the future; and what are the cost implications.

In the context of renovation, the term **'functionally, technically and economically feasible'** ensures that the requirements outlined in the EPBD are not excessive and that they only apply when cost effective. The notion of feasibility applies to EPBD Article 7 as well as Articles 8, 14 and 15. These articles cover the major renovation of buildings and building elements, Technical Building Systems (TBS), Self-Regulating Devices (SRD), and Building Automation and Control Systems (BACS)..

The EC issued guidance on how to apply the notion of feasibility in relation to Articles 8, 14 and 15. Economic feasibility considers the proportionality of the costs of a planned intervention to the benefits. Decisions should also consider whether the technical characteristics of the system prevent the requirements from being applied, or whether the changes would impair the operation of the system or the use of the building. Ultimately, it is up to public authorities to establish clear guidelines and standard procedures to identify cases which do not have assured feasibility.

The EPBD, as amended by Directive (EU) 2018/844 (EPBD), agreed that, as part of the 2019 Clean Energy for all Europeans package, a further deadline was to be set in March 2020 for Member States to implement national Long Term Renovation Strategies (LTRS) (previously required under the EED), setting the path, policy measures and mobilising financing needed to decarbonise their existing building stock by 2050. This led to lower energy demand in the operational phase. However, energy is used not only in the operational phase, but also during construction. It will therefore be important to evaluate energy use of a building over its entire lifetime to get a more accurate depiction of overall energy consumption.

Therefore, Member States have exchanged information about how **the Life Cycle Analysis (LCA)** approach is to be implemented and reviewed how far Member States have analysed and/or discussed the inclusion of LCA in energy performance requirements or are planning to do so in the future.

To meet the EU’s climate and energy targets for 2030 and reach the objectives of the European Green Deal, it’s vital to direct investments to sustainable projects. EU taxonomy is at the core of the Sustainable Finance Action Plan and will help create a classification system for environmental and sustainable economic activities. This will act as a common language for investors when investing in climate positive projects. The Taxonomy Regulation, published in June 2020 (with delegated acts published in 2021), develops technical screening criteria for the construction and renovation of buildings, sale and ownership, installation of energy efficient equipment, and for manufacturing in the supply chain. It also sets out that those buildings larger than 5,000 m^2 must calculate the life-cycle Global Warming Potential (GWP) resulting from construction at each life cycle.

Endnotes

1. https://epb.center/
2. EU Pilots are an informal communication tool between the European Commission and Member States. The European Commission uses this tool to ask specific questions to Member States or clarify specific issues, without resorting to the formal infringement procedure
3. https://ec.europa.eu/energy/topics/energy-efficiency/energy-performance-of-buildings/energy-performance-buildings-directive/eu-countries-2018-cost-optimal-reports_en?redir=1

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