CONCERTED ACTION
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1. Introduction

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

This report focuses on the implementation of Articles 3, 4 and 5 of the EPBD, as well as its Annex I on the calculation methodology and Annex III on cost-optimality.

An important element of work on the EPBD is the implementation of the package of the energy performance of buildings (EPB) Standards[1], and their adaptation and use in the energy performance calculation methodology in MSs. This builds further on previous CA EPBD experience and existing material on cost-optimality.

In the future, new technical elements of interest might be identified based on needs arising from the discussions in the CA EPBD around new buildings, existing buildings, certification and inspection. Significant interaction is expected between these areas, as well as with the CAs for the RESD and the EED.

2. Objectives

In the past, the CA EPBD has already undertaken considerable work on CEN's first and early second versions of EPB Standards for calculating the building energy performance. Furthermore, the CA EPBD has evaluated, commented on and used the methodologies for cost-optimality.

The CA EPBD's current feedback to CEN builds on this work and supports MSs with the implementation and national adaptation of the new set of EPB Standards, supporting solutions to new challenges arising from this process.

All MSs have developed and implemented national adaptations to their first version of energy performance methodologies and calculation procedures. A combination of experiences and solutions from MSs, as well as lessons learned and reflections on best practices, will facilitate the process of implementation of the new set of EPB Standards.

Some of the key topics covered by the Technical Elements team are:

- adaptation of existing calculation procedures based on the ongoing revision of EPB Standards;
- calculation of energy performance and cost-optimality;
- implementation of cost-optimality procedures in the national setup of minimum performance requirements.

In parallel, the team collected lessons learned from certification and inspection schemes in MSs, in order to improve the schemes, and discussed issues with accounting for onsite and offsite renewable energy in the energy performance calculations for new and existing buildings.

Similarities and/or differences between energy related products as described in the EcoDesign Directive (2009/125/EC) and as laid out in EPBD procedures will be discussed in the future. Discussions will explore the "holistic approach" applied in buildings versus the more prescriptive elements for component requirements. Additionally, the needs and possibilities for easy access to reliable input data from the energy labelling of products for the calculation of a building's energy performance will be evaluated.

3. Analysis of Insights and Main Outcomes

The Technical Elements analysis deals 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 descriptions of these topics may also be found elsewhere in this book.

3.1 A new set of EPB standards

In 2010, the European Commission gave CEN the mandate (M/480 EN) to create a new set of standards for the calculation of the energy performance of buildings. The participants of the CA EPBD have reviewed the development of the new EPB Standards and their possible applicability in national legislation. MSs focused especially on the practical implementation and on the transition from the current standards. In particular, it seems that the new EPB Standards are complex and can be difficult to understand, and there is a perceived gap in technical support and guidance[2]. The main outcomes of the discussions were:

- Implementation will depend on the context within each MS.
- Calculation methods are in some MSs defined in legal documents, which can make the transition to new EPB Standards more difficult, particularly when the standards are inter-dependent.
- MSs use a mixture of monthly and hourly calculation methods, but a discussion of the relative merits of each is missing.
- Any transition to the new EPB standards must be smooth to ensure consistency.
- There is little incentive for MSs to implement the new EPB standards, unless they improve existing methods.

The overall procedure for calculating a building's primary energy performance using the new EPB Standards is illustrated in Figure 1 and was put to formal vote in late 2016. The voting resulted in the acceptance of all standards, except the standard concerning indoor air quality. The standards went through a final editing by CEN and ISO, based on the editorial comments. Most of them were published in the summer of 2017[3].

In the Liaison Committee, a major focus of the dialogue with the standards developers was on the usability of the new set of EPB Standards in relation to their implementation in national regulations. The standards now include flexibility for MSs to implement them in their regulations in a stepwise approach, most likely beginning with the overarching Standard EN/ISO 52000-1[4]. They also include flexibility to set national calculation conditions in regulations or in a national annex[5]. It is expected that this flexibility will lead to wider uptake of the new set of EPB Standards in national regulations.

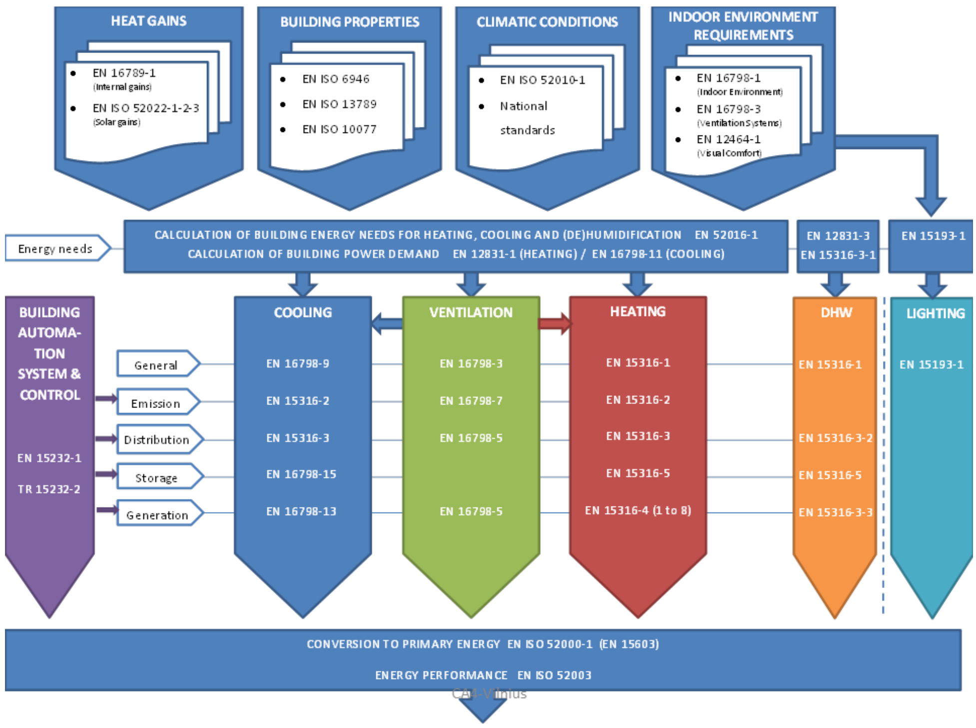

Figure 1. Schematic overview of the overall structure of the new EPB Standards for the calculation of a building's primary energy performance.

For each new standard, an Excel spreadsheet has been developed by CEN to demonstrate the functionality of the standard and support the further development and use of the EPB Standards by software developers. This demonstrates how the rules are to be interpreted. The structure of the new EPB Standards is modular, which offers the possibility of replacing single modules as long as the input/output structure is preserved.

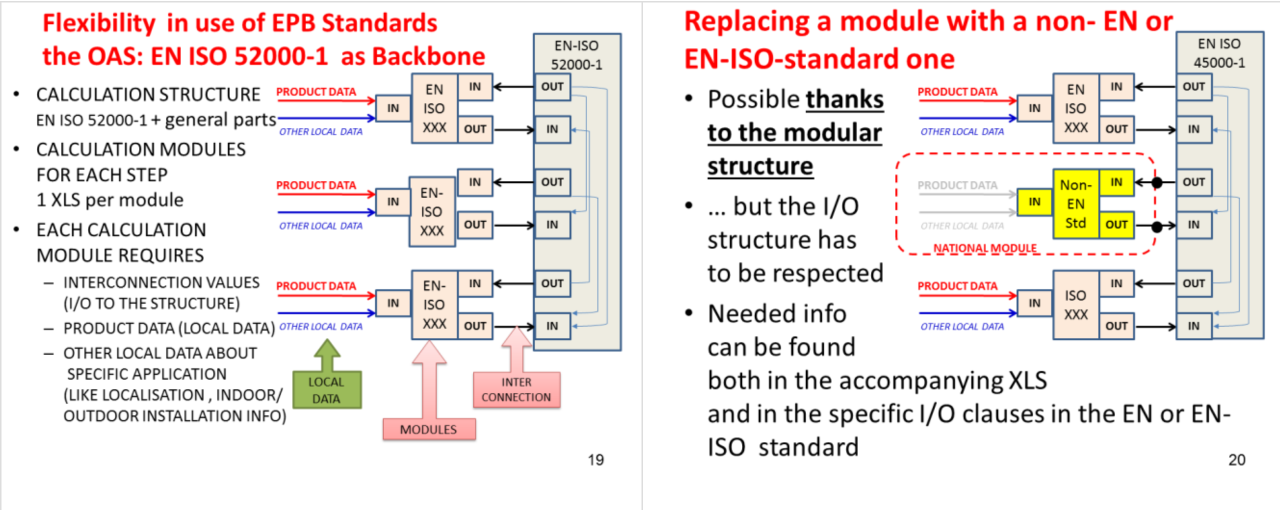

Figure 2. The new EPB Standards are created as individual modules.

In general, MSs delegates felt that the new EPB Standards will provide valuable support for the implementation of the EPBD. The CEN committees emphasised that the new standards have been developed to offer flexibility for their application throughout Europe and worldwide. Furthermore, it was discussed whether the EC should invest in a common software core; it was agreed that this issue should be analysed further and that an answer would be required before MSs begin implementation.

In parallel to the development of the new standards, a consortium was established by DG Energy to assess the usability of the draft EPB Standards, using example cases. The standards were examined as a package and tested for consistency between inputs and outputs. The data analysis further evaluated the degree of competence required to gather the input data as well as quality, accuracy and error rate. In addition, the usability analysis also considered the ease of use and the time and effort required. An example case calculation for a recently constructed office building with a total floor area of 6,000 m^2 (useful area 4,800 m^2) and an envelope area of 7,961 m^2, heated by district heating and without mechanical cooling, produced the following statistical information:

- There are nearly 1,000 inputs for this specific building assessment.
- Of these inputs, around 500 come from "*internal*" sources, such as other standards or tables in (national) annexes.
- Around 500 inputs need to be provided by the assessor; these concern the building, the systems and some general climate or behavioural data.
- If inputs per zone are taken into account, the total number of input values to be provided can increase to around 700 (in building models with three zones).
- Systems-related inputs are by far the most numerous; these concern not only static properties (capacity or length of pipes and ducts) but also dynamic properties (functioning of the system over a certain period).

Some overall conclusions from this example case study were:

- The “one-size-fits-all” approach in the structure of the EPB Standards leads to detailed calculations, in order to also cover more complex cases.
- The drawbacks of such a detailed approach are:
  - many input data need to be specified (500-700 for a typical building);
  - many details are not relevant for simple assessment situations, but choices still need to be made for every input, which negatively impacts the usability of the standards without adding value to the assessment.
- The approach does not guarantee easy incorporation of new building/system configurations, and can even impede it, e.g., for uncommon systems that are excluded from the calculation methodology described in the standards.
- The modular set-up of the EPB calculation can minimise some drawbacks but assuring consistency in the set-up and proper exchange of data is more difficult.
- The use of default values could solve some of the problems, but it would be necessary to ensure that default values are realistic.
- The current energy performance calculation system could be converted into a user-friendly integrated energy performance calculation core that includes standard input data.
- A more systematic approach for the management of primary building input data is needed.
- The use of a reference building in the calculation can reduce the significance of systematic errors.

Highlights of 3.1	The new package of the final draft EPB Standards has been through formal voting in CEN and ISO in late 2016, and was finished in January 2017, with all, except one standard, concerning indoor climate, accepted. The standards come from the different CEN TC's involved in mandate M/480: TC89, TC156; TC169; TC228, TC247 and TC371. The standards come from the different CEN TC's involved in mandate M/480: TC89, TC156; TC169; TC228, TC247 and TC371. The voting showed that all except one standard, concerning indoor climate, were accepted. DG Energy is encouraged to support the development of a common calculation core6 to ease implementation of the new set of standards in MSs. Example cases have highlighted some weaknesses in the draft set of the standards. It seems that the complexity of the standards is overwhelming in some cases, e.g., in existing buildings, due to the considerable input data required in combination with the lack of detailed information for these buildings. The use of default values can solve some of the problems, but it is necessary to ensure that the specific values are realistic. The package of the EPB Standards was published by ISO and CEN in June 2017.

Main Outcomes of 3.1

The new EPB Standards developed by CEN were discussed in four sessions during the first two meetings of the CA EPBD IV. MSs gave valuable input to CEN, resulting in adaptations of the standards and development of example cases to document the standards' usability.

The EPB Standards were approved in January 2017 and published in June 2017. Implementation of the standards in MSs' legislation initiated in late 2017.
There are large differences among MSs regarding their plans for the implementation of the new EPB Standards. These range from those MSs that intend to implement the new EPB Standards as soon as possible, over those MSs that require the standards to be available free of charge in their national language before any decision can be made, to MSs who do not plan to implement the new set of EPB Standards at all. In the planning for the implementation of the new EPB Standards, few MSs seem to be moving from monthly calculations to hourly simulations. The intention among other MSs is to use hourly simulations only for more complex buildings (e.g., non-residential) and NZEBs, where more precision is required to accurately model the buildings. In some MSs, hourly simulations are used only for certain parts of the calculation (e.g., cooling).

3.2 Energy Performance Certificate (EPC) calculations

3.2.1 Previous changes in MSs EPC

A desk study on how MSs had rescaled or renewed their EPC between 2008 and 2014 found that many MSs had made changes. Alterations to the EPC included adding classes, changing limits, changing colours and layouts, many of them to accommodate the NZEB requirement in 2020. Many of these changes are directly connected to regulations for new buildings or to general improvements for existing buildings.

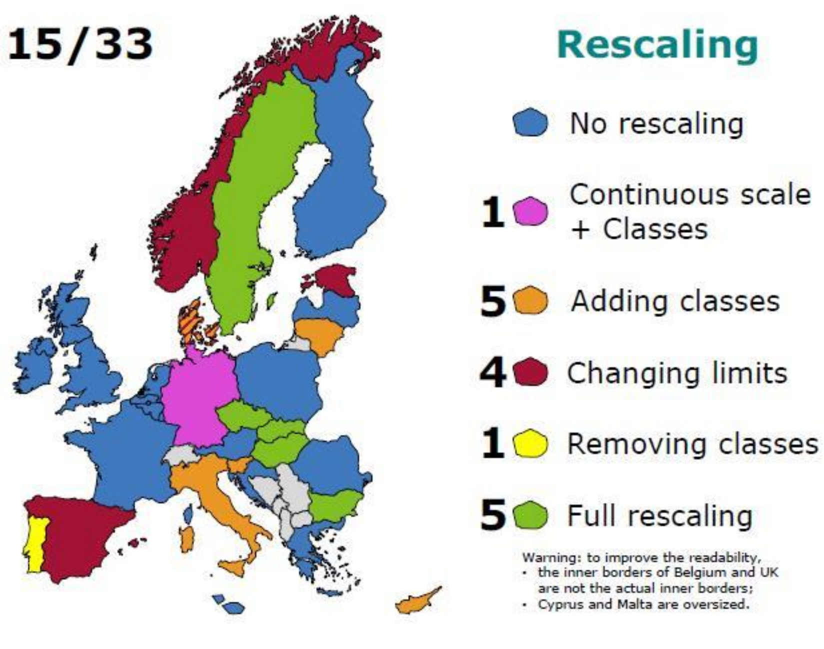

Figure 3. MSs' changes to their EPC were analysed from information collected for the Country Reports included in the 2010 and 2016 CA EPBD books.

Basically, there are 3 options for rescaling the label scale of the EPC:

1. No change is made to the existing labelling scale; buildings constructed according to new, tightened energy requirements are placed in the top category. This approach is simple but gives no further motivation for building owners to improve their building's energy performance. Better energy performance values are not reflected in the certificates at the top of the scale, as indicated in the left column of Figure 4.
2. Certificates that have been previously issued remain unchanged, and new, narrow top categories are implemented to reflect the new energy requirements. This option avoids problems with the "old" certificates. It could work, provided that accurate and motivating new top categories are implemented and that energy performance is expressed precisely according to variations in energy performance at the top of the scale. One of the drawbacks of this option is that the number of categories increases, and there are some other practicalities that need to be addressed, such as the question of colours, letters, or terms.
3. The number and the names of categories remain the same, while the thresholds are modified. The advantage to this approach is that the number of categories remains unchanged. On the other hand, the "old" certificates also need to be changed and the issuing data becomes very important, to be able to understand the full meaning of the label value on the certificate.

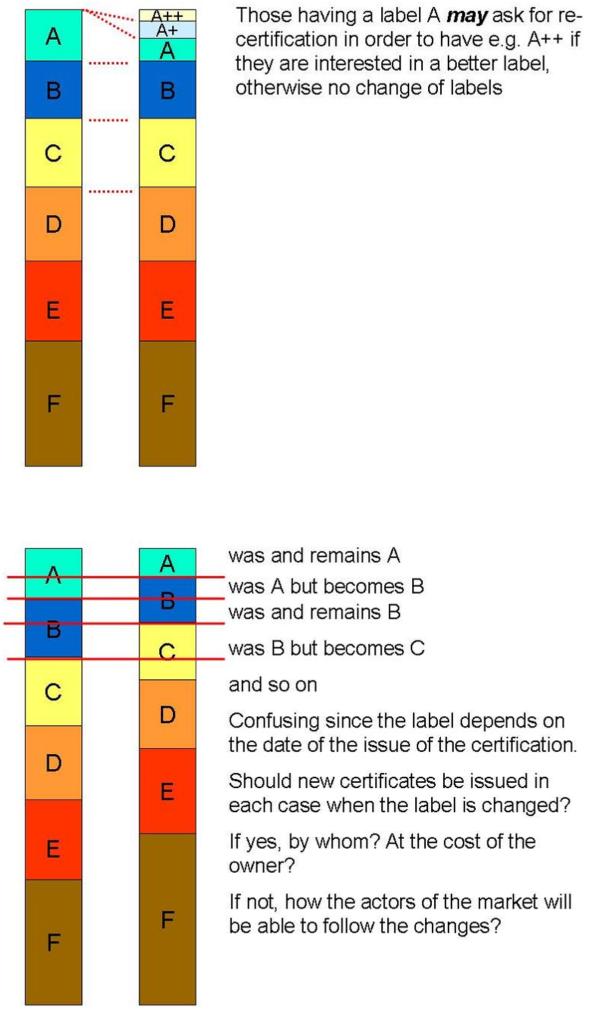

Figure 4. Different strategies for changing the EPC scale (options 2 and 3).

3.2.2 Calculating realistic energy savings

The energy performance shown in most MSs' EPC is based on a standardised calculation of the primary energy demand. This, however, may not be the same as the measured energy consumption in a building, and savings presented in the EPC might differ from the experienced energy savings. The EPBD does not envisage the calculation of non-standard energy consumption, and hence expected energy savings. Nevertheless, realistic estimations of energy savings are necessary in order to determine the time scale of returns on investments. In Sweden, the EPC for new buildings is based on metered energy after two years of use and energy performance calculations prior to construction must reflect the expected metered energy use.

CA EPBD investigated the possibilities and barriers associated with using the EPC building data model (i.e., the input parameters collected from the building, in order to carry out an energy performance calculation using an approved calculation tool) for the additional purpose of calculating energy savings caused by user behaviour. Information on the physical description of the building envelope and installations in the data models that are used to calculate the energy performance in the EPC is generally accurate. However, the calculated energy demand deviates from the measured consumption, primarily due to user behaviour that varies from the standard assumptions. Building data models can then be used – after modifications of the standard input parameters, i.e., internal gains and losses, usage patterns, indoor and outdoor climates – to calculate realistic energy demand and potential savings. Some MSs allow the alternative use of the EPC model for a more detailed analysis of the energy saving potential, e.g., the Slovak Republic, Lithuania, the UK, Denmark and Hungary.

The ownership (Figure 5) of the EPC building data model can in some cases hinder its use for alternative calculations. This can happen, for example, when the EPC data is owned by the expert who carried out the certification and created the EPC building data model, whereas additional calculations would be carried out by a third party.

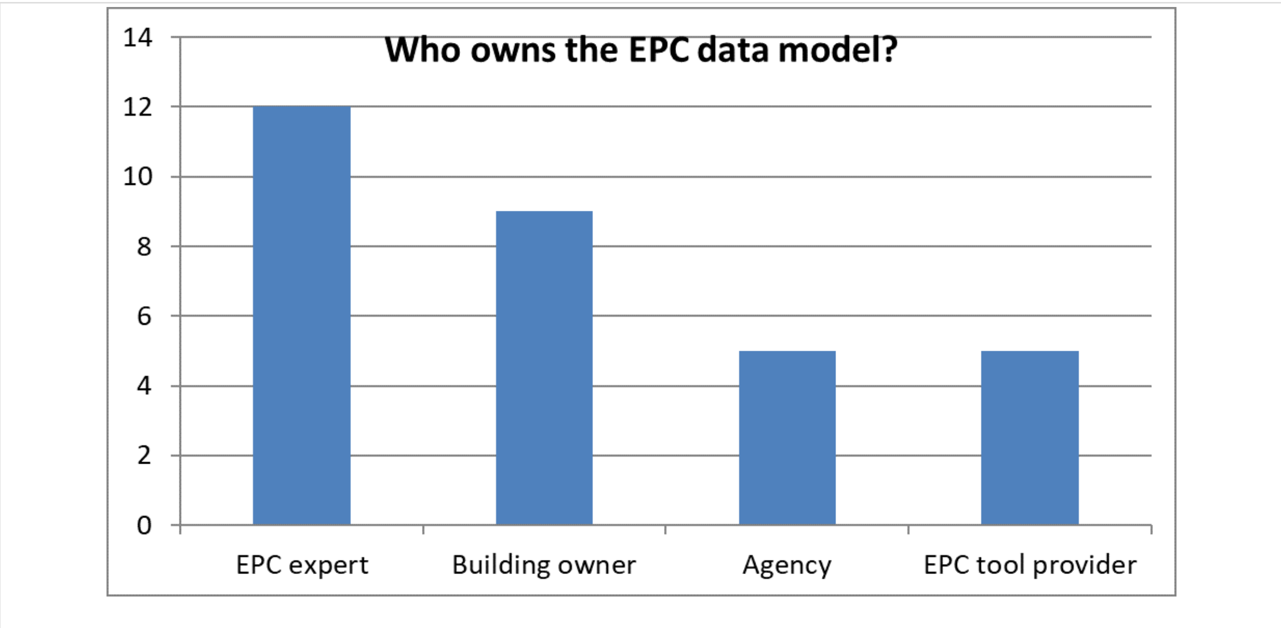

Figure 5. Ownership of EPC building data model in MSs participating in the survey. Multiple ownership occurs in some MSs.

From the selected MSs' examples, it appeared practical to modify critical input parameters to predict more realistic energy consumption calculations for energy savings. For example, the key variable parameters are occupancy behaviour (number of users, use of domestic hot water and use of appliances) and temperatures (both indoor and outdoor). From the example cases, these adapted models produced results that closely align with the measured energy consumption. MSs gave several different examples for adapting the building data model to the actual conditions:

- Denmark used the energy performance calculation model to compare the gap between actual measured data and the standardised EPC.
- The Walloon Region, Belgium used an adapted model for additional reports based on the EPC model data.

- Latvia used an adapted model (calibrated against measured consumption) instead of a standardised EPC model.

- France used an adapted model to study the coherence between asset and operational rating methods.

Discussions highlighted a conflict between the clear benefits of improving model accuracy with the frequent lack of interest among consumers. This lack of interest can be explained partly by other issues (i.e., economy) garnering more attention, and partly by the inconsistency between standard calculations and measured energy consumption. The most important contribution for any calculation is in the value added to decision-making, but no direct benefit will be realised in practice if the consumer is not sufficiently engaged. For instance, building-owners tend to not calculate the energy savings they might obtain when carrying out other modifications to their property; there seems to be a lack of interest in the potential for energy savings. Decisions taken by building-owners tend to be primarily driven by comfort conditions or issues of maintenance and improved functionality. However, it is important to show in the EPC how energy saving measures would also result in co-benefits, e.g., comfort improvement in order to incentivise building-owners.

Highlights of 3.2	It has been necessary in some MSs to change the scaling of the EPC labels in order to accommodate the approaching NZEB requirements. In most cases, this has been done by sub-dividing the top class into narrower classes, representing steps, e.g., intermediate building regulation requirements, towards the NZEB requirement in 2020. In most cases, the new and the old scale co-exist until all “old” certificates have been replaced by new ones or become outdated. In other cases, only an automatically updated on-line version of the certificates is valid. EPC calculations are based on standard assumptions, hence calculated energy demands and potential energy savings may not match the measured consumption. However, energy performance building data models can be used for calculation of realistic energy demands and hence equally realistic energy savings if modified to reflect the actual conditions in buildings. In some MSs, it is possible to use the EPC model for more detailed analyses of the energy demand and the energy saving potential. However, ownership of the model sometimes creates obstacles.

Main Outcomes of 3.2

The motivations for rescaling the EPC vary and include, among others:

- ensuring the EPC's contribution to making it more attractive to build or renovate very efficient buildings;
- inefficient buildings rated too high in old EPCs;
- solving problems with old EPCs for apartments;
- stricter energy performance requirements for new buildings, and introduction of NZEB in national requirements;
- changing from energy use to primary energy use.

Main Outcomes of 3.2
Discussions focused around the co-existence of old and new EPCs on the market, and whether this might create confusion for the public in terms of understanding the energy performance of the building. Displaying realistic energy savings in the EPCs is not the prime focus since buildings are to be compared excluding the influence of the occupants. Building owners undertake improvements for many reasons apart from saving energy, especially when purchasing or renting a property. Improved functionality and indoor climate are generally considered the two main drivers for carrying out upgrading works. Energy savings are in many cases seen as an additional benefit to planned renovation. Only a few MSs seemed open to the possibility of using the energy performance building data model for purposes other than issuing an EPC. Among the prime reasons for this are the ownership of the building data model and the risk of incompatibility between tools that use the same building data model, but different energy performance calculation tools.

3.3 Calculating energy performance

There are specific issues related to energy performance calculations for new buildings applying for a new building permit and for the energy performance certification of an existing building.

3.3.1 Innovative systems

This topic mainly relates to new buildings, although many of the findings are equally valid for existing buildings.

The progress towards NZEB in MSs has led to more innovative technologies being introduced to the market over the last few years. The purpose of this topic was to collect and exchange initial experiences with such technologies in the MSs.

Four categories of technologies were discussed, with wide variations in the frequency and methods of their use, and in the types of buildings involved. Significant differences were also found in ways in which the systems' impacts on building energy demand were calculated. Exchange of knowledge between MSs and CEN might prove helpful for a broader use of innovative technologies in the future. The four categories of technologies are as follows:

- *Demand-controlled ventilation* is mainly divided into mechanical exhaust systems and balanced mechanical ventilation systems with heat recovery coupled to different control strategies. The calculation is often performed using a detailed dynamic simulation method as part of the simplified standard calculation method, although a few countries use fixed factors as rough estimates.

- *Building automation systems* can be grouped according to EN/ISO 15232 into classes A to D, with class A being the most advanced holistic building automation systems, and class D being simple manual controls. Classes A and B are mostly applied to new non-residential buildings. Some MSs are considering introducing requirements concerning levels of building automation. The calculation of the impact of building automation systems varies among use of fixed factors as rough estimates, detailed calculations within the assessment method, and use of external dynamic simulation tools. In several MSs, building automation systems cannot be assessed directly, using the national method and hence provision must be calculated in alternative ways. Generally, energy savings seem to be overestimated, and only occur after a thorough commissioning of the system.

- Information on seven (7) different types of *reversible heat pumps* was collected and discussed, and categorised according to the supply source and the heat delivery system. The use of specific systems differs among MSs. In Sweden, reversible heat pumps can be calculated by using a dynamic external simulation tool. Other MSs assess the impact of heat pumps either by using a detailed method within their calculation procedure or by using a fixed factor as rough estimate. The obvious advantage of a reversible heat pump is that only one system is needed for heating and cooling.

- Several still-innovative *advanced solar shading systems* were discussed by the participants, for example inter-panel shading devices, semi-transparent PV, double façade systems with integrated shading systems, movable sun-protection glazing and bio-shading. Most systems can be modelled fully only by using an external dynamic simulation tool. As an example, bio-shading is calculated in one MS within the regular calculation method by using a rough factor, and in another MS by using an external dynamic simulation tool. However, most MSs do not take bio-shading into account in their national calculation standard.

3.3.2 Costs and energy performance

Cost-efficient technologies, strategies or processes for NZEBs

The costs for NZEBs compared to those for buildings complying with current requirements, ranging up to an additional 500 €/m^2 or 50%, are presently considered a barrier for increasing the number of NZEBs. A previous collection of case study buildings resembling NZEB in the CA EPBD has shown that the additional costs were, on average, about 10% of the total costs, or roughly about 200 €/m^2.

A short, more recent questionnaire on cost-effective technologies, strategies and processes was answered by 24 MSs plus Norway and one region of Belgium. The estimated additional costs are up to 500 €/m^2 or up to 50%. Eight countries have guidelines for cost-efficient buildings and some countries use the cost-optimal EPBD analysis as guidance for cost-efficient buildings. One MS claims that, for residential buildings, there will be no additional cost and therefore no cost barrier in this country.

In the construction process, it is important to include energy efficiency at each stage. Additionally, the use of building information modelling (BIM) can help with quality control and effective communication among different teams in the design and construction process. In the design process, architects and engineers are now working closer together than they did 10 years ago. This decreases the number of iterations and facilitates an increased focus on energy performance.

Cost-efficiency of technical systems depends on the climate, the energy supply mix, the existing energy infrastructure, subsidy policies and consumer perceptions. Replicating solutions from other countries is also difficult, due to differences in building tradition, cost levels, legislation, energy infrastructure, climate, etc.

Commonly, PV and heat pumps are popular and often combined. Solar thermal systems may be cost-effective, as domestic hot water is one of the last remaining large energy demands in NZEBs. Mechanical ventilation systems with heat recovery are cost-effective in colder climates. It seems that direct electric infrared heating is becoming popular in countries with low prices and low primary energy factors for electricity. In general, control and automation systems can be cost-effective, and LED lighting with presence detection and daylight control is generally cost-effective as well.

In the building envelope, improving U-values and/or use of double or triple glazing is often cost-effective, but there is a need to balance the resulting decrease in heating demand and the subsequent increase in cooling demand. Shading devices may well be a necessity in NZEBs to secure a comfortable indoor climate. Taking into account factors such as the location and orientation of the site for the optimal utilisation of solar gains or shadings is often cost-efficient in new buildings.

Cost, available time and quality are closely linked, but a specific problem arises when improved quality does not increase financial value.

Experience from the first round of calculating cost-optimal levels

Experience from EU MSs' first round of cost-optimal calculations provided valuable input ahead of the second round of calculations. A short survey on the first round of the calculation and reporting of cost-optimal levels for new and existing buildings helped to identify key areas for the revision of the guidance document and the procedure. This concerns energy prices, the calculation of energy demand, references to new standards, and simplifications of the procedure in general.

The European Commission has financed and is still financing several projects dealing with cost-effective technologies and strategies for NZEBs. One of these, conducted by Ecofys[7], was thoroughly discussed in the CA EPBD. One of the conclusions from the Ecofys report was that, despite the guidance provided to MSs regarding the calculation of global costs and the reporting of the calculation of energy demand, further clarification may be necessary. Furthermore, the equation used in the guidance document for calculating the gap between the cost-optimal level and the current requirements should be applied.

The CA EPBD recommended that there should be increased focus and clarity in reporting, and that the Ecofys' suggestions[1] for standard reporting and the reporting template from Annex III of the regulation should be used.

Specific recommendations from MSs for further improving the procedure were that:

- More guidance is needed on establishing and using reference buildings.
- The number of measures and simulations required should be optimised to eliminate unnecessary calculations and ensure that calculations are as relevant as possible.
- A standard economic analysis procedure should be developed and performed.
- The methodology for calculating cost-effectiveness should be consistent with the methodologies used for calculating primary energy factors and the energy performance of buildings.
- Both the calculation and the reporting should be simplified.

Highlights of 3.3	New and/or innovative systems will be increasingly used in both new buildings and existing buildings undergoing major renovation. Furthermore, in order to support innovation, it is necessary to integrate the effect of these systems into national calculation procedures, either by including them in the standard calculation tools or by proving their effectiveness in external tools.

	The additional costs of NZEBs compared to those of buildings just complying with current requirements are considered to be a barrier for increasing the number of NZEBs. In the construction process, it is important to include the energy efficiency at each stage. A fundamental difference among procedures is whether the primary energy factors apply to total or non-renewable primary energy (or both), since the alternatives imply different energy policy objectives. Several MSs also acknowledge that their primary energy factor values reflect national energy policy objectives.

Main Outcomes of 3.3

MSs have different ways of integrating new and innovative systems in buildings' energy performance calculations; this creates obstacles to innovation and prevents innovative systems' penetration into the free market. It is important to continue to facilitate the promotion of new and innovative systems for energy efficient buildings and automation.

The second round of calculating cost-optimal levels for new and existing buildings is due in March 2018. MSs would welcome more guidance on the definition and use of reference buildings for the calculation of the cost-optimal level, and suggest that the number of measures and simulations needed be optimised so as to eliminate unnecessary calculations and ensure that calculations are as relevant as possible.

The costs for NZEBs compared to those for buildings complying with current requirements, ranging up to an additional 500 €/m^2 or 50%, are presently considered a barrier for increasing the number of NZEBs. It is important to emphasise more on the benefits of NZEBs, among which, achieving best quality for the budget available.

Comparison between measured and calculated energy consumptions resulted in interesting findings. Calculated energy consumption seems to identify (physical) opportunities to reduce consumption, but it is likely that, on average, the levels of savings that are likely to be achieved – especially in dwellings with high initial energy use per m^2 floor area – are overestimated.
A transparent definition of primary energy factors in EU MSs is key for allowing comparison of energy performance requirements for existing new and NZEB buildings.

3.4 Renewable Energy Systems (RES)

Inclusion of RES in the calculated energy performance of buildings is a key issue for new buildings that comply with national NZEB requirements. Most RES solutions are equally important for existing buildings, especially those undergoing major renovations. The following section deals with technical issues related to calculation and implementation of RES.

3.4.1 RES in an urban context

The CA EPBD analysed which RES technologies can generally be assessed as part of the overall energy performance calculation and which ones can fulfil possible direct RES requirements as part of national NZEB definitions and energy performance calculations. The result is an overview by MSs of the applicability of RES technologies. Participating MSs vary considerably in the RES solutions they include in their energy performance calculations, and the solutions which can be used to fulfil NZEB RES requirements. Some technologies can, in general, be accounted for in the energy performance calculation in all 24 MSs that took part in the evaluation: for example, solar thermal panels for domestic hot water generation and heating, electricity production from PV for use in the building (self-use), biomass boilers and heat pumps coupled to external air/exhaust air/ground or ground water (Figure 6). Other RES technologies can be accounted for in the energy performance calculation in about half of the MSs examined – examples include PV for feed-in, RES as part of district cooling, micro-wind turbines (self-use or feed-in) and local hydropower for self-use. Relatively few countries allow for RES electricity via the grid (with a specific contract) and local hydropower for self-use[8] or feed-in.

Country / Solution	BE-BR	BE-FL	BE-WA	BG	CY	DE	DK	EE	GR	ES	FI	FR	HR	HU	IT	LT	LV	MT	NL	NO	PL	PT	SE	SK	SL	UK	Σ Yes	Σ No	Σ Others
RES as part of district heating	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y		Y	N	Y	Y	Y	21	4	1
RES as part of district cooling	N	N	N	Y	Y	Y	N	Y	Y	N	Y	Y		N	Y	N	N	N	Y	Y	N	Y	N	N	Y	N	12	13	1
Solar thermal panels for DHW	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	26	0	0
Solar thermal panels for heating support	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	25	0	1
PV for self-use	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	26	0	0
PV for feed-in	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	17	9	0
PV for heating (input to heat storage)	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	24	2	0
PV/T hybrid solar collectors for self-use	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	24	2	0
PV/T: PV for feed-in, T for self-use	Y	Y	Y	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	19	7	0
Micro wind-turbine for self-use	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	18	8	0
Micro wind-turbine for feed-in	N	N		N	Y	Y	N	Y	Y	N	N		N	N	N	Y	Y	Y	Y	Y	N	N	N	Y	N	N	10	14	2
Local hydro for self-use	N	N	N	N	N	N	Y	Y	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	15	11	0
Local hydro for feed-in	N	N	N	N	N	N	N	Y		N	N	N	N	N	N	Y	Y	N	Y	Y	N	N	N	N	Y	N	6	19	1
Biomass boiler	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	25	1	0
Biomass CHP	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y	Y	Y	N	N	Y	Y	Y	Y		Y	N	Y	Y	Y	20	3	3
HP coupled to external or exhaust air	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	26	0	0
HP coupled to ground / ground-water	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	26	0	0
Direct geothermal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	24	2	0
Direct ground water cooling	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	22	4	0
RES electricity via grid (specific contract)	N	N	N	Y	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	4	22	0
Alternative: higher insulation level	Y	Y	N	Y	N	Y	N	Y			N	N	N	N	Y	N	N	N	Y	Y	Y	N		N	Y	N	10	13	3

Figure 6. RES sources that MSs accept to be included in their calculations of building energy performance. Legend: white – no answer, grey – answer given between yes and no.

For urban, multi-family houses, most MSs allow RES systems on garages and other associated buildings to be included in the energy performance calculation of the building, but the deciding factor is the ownership of the system and/or the boundary of the building plot. Most MSs also allow the use of community systems in the energy performance calculation as long as there is a direct connection to the building. The use of waste heat from industry or wastewater heat pumps is allowed in energy performance calculations by some MSs, but others do not have calculation methods to account for these.

Some MSs cannot account for certain types of RES technologies (e.g., a combination of PV and solar thermal; local hydro power), due to the lack of calculation procedures, either because the procedures are not covered in the EPB Standards or because there is very little or no local use of these technologies and, therefore, no need to develop such procedures. In some MSs, there are additional procedures to deal with technologies for which there is no standard calculation defined.

Some MSs impose limits on the amount of locally generated energy that can be accounted for in the energy performance calculation, and others do not allow any exported electricity to be accounted for, in order to avoid double-counting in the EPC and the grid primary energy factors. Some MSs impose additional requirements on the energy performance of buildings instead of requirements on RES. Imposing limits can make designers think harder about reducing the energy demand, prevents double-counting and can make grid integration more manageable. Not imposing limits can encourage greater adoption and, therefore, maximise the potential of RES on buildings. The existence of limits creates a more level playing field among different building types and RES availability, while non-existence of limits creates a more level playing field among different heating systems.

The use of higher insulation levels as an alternative to RES is only applicable in a few MSs. Some additional RES solutions for urban, multi-family houses that were identified during the discussions included heat recovery from showers, purchase of green certificates and economical participation in RES projects not directly connected to the building or the building site.

Highlights of 3.4	There is significant variation in the RES supplied at the building or nearby that are accepted in MSs' energy performance calculations. Imposing limits on locally generated energy that can be accounted for in the energy performance calculations can make designers think harder about reducing energy demand, prevents double-counting and helps to make grid integration more manageable, while not imposing limits can encourage greater adoption and therefore maximise the potential of RES on buildings.

Main Outcomes of 3.4
Inclusion of energy supply from RES in MSs' building energy performance calculations is dealt with very differently. Some MSs only allow inclusion of energy from limited RES, while others are willing to accept input from a variety of sources, and some even accept additional insulation to compensate for a lack of RES supply. In an urban context with little space on the building and in its immediate surroundings, combined with limitations due to neighbouring buildings, overly rigid requirements for RES may hinder efforts to meet the requirements for a certain RES share in buildings that comply with national NZEB requirements. Some MSs impose limits on the amount of locally generated energy that can be accounted for in the energy performance calculations and others do not allow any exported electricity to be accounted for, in order to avoid double-counting in the EPC and grid primary energy factors.

4. Lessons Learned and Recommendations

The modular structure of the new EPB Standards, valid for all building types, allows for a flexible system that can be easily adapted to national requirements while maintaining the overall structure of the calculation procedure. However, a methodology targeting all building types results in simple cases being overly complicated and necessitating an excessive amount of input information. The intention among a few MSs is to use hourly simulations only for complex buildings (e.g., non-residential) and for NZEBs, where more precision is required to accurately model the buildings, while using simplified calculations for existing buildings. In some MSs, hourly simulations are used only for parts of the calculation (e.g., cooling and summer comfort). It was recommended that the EU should establish a common, modular calculation core, leaving the establishment of national user interfaces to MSs; the recommendation has been accepted, and the process has begun.

Some MSs have, over time, changed the thresholds of their EPC to accommodate room for new, stricter building energy classes that move towards NZEB. Naturally, EPCs should facilitate promotion of NZEB by distinguishing them from other buildings on the scale, and reluctance in adapting the scale should not hinder this process.

Energy savings displayed in the EPC are, in most cases, calculated based on a standardised use of the building and thus do not necessarily reflect actual energy savings. However, this does not seem to present a barrier to building owners' willingness to invest in energy savings, as this is primarily carried out in combination with planned renovation and in order to improve indoor climate and building functionality. Building energy performance calculation models should be made available for use in other calculation tools for more realistic energy saving calculations.

The EPBD allows the use of either measured consumption or calculated energy demand as a means of determining the energy performance rating of buildings. In practice, the use of calculated ratings is by far the most common choice, not least because the use of measured consumptions is impossible for buildings that are not yet constructed or in use. However, measured energy performance facilitates a more realistic estimation of energy savings compared to energy savings based on calculated energy performance. It seems that calculated energy savings overestimate the levels of savings that are likely to be achieved – especially in dwellings with high initial energy use per m^2 floor area.

The costs for NZEBs compared to those for buildings complying with current requirements, ranging up to an additional 500 €/m^2 or 50%, are presently considered a barrier for increasing the number of NZEBs. In the construction process, it is important to include the energy efficiency at each stage.

The main recommendation to the European Commission is that there should be increased focus and clarity in the reporting of calculating cost-optimal levels. Additionally, it was mentioned that the guidance provided to MSs regarding the calculation of global costs and the reporting of the calculation of energy demand could be improved.

There is a great variety of ways in which MSs include energy from RES in their energy performance calculations. In some MSs, only limited RES are considered in the calculations, while other MSs are willing to include a more complete spectrum of solutions. Imposing limits on locally generated energy that can be accounted for in the energy performance calculations can make designers think harder about reducing energy demand, prevents double-counting and can help to make grid integration more manageable. In contrast, not imposing limits can encourage greater adoption and, therefore, maximise the potential of RES on buildings. In order to meet the requirement for the RES share in NZEBs, some MSs are even willing to include additional insulation levels to compensate for a lack of RES, for example in urban contexts where there may be limited free space on or near the building.

A fundamental difference between procedures is whether the primary energy factors apply to total or non-renewable primary energy (or both), since the alternatives imply different energy policy objectives. Several MSs also acknowledge that their primary energy factor values reflect national energy policy objectives. A transparent definition of primary energy factors in EU MSs is key for allowing the comparison of energy performance requirements for existing, new and NZEB buildings. Also, setting primary energy factors has significant implications on the effect of the integration of renewable energy in the energy performance of buildings.

Endnotes

1. https://epb.center/
2. In 2018, the European Commission has launched a specific contract to close this gap.
3. In December 2018, the full set of EPB Standards was published.
4. The standard is preliminary until the final approval of the edited version.
5. By using Annex A/B solutions included in all the standards.
6. A specific contract to support this point has been launched.
7. Boermans, J. Grözinger, B. von Manteuffel, N. Surmeli-Anac, A. John, K. Leutgöb, & D. Bachner. Assessment of cost optimal calculations in the context of the EPBD (ENER/C3/2013-414) - Final report. ECOFYS Germany GmbH. Cologne, Germany, 2015.
8. Without using the national grid as a buffer. This may include a battery.

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