CONCERTED ACTION
ENERGY PERFORMANCE
OF BUILDINGS

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Ministerie van Binnenlandse Zaken en Koninkrijksrelaties

Foreword
by

Drs S.A. Blok
Minister for Housing and the Central Government Sector

The Energy Performance of Buildings Directive (EPBD) is an instrument for enhancing the building regulations on energy performance of the building stock in the EU member states. The directive sets binding targets that have to be transposed into national law and implemented via national regulations.

To enhance the sharing of information and exchange of experiences from national adoption and implementation of this Directive, the European Commission established a joint initiative with representatives of the national implementation bodies: Concerted Action EPBD. Since 2005, this Concerted Action EPBD has been the meeting place for national representatives working on the implementation of the EU directive into national measures and policies. Experience shows that the Concerted Action have substantially contributed to a better understanding of the implementation challenges and the pro and cons of various strategies to implement the EPBD requirements in a cost effective way into the national context of member states. Moreover, this exchange has resulted in more convergence in the national approaches towards the implementation.

I welcome this report, which demonstrates again the positive effect of the dialogue and exchange of best practices of implementation of regulations between the Member States, on topics in the field of certification schemes, inspection themes, training, nearly zero-energy buildings, compliance and control, support initiatives and energy performance requirements and cost-optimum methodology.

The Member States are now working hard to improve the energy performance of residential and commercial buildings. But we still face a big challenge in the renovation of the vast existing buildings stock into zero energy buildings. This revolution can’t be realized by only formulating new EPBD legislation. This achievement needs a much broader perspective on energy transition. Therefore it is inevitable to take forward the new strategy of implementing the European Energy Union to reach a single European energy market. The challenge for the new recast of both the Energy Performance Directive and the Energy Efficiency Directive is to give Member States their freedom to facilitate and realize energy transition in a way that fits with the wide diversity of national developments. In this process the European Commission can give important guidance on this new approach through the Strategy on Heating and Cooling.

Even more then in former phases Concerted Action EPBD will be important for Member States to exchange experiences with each other, contributing to the development into an energy neutral European building stock.

I look forward to the next report in two year’s time, which without a doubt will reflect a further progress along the road towards 2020 and beyond.

Drs S.A. Blok
Minister for Housing and the Central Government Sector

Editor's message

This book marks 10 years of implementation of the EPBD. This is my fourth and last editorial for a series of books that started in 2008 and that I had the privilege to compile and edit. I would like to use this editorial to state a few personal views about these 10 years of remarkable evolution on energy efficiency of buildings in Europe. I will highlight the many positive aspects that the EPBD brought along, but I also take the liberty to point out a few things that did not develop as well as it might have been expected. This is thus a small personal contribution towards solutions for tackling the challenges for a yet better future EPBD.

It has also been 10 years since MSs (and Norway) started to collaborate in the Concerted Action (CA) EPBD to find the best ways to implement the EPBD. There has been a huge progress since then. Early efforts concentrated on the Energy Performance Certificates (EPCs), its form, contents, who could issue them, even on how to keep track of them after they were issued, and how to take advantage of them for better informed policymaking. Few countries implemented central databases at the beginning of the process, and this was one of the first lessons learned from the CA EPBD, later included as a mandatory requirement in the Directive 2010/31/EC that replaced Directive 2002/91/EC. Calculation methodologies, how to recognise and train Qualified Experts (QEs) and how to 'sell' EPCs to the general public, the professionals and the building industry were also among the first challenges tackled by the CA EPBD.

With its recast in 2010 (Directive 2010/31/EC), new challenges were faced by MSs. Foremost among them, the cost-optimal calculations for setting minimum requirements and the path towards Nearly Zero-Energy Buildings (NZEBs) by 2020. While the first issue seems to be well solved by almost every country by now, NZEB continues to be a major challenge and it is yet unclear how much progress will be reached by 2020, especially for the much needed rennovation of the huge stock of existing buildings with poor energy performance. Once again, the CA EPBD tackled these issues head-on during the last 5 years. The problems, possible solutions, conclusions and recommendations are well described in part A of this book.

New issues gradually emerged during this decade. For example, the EPC became a focus of controversy: how good and reliable was it? Could it be used for informed decisions for investments? Was there any quality control and enforcement by authorites, or was it just another piece of paper that someone needed to obtain and include in a purely administrative check, if any? Gradually, many MSs started to implement more effective enforcement and quality control procedures, as the EPBD also required them to do so after Directive 2010/31/EC, but, from reading the chapter on "Compliance and Control" in part A of this book, as well as consulting the various country reports in part B, it is easy to conclude that there is still much room for improvement.

The EPCs were designed as an important information source for consumers and authorities alike. The inclusion of the energy rating in advertisement, ensuring that the information was available to consumers from the very first stages of the market, was one of the measures with great impact that Directive 2010/31/EC brought along. EPCs were (and still are) meant to include recommendations for improving energy efficiency in buildings. But it was soon concluded that a 'good' EPC, suitable for making investment decisions, would be rather expensive. To lower the cost of the EPCs, and make them more acceptable by the citizens and the building market, most of the EPCs, especially for existing buildings, are produced using a range of default values that may prevent the final product from conveying a fair picture of the reality. In most cases, banks will not accept an EPC as the basis for an informed loan application for renovation works. An energy audit, as defined by the Energy Efficiency Directive (EED - Directive 2012/27/EU), would be normally required. So, an apparent contradiction evolved: EPCs should offer accurate information, but they would then be rather expensive; thus, compromise solutions with much lower costs were adopted in many countries and EPCs lost their announced value as a source of valuable recommendations for improving the energy efficiency of a building or an apartment. In many countries, recommendations became vague standard statements that can be produced without even having a QE visiting the building. This clearly calls for an evolving concept for EPCs, meant solely for comparing buildings according to some standard typical pattern of use and according to what it would be expected to perform under default conditions, regardless of its actual present status.You will also find a good discussion about these issues in part A of this book.

Mandatory inspections of heating and air-conditioning (AC) systems are also part of the EPBD. These have always been a problematic issue, as their cost-effectiveness soon came into question, even in countries with demanding climates. Alternative measures, allowed since Directive 2010/31/EC came into force for both heating and AC systems, are becoming more and more popular among MSs. Proof that these alternative measures are as effective as a real inspection system is however another area that warrants careful consideration. 'Proof' might even be a scientifically incorrect word to use in this context, as so many assumptions are called for that there is ample room for imagination and creativity around. Is this really the best way? Would good regular maintenance together with replacement of obsolete units produce the same or even better results? What is the role for regular monitoring of large systems? Readers will be able to find a good discussion on these issues in the chapter on "Inspections" in part A of the book, and the country reports in part B shall certainly be the best proof of how much progress would still be needed to reach full compliance with the inspection requirements of the EPBD.

From this short introduction, it is clearly evident that the EPBD is a success story in many respects:

- MSs improved their minimum energy efficiency requirements for buildings, taking into account cost-optimality for a long (ca 30 years) life-cycle approach;
- MSs introduced certification and EPCs are now becoming common place, even present in advertisements like any other consumer item, e.g., a washing machine, an air-conditioner or an automobile;
- combined with EED requirements, EPCs became a tool to identify priorities for renovation of existing building stocks, public or private;
- there are some meaningful plans for the energy renovation of the existing building stock.

But the EPBD has also shown quite a few shortcomings. Some of them resulted from good ideas that MSs simply failed to implement, e.g., enforcement and quality control, taking advantage of EPC databases, namely for policy making, display of EPCs in public buildings, etc. Others clearly raise cost-effectiveness issues, e.g., inspections of heating and AC systems, or even requiring demanding NZEB levels, particularly in the renovation of the existing building stock. Yet others simply need to evolve to become fit for purpose, or to redefine the purpose, e.g., the role of recommendations in EPCs and the role of EPCs for financial instruments and incentives.

This book describes and discusses all these aspects in good detail:

- in part A, experts in each thematic area offer good technical discussions of the issues, provide statistics, and list possible solutions and recommendations;
- in part B, country reports describe the status of implementation in all 28 EU MSs and in Norway. Readers can get valuable information about how each country dealt with each EPBD requirement, taking into careful consideration what is said, how it is said, and, also, by identifying what is not said.

I hope that you will find this book a valuable source of information. I also hope that the facts and lessons it describes will enable the European Commission, the European Parliament and Member States to produce a third, more effective and more realistic version of the EPBD in a year or two from now, fully obeying the principles of the 'better regulation' initiative: forward looking and as demanding as possible; not losing sight of the overall goals of sustainability and economy; fully open to new ideas and innovation, but fit for purpose, realistic and avoiding undue burden on MSs and their citizens; consolidating and only introducing minor improvements on what is working well; forcing better compliance where it is clearly lacking, but also having the courage to drop the ideas and requirements that have simply proven themselves to be innefective or unrealistic.

The CA EPBD shall continue in the next few years under the leadership of an esteemed colleague, Jens Laustsen. We were both part of the group that came up with the idea of using the Concerted Action instrument to tackle the EPBD and get its improved implementation throughout Europe when the EU Commission timely and wisely proposed the new instrument back then. I am sure the CA EPBD will continue to be an effective instrument under Jens's leadership. I look forward for the next update of this book in a not so distant future. It has been my privilege to lead this Concerted Action for a decade, and I wish to thank all the many representatives from every participating country, as well as the many EC officers and other EU and foreign experts with whom I had the honour and pleasure to interact during this decade. Without everybody's outstanding collaboration, these books, and the contributions towards a better and more effective implementation of the EPBD in Europe, would never have been possible. Thank you very much.

Eduardo Maldonado
Professor, University of Porto, Portugal

Part A – Core Theme Reports

Certification

OVERVIEW AND OUTCOMES

AUGUST 2015

1. Introduction

The Energy Performance of Buildings Directive (EPBD, Directive 2010/31/EU) aims to steer the building sector towards ambitious energy efficiency standards and increased use of renewable energy sources. The Energy Performance Certificate (EPC) plays a key role in this process, as it informs potential tenants and buyers about the energy performance of a building unit (e.g., an apartment or office) or of an entire building, and allows for comparison of buildings and building units in terms of energy efficiency. The underlying idea is that the EPC should influence the demand for buildings with excellent energy efficiency performance and a high proportion of energy from renewable sources, increase their market value, and thus influence building owners to renovate their buildings.

This report provides an overview of the developments and achievements accomplished from 2011 to 2015 regarding EPC-relevant topics of the EPBD, including: advertising requirements and the role of real estate agents, mandatory provision of recommendations for improving energy performance as part of the EPC, and the obligatory display of the EPC in non-residential buildings occupied by public authorities and frequently visited by the public.

The report attempts to include the relevant information from every Member State (MS) in the EU. However, as this was not possible for every aspect, the total number of MSs covered by some of the statistics included in this report may be lower than 28 (or 29 including Norway).

2. Objectives

According to the EPBD, EU MSs shall ensure that an EPC is issued for buildings or building units which are constructed, sold or rented out to a new tenant, along with periodic certification of buildings which are occupied by public authorities and frequently visited by the public. This report summarises lessons learned regarding the certificate's content (layout and information included, acceptance of the certificate by the real estate sector, use of the certificate data for monitoring processes, etc.), the certification process itself, and the use of the certificate in advertising buildings offered for sale or rent, or frequently visited by the public.

The key objectives of this report are described below.

2.1 Key objective 1: Providing an overview of existing solutions

The first key objective is to summarise the approaches of MSs that have successfully dealt with the challenges of the EPBD regarding certification and making use of the EPC, in order to provide positive examples for other MSs to follow.

2.2 Key objective 2: Providing an overview of aspects MS should pay more attention to

The second objective is to identify areas which need further attention, in order to tap the full potential of the EPBD and especially of building certification.

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3. Analysis of insights

This report presents an overview of the following topics, summarising opinions, solutions, challenges, and opportunities for future development:

> the EPC and the real estate sector, including advertising requirements and the role of real estate agents, display of energy certificates, and making the EPC more user-friendly for the general public;
> validity of EPCs, including use of default values and calculation of realistic energy savings, mandatory inclusion of recommendations for improving energy efficiency, and the trade-off between EPC cost and content;
> making the best use of EPCs, including examples of how MSs use EPC databases, and the EPC as a supporting document for subsidies related with energy efficiency.

3.1 EPC and the real estate sector

According to Article 12 of the EPBD, an EPC must be presented and handed over to the prospective tenant or buyer. The role of the EPC is strengthened by mandatory publication of the energy performance indicator contained in the EPC, according to the national legislation valid at the time for advertising a building for sale or rent. According to EPBD Article 13, EPCs must be displayed on buildings occupied by public administration and frequently visited by the public, and on buildings frequently visited by the public in general, if an EPC has been issued according to Article 12.

The publication of the energy performance indicator of a building or building unit in advertisements in the commercial media is important for creating awareness of buildings' energy performance among potential buyers or tenants, as is the obligation to display EPCs in frequently visited buildings. Since publication and advertising of EPC indicators have become mandatory, the public has frequent encounters with energy indicators and related information. This is one way to boost awareness. Transaction studies show that, under similar location conditions, energy efficient buildings sell or rent faster and at a better price than buildings with low-grade energy efficiency performance. For example, in the case of The Netherlands, Brounen, Kok and Menne[1] suggest that an otherwise identical house with an A-rating retails for about 12% more compared to a house with a G-rating. Although the housing market, like most other sectors, has been affected by the economic crisis, and results need to take the latest developments into account, this tendency has been confirmed in more recent work building on the initial study described above[2] and on other work carried out in this field[3]. These factors reinforce the importance of the quality of information real estate agents provide at the point of sale, and the importance of compliance in two respects: first, the actual publication of the required type of energy indicator, and second, the publication of the correct energy indicator number.

3.1.1 Requirements of advertising and the role of real estate agents

The publication of EPC indicators in advertisements is crucial for making a building's energy performance visible. The MSs' legal frameworks require the publication of selected EPC information, while also specifying how this information has to be published, for example in the form of the specific energy class (e.g., A, B), or numerical values (e.g., kWh/m².year or CO_2 emissions). Some countries allow several options, and the majority requires the building's energy class.

In practice, there is still room for improvement:

> Experiences suggest that mandatory publication must be combined with clear and proportionate sanctions that can and must be enforced, in order to

[1] *Dirk Brounen, Nils Kok, Jaco Menne. Energy Performance Certification in the Housing Market. April 2009. www.dgbc.nl/content/energy-performance-certification-housing-market (2015-09-07)*

[1] *D. Brounen, N. Kok, On the economics of energy labels in the housing market, J. Environ. Econ. Manage. (2011), doi:10.1016/j.jeem.2010.11.006*
Quarterly Report Q3 2013, Dirk Brounen (2013) - in Dutch, in English: www.tias.edu/en/knowledgeareas/area/real-estate/article/energy-label-most-popular-in-non-urban-areas (2015-03-23)

[2] *Energy performance certificates in buildings and their impact on transaction prices and rents in selected EU countries. FINAL REPORT, European Commission (DG Energy), 19 April 2013*

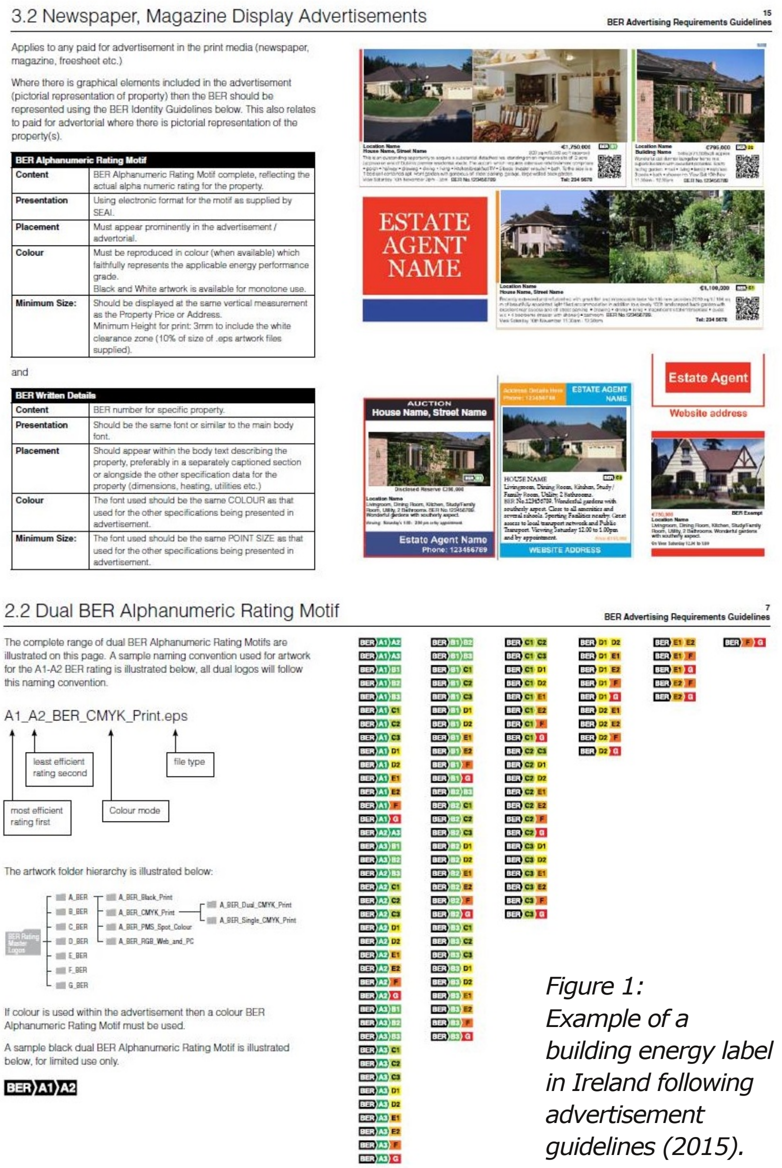
[3] *For example: F. Fuerst, P. McAllister, A. Nanda, P. Wyatt (2013): An investigation of the effect of EPC ratings on house prices. A report for the Department of Energy and Climate Change www.gov.uk/government/uploads/system/uploads/attachment_data/file/207196/20130613_-_Hedonic_Pricing_study_-_DECC_template__2_.pdf (2015-10-02)*

achieve a substantial increase in publication of energy indicators and subsequent market impact. This systematic compliance check is not consistently enforced in the majority of MSs and needs serious improvement.

> Only in a few MSs (Belgium-Flemish region, Portugal and Ireland) have guidelines been developed for the use of EPC data in advertisements, in collaboration with real estate agents, for either mandatory (Ireland – Figure 1) or voluntary (e.g., Portugal – Figure 2) utilisation. These guidelines ensure that the energy indicators can be easily identified, that energy information does not get lost among the rest of the advertisement, and that additional expenses are avoided by exactly specifying the requirements for publication in print media and internet media, either displayed on the computer screen or on the mobile phone.

The publication of the EPC reference number as part of the advertisement allows for a convenient comparison of the published information with the respective information stored in the EPC database, to check whether the published information is correct, or whether an error has occurred. EPC databases can also provide services to real estate agents by offering quick and easy access to the general building information they need for advertising, as in Portugal for example. Services and compliance checks are based on the availability of an EPC database that is at least partly accessible to the public. The concept of permanent but limited access is based on the consideration that not all data stored in the databases needs to be accessed by all stakeholders. Limited access could also mean access only to specific information of the datasets, complying with data protection and/or privacy requirements.

However, in some countries, e.g., Germany and Austria, there are serious data protection concerns, so access to the EPC database is only allowed for directly-involved experts, and occasionally for policy makers and researchers working on specific projects. Therefore, other solutions for co-operation with real estate agents and compliance checks might be necessary. Nevertheless, countries with strong data privacy concerns should be aware that denying access to EPC databases to all or certain stakeholders might ensure data protection, but limits transparency and the effort to create energy efficiency awareness.



3.2 Newspaper, Magazine Display Advertisements

Applies to any paid for advertisement in the print media (newspaper, magazine, freesheet etc.)

Where there is graphical elements included in the advertisement (pictorial representation of property) then the BER should be represented using the BER Identity Guidelines below. This also relates to paid for advertorial where there is pictorial representation of the property(s).

BER Alphanumeric Rating Motif	
Content	BER Alphanumeric Rating Motif complete, reflecting the actual alpha numeric rating for the property.
Presentation	Using electronic format for the motif as supplied by SEAI.
Placement	Must appear prominently in the advertisement / advertorial.
Colour	Must be reproduced in colour (when available) which faithfully represents the applicable energy performance grade. Black and White artwork is available for monotone use.
Minimum Size:	Should be displayed at the same vertical measurement as the Property Price or Address. Minimum Height for print: 3mm to include the white clearance zone (10% of size of .eps artwork files supplied).

and

BER Written Details	
Content	BER number for specific property.
Presentation	Should be the same font or similar to the main body font.
Placement	Should appear within the body text describing the property, preferably in a separately captioned section or alongside the other specification data for the property (dimensions, heating, utilities etc.)
Colour	The font used should be the same COLOUR as that used for the other specifications being presented in advertisement.
Minimum Size:	The font used should be the same POINT SIZE as that used for the other specifications being presented in advertisement.

2.2 Dual BER Alphanumeric Rating Motif

The complete range of dual BER Alphanumeric Rating Motifs are illustrated on this page. A sample naming convention used for artwork for the A1-A2 BER rating is illustrated below, all dual logos will follow this naming convention.

Figure 1: Example of a building energy label in Ireland following advertisement guidelines (2015).

Figure 2: Example of building energy label in Portuguese following advertisement guidelines (2015).

3.1.2 Display of energy certificates

Display of the EPC is important for creating awareness of energy efficiency: buildings occupied by public authorities and frequently visited by the public must display their EPC, as must other buildings frequently visited by the public for which an EPC should have been issued. Observations in MSs indicate substantial room for improvement in many countries.

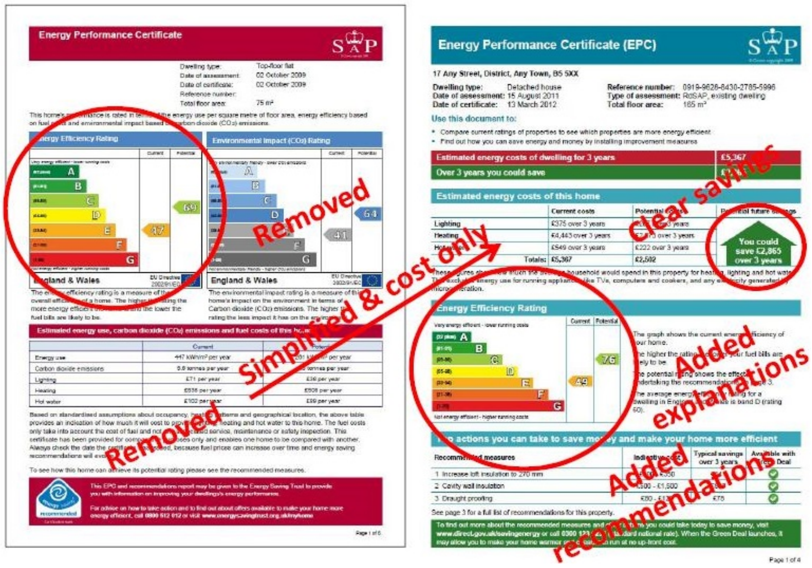
A 2015 survey of MSs about the display of EPCs showed that only four MSs have collected numbers on the buildings displaying the EPC: in two countries less than 10%, in one country more than 50% and in another one more than 90% of these buildings display their EPCs. Only six MSs indicated that there are penalties for not displaying the EPC. However, enforcement in these countries is also lacking.

There is a general lack of EPCs that are visibly displayed, and compliance checks are difficult, mainly due to insufficient definition of the terms “frequently” and “visited by the public”. A closer look at frequently visited buildings occupied by public authorities and their possible reasons for not displaying the EPC reveals an issue with long-term leases: if, for lack of obligation, an EPC has not yet been issued, the leasing public authority would have to commission the calculation of the EPC, resulting in additional costs. Avoiding these additional costs is one explanation of why the obligation to display the EPC is ignored in MSs without any clear enforcement procedure in place. This demonstrates the importance of compliance checks.

In order to be able to check and ensure compliance, either more definitions and explanations, or a radical simplification and clarification of the existing Article 13 would be necessary. In this respect there are good examples from European countries such as Norway. In Norway, the law was simplified and all non-residential buildings with net useful area above 1,000 m^2 must display the EPC. In addition, a strict enforcement procedure should be in place whereby, for example, a person is appointed responsible for the display of the EPC in a specific building, and an inspection of all relevant buildings takes place. Consequences (penalties) should be specified in case of non-compliance.

Buildings occupied by public authorities are expected to set a good example and play a leading role in terms of energy efficiency, and to showcase this by displaying the EPC. Presently, it seems that public authorities in most MSs do not comply, in practical terms, with the obligation to display the EPC, even if it is written into the law. This might have a negative impact on general awareness, as well as on compliance from the private sector.

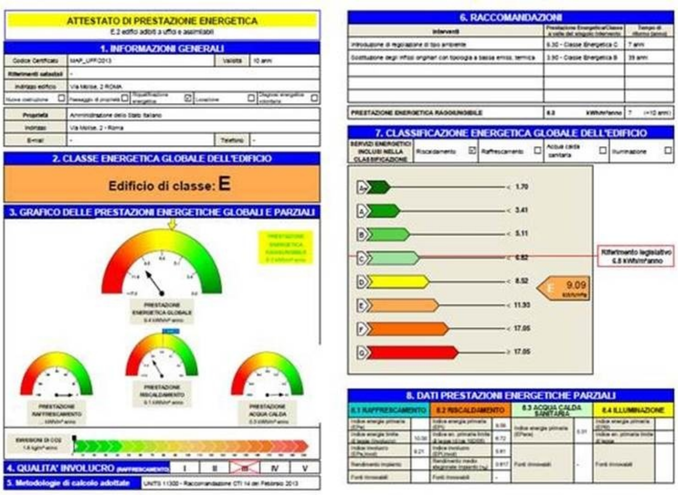
Figure 3: Example: The old (before 2012) and new EPC in The UK.

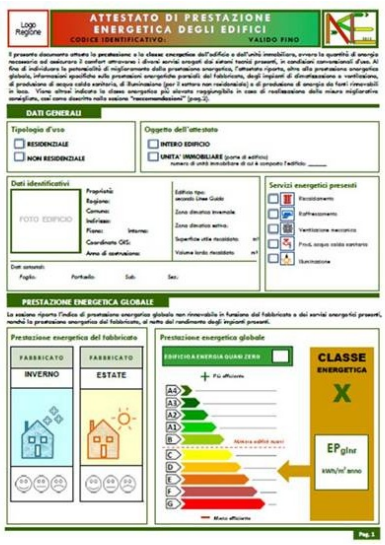


3.1.3 Making the EPC more user-friendly for the general public

Although there is more awareness of energy efficiency among consumers thanks to the EPC, much improvement is still necessary. Regarding the market impact of increased demand for energy efficient buildings, a German study shows that consumers’ expectations about the EPC are still partly wrong, with the conclusion that the EPC is too technical and complicated for consumers to understand it. These conclusions are shared by most of the MSs represented at the Concerted Action EPBD. The UK, Germany, and Portugal have already

Figure 4: Example of the 2014 EPC and the draft of the new Italian EPC (2015).





undertaken efforts to make the EPC more user-friendly. Taking into account the interests of the general public, the use of technical language has been reduced to a minimum on the first pages of the EPC and more self-explanatory icons are used, whereas the technical sections, addressing experts and authorities, have been moved to the end. In Italy, a new and improved layout for a national EPC has been designed based on the lessons learnt. Figures 3 and 4 show the previous version and the improved EPC in parts of The UK and in Italy.

Regarding user-friendliness, the majority of MSs chose, at least for the present, not to explicitly show the Nearly Zero Energy Building (NZEB) level on the EPC front page. This may be due to MSs not linking the NZEB levels to an energy performance class in their EPC system, or because NZEBs are not yet common in those MSs and, being a technical term, it is considered difficult to explain. On the other hand, showing the NZEB level could be an element for promotion, as is the case in Germany, where the term NZEB is not explicitly used either, but comparable terms like *"Energieeffizienzhaus-Plus"* are used, which people are familiar with due to awareness campaigns and funding schemes. More information on these aspects is available in the chapter "Towards 2020 – Nearly Zero-Energy Buildings" in this book. In any case, user-friendliness of EPCs must be a priority.

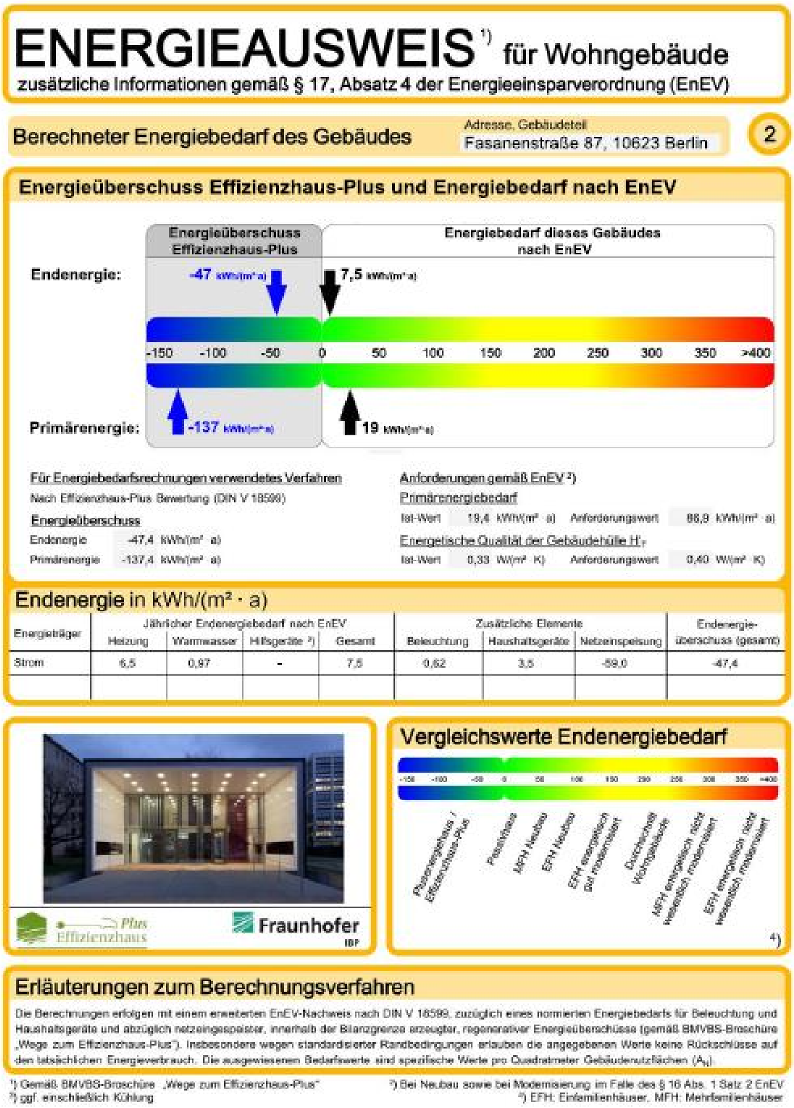
Clear guidelines are needed on how to include energy information in advertisements to ensure visible and meaningful publication.

Allowing partial access to certain sections of the EPC databases allows real estate agents to easily access the information required for advertisements. It also allows clients to check the published information.

Displaying EPCs in public buildings visited by the public is important for creating awareness of energy efficient buildings, but is often lacking in practice in most MSs. There is significant room for improvement.

User-friendliness of EPCs must be a priority, and some MSs have started to identify weaknesses and to improve and clarify the EPC presentation.

Figure 5: Example of a German EPC with indication of the requirements for "Passivhaus", "Effizienzhaus Plus", "Plusenergiehaus") (2015).
Legend:
- Energieausweis für Wohngebäude: Energy Performance Certificate for residential buildings
- Berechneter Energiebedarf des Gebäudes: Calculated energy demand of the building
- Energieüberschuss Effizienzhaus-Plus und Energiebedarf nach EnEV: Energy surplus of energy efficient house-plus and Energy demand according to (German) energy saving regulations
- Endenergie: Final energy
- Primärenergie: Primary energy
- Vergleichswerte Energiebedarf: Comparative values of energy demand
- Erläuterungen zum Berechnungsverfahren: Explanation of calculation method



ENERGIEAUSWEIS[1)] für Wohngebäude
zusätzliche Informationen gemäß § 17, Absatz 4 der Energieeinsparverordnung (EnEV)

Berechneter Energiebedarf des Gebäudes — Adresse, Gebäudeteil: Fasanenstraße 87, 10623 Berlin — 2

Energieüberschuss Effizienzhaus-Plus und Energiebedarf nach EnEV

Energieüberschuss Effizienzhaus-Plus | Energiebedarf dieses Gebäudes nach EnEV

Endenergie: -47 kWh/(m²·a) | 7,5 kWh/(m²·a)

-150 -100 -50 0 50 100 150 200 250 300 350 >400

Primärenergie: -137 kWh/(m²·a) | 19 kWh/(m²·a)

Für Energiebedarfsrechnungen verwendetes Verfahren
Nach Effizienzhaus-Plus Bewertung (DIN V 18599)

Energieüberschuss
Endenergie -47,4 kWh/(m² · a)
Primärenergie -137,4 kWh/(m² · a)

Anforderungen gemäß EnEV [2)]
Primärenergiebedarf
Ist-Wert 19,4 kWh/(m² · a) Anforderungswert 86,9 kWh/(m² · a)
Energetische Qualität der Gebäudehülle H'_T
Ist-Wert 0,33 W/(m² · K) Anforderungswert 0,40 W/(m² · K)

Endenergie in kWh/(m² · a)

Energieträger	Jährlicher Endenergiebedarf nach EnEV				Zusätzliche Elemente			Endenergie-überschuss (gesamt)
	Heizung	Warmwasser	Hilfsgeräte [3)]	Gesamt	Beleuchtung	Haushaltsgeräte	Netzeinspeisung	
Strom	6,5	0,97	-	7,5	0,62	3,5	-59,0	-47,4

Plus Effizienzhaus — Fraunhofer IBP

Vergleichswerte Endenergiebedarf

-150 -100 -50 0 50 100 150 200 250 300 350 >400

Plusenergiehaus / Effizienzhaus-Plus; Passivhaus; MFH Neubau; EFH Neubau; EFH energetisch gut modernisiert; Durchschnitt Wohngebäude; MFH energetisch nicht wesentlich modernisiert; EFH energetisch nicht wesentlich modernisiert [4)]

Erläuterungen zum Berechnungsverfahren

Die Berechnungen erfolgen mit einem erweiterten EnEV-Nachweis nach DIN V 18599, zuzüglich eines normierten Energiebedarfs für Beleuchtung und Haushaltsgeräte und abzüglich netzeingespeister, innerhalb der Bilanzgrenze erzeugter, regenerativer Energieüberschüsse (gemäß BMVBS-Broschüre „Wege zum Effizienzhaus-Plus"). Insbesondere wegen standardisierter Randbedingungen erlauben die angegebenen Werte keine Rückschlüsse auf den tatsächlichen Energieverbrauch. Die ausgewiesenen Bedarfswerte sind spezifische Werte pro Quadratmeter Gebäudenutzflächen (A_N).

[1)] Gemäß BMVBS-Broschüre „Wege zum Effizienzhaus-Plus"
[2)] Bei Neubau sowie bei Modernisierung im Falle des § 16 Abs. 1 Satz 2 EnEV
[3)] ggf. einschließlich Kühlung
[4)] EFH: Einfamilienhäuser, MFH: Mehrfamilienhäuser

3.2 Validity of EPCs

Article 11 of the EPBD requires MSs to establish a system of certification for the energy performance of buildings and specifies the content and the purpose of the EPC. Among other things, EPCs should allow for the energy-related comparison of buildings and building units, and thus empower potential buyers or tenants to make an informed choice, taking energy efficiency into account.

Higher quality of certificates makes schemes more credible, so quality assurance of the EPC is necessary for its use as an information tool for customers, as a supporting document for subsidies related with energy efficiency, and for reporting obligations towards energy efficiency targets. A well-developed Quality Assurance (QA) scheme allows for improving the whole certification system (including feedback to policy makers), and there are clear procedures and sanctions.

During the process of certification there are mainly two elements that determine the quality of the final result and how the public will perceive it: the input data used for calculation and the framework of quality assurance that is applied.

Possible QA actions can address and improve different aspects of the whole EPC process. These aspects include: (1) training, (2) accreditation, (3) development of method/procedure, (4) on-site inspection, (5) software use, (6) presentation/content of the certificate, (7) quality control and (8) market response. Other important elements for the most effective use of the EPC are a central EPC database and appropriate software. This report does not discuss all these aspects (they are discussed in other reports), and is instead concentrating on three specific aspects:

> use of default values and calculation of realistic energy savings (related to the development of the method / procedure);
> mandatory provision of recommendations for improving energy efficiency (related to presentation / content of the certificate);
> trade-off between EPC cost and content (related to method/procedure and market response).

More information on quality aspects is available in the chapter “Compliance and Control of Regulations and Certificates” in this book.

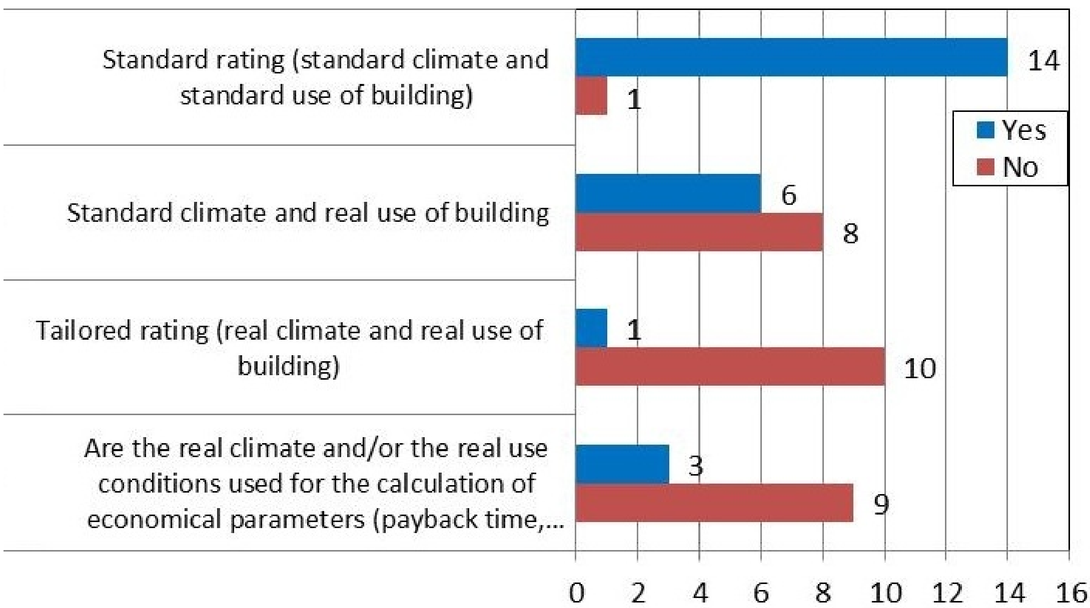
Concerted Action EPBD (CA EPBD) participants identified regular mandatory training for EPC assessors as one of the most effective methods to ensure EPC quality and to avoid mistakes. This training should include knowledge transfer on specific matters related to testing and site visits to evaluate the procedures.

3.2.1 Use of default values and calculation of realistic energy savingss

The EPC serves two different purposes:

1. It shows the energy performance of the building and reference values (e.g., minimum energy performance requirements) in order to make it possible to compare it with other buildings.
2. It informs homeowners of energy savings potential, in order to motivate them to invest in improving the energy efficiency of the building.

Figure 6: Operational conditions used for the calculation of energy indicators and energy classes on energy certificates; based on a 2013 survey.



The EPC rates the building and not the way it is used. Elements in the calculation, e.g., payback time, cost-optimality, and cost-effectiveness of recommendations, depend on the actual energy performance in which the users play a significant role. In many countries (Figure 6), calculation is based on a standard climate, standard user behaviour, and other default values, which might deviate more or less from the actual situation, depending on each specific case/building. While for the first purpose of the EPC, which is to show a building's energy performance, it is appropriate to use default values to achieve comparable calculation results, this might result in the calculation of seemingly distorted energy savings and thus compromise the second purpose of the EPC, i.e., to inform about the energy savings potential. As a result, it is necessary to strike a balance between these two objectives.

One of the challenges is how to obtain realistic values rather than simply using possibly unrealistic default values without increasing the cost of data collection, bearing in mind that building documentation is not available for the majority of the building stock in need of renovation. Therefore, in existing buildings the focus should be on further developing default values to allow for the comparison of buildings and on coming closer to realistic energy savings calculations at the same time. A good example is the publication of detailed building typologies at the regional level, thus providing default values that are closer to reality (e.g., Germany and Luxemburg). There are also other suggestions for possible solutions, such as ensuring that recommendations accompanying the EPC relate to actual climate and energy consumption (e.g., as Norway and The UK require).

3.2.2 Mandatory provision of recommendations for improving energy efficiency

EPC recommendations enhance awareness of the potential to improve buildings' energy efficiency.

The quality of the recommendations for improving energy efficiency is determined by the technical suitability and cost-effectiveness for the specific building. The way these recommendations are presented to the building owner can play a decisive role in the subsequent decision to take action. There is a trade-off between tailor-made, building-specific recommendations and recommendations taken from a standard list. While tailor-made recommendations will be most appropriate for actual building renovations, standard lists of recommendations reduce the cost of the EPC and may provide the basis for easier monitoring of the implementation of EPC recommendations (see Figure 7).

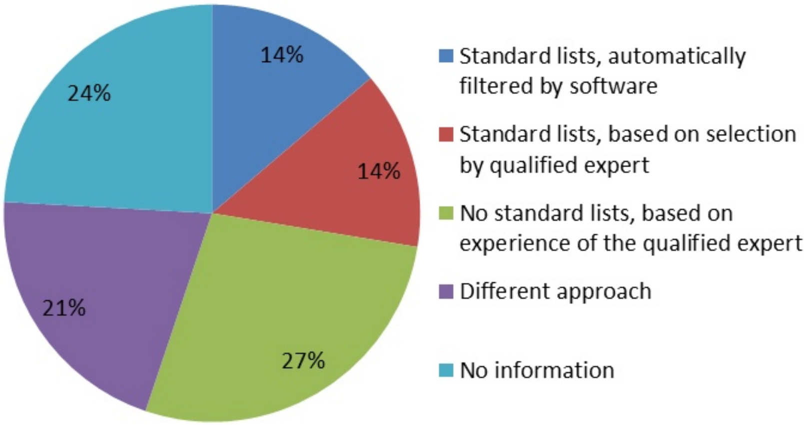


Figure 7: Options for selecting recommendations; based on national reports 2014.

It is important to monitor the implementation of recommendations in order to receive feedback on their success and to quantify the energy savings achieved. The refurbishment rate can be documented more easily and strategic actions, such as support mechanisms for improving energy efficiency, can be optimised on a regular basis. However, as of 2014, only a few countries have succeeded in implementing a system for monitoring the implementation of recommendations, among them Lithuania, The Netherlands and France.

To summarise, there is a clear distinction between EPC recommendations providing guidelines for potential energy savings, EPC tailor-made recommendations, and the detailed energy audit providing detailed and specific data for renovation planning of complex buildings. The detailed energy audit is not regarded as part of the EPC scheme, but as a necessary next step after having completed the EPC. This distinction is necessary for clients' acceptance: an EPC cannot substitute for detailed refurbishment planning, nor has it been designed to do so.

3.2.3 The trade-off between EPC cost and content

The EPC is the most visible part of the EPBD. In several MSs, the EPC has become one of the most-discussed building documents: EPCs should be easily affordable whilst providing a maximum of specific information in order to meet various expectations, resulting in a trade-off between cost and content. However, it is clear that the EPC is first of all a policy instrument and an information tool, and it cannot be a substitute for other detailed technical documents used in the construction and real estate sector.

The majority of MSs declare that the cost for single-family houses is between 100 € and 400 € per EPC (see Figure 8). EPCs for multi-unit residential buildings cost more. Several MSs provided information on EPC cost for non-residential buildings, typically in the range of 1-2 €/m², and in one country up to 5 €/m². Information on lump sums is around 1,500 € per non-residential building. The reasons behind the variety of EPC costs are unclear and should be explored. A country's economic strength does not seem to have a strong influence on the EPC cost.

Figure 8: Cost of EPCs for single family homes, based on national reports 2014.

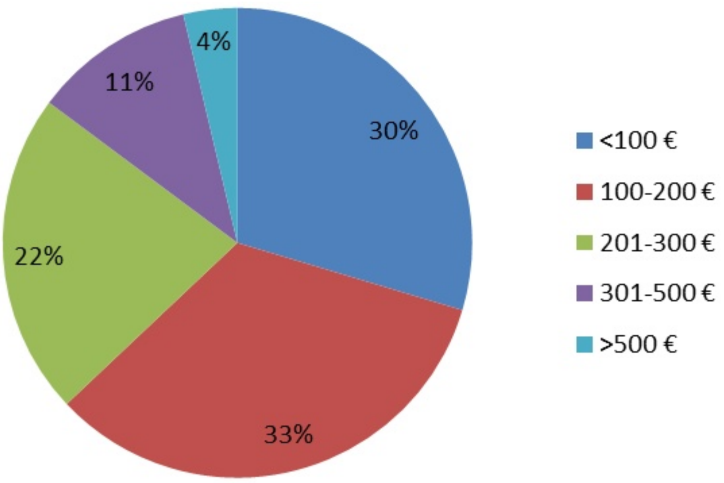
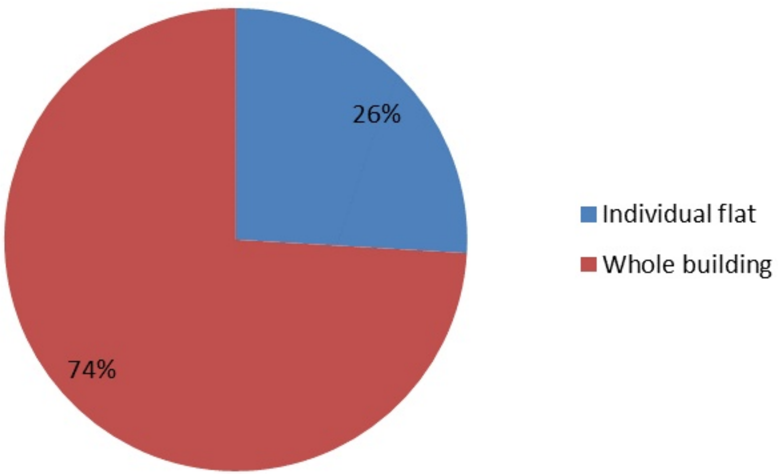


Figure 9: Certification of apartments and blocks of apartments; based on national reports 2014. Note: "Whole building" includes also a whole building EPC valid for the individual apartments in a specific building.



The trade-off between cost and content of recommendations for improving energy efficiency, also came to the fore during the discussion of certification methods for multi-unit residential buildings: there are certification systems in place certifying either individual apartments or whole buildings, or allowing for both approaches to be alternatively applied (see Figure 9).

It is difficult to have a simple and affordable certification method and at the same time provide useful information for both the whole building and each apartment. The certification of an individual building unit could provide tailor-made measurements for its refurbishment, especially when there is an individual heating system and the cost of the EPC is borne by the owner. However, it is difficult to provide suggestions for measurements concerning the whole building, e.g., roof insulation or replacement of a common boiler. The certification of the whole building, on the other hand, provides recommendations for the building envelope, and the heating system and its costs are divided among the owners. However, the energy indicators relating to the whole building can be different from the energy indicators for single units, depending on their location in the building. It would be best to have a certificate for both the building as well as for the individual apartment, but this is considered to be too expensive.

EPC quality as a term is composed of objective elements (e.g., correct calculation according to standard recommendations) and subjective elements (e.g., users' expectations about the kind of information the EPC provides or should provide).

There is a clear trade-off between the demand for affordable EPCs on the one hand and the manifold purposes the EPC should or could serve on the other hand, requiring technical accuracy and thus more effort, resulting in higher EPC cost. However, as the EPC lasts 10 years, higher EPC cost might be acceptable and worth the effort.

Across the EU, the EPC cost for a single-family house is typically between 100-400 €, and for a non-residential building between 1-2 €/m².

3.3 Making the best use of EPCs

The EPC and its recommendations provide information and advice to owners and tenants of buildings on how to assess and improve a building's energy performance. The EPC database delivers useful information for energy-related policy assessment and development, such as for reporting energy savings due to energy efficiency measures carried out in the building sector, or for launching investment strategies for increased energy efficiency standards in building renovation.

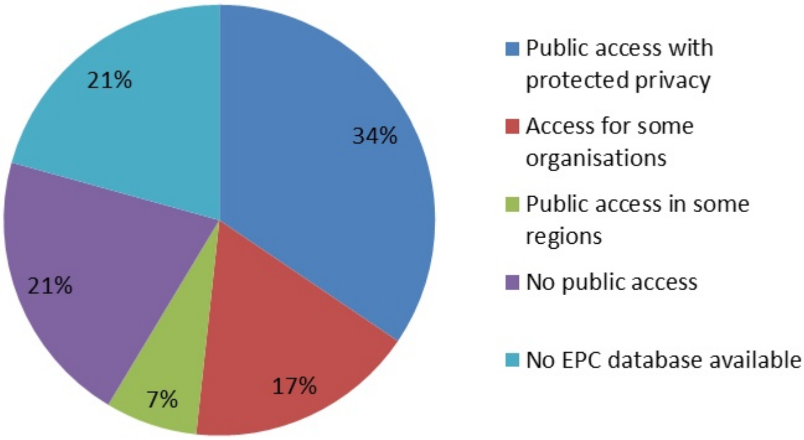


Figure 10: Public access to EPC databases, based on results from the IEE project REQUEST2ACTION, http://building-request.eu/ (2015).

Apart from EPC information stored in the central database, EPCs can be used in various other contexts, e.g., as adding the EPC as a supporting document to the national Green Building Council assessment scheme (e.g., in The Netherlands, Austria), using the EPC for specific programmes (e.g., "fresh schools" programme in The Netherlands), or as a supporting document for subsidies rewarding improved energy efficiency (e.g., Cyprus, Austria).[4]

3.3.1 Examples of Member States making use of EPC databases

MSs have set up EPC databases to monitor EPBD implementation, to control the energy certification process, and to collect data on the building stock in order to provide data for decision making. Utilisation opportunities depend on how access to the EPC database is regulated and whether EPC information can be linked with other data. Many MSs have chosen an open access system to limited or selected EPC information, while in other MSs access is only possible for the authorities, or granted to selected organisations, such as research entities (see Figure 10).

The information extracted from the EPC register can be useful to check if the energy labels on the advertisements for buildings offered for sale or rent are correct. An automatic quality check during the uploading of EPCs and their input data[5] to the database identifies common mistakes in EPC calculation, and thus supports the adaptation of training courses addressing energy experts. Apart from specific purposes like those explained above, another effective use of the EPC database lies in combination with other databases. For example, in Scotland the local authorities need effective data on the housing stock to plan their energy saving programmes. They focus on areas with high levels of fuel poverty. Reliable information on buildings' energy performance, in combination with the data from other relevant databases in these areas, enables them to negotiate with energy suppliers accordingly.

3.3.2 EPC as a supporting document for subsidies related with energy efficiency

EPCs can be used as an objective evidence of the quality of energy-related renovation of the final construction in order to engage stakeholders in achieving the policy targets for European energy and climate protection. In the residential sector, the EPC is already being used in many countries as a document necessary to obtain financial support and subsidies for increased energy efficiency. In 2015, EPCs are required in 10 countries as eligibility for such schemes, most often both before and after the renovation, but there are also 11 countries with subsidy systems that do not require an EPC. In this context, EPC quality assurance plays a key role in a growing number of MSs.

In the non-residential building sector – both commercial and public – because of lack of awareness, information and motivation, followed by lack of confidence in the return of investment, energy efficiency has not yet fully penetrated the market. In general, public buildings should be exemplary for private commercial buildings, although, in fact, it is more difficult for them to access financing. In the private sector, short payback periods and the investor-user

[4] *For more information see also www.buildup.eu/financing-schemes and "Towards improved quality in energy efficient buildings through better workers' skills and effective enforcement - A view of the Concerted Action EPBD on Challenges and Opportunities" at www.epbd-ca.eu/ca-outcomes/2011-2015*

[5] *More information on these aspects is available in the chapter "Compliance and control" of the EPBD in EU, in this book.*

dilemma still hinder investments in energy efficiency. The life cycle cost approach is a method for assessing the total cost of facility ownership and a motivation to convince investors constructing for their own use. However, for wide application, there are still open challenges, such as how to take into account user requirements changing over time, and how to deal with lifetime of components and intensity of maintenance in the calculation.[6]

To overcome the challenges of financing energy efficiency measures in non-residential buildings, EPCs could become a supporting tool, as has already happened in some countries (e.g., The Netherlands). However, in the commercial sector, the EPC as an asset rating is often not regarded as an investment grade instrument by financing institutions. More information on this topic is available in the chapter on the Effectiveness of Support Initiatives, in this book.

The European Investment Bank (EIB) could play a unique role in strengthening the EPC as it is owned by the MSs and should support them to achieve the 20-20-20 targets. Projects would be eligible for funding from the EIB only if there is proof that they will result in a significant amount of energy savings, CO_2 savings, or use of renewable energy. The EPC can be used as proof, but at present it is not a mandatory condition. If the EIB would also explicitly require an EPC, this would help to consolidate the position of the EPC.

Making the best use of the EPC occurs at two levels: EPC data stored in the central database can be used for policy making and for complying with national reporting obligations.

In case of public accessibility to parts of the database, stakeholders in the real estate and construction sector as well as the general public can make use of EPC information for their own purposes.

The EPC itself could be used not only for obtaining a building permit, but also for getting financial support for increased energy efficiency.

4. Main outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Requirements of advertising EPC indicators	There is an established co-operation with real estate agents and guidelines for using EPC information in advertisements in only a few MSs.	Voluntary or mandatory guidelines for publication of EPC indicators in advertisements are useful to make sure that important information is appropriately presented.	MSs should develop their own guidelines together with the real estate sector, based on the experience of innovators in the area of advertising guidelines (Ireland, Portugal and Belgium-Flemish region).
Access for real estate agents and the public to EPC databases	Space in ads is limited, but an Internet link to the EPC database provides more information: real estate agents can access building data for advertising and clients can check the published EPC information.	Co-operation with real estate agents is essential as they provide the EPC information at the point of sale or rent.	Publicly accessible parts of EPC databases are necessary. MSs with prevailing data protection concerns should find ways to overcome this limitation.
Display of Energy Certificates	EPC display is important for creating awareness of buildings' energy efficiency. The definitions of EPC display requirements in the EPBD allow for different interpretations by MSs.	At the end of 2014, most MSs did not check nor enforce compliance with display requirements. There is room for improvement by public authorities.	EPBD definitions and requirements for EPC display must be clarified in national laws. One solution is to extend the requirement to all non-residential buildings with more than 250 m^2 of floor area.

[6] *Further information on Life-Cycle Cost Analysis (LCCA): www.wbdg.org/resources/lcca.php, https://ec.europa.eu/energy/intelligent/projects/en/projects/lcc-data#results*

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Use of the EPC and meaning of the indicators	EPCs should serve several purposes, and an asset rating alone will not be useful for calculation and recommendation of energy efficiency improvement measures.	The potential of the EPC has to be reconsidered in the context of identifying economically viable recommendations for improving energy efficiency and in the context of financing renovations.	MSs must make the EPC more user-friendly: what kind of information is provided and how target groups can make use of it should be clear and self-explanatory.
Making the EPC user-friendly	It is important to adapt the EPC (layout and content) according to the needs of the users (authorities, experts, the general public and building owners).	The layout and user-friendliness of the EPC is crucial. Using less technical language and icons makes it easier for the owners and general public to understand it.	Text should be short and retrofit recommendations should be on the first pages. The more technical information should be moved to the second part of the EPC.
The estimation of buildings' realistic energy consumption	Default values are useful (in terms of cost and liability) to produce comparable calculation results, but may result in distorted energy savings calculations (when applied to certain buildings/uses).	More realistic setting of boundary conditions and further developing of default values is crucial for calculating more realistic potential energy savings.	Trainings and national guidelines are necessary to enable experts to determine realistic default values for energy savings calculations that are closer to reality.
Trade-off between high degree of standardisation (low cost EPC) and tailor-made EPCs (high cost EPC)	Standard lists of recommendations are a basis for easier monitoring of the recommendations, but they do not substitute for detailed energy audits needed for renovation planning of complex buildings.	Monitoring the implementation of recommendations is important to assess policies and report energy savings.	EPCs must include good recommendations for improving energy efficiency. MSs should monitor the implementation of recommendations to reshape energy efficiency policies.
The EPC as a supporting document for subsidies	In many countries, EPCs are used as required evidence of increased building energy efficiency to reward building owners e.g., by means of subsidies or tax reduction.	In this case, making use of the EPC with an asset rating is appropriate because what is awarded is the building energy efficiency, and not the way the building is used.	Quality assurance is crucial: it must be ensured that EPCs are calculated correctly and that the building is constructed as designed.
Examples of good use of data from the national/ regional EPC databases	EPC-databases are being used intensively in several MSs for developing policy documents, improving building regulations, conducting research on building stock, preparing statistics or training energy experts.	The EPC database provides a good overview of the building stock and is more useful in combination with other relevant databases.	MSs should link the EPC-databases with other energy related databases, in order to tap the full potential for decision-making and policy development.

5. Lessons learned and recommendations

The EPCs' potential to create sustainable awareness depends mainly on two aspects: first, that an EPC is actually issued, and second, that EPC indicators are correct, in order to build trust in the EPC as a reliable information tool. Thus, quality assurance and user-friendliness of the EPCs are crucial. Display of an EPC in public buildings and buildings frequently visited by the public is also important, but there is still a long way to go for most MSs to improve in this respect.

The presence of energy indicators in the media contributes to customers' awareness of and demand for energy efficient buildings. In this context, cases have been seen where poor energy indicators have been hidden in advertisements, which sometimes include creative solutions such as A (not yet rated), C+ or D-, which do not exist as part of the national legislation but allow the building performance to appear better than it actually is. Such deviations might concern honest errors, but they could also happen intentionally, e.g., because studies show that buildings with good energy performance sell or rent more quickly. In order to prevent not just mistakes but also fraud, some countries (e.g., Portugal, Belgium and Ireland) have developed mandatory or voluntary guidelines on how energy-related information should be presented in the media.

The experiences of these countries show how important it is to engage the stakeholders, namely real estate agents and their associations, but also print and electronic media, in the process of developing guidelines. This involvement assures that guidelines will be accepted, information is placed correctly, and mistakes regarding energy labelling are avoided.

Concerning access to EPC databases, data privacy issues are important in some countries and must be dealt with with care. However, accessing EPC databases and making use of EPC data offers interesting opportunities, which have to be considered as well. Investment in building renovation opens new opportunities for new services. For this purpose, it could be useful to provide at least limited access to EPC databases because new services can only be developed if comprehensive data analysis is possible. This has triggered a ‘rethinking’ process in Denmark, and other countries should also consider following suit.

The reliability of the EPC is crucial for its acceptance. Calculating the EPC based on actual building components and technical systems data instead of using default input values will result in a more realistic picture, but may increase the cost of the EPC. While data availability is good for new construction projects, existing buildings lack specific information for EPC calculation. Instead of carrying out costly data collection exercises, it is recommended to further develop default values to arrive at more realistic EPCs while keeping costs modest. Combined EPCs consisting of asset rating and operational rating represent a cost-efficient approach to provide realistic information about the actual building energy consumption. This is an essential precondition for the recommendation of cost-effective renovation measures.

The EIB, which is owned by the MSs and will support them in achieving the 20-20-20 targets, should request EPCs as mandatory proof for the projects that they finance, before and after the renovation, as the EPC indicates the building-related energy demand, CO_2 emissions, and renewable energy use. The EIB’s use of the EPC will contribute to the EPC’s solid reputation and will also provide an added incentive for MSs to comply with the EPBD. The same principle is already required by the EPBD for national support of building renovation, though not all MSs have fully applied this requirement yet either.

Inspections

OVERVIEW AND OUTCOMES

AUGUST 2015

1. Introduction

This report covers regular inspection of heating and air-conditioning (AC) systems and the alternatives to it that are allowed by the Energy Performance of Buildings Directive (EPBD). It has been extended to include technical building systems (TBS) as well. The subject matter comprises:

- *inspection schemes themselves (how they are set up and operated, frequency of inspection, the inspection procedure to be followed, and the reporting of results and recommendations);*
- *alternative measures that can produce an equivalent impact in terms of saving energy;*
- *how equivalent impact should be demonstrated and reported;*
- *electronic monitoring and control systems that can be recognised as a partial substitute for inspection;*
- *the regulatory requirements for technical building systems in existing buildings.*

The first version of the EPBD (Directive 2002/91/EC) had to be transposed by January 2006. For heating systems with boilers there were two options: regular inspection or alternative measures having an equivalent overall impact. Member States (MSs) who already had compulsory regular maintenance schemes were able to adapt them, but for others this was a new and unfamiliar task. In addition to developing the technical content of procedures and reports, it was necessary to build up a suitably qualified and/or accredited workforce, introduce scheme operating procedures with quality controls, and create codes of conduct and arrangements for handling complaints and appeals. For AC systems, inspection was obligatory as there was no option to adopt alternative measures.

The current version of the EPBD (Directive 2010/31/EU) had to be transposed by 9 July 2012 at the latest. It changed the scope of the inspection requirements, and allowed alternative measures for AC as well as for heating. All existing schemes had to be adapted to meet the new scope. Directive 2010/31/EU also introduced a new requirement for regulations concerning TBS in existing buildings, the scope of which extended to design, installation and control as well as energy performance. The Directive requires penalties to be imposed for any infringements of the national provisions.

Two of the CEN standards written for the EPBD cover inspection of heating and AC systems. Others have some relevance to the performance of TBS. However, the first set of CEN standards written for the EPBD was delivered too late to be fully used in national transpositions of Directive 2002/91/EC (the first version of the EPBD), and they were unsuitable for inclusion in transpositions of Directive 2010/31/EU (the second version) as the scope had changed. The CEN standards are being re-written to match Directive 2010/31/EU and are expected by 2016.

2. Objectives

The objectives of the Concerted Action EPBD (CA EPBD) work on inspections and TBS were:

- To develop a wider understanding of the detailed requirements and options in the EPBD concerning inspection of heating and AC systems. Variations can be introduced according to system type, fuel, power rating, monitoring, and control.

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> To consider regulations for existing buildings with newly installed, replaced, or upgraded TBS. Regulations are needed not just for energy performance but also for proper installation, dimensioning, adjustment, and control. Regulations must also encourage intelligent metering.
> To understand feasible alternatives to inspection and their effect on the energy used by heating and AC systems.
> To develop the methodology whereby it can be shown that alternative measures have an equivalent impact to inspection, and examine ways in which equivalence is reported to the EC.

Ongoing technical and legislative developments and new standards for the energy performance of Heating Ventilation and Air-Conditioning (HVAC) systems are relevant to these objectives. They include system performance measurement, labelling, monitoring and control, and a possible connection with energy auditing for the Energy Efficiency Directive (EED – 2012/27/EU).

Figure 1: Intervals between inspection of heating systems.

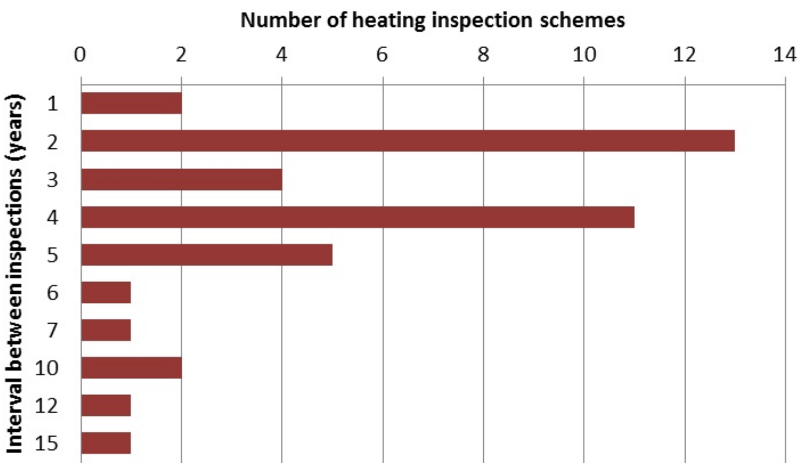
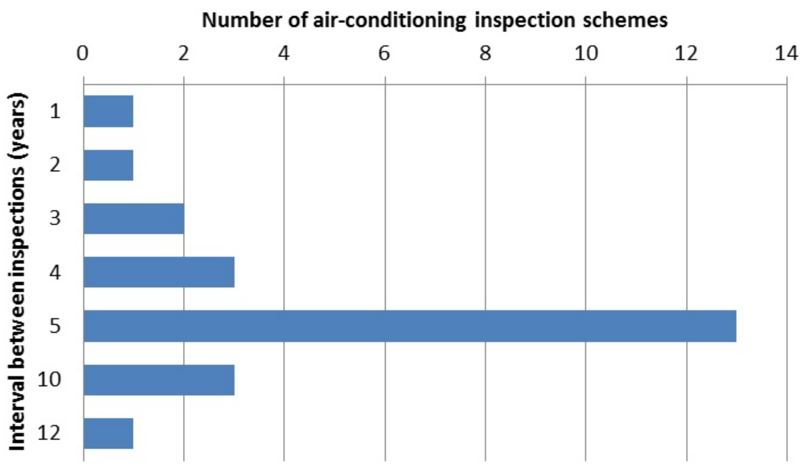


Figure 2: Intervals between inspection of air-conditioning systems.



3. Analysis of insights

3.1 Understanding the options

3.1.1 Scope and frequency of inspection

Regular inspection stands apart from other requirements of the EPBD, and many options are allowed. Schemes can be designed with different intervals between inspection for the various types of heating and cooling plant, their rated output, and the fuel used. Other factors that can be taken into consideration are the likely costs and benefits of inspecting each type, and whether or not an electronic monitoring and control system has been installed.

A comparison between MSs shows that they have made widely different choices, as permitted by the Directive. Their choices reflect variations in national conditions, customs, and practices, as well as ideas about relative costs and benefits. The overall cost of inspection is strongly affected by the frequency and intensity of inspection. No formal cost-benefit studies of inspection schemes in operation are required by the Directive, and enquiries made by the CA EPBD have not found any. Although inspection can be lightened or reduced when electronic monitoring and control is installed, so far only one MS is intending to take advantage of this option.

3.1.2 The meaning of "regular"

The interpretation of "regular inspection" has been clarified by the Commission services, saying that it should occur at least twice within the typical lifetime of the system. As the typical average lifetime of modern boilers is around 15 years, a reasonable maximum interval between inspections of heating systems (where not already fixed by the Directive) would, in that case, be 7 years. In practice, all MSs with inspection schemes have different inspection intervals depending on plant type and size. These are shown in Figures 1 and 2 (for MSs that adopted inspections rather than alternative measures). It can be seen that there is a wide variation for heating systems to allow for different fuels and boilers sizes, whereas for AC the most common inspection interval is 5 years.

3.1.3 Synergy with energy auditing

Energy auditing is a requirement of the Energy Efficiency Directive (EED). It applies to the buildings of large enterprises (businesses), but also has to be available as an option to smaller enterprises and the residential sector. As both inspection and audit involve visits to site by an independent qualified expert, there is an interest in the extent to which the two Directives overlap. There is also the building certification requirement of the EPBD, making a third activity in which a qualified expert has to visit a building.

Taken together, there may be opportunities to combine these activities within a single operating scheme. In four MSs, the regulations are shared, while still distinguishing the technical activities. Following the procedures and producing the reports for energy auditing and regular inspection are separate specialised activities, but some of the necessary skills and some of the data may be the same. Sharing of organisational arrangements (the Code of Conduct, for example) is likely to be feasible. This is a relatively new area for investigation, and has only been examined by the national representatives in the CA EPBD in late 2014 / early 2015.

3.1.4 Alternatives to inspection

Alternatives to inspection (known as “alternative measures”) are chosen by MSs who consider that physical inspection is too expensive relative to the likely benefits, or is unworkable for other reasons. They are more common in MSs that did not already have an established compulsory maintenance regime and workforce (such as regular boiler safety inspections, or the chimney sweeps). Figure 3 shows which MSs have chosen alternative measures.

Reasons for their choices are given in individual country reports. They include high cost relative to benefits, the small number of individual boilers compared with district heating, and that regulations already ensure high standards beyond which there is little scope for improvement. Other factors influencing the decision are that inspection is intrusive and unpopular, has doubtful benefits as there is no obligation to follow the recommendations in the inspection report, and the risk that it becomes simply a ‘compliance exercise’ with little value.

Figure 3: Implementation of inspection or alternative measures.

It is notable that all the MSs who have an inspection regime for heating systems have also chosen to inspect AC systems. Speculative reasons are that some MSs have a greater ‘propensity to inspect’ than others, and that there is a stronger case for alternative measures for heating than AC because there are large numbers of small heating installations in residential premises.

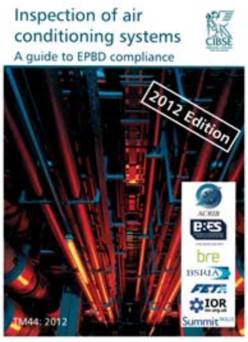
The selection of alternative measures carries the obligation to produce a report every 3 years demonstrating that the impact is equivalent to what would have been achieved if a regular inspection scheme had been operating instead. The report is often described as the “equivalence report”.

There is no restriction on what can be chosen as alternative measures, other than that they must deliver reductions in energy usage by heating and AC systems, and they must not be double counted with measures introduced to comply with other parts of the EPBD or with other Directives (e.g., the obligations set on the energy suppliers by the EED).

Member States can make many different choices when deciding how to implement regular inspections under the Directive, and have taken advantage of this flexibility.

Thirteen (13) have chosen alternative measures in place of inspection of heating systems. Seven (7) have chosen alternatives to air-conditioning inspection, this being a new option available since transposition of Directive 2010/31/EU in 2013.

Figure 4: A guide on inspection procedure (TM44).



3.2 Inspection methods and their impact

3.2.1 Standards

Two CEN standards were written for inspection of heating[1] and inspection of air-conditioning[2] systems to meet the requirements of Directive 2002/91/EC. They are being re-written to match the changes in Directive 2010/31/EU and revised versions have been produced for public consultation in summer and autumn 2015.

Earlier CA EPBD work has indicated that 87% of MSs do not use the CEN standards or only use them selectively, extracting parts rather than citing the whole document. Interpretation into practical guidance at a working level is necessary, such as the CIBSE Technical Memorandum[3] which preceded EN 15240 and influenced its development. At working level, it is necessary for each step of a robust overall procedure to be defined, explaining what has to be done, what has to be recorded, and how to deal with difficult and exceptional circumstances.

MSs have requested that revised CEN standards are made more straightforward and procedural, focusing on the simpler options, so that they can be referenced in legislation without the need to produce accompanying guidance and interpretation.

3.2.2 Review of schemes

After 6 years of experience, at least 5 inspection schemes have been reviewed. Changes were needed partly to meet the new requirements of Directive 2010/31/EU, partly to improve the way schemes worked, and partly as a result of other alterations to the structure or scope of national regulations. Difficulties to be overcome included collection of data, how to deal with incomplete inspections, rules for distinguishing between “simple” and “complex” systems, and how reports could be made more suitable for non-expert building owners. The lack of data about installed equipment and the amount of time required to collect it is a widespread difficulty, especially for complex systems. This indicates that better methods of information management are needed.

3.2.3 Assessment of efficiency and capacity

Inspection requires examination of all accessible parts of the system, which is relatively straightforward though some defects will not be visible. The more difficult aspects of inspection are reporting on system efficiency and capacity relative to the demand of the building. These call for a level of

[1] *EN15378: Heating systems in buildings — Inspection of boilers and heating systems*

[2] *EN15240: Ventilation for Buildings – Energy Performance of Buildings – Guidance for inspection of air-conditioning systems*

[3] *CIBSE Technical Memorandum TM44: Inspection of air conditioning systems*
www.cibse.org/Knowledge/CIBSE-TM-%281%29/TM44-Inspection-of-Air-Conditioning-Systems

engineering knowledge beyond that normally held by maintenance technicians. Yet it is unnecessary to estimate efficiency and capacity with great precision, as a heating or cooling system has to be very inefficient or very severely mis-matched to the building before a recommendation to replace it becomes cost-effective. The conclusion is that simple methods would be sufficient, without extensive calculations, and they could be based on available information such as manufacturers' test results, data from EPCs, and tables of building characteristics based on a simple classification system. Frequently the methods are not prescribed by regulation, being left to the decision of the inspectors. Although, in theory, the heat demand of the building might be obtainable from an Energy Performance Certificate (EPC), none of the MSs has said that EPCs may be used as input to the assessment of suitable capacity.

3.2.4 Advice following inspection

The essential purpose of inspection is to recommend improvements to energy performance that are cost-effective, but deciding what is cost-effective is not straightforward. Many inspection reports tend to be over-complicated and poorly suited to the needs of non-expert building owners; this means they are at greater risk of being ignored. Advice on building improvements is already being given in EPCs, where much more attention has been paid to making reports 'user-friendly' (more readily understood), though the opinion of MSs is that the information produced for EPCs is not sufficiently detailed for heating and AC systems.

For heating systems, the IEE project MOVIDA[4] (completed in 2013) studied the prospect of generating advice systematically, with computer assistance. The project developed an inspection software tool, in an attempt to rationalise, and partly automate, advice given in inspection reports. Practical difficulties prevented its widespread adoption; the reasons were legal or organisational barriers, and a lack of commercial incentives. However, MOVIDA reports were liked by customers and the tool remains available for national adaptation, with the potential to improve consistency of advice.

Inspection schemes have been running since 2009 and, in at least 5 cases, reviewed.

Missing information is the biggest impediment to speedy inspection.

Inspection reports tend to be overcrowded with technical detail, rather than focusing on important messages for non-technical building owners.

Little has been done so far to evaluate the wider impact and cost-effectiveness.

3.3 Alternative measures with equivalent impact

3.3.1 Allowable alternatives

Alternative measures always include advice in some form, though not specific to each installation. In addition they comprise publicity and promotional campaigns, grants and financial incentives, tax relief, voluntary inspection and voluntary agreements, compulsory maintenance, regulations to replace old and inefficient components, and energy company obligations in excess of those needed to meet EED targets.

There is no uniformity in approach to advice or other alternative measures, as the EPBD does not require it. Nor is there any consistency in the impact assessments and preparation of what have come to be called the "equivalence reports". There are a number of questions about alternative measures without conclusive answers, such as:

> What type of advice can be considered to fulfil obligations under the EPBD? For example, must it be limited to advice about the systems themselves, or can it be expanded to changes to the building that would reduce demand?
> How is the impact of advice to be measured, and over what periods?
> What data is required to do so?
> What would have been the impact of inspection if that had been carried out instead?

The first two equivalence reports under Directive 2010/31/EU were due in June 2011 and June 2014 and, for heating systems at least, the reports are starting

[4] *MOVIDA ("MOVing from Inspection to Domestic Advice by service companies") – www.movida-project.eu*

to deal with these questions more specifically. For AC systems no experience has yet been built up by MSs. Directive 2010/31/EU, unlike 2002/91/EC, includes forecasting for a period ahead in addition to reporting the preceding period.

3.3.2 Demonstration of equivalent impact

The equivalence reports sent by MSs to the EC in 2011 were unsatisfactory in many respects and unacceptable to the EC, leading to demands for further information within the 9 month additional limit allowed by the EPBD. Expectations on reporting were clarified in letters sent to MSs in August 2012, in which the EC set out the information needed to demonstrate equivalent impact. Requested information includes a description of the alternative measures, a description of a hypothetical inspection scheme which they replace, a statement of the methodology used together with its sensitivity to critical assumptions, and results from the assessment of each scenario expressed in units of energy.

The principal components of the impact assessment are shown in Figure 5. As there is no inspection regime in a country that has chosen alternative measures, comparison with what an inspection scheme would have achieved can only be speculative. Comparison with other countries that do operate an inspection regime may have some limited validity, but the EPBD does not require the impact of an inspection regime to be evaluated and MSs have not done so. Consequently there is no body of data (albeit in other countries) with which comparison can be drawn.

Figure 5: Components of the impact assessment study.

Scenarios	no intervention
	inspection
	alternative measures
Data	building stock model
	boiler system or air-conditioning system stock model
	energy usage by these systems
Assumptions	improvements that might be recommended
	the energy-saving value of each type of improvement, and its duration
	how many of each type were recommended, and how many were carried out

3.3.3 A reporting framework

The CA EPBD has done a lot of work exploring what is relevant and necessary in an equivalence report for heating systems, and how data for it should be gathered and analysed. A working group has produced a reporting framework, intended to encourage greater uniformity by using a structured approach. The framework describes two principal methods, known as 'top-down' and 'bottom-up' (Figures 6 and 7). They formalise what has already been done in some countries. The choice of which to use depends mainly on the type of data available: 'bottom up' is more suitable where there is a reasonable set of data on buildings and heating or AC systems, whilst 'top down' can be used where only national energy usage data is available.

Outline requirements for the information needed to demonstrate equivalent impact have been provided by the EC, and the CA EPBD developed a reporting framework and a public report on comparing alternative measures with inspection.

So far, experience is available only in regard to equivalence reports for heating systems. More experience needs to be accumulated from MSs for equivalence reports for air-conditioning systems.

3.4 Electronic monitoring and control systems

Automatic building monitoring and control is recognised by the EPBD and can be used to develop benchmarks and reduce inspection frequency. European projects show that it has the potential to find energy saving opportunities more cheaply and effectively than regular inspection alone. But MSs have not yet decided what technical characteristics of monitoring systems are essential, and how regulations should allow monitoring to be combined with inspection effectively.

3.4.1 Experience with monitoring

Physical inspection is necessary to assess the age and condition of equipment, and its suitability for purpose. Monitoring can show whether systems are using energy in line with the expected demand from a building of comparable type, size and occupancy. It also reveals demand patterns, and alterations in performance consequent to changes such as maintenance, operation, replacement of components, or adjustment to control settings.

Figure 6: Framework for top-down analysis.

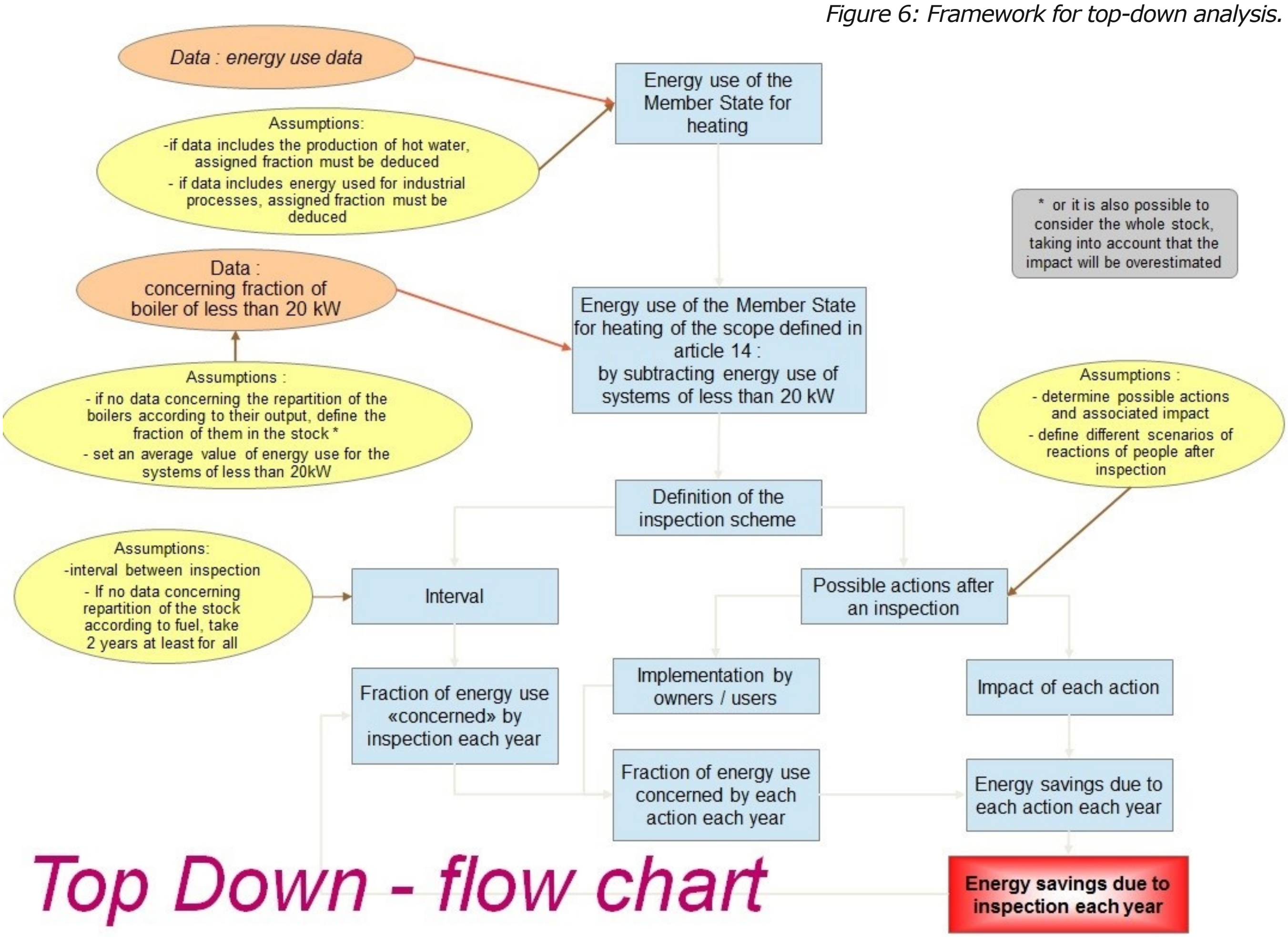
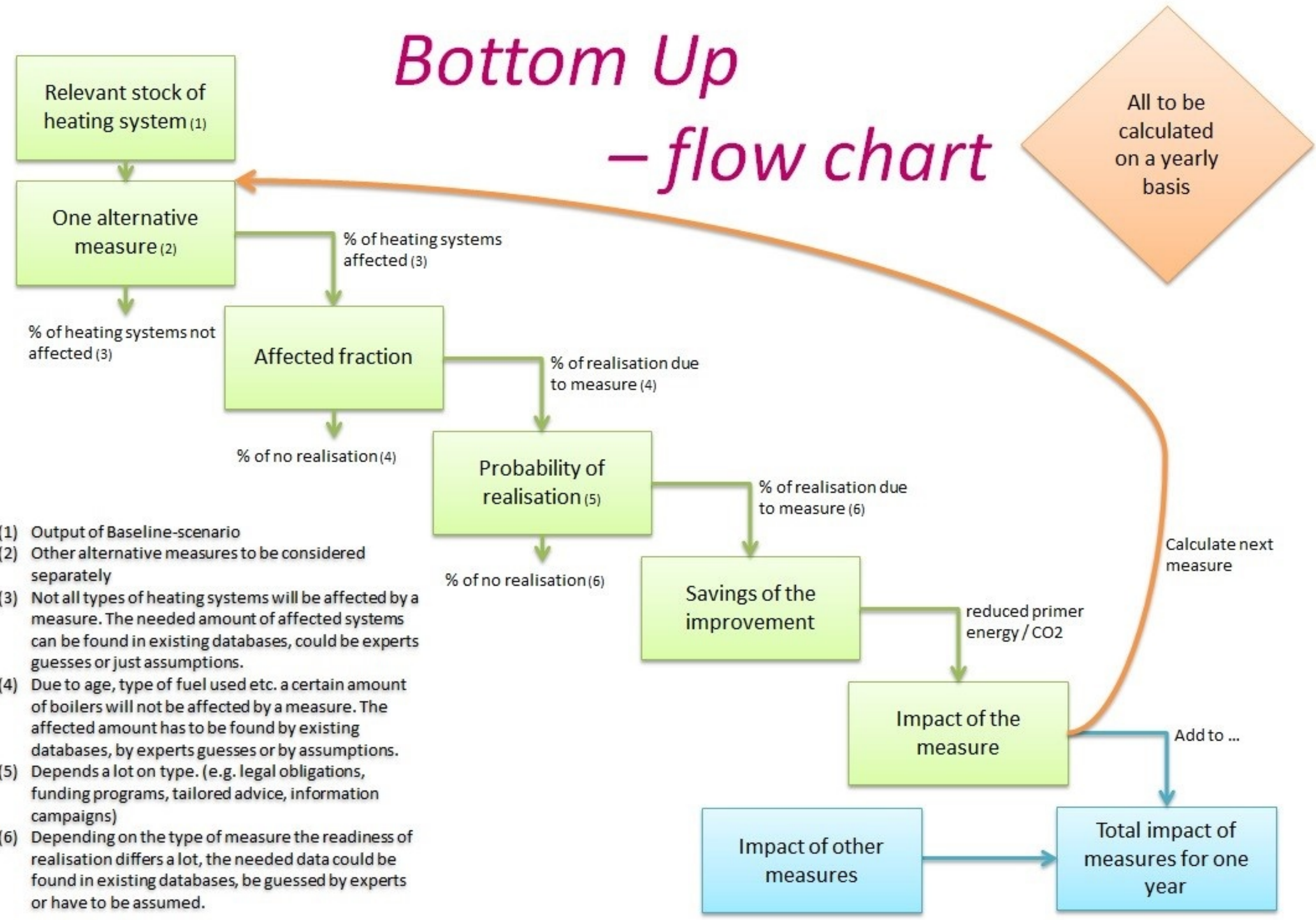


Figure 7: Framework for bottom-up analysis.



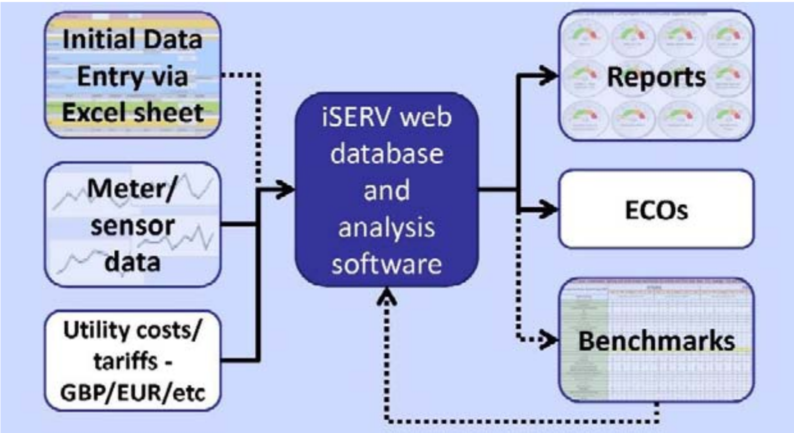
(1) Output of Baseline-scenario
(2) Other alternative measures to be considered separately
(3) Not all types of heating systems will be affected by a measure. The needed amount of affected systems can be found in existing databases, could be experts guesses or just assumptions.
(4) Due to age, type of fuel used etc. a certain amount of boilers will not be affected by a measure. The affected amount has to be found by existing databases, by experts guesses or by assumptions.
(5) Depends a lot on type. (e.g. legal obligations, funding programs, tailored advice, information campaigns)
(6) Depending on the type of measure the readiness of realisation differs a lot, the needed data could be found in existing databases, be guessed by experts or have to be assumed.

The CA EPBD participants have explored the capabilities and potential for electronic monitoring and control of heating and AC systems, and in particular how allowance might be made for it in regulations. The European HARMONAC[5] project (completed in 2010) had found that the average energy savings potential for individual AC systems was 35-40% of their measured consumption and indicated that monitoring was more likely to be cost-effective than universal inspection. A later European project, iSERV[6] (completed in 2014), was designed to look at the prospects for automatic monitoring of buildings on a larger scale. The iSERV project acquired data from 733 systems in 16 countries.

These projects concluded that automatic monitoring schemes should offer continuous feedback on performance over long periods, and that monitoring revealed many installations had much greater potential for savings than the inspections had suggested. Monitoring identifies "energy conservation opportunities" (ECOs) and produces national benchmarks, as illustrated by the general concept (Figure 8). The combination of inspections and monitoring helps to find measures that an inspection on its own would not be able to identify. However, some measures become ineffective after a while (filter changes, control adjustments, etc.) and continuous monitoring can show when they need to be repeated. MSs will have to decide what characteristics are required of an acceptable monitoring scheme so that it can be recognised as a partial substitute for inspection.

One MS is following these recommendations (see 3.4.2).

Figure 8: Monitoring to find 'energy conservation opportunities' (ECOs) and develop benchmarks.



Economies of scale may be achievable through cooperation between MSs. An example is sharing the evidence of the impact of building-related measures carried out for the EED.

Furthermore, there are two areas in which the EED and EPBD call for similar activities (although there are important differences in scope and results). The first is energy auditing and regular inspection, as discussed in 3.1.3. The second is smart metering and billing for the EED, and intelligent metering and active control of TBS for the EPBD, as discussed in 3.5.3. In these areas there would be advantages in developing the same methods and working practices for both the EED and EPBD.

3.4.2 Monitoring to facilitate or replace inspection

In the context of regulations for the EPBD, a way of handling cases of apparently bad performance would need to be developed and legally supported. Regulations would have to be framed so that inspection is required of those installations provisionally identified as inefficient by the monitoring scheme. Selection of badly performing installations should be by specified objective criteria, but may still require expert engineering judgment. Difficulties arise not so much at technical level (e.g., availability of monitoring equipment, transmission of data) but on defining the concepts (e.g., what is a monitored building, how does the level of performance change the defined frequency of inspections) and how to frame this in legislation.

In short, MSs did not feel confident on putting these ideas into law. At present, only one MS is preparing regulations that will recognise monitoring as a partial substitute for inspection. Nevertheless, doing so more widely would allow inspection requirements to be relaxed, creating a financial incentive to join an approved monitoring scheme. Presentation of the case for building this option into national legislation requires convincing evidence and further thought, and the CA EPBD has produced a report[7] suggesting how to approach this. Even if not feasible at present, it is important that national legislation does not block the opportunity for automatic monitoring in future.

[5] *HARMONAC – Energy Consumption in European Air Conditioning Systems and the Air Conditioning System Inspection Process www.harmonac.info*

[6] *iSERV – Inspection of HVAC Systems through continuous monitoring and benchmarking www.iservcmb.info*

[7] *Concerted Action EPBD Report www.epbd-ca.eu/outcomes/Report_Automatic_Monitoring.pdf*

3.4.3 Building management systems as contributors to monitoring

More recently there has been interest in building management systems (BMS) as another means of continuously collecting data about system performance. European Standard EN15232:2012 was created to establish conventions and methods for estimating the impact of building automation and control systems on energy performance and energy use in buildings. A building control assessment scheme implementing EN15232:2012 and a rating label (Figure 9) has been developed by the trade association (eu.bac) to facilitate this. The assessment scheme and label are concerned with control capability rather than measured energy performance of systems and buildings, but they may have a role to play in determining how relevant data can be captured and transmitted to automatic monitoring schemes for continuing long-term analysis.

Before BMS can be used in the wider concept of schemes for automatic monitoring and analysis by a central service, further work has to be done to agree on standard data formats and transmission protocols. Such developments could be pursued at EU level as technical projects or in standards committees. No MS has yet implemented any measure including BMS in relation to inspection requirements.

Intelligent Energy Europe (IEE) projects show that electronic monitoring and control has the potential to find energy saving opportunities more cheaply and effectively than regular inspection alone.

A large number of buildings can be monitored continuously, with reports generated automatically when certain conditions are detected.

MSs have yet to decide what technical characteristics of monitoring systems are essential, and how regulations should allow monitoring to be effectively combined with inspection. This could be facilitated by work at EU level.

The increasingly wide use of BMS may be the key to further progress, though standard data formats and transmission protocols will have to be agreed to ensure interoperability between devices and equipment from different manufacturers and the networks infrastructure.

Figure 9: eu.bac label for building automation and controls.

3.5 Technical Building Systems (TBS)

3.5.1 System performance

The EPBD defines 'Technical Building Systems' and the need to regulate them when they are newly installed, replaced or upgraded, in existing buildings. In new buildings, regulation is optional. Confusion has arisen about the interpretation of "existing buildings", which is sometimes taken to mean only buildings that are undergoing renovation. The EPBD makes clear that regulations are needed for all TBS installations, whether or not the building is undergoing renovation.

The EPBD requires that the regulations cover energy performance, proper installation, dimensioning, adjustment, and control. TBS must be considered at the system level, which is distinct from whole building performance (as measured for EPCs) and individual product performance, as measured for minimum standards and energy labelling under other Directives, e.g., the Ecodesign Directive (Directive 2009/125/EC).

Analysis of systems needs building data, as the service demand from the building affects dimensioning and performance. Calculations are usually required.

Designers and installers need established procedures to follow, which are technology dependent; e.g., there should be separate methods for boilers, warm air units, heat pumps, and other types of heating systems.

Some MSs have now developed practical methods for this purpose. In 5 MSs, calculations are needed to ensure the installation will meet a minimum standard of energy performance. Methods are not necessarily the same as for new buildings, as comprehensive data is not likely to be available, but in 3 cases MSs expect the same calculations to be performed. Calculations may hamper rapid replacement in circumstances where building data is not available and restoration of the service (especially heating) is urgent, although it has been reported that this does not cause serious problems and very few requests for exemption are received.

All MSs who have responded to surveys have some regulations in place for TBS, and at least 13 set minimum standards for energy performance of TBS. However, coverage of all the technologies, including installation, dimensioning, adjustment, and control, is a significant challenge. There is more work to be done, especially for combinations of systems (explicitly mentioned in the EPBD). Common examples are integrated systems for heating and hot water, and for heating and cooling. Comprehensive coverage, and comparability between MSs, are subjects that remain to be explored.

3.5.2 TBS in new buildings

Regulations for TBS are not obligatory in new buildings. Nevertheless, at least 18 MSs apply TBS regulations to new as well as existing buildings, and in 12 cases the same regulations apply to both. The position is summarised in the Table of Key Implementation Decisions[8]. The Table shows that 13 MSs have minimum performance requirements of some kind in new buildings for heating, 10 for hot water, 6 for AC, and 6 for large ventilation systems. Such requirements may apply to generation, distribution, thermal emission, control, specific fan power, and heat recovery.

3.5.3 Intelligent metering of TBS

Each of the EPBD, the Electricity Directive (2009/72/EC) and the Energy Efficiency Directive (2012/27/EU) have requirements for intelligent metering systems or smart meters. They can be summarised as:

- EPBD: Article 8(2) - encouragement to install intelligent metering systems whenever a building is constructed or undergoes major renovation. This must be in line with Annex 1(2) of the Electricity Directive (intended to assist the active participation of consumers in the electricity supply market), and the further encouragement where appropriate to install active control systems for TBS such as automation, control and monitoring systems (intended to save energy).
- Electricity Directive: Article 3(11) - introduction of intelligent metering intended to optimise the use of electricity; also Annex 1(2) - intelligent metering intended to assist the active participation of consumers in the electricity supply market.
- Energy Efficiency Directive: Article 9(1) - installation of smart meters for final customer's electricity, natural gas, district heating, district cooling, and domestic hot water, intended to show actual energy consumption and actual time of use.

There is some scope for integration of all these at the technical level for interoperability, data collection, and transmission and display of data. In the context of a proper implementation of EPBD Article 8, without detriment to the requirements of the other Directives, intelligent metering could apply as well to individual TBS, so that their consumption can be monitored and analysed individually.

TBS are clearly defined by the EPBD and regulations must provide for their proper installation and performance in existing buildings, but MSs have given little attention to this part of the EPBD until recently.

While progress has been made, coverage is by no means complete for all the requirements with all the technologies involved.

"Existing buildings" means all such buildings, not just those undergoing major renovation. Regulations for TBS in new buildings are optional, though a significant minority of MS have applied them.

Although the purposes are different, the requirements for intelligent metering systems and smart meters in each of the EPBD, Electricity Directive and Energy Efficiency Directive can be integrated at the technical level.

[8] See www.epbd-ca.eu/countries/indicators

4. Main outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
MSs' decisions on how to implement Directive 2010/31/EU	MS choose inspections or alternative measures (and variants of both) for a variety of reasons.	Thirteen (13) MSs have chosen alternative measures for heating systems and 7 for AC systems.	Evaluation of equivalence reports for alternative measures by the EC.
Frequency of inspections	Changes to scope of inspection. New options to adjust frequency of inspection. Additional requirements for reporting to building owners.	Inspection frequency varies widely among MS.	A better understanding of the trade-off between inspection frequency and the costs/benefits for different system types.
Inspection methods	Review of schemes, which have been in operation since January 2009. Re-writing of the CEN standards for inspection. Possibility of linkage with EPCs to assess demand.	Main problems are collecting data, classifying systems, access difficulties, accuracy, and making reports intelligible to non-technical building owners. Load reduction measures should be treated with greater importance.	Data collection should become a less skilled procedure. Clear classification of system types. Examination of cost-effectiveness. Overlap with energy audit.
Synergy with energy audit	Prospect of sharing some activities with energy auditing (requirement from EED for enterprises).	The scope and intention of regular inspection and energy audit are different: however, some aspects overlap and can be shared.	Rationalisation of the various skills and organisational arrangements needed for experts to visit buildings.
Energy saving impact of inspection and the recommendations following it	Little knowledge about quality and influence of inspection reports. Use of data from inspections to develop national stock models for plant type, age and energy performance.	Impact has not been assessed. Reports are not analysed for usefulness, accuracy, or impact. Follow-up surveys and cost-benefit studies have not been carried out to inform prospective changes.	A standard data structure for reports to permit central storage and analysis. Reporting re-designed to address non-technical building owners. Links to recommendations in EPCs.
Equivalence reports: advice instead of inspection for heating and cooling systems	Information from EC on what is expected. Comparison with hypothetical inspection schemes. Data requirements.	A reporting framework has been developed. A hypothetical inspection scheme has to be defined for comparison.	Better understanding of methodology to produce quantified results. Reports now require forecasting as well as retrospective analysis.
Automatic monitoring and control systems as a means of reducing inspection frequency	Monitoring as an option recognised by the EPBD. Justification for reduced frequency of inspection of monitored systems.	Monitoring not yet implemented by any MS; there is low awareness of its potential. Concerns remain about privacy, security, safety and cost-effectiveness.	Study costs and benefits of automatic monitoring and how to apply it in a regulatory context. Incentives to create monitoring schemes.
Prospects for monitoring (collecting and analysing energy data) of HVAC systems in many buildings across Europe	Comparison with physical inspection. Success at finding energy saving opportunities more cheaply. Production of benchmarks for performance comparison.	Monitoring is more useful for larger buildings, usually with AC but also other TBS. Regulations should allow for future monitoring, even if not ready and proven at present.	Define the qualities required of an 'approved' scheme, inspection being necessary only when poor performance is found. Extend passive monitoring to active control, and link with BMS.
TBS with pre- and post-installation requirements	Experience that lies in areas other than the EPBD (e.g., building codes). Slow progress by MSs in catching up with these EPBD requirements.	A system approach is needed. Calculations using building data are necessary, and may be difficult for installers.	Synergy with product regulations under Ecodesign, which now look more widely at system performance.
TBS in existing buildings	Scope of the regulations: are they wide enough?	Regulations must apply to all new and replacement TBS installations.	Focus must shift towards system installation procedures, rather than requirements on major renovation.

5. Lessons learned and recommendations

The range of permissible implementation options for inspections needs careful thought as the decisions made have a large influence on the cost of an inspection scheme. Member States (MS) of the EU have already made their decisions for transposition and are not likely to change them until the Energy Performance of Buildings Directive (EPBD) is next reviewed, but aspiring members (in the Energy Community[9]) are actively considering all options.

The EC has clarified their understanding of the meaning of “regular” inspection, and has emphasised the revised scope of inspection under the Directive 2010/31/EU. Inspection schemes should be checked to ensure they now include all “accessible parts” and, in the case of heating systems, include boilers using any fuel.

Despite the success of EU projects on automatic monitoring, no MS has yet included an allowance for monitoring within inspection regulations – although the EPBD specifically allows for it. Doing so would help to create an incentive for building owners, and a consequent demand for new commercial monitoring services.

Regular inspection of heating and air-conditioning (AC) systems is similar in operation to other inspection activity, notably building certification for Energy Performance Certificates (EPCs) and energy auditing for the Energy Efficiency Directive (EED). The separate activities might be combined under one organisational structure, while keeping the inspection procedures themselves separate from one another.

The EC has also clarified what information should be provided to demonstrate that alternative measures have an equivalent impact to inspection schemes. The new reporting framework developed by the Concerted Action EPBD (CA EPBD) takes account of this, and can be used to make reporting more straightforward in the future.

Regulations for technical building systems (TBS) in existing buildings are starting to be introduced and may require design calculations. This strengthens the need for better preservation of, and access to, relevant building data (e.g., heat loss figures). Methods used are technology-dependent, and more work is needed to produce a comprehensive set of design and installation procedures for all the technologies used in existing buildings.

Training

OVERVIEW AND OUTCOMES

AUGUST 2015

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1. Introduction

Focus on the training of experts is essential in ensuring the transfer of knowledge on issues related to the Energy Performance of Buildings Directive (EPBD). Within the framework of Article 17 of Directive 2010/31/EU, Member States (MSs) must ensure that the energy performance certification of buildings and the inspection of heating and air-conditioning systems are carried out in an independent manner by qualified and/or accredited experts.

From 2013 - 2015, Concerted Action EPBD (CA EPBD) participants discussed the necessity of retraining those experts already authorised to issue Energy Performance Certificates (EPC), in order to tackle the new challenges that will come with the introduction of Nearly Zero-Energy Buildings (NZEB), and in order to assess effective approaches to training new experts. The training discussions were based on lessons learned since the beginning of the EPBD implementation, and took into account the conditions for new constructions, as well as renovation of existing buildings. In particular, the group considered the use of realistic energy saving estimations highly important during the process of preparing the recommendations for improvements to be included in the EPCs. Different areas of energy saving possibilities were considered to create a basis for co-ordinated approaches to training and accreditation of experts.

The CA EPBD also discussed the synergy between inspection (set in the EPBD) and energy audits (set in the Energy Efficiency Directive - EED), including joint training of experts/inspectors for both objectives.

This chapter addresses mainly the issue of training and qualification of experts. The same topics can also be found in other chapters in part A of this book, viewed from different perspectives.

2. Objectives

The principal objectives of the CA EPBD work were the identification of new problems and of those still remaining, connected to the activities of the experts in the process of energy performance certification and regular inspection of heating and air-conditioning systems. The group also explored possible synergies between issuing EPCs, carrying out the system inspections required by the EPBD and carrying out energy audits required by the EED.

2.1 Training requirements

A first group of objectives focused solely on the training of the experts themselves. There was a strong need to develop a wider understanding of the new requirements of the Directive 2010/31/EU related to experts in both areas of activity (EPCs and inspections). The main issues of discussion focussed on trainings based on modular education of experts, identifying the links between energy certification of buildings, inspection of technical systems and energy audits.

2.2 Training subjects

Most experts assessing buildings have been authorised in accordance with the national legislation in individual MSs, directly linked to Directive 2002/91/EC. Directive 2010/31/EU introduced different approaches to several topics, requiring a transfer of more knowledge and skills to experts. It was thus necessary to assess if there were additional training needs following the introduction of new concepts, such as NZEBs and cost-optimal levels on *minimum requirements of energy performance of buildings*, as well as the increased focus on integration of Renewable Energy Sources (RES).

Attention was also devoted to discussing the precision required for assessing the technical properties of buildings, building units and building components, as well as technical systems, *in view of the accuracy of the energy rating*.

The group also concentrated on training needs, namely on the need to retrain qualified experts, recognised on the basis of Directive 2002/91/EC, on how experts should be trained to interact with owners, on how to deal with real energy consumption and on how to produce better (more realistic) recommendations for energy efficiency investments.

3. Analysis of insights

3.1 Synergy between inspections (EPBD) and energy audits (EED), including training of experts/inspectors

The EPBD requires regular inspection of heating and air-conditioning systems (Articles 14 and 15). The EED has a requirement for energy auditing that includes reporting on heating and air-conditioning systems in buildings (Article 8). Some of the activities of an energy audit carried out for the EED are similar to those for an inspection for the EPBD, although the purpose and level of detail is different. There is, however, potential for integration or coordination. Therefore, it is necessary to analyse which procedures could be combined or shared, to meet both EPBD and EED requirements.

In most countries, regular inspections and energy audits are managed by different legislation. The inspection procedure is generally well-defined. The audit procedure, however, has not yet been exactly defined in many MSs, and its scope is much wider - it covers building structures, technical building systems and occupants' behaviour. Therefore, energy auditors could possibly prepare EPCs, but the EPC assessors cannot undertake energy audits without further training. Reporting templates for inspections and energy audits are different, reflecting their different purposes and procedures. EPCs, inspections and audits are performed at different occasions and intervals, limiting the opportunity for shared activity. Carrying them out at the same time could offer significant opportunities for reducing costs and achieving more reliable results.

There are differences in the levels of education and length of experience required for the experts carrying out inspections and audits. Energy auditing requires a wider range of professional experience than inspections alone. Energy auditors also must have broader knowledge than the experts undertaking energy performance certification. In addition, the EPC results do not contain enough details to be used for heating and air-conditioning system inspections.

The greatest area of overlap is the requirement that an energy audit draws a reliable picture of overall energy performance and identifies the most significant opportunities for improvement. This is similar to the requirement for heating and air-conditioning system inspections for the EPBD, which must include an efficiency assessment and then make recommendations for the cost-effective improvement of the energy performance of the inspected system. In this regard, EPCs may provide useful input for broader energy audits[1].

In some cases, experts that are authorised to carry out air-conditioning inspections also fulfil the preconditions to issue EPCs. Modular training of experts has some benefits, e.g., experts can be trained specifically in the particular sector they are interested in, and can expand their training as and when they wish, without having to undergo training in the areas where they are already qualified.

CA EPBD participants have identified significant potential interactions or intersections between the obligations and needs to be addressed by provisions in both the EPBD and EED regarding training, accreditation, certification and registration of experts. Experts may be needed for overall energy auditing or building assessment, or for specific assessment or inspection of particular technical systems within the buildings.

[1] *Such synergies are explored in the Commission guidance note on Article 8 of the Energy Efficiency Directive, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013SC0447&from=EN*

The quality and pace of improvement in the energy performance of buildings depends vitally on the number and quality of available experts. There are clear advantages of co-ordinated approaches, mainly to maximise synergies and avoid duplicated efforts. The institutional arrangements for developing and delivering suitable training and accreditation may often be complex and fragmented. Combining the obligations under EPBD Article 17 and EED Article 16 in particular, but also considering EPBD Article 20 and EED Articles 8, 16 and 17, MSs are required to ensure that certification and/or accreditation schemes for the qualification and training of experts are available for energy services providers, energy audits, energy managers and installers of energy-related building elements.

CA EPBD participants concluded that MSs should explore the provisions of Article 17 of the Directive 2010/31/EU with a particular focus on seeking national provisions that ensure the reliability of EPC experts and are coordinated with similar EED provisions for energy auditors. For both processes, the legal basis, methodology and the required level of education of experts/auditors are identical. The content of training should be modular for activities undertaken following the EPBD and/or the EED.

In terms of content, the main barriers are currently the lack of accredited institutions offering the required training at sufficient quality, and also a lack of individual assessors. From the process point of view, the biggest barrier is a conflict of interest, as EPC assessors are often certified by a public compulsory procedure, and energy auditors are normally part of voluntary schemes, so a dialogue is almost impossible. The most important key challenges were that EED auditors can use the EPC as part of the auditing process, the lack of national experience with energy audits in certain areas (e.g., of industrial projects) and, last but not least, the costs of the EPC, inspection or audit, and the consequences that could result from a situation in which the owner is not willing to implement the EPC recommendations.

Regular inspections and energy audits have been kept separate in almost every MS, at least at the regulatory and technical levels. Qualifications of experts carrying out inspections and audits overlap to some extent. There are opportunities for greater cooperation in programme operation, accreditation, codes of conduct, quality assurance, databases and publicity.

Training should be modular since the EPBD only covers one part of the broader boundaries of the EED.

Training programmes should have the same basis but should differ in details.

Energy auditors could possibly create EPCs, but the EPC assessors cannot perform energy audits. It should be possible, however, to have the same person (with adequate qualifications and training) accredited for both EPBD and EED.

3.2 Does Directive 2010/31/EU require retraining the experts?

The question if there is a need for re-training experts arose from the new approaches in the Directive 2010/31/EU, especially those focussing on training related to progress in establishing NZEBs and to updated calculation procedures, and the new control procedures for Energy Performance Certificates (EPC). There are particular issues which may possibly impact the updated calculation procedures and may result in the need for re-training. For example, cost-optimal and NZEB calculations can result in new and more strict requirements in MSs, which in turn can lead to more precise or more detailed methods for calculating the energy requirements, or at least some additional parts of the calculations to deal with solutions involving advanced and innovative technologies.

The analysis and discussion focused on whether the EPBD would require changes in the national training process for EPC issuers or inspectors (where applicable) and on clarifying the actual need for re-training experts who had already qualified according to Directive 2002/91/EC. Twenty-five countries indicated the need for additional training. Nine MSs consider starting with additional training a priority. In most of the MSs, legislation was amended (see Figure 1) and this led to an increase in the number of experts in one third of MSs. Most attention was given to dealing with NZEBs, integration of Renewable Energy Sources (RES) and calculation of alternative Heating Ventilation and Air-Conditioning (HVAC) systems. Cost-effective calculation for different refurbishment options was also an important aspect.

Most countries agree that training for on-site inspections is required. In order to be

Figure 1: Type of legislation used by MSs to establish training of experts.

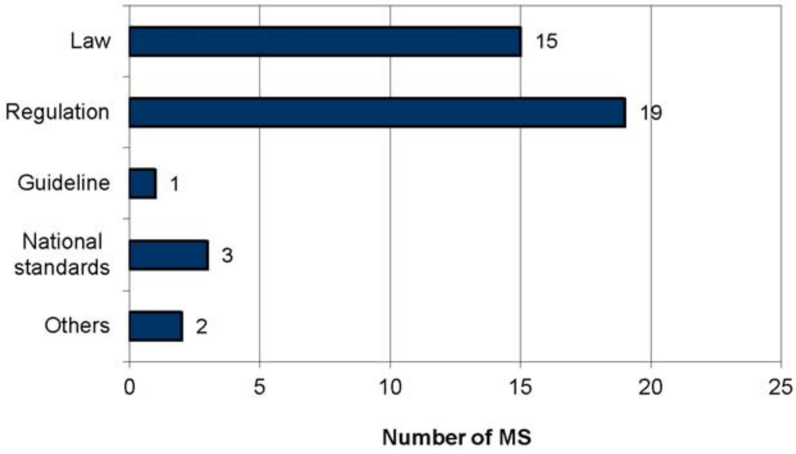
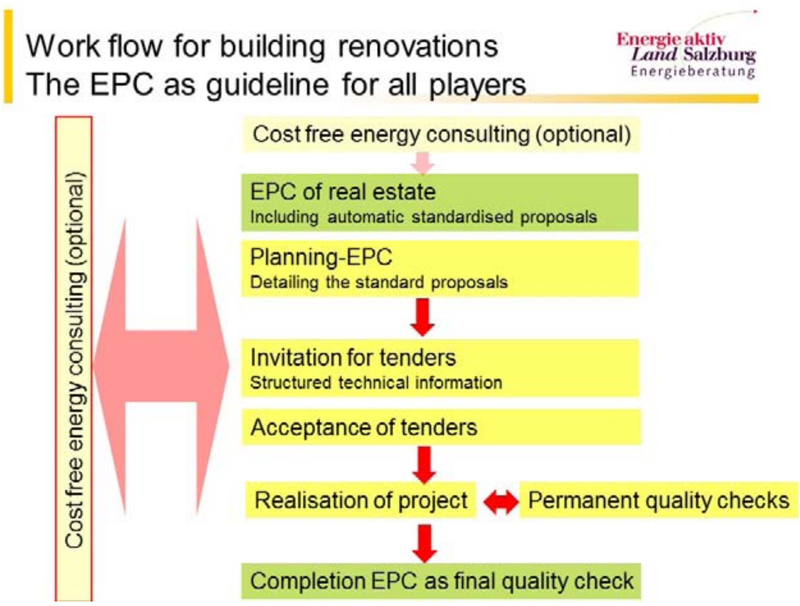


Figure 2: The EPC as final quality check during building renovations, using the "Gecko" EPC tool.



able to properly quantify the heating and cooling needs and to assess the correct sizing of the systems, the experts should have access both to the building and its technical systems during inspections. They need on-site training to be able to correctly identify the main characteristics of the systems (Figure 2).

On the other hand, MSs concluded that a special training on EPCs for NZEB was not necessary (i.e., specific training for producing EPCs or NZEB). Instead, awareness-raising and education for all professionals in the sector is the main policy and measure to support NZEBs in twelve MS (as opposed to training only for already registered experts).

Two examples of MS NZEB plans referring to training and education of experts are described next:

- Cyprus: Examination of the current Vocational Education and Training System for technical occupations concluded that continuous review and upgrading of the existing programmes is an absolute necessity, as is the addition of new, targeted programmes on emerging critical technologies, the training of instructors to renew and enrich their knowledge, and the provision of incentives and measures to increase the flow of Cypriot young people into technical occupations.
- Germany: Finding a well-qualified expert is one of the first steps in a high-quality, energy-efficient refurbishment, or when constructing a new building. The national list of energy efficiency experts for the support programmes of the Federal Government in the field of energy efficiency aims to improve the quality of local energy consulting services by means of uniform qualification criteria, proof of regular advanced training and random checks of the results.

Directive 2010/31/EU does not require significant re-training of experts in MSs, however twenty-five countries indicated the need for additional training.

The experts need to know more about the details of technical problems, how to integrate RES into existing buildings, advanced technologies and new materials.

Training for on-site inspections is required. The experts should be able to access both the building and its technical systems.

3.3. How to produce recommendations based on realistic energy savings in EPCs

As most MSs use fixed or other kinds of default values as inputs for energy performance calculations of existing buildings, it is expected that the calculated energy performance will differ from the measured energy consumption. EPCs are to be used as a means of comparison between buildings or building units, and not as a replacement for precise audits that produce more realistic estimates of energy consumption.

This topic was inspired by the revision of the calculation methodologies for certification that many MSs have been implementing. The discussion focussed especially on the following issues:

> the effect of user behaviour on actual energy performance and the distinction between the real energy consumption and the calculated energy use;
> realistic correction factors to be applied in the monthly method to provide results comparable to those achieved by hourly calculation;
> the increased importance of more precise calculation methodologies to handle the (supposed) increasing number of high performance buildings.

National studies showed that the actual operating hours, actual internal temperature, occupants' behaviour and control strategy have the highest impact on energy performance and/or energy class.

As a consequence, the calculated energy savings from the energy upgrades recommended in the EPC will also deviate from the actual achieved energy savings. Adjusting input boundary conditions to the actual values, will often result in realistic (comparable with measured energy consumption) calculated energy demands. This even happens with simple, quasi-stationary calculation tools using monthly average values.

In existing buildings, the focus should be on further developing default values to come closer to realistic energy consumption calculations. Regarding the default values, U-values are critical, as well as indoor climate conditions and the outdoor climate. EPC recommendations thus need to be carefully considered. However, most MSs have decided to use standard or default values for EPCs or calculation of energy performance. Figure 3 gives some indications of this. For the MSs that use this strategy, training for experts on how to use these values in the calculations is very important (see 3.4).

The technical background of experts needs to be well adjusted to the needs of issuing EPCs, and their training needs to be designed to match the precise needs for energy certification.

Use of building-specific data could be helpful. Experts should be trained to select appropriate boundary conditions.

Time (cost) needed to collect relevant data must be considered.

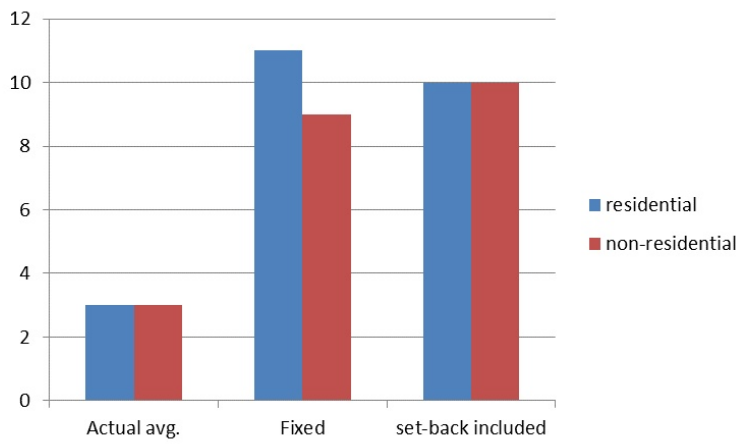
3.4. Training experts on how to take into account real energy consumption in EPC recommendations

Producing good recommendations for energy saving measures for existing buildings is an essential task for the expert when preparing an EPC. The EPBD requires the inclusion of cost-effective recommendations for improvement of the energy performance of a building (or building unit) in the EPCs (Article 11). These recommendations should thus be based on realistic energy savings that can be achieved following their implementation.

The energy performance of buildings is determined by building properties such as U-values, thermal bridges, leakages, solar heat gains, and efficiency of the heating/cooling systems. In addition, the actual energy consumption is influenced by user behaviour. If recommendations for energy efficiency investments are only based on the assessment of the technical building performance based on standard use patterns, energy cost reduction potential might not be realistic. Experience shows that occupants living in very inefficient buildings often do not heat all the rooms in the building/flat, or do so only part of the time, and therefore the actual energy consumption is less than that calculated based on the technical building data (prebound effect). Energy consumption is lower, but hygienic problems might occur.

The EPC has to avoid any influence from occupant behaviour, as it must serve as a neutral tool supporting the market choice of a new owner or renter. However, EPCs should show a realistic impact based on energy improvement recommendations depending on the actual use of the building. Experts must be trained to provide suitable recommendations.

Figure 3: Use of actual average or fixed values in the energy performance calculation in MSs (from a sample of MSs in 2014).



4. Main outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Does the EPBD require the retraining of qualified experts?	The amended national legislation, NZEB requirements and integration of RES and innovative technologies may result in the need for additional training for qualified experts.	In most MSs, retraining is voluntary, but there are retraining opportunities in most MSs.	MSs should consider establishing a mandatory continuous training programme, with regular training necessary to keep the qualified expert accreditation.
Training experts on how to take into account real energy consumption in EPC recommendations and estimate realistic energy savings in EPCs.	In most MSs, the EPC excludes any influence of the occupant behaviour and schemes often use fixed default values as input for energy performance calculations.	The recommendations in EPCs should not create false expectations for building owners and tenants.	Methods of calculation of recommendations should produce more realistic projections of energy savings, unlike the model to calculate the EPC energy indicator.
Training of experts and inspectors to take advantage of the synergies between inspections (EPBD) and energy audits (EED).	Both Directives require recommendations for cost-effective improvements and involve buildings and technical systems. Part of the work for inspections and for producing EPCs is also necessary in energy audits.	Energy auditors could possibly produce EPCs, but the EPC assessors may not be able to carry out energy audits. A clear definition of curriculum and required expertise for each activity is needed.	MSs should develop and offer modular education schemes to train experts that can perform EPBD and EED assessments, leading to substantial cost reduction for building owners.

5. Lessons learned and recommendations

Most of the experts assessing buildings in Europe receive authorisation in accordance with national legislation in the individual Member State (MS); this was directly linked with Directive 2002/91/EC in 2002. Directive 2010/31/EU introduced a slightly different approach on several topics, e.g., the introduction of NZEB, RES and cost effectiveness calculations. MSs should require a continuous professional training programme to help qualified experts to remain up-to-date and thus allow them to retain their license, in addition to any voluntary training that MSs now offer.

The topics in which changes in training are necessary are to address new requirements on energy performance, changes in EPC content, new calculation procedures, introduction of NZEB and increased influence of RES and advanced innovative systems, as well as recommendations that may be closer to reality and not lead to false expectations.

Modular training focused on application is also needed. This programme should include specific trainings to cover the needs of experts based on problems identified through quality assurance programmes. Ideally, synergies with training of EPC experts, inspectors of heating and air-conditioning systems, as well as energy auditors for the EED should be identified and implemented at the MS level.

Energy performance requirements using

Cost-optimal levels

OVERVIEW AND OUTCOMES

AUGUST 2015

1. Introduction

The Energy Performance of Buildings Directive, (EPBD, Directive 2010/31/EU) and particularly Article 4.1 recital 14, obliges Member States (MSs) to "assure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels". MSs shall also "take the necessary measures to ensure that minimum energy performance requirements are set for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels".

The cost-optimal level is defined in Article 2.14 of the EPBD as "the energy performance level which leads to the lowest cost during the estimated economic lifecycle" from two different perspectives: financial (looking at the investment itself at the building level) and macro economic (looking at the costs and benefits of energy efficiency for society as a whole).

The cost-optimal levels must be calculated following specific guidelines. Article 3 and Annex I of the EPBD define the energy performance calculation methodology. Article 5 and Annex III set out how to undertake comparative analysis between the different options that results in the definition of the cost-optimal levels. Energy performance must be calculated according to a specific methodology, which must also be developed by MSs in line with the requirements set out in Annex I of the EPBD.

MSs must report on the comparison between the minimum energy performance requirements and calculated cost-optimal levels using the comparative methodology framework provided in Articles 5.2, 5.3 and 5.4 and Annex III of the EPBD.

To support MSs in calculating the cost-optimal levels, the EU published regulations for the comparative methodology framework (Commission Delegated Regulation, 244/2012) and accompanying guidelines (2012/C 115/01)[1].

This report deals with questions relating to Articles 3-8 of the EPBD, as well as Annexes I and III, i.e., it is not limited to issues related to cost-optimality, but also touches on general issues related to procedures for calculating a building's energy performance. It describes the main discussions and conclusions reached by the Concerted Action (CA) EPBD on these issues.

2. Objectives

In March 2012, the Commission published the comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements. The comparative methodology framework was established in accordance with Annex III of the EPBD and it differentiates between new and existing buildings and between different categories of buildings. Furthermore, a document guiding MSs on how to perform the cost-optimum calculations and analyses was published in April 2012.

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[1] Both documents are available at the European Commission's web site: http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

MSs have calculated their cost-optimal levels of minimum energy performance requirements using the comparative methodology framework and relevant parameters, such as climatic conditions and the practical accessibility of energy infrastructure, and compared the results of this calculation to the minimum energy performance requirements in force. If this calculation demonstrated a deviation from the requirements larger than 15%, the MS should have taken action to modify the requirements, or indicated a way to make the requirements come within a 15% deviation within a reasonable period of time.

One of the primary objectives of the CA EPBD's work during 2010-2015 has been to facilitate exchange of experiences between MSs and the EC on how to carry out calculation of MSs' cost-optimal energy performance levels. Additionally, MSs were offered the opportunity to discuss the reports required by the EC and to suggest improvements to the accompanying guidelines. Due to MS calculation of the cost-optimal levels, it was possible to create an overview of the potential impact on MS minimum energy performance requirements.

The CEN has developed a number of standards. Though these standards are not directly implemented in every national energy performance procedure, most countries use CEN-compatible approaches. The package of CEN standards relating to the EPBD are undergoing revision during 2013-2016, and new versions of the Standards are expected by 2016. MSs are following the progress of this work, and there is close collaboration between the CA EPBD and the CEN. In particular, the CA EPBD has provided the CEN with input towards preparation of the revised set of standards. A Liaison Committee was established with the objective of making MSs' needs regarding the usability of the Standards explicit, in order to contribute to the effectiveness of the standards from the MSs' perspective. The Liaison Committee acts as a liaison between the CEN and the EPB Committee (formerly Energy Demand Management Committee -EDMC, representing the MSs) during the development of the revised EPBD-CEN standards, and interacts with the European Commission and the CA EPBD to mutually benefit from the knowledge and experience available. Collaboration between MSs and the CEN is ongoing.

The introduction of Nearly Zero-Energy Buildings (NZEB) will require an increased focus on calculation procedures and on which renewable energy sources (RES) are to be included in future NZEB requirements at a national level. Methodologies for calculating NZEB energy performance and inclusion of RES in the calculations have been investigated and are also discussed in the chapter "Towards 2020: Nearly zero-energy buildings" in this book. The Commission Delegated Regulation (No. 244/2012) states that the calculation of costs for establishing NZEBs should be included as a variant in the MS calculation exercise to identify the cost-optimal levels for new and possibly also for existing buildings.

With the increased energy performance requirements of NZEBs included in future national building regulations, compliance checking of new buildings' performance becomes increasingly important. The significance of quality control in the entire building process (from design, through construction to the final building stages) is a topic that has been discussed, but will require further attention.

3. Analysis of insights

Since the publication of the EPBD Directive 2010/31/EU, MSs have performed their own national calculations of cost-optimal energy performance levels for new and existing buildings. Therefore, the focus of discussions within the CA EPBD has been on exchange of experiences regarding the calculations, the identification of reference buildings and energy saving measures, the interpretation of the rules and guidelines provided by the EC, and the implications on national energy performance requirements.

The following topics are presented in this section:

> energy performance calculation procedures;
> calculating cost-optimal energy performance levels;
> energy performance requirements for new and existing buildings.

Some of these topics were also discussed within a wider context in the CA EPBD and therefore are also addressed from different perspectives in other chapters in part A of this book.

3.1. Energy performance calculation procedures

Energy performance methodologies have mostly been dealt with before the Directive 2010/31/EU, therefore only special topics that have been discussed after 2010 are described in this section. For information about topics previously discussed, information is available online[2].

3.1.1 Handling exceptions and innovative systems

Innovative and not-commonly-known systems and materials, e.g., in preparation for constructing NZEBs, cannot always be handled directly by the national energy performance calculation tools. A survey among MSs showed that there are three fundamentally different ways of handling exceptions and innovative systems in the MS energy performance calculations:

1. The performance of the innovative component or system may be evaluated with a *separate (unofficial, but validated) tool*. The results from this unofficial evaluation would then create *input for the official tool(s)* to give the same effect as calculated by the separate tool used for evaluating the performance of the innovative component/system. An example of this approach is the calculation of preheating of ventilation air in underground ducts using a separate software. The calculated input is then dealt with as increased heat recovery efficiency in the official calculation tool, resulting in the same annual improvement of energy performance as calculated by the separate tool. This method can be more or less formalised through its general acceptance and the implementation of verification requirements. Among the *advantages* are: the method is quick and flexible; comparison between different tools is possible; the user can use specialist tools when appropriate. On the *disadvantages side* are: problems with result verification; results may depend on selected input data based on unreliable (user-dependant) methods; lack of compatibility of results; unclear legal aspect; CEN standards are not available for all innovative technologies.
2. *No single calculation tool* is prescribed, and it is thus possible to find a wide variety (ranging from ordinary, quasi-stationary monthly methods to advanced dynamic simulations) among those accredited tools that are capable of calculating or simulating advanced/innovative technology or material. The *advantages* of this method are: it is flexible as any appropriate tool may be used; it will boost competition in the market. Among the disadvantages are: different tools will give different results thereby giving the possibility to use the tool that gives the most favourable results; it is necessary to create additional quality control for results from various tools. The *disadvantages* are considered so serious that this alternative is not recommended.
3. Advanced or innovative technologies can be used *only after calculation routines have been implemented* in the official calculation tool(s). The manufacturers need to provide the necessary information for evaluating and implementing the requested methodology. The main *advantages* of this method are: it provides a wide market introduction for new technologies; it is legally acceptable; the quality of the information is uniform and coherent. The main *disadvantages* are: implementation is slow and expensive; it is costly for the authorities; it increases the complexity of the tool; it may exclude small, innovative market players. With this approach, it is suggested that groups of manufacturers in a MS jointly pay for testing and development as well as validation, which will produce an acceptable procedure (which may, however, require independent development).

The best solution would be a combination of the different approaches. The method chosen and the way different methods are combined depend to a high degree on the legal framework of each MS. Using a combined approach allows for the optimal solution in any context and offers increased flexibility. An example of a combined methodology would be: when a MS, which is normally using method one or three, in case the calculations need to account for an innovative system, allows the use of alternative calculation tools.

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[2] *See www.epbd-ca.eu/outcomes/CA_Annex_4_Procedures.pdf and www.epbd-ca.eu/outcomes/CT_Reports_14-04-2011/CT4_Procedures.pdf*

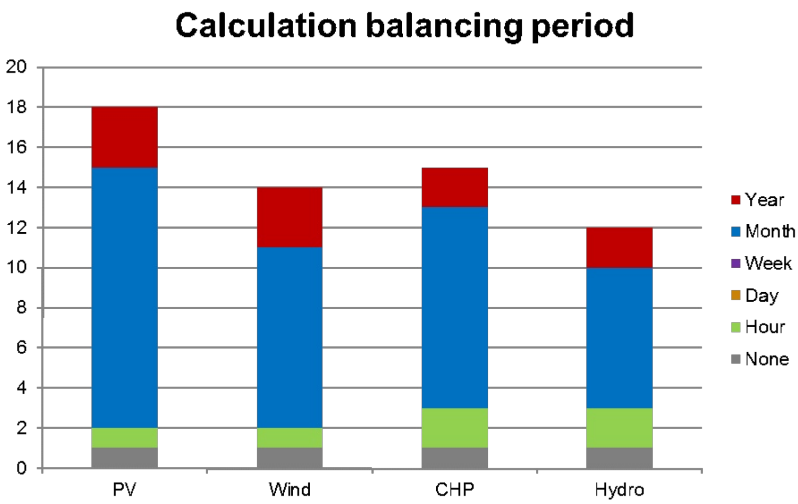
The use of the alternative tool should, however, only be allowed after application and proper validation of the tool and models used.

It will be increasingly important to enable inclusion of innovative systems and materials in energy performance calculations as requirements approach NZEB levels.

3.1.2 Introduction of renewable energy sources in the energy performance calculations

MSs have different approaches on how to handle RES in their energy performance calculations and legislation. Electricity production from photovoltaics (PV) is generally accepted in most MSs, but there are differences in how the electricity is accounted for in the national calculation procedures. A few MSs allow for an annual balancing of the electricity production, while the rest of the MSs balance the electricity production on a monthly basis - primarily due to the overall balancing period of the national calculation tools, which in most cases is monthly (Figure 1). More or less the same differences and approaches apply for RES-based heating and cooling production.

Figure 1: Balancing period for electricity production from RES for selected MSs.



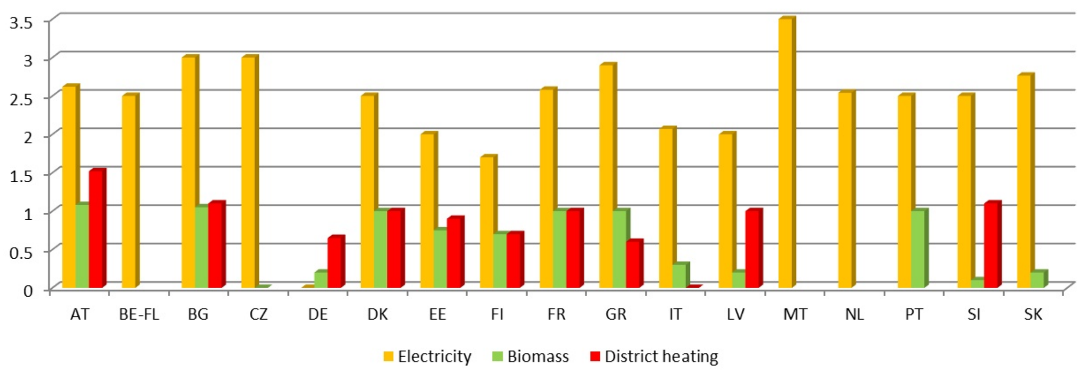
Beyond considering different RES sources when calculating buildings' energy performance, another issue is the primary energy-weighting factor used in the calculation of the RES contribution and the amount of RES energy that can be subtracted from the calculated energy performance. The primary energy factors for different types of RES vary among MSs (Figure 2). The primary energy factor for biomass varies between 0 and 1.08. This diversity reflects different political ways of looking at biomass, beyond pure combustion chemistry. A primary energy factor of 0 reflects 100% clean fuel, while 1.08 may indicate that biomass is a scarce resource and not always possible to replace. In the first case, almost no energy saving measures will be profitable in case of a major renovation. The same variation in calculations is found for other heat sources, e.g., district heating that varies between 0 and 1.52.

From a sample of twenty MSs that provided detailed information on this issue, seventeen MSs allow inclusion of electricity from PV, while twelve allow electricity from local wind-turbines and combined heat and power (CHP) to be included in the calculated energy performance of buildings. Nine of these twenty MSs also allow the inclusion of electricity from hydropower.

Production of heat from RES is, like the production of electricity, also accounted for differently in different MSs. Here the diversity in possible sources of heat production is much more significant than for the production of electricity, and methods of handling these different sources vary significantly.

For instance, passive cooling is taken into account in most MSs' national calculation tools, while active cooling technologies based on RES are in most cases not addressed, or handled indirectly in the national tool for calculating buildings' energy performance.

Figure 2: Primary energy factors for electricity, biomass, and district heating (average for selected MSs).



One way for MSs to increase the share of RES in a building is to offer subsidies to building owners for setting up systems for RES production. From inquiries sent to selected MSs, it seems that the most subsidised RES systems for electricity generation are PV and on-site wind turbines. The most subsidised RES systems for heating are solar thermal- and heat pump-based systems. For RES-based solar cooling, only one MS has a subsidy scheme and other RES-based cooling production methods are only subsidised in a few MSs. In some MSs, the possibility of obtaining subsidy for RES-based systems depends on the circumstances: either a local utility company offers subsidies for their local customers, or subsidies only apply if certain conditions are fulfilled, e.g., replacement of an old oil burner with a ground coupled heat pump.

Since the implementation of NZEBs must become the norm by 2018-2020, there is an ever-increasing need for MSs to clarify their understanding of NZEBs. It is not possible to compare NZEB requirements for MSs that already have an established definition, due to variations in climate and in the way requirements are set up, but there are significant variations in the understanding of NZEB among MSs. This topic needs close monitoring in the future, and further information can be found in the chapter “Towards 2020: Nearly Zero-Energy Buildings” in this book.

It is important for MSs to ensure that unrealistic low primary energy factors do not hinder deployment of NZEB efforts and effective energy saving measures in existing buildings.

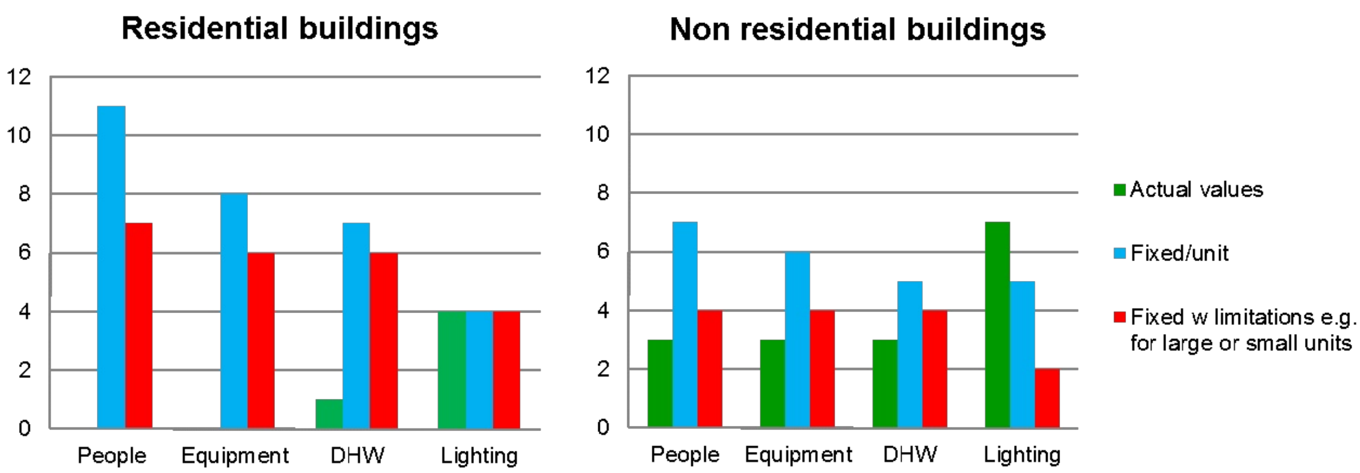
3.1.3 Estimating realistic energy savings in Energy Performance Certificates

Given the fact that most MSs use fixed or other kinds of default values as boundary conditions for input data for energy performance calculations (Figure 3), it is not surprising that calculated energy performance normally differs from measured energy consumption. Consequently, the calculated energy savings due to energy upgrades suggested in the Energy Performance Certificate (EPC) will also deviate from the energy savings actually achieved. On the other hand, the aim of the EPC is not to calculate real energy consumption and hence energy savings but, rather, to compare building energy performance under a standard pattern of use.

Adjusting input boundary conditions to actual values may result in realistic (in comparison with measured energy consumption) calculations of energy demands. This is also the case for the simpler, quasi-stationary calculation tools using monthly average values.

The optimal solution for creating EPCs and calculating realistic energy savings is achieved by carrying out three calculations: one calculation using default values to calculate the label itself and then one with actual input parameters for calculating energy performance both before and after implementing energy saving measures. This suggestion however, is not required in any MS. Additionally, actual values may be difficult to identify, so it is necessary to make adjustments for reality. Even if actual values are available, there are still issues that cause calculated energy savings to differ from the savings

Figure 3: Type of input parameters used in MSs for internal loads in energy performance calculations.



achieved: the 'prebound' effect, i.e., before refurbishment, users of buildings with poor energy efficiency are using less energy than predicted, and the 'rebound' effect, where users of energy-refurbished buildings use more energy[3] than predicted; therefore the amount of energy saved is lower than expected.

There is no doubt that this issue will continue to be a central part of MSs' discussions on achieved energy savings and on how the EPC can be used as a tool to promote and assess energy savings. The EPC as a tool for building benchmarking, independent of user behaviour, is undoubtedly very valuable. This is comparable to car energy labelling, where although no-one expects to be able to obtain the same degree of economy as stated by the manufacturer, it is generally agreed that the relative comparison between two cars is reliable. EPCs should continue to act as a benchmarking tool for buildings that is independent of user behaviour. It may however be supplemented by additional calculations for realistic energy consumption and hence savings valid for the actual building and its use, e.g., use of realistic indoor temperature, ventilation rate, hot water consumption, pattern of use of heating systems in moderate southern EU climates, etc.

3.1.4 Buildings as providers of demand side flexibility

A collaboration between the three Concerted Actions (i.e., the CA on the Renewable Energy Sources Directive, the CA on the Energy Efficienty Directive and the CA on the Energy Performance of Buildings Directive) has been established to investigate the possible promotion within the three Directives of Demand Side Flexibility (DSF), i.e., flexible use of electricity by customers based on price signals.

DSF has the potential to contribute to an affordable, reliable and sustainable electricity system. DSF is considered to have many and significant potential benefits as it increases the flexibility of the electricity system. The existing electricity system already includes a high degree of flexibility provided mostly by stand-by power plants and a few large customers.

The increase of intermittent (renewable) generation will result in a greater need for flexibility. However, DSF is not expected to deliver this flexibility alone: storage, fuel shift technologies, more interconnection between MSs and optimal functioning of the EU internal energy market will all contribute to meeting the need for flexibility.

Buildings conditioned by a heat pump or by direct electric heating, especially NZEBs with large inertia and, thus, with a long time constant, will be able to offer induced or postponed use of electricity especially in periods with fluctuating electricity production from renewable energy. In this way, the building can use extra electricity in periods with abundance and help reducing the peak-demand by postponing demand in periods with shortage. A building's thermal mass and its built-in potential water storage can provide flexibility by shifting the temperature setpoint within the acceptable comfort range (or even more in hours outside use) and thus allow for acceleration or delay of energy demand. In case of overheating or undercooling a building in periods of abundant RES-based electricity, the building's overall energy consumption will increase, while overall CO_2 emissions may well decrease. If DSF is going to be included in MS building energy requirements in the future, there is thus a clear need for new regulation and calculation procedures, both taking into account the value of flexibility for the electricity grid.

There is little doubt that DSF in general will draw increased interest in balancing the growing production of electricity from RES and hence the fluctuating production that is sometimes out of phase with traditional electricity demand. This will call upon buildings to become active players and provide their share of DSF in the future by induced use of green electricity at periods with abundance and deferred use in periods with shortage of green electricity.

It is not always possible to directly address innovative and uncommon systems and materials in the national most energy performance calculation tools, e.g., in preparation for constructing NZEBs. Three fundamentally different ways of handling exceptions and innovative systems were identified.

There is a large diversity among MSs regarding inclusion of RES in national definitions and requirements. In some

[3] *Minna Sunikka-Blanka & Ray Galvina (2012). Introducing the prebound effect: the gap between performance and actual energy consumption. Building Research & Information. Volume 40, Issue 3, 2012.*

cases, RES contributions are calculated with a primary energy factor of 0, making almost no energy saving measures cost effective.

Standard calculations, as carried out in the EPC, are the best tool for benchmarking buildings without influence of the users. Estimates of realistic energy savings require additional calculations, taking into account user behaviour.

3.2 Calculating cost-optimal energy performance levels

The EPBD requires MSs to report on the comparison between their legal minimum energy performance requirements and calculated cost-optimal levels using the comparative methodology framework. The Comparative Methodology Framework is accompanied by Guidelines from the Commission to enable the MSs to:

> Establish at least nine reference buildings – one for new buildings and two for existing buildings subject to major renovation, for single-family, multi-family, and office buildings respectively. In addition to office buildings, MSs must establish reference buildings for other non-residential building types for which energy performance requirements exist, e.g., educational buildings, hospitals, hotels and restaurants, sports facilities, wholesale and retail trade services buildings, and other types of energy-consuming buildings. Several building types can be represented by the same reference building type, e.g., hotels and prisons, or offices and universities, if appropriate.
> Define packages of energy efficiency measures to be applied to these reference buildings.
> Assess the primary and final energy needs of the reference buildings and the impact of the applied improvement measures.
> Calculate the life cycle cost of the building after energy efficiency measures are implemented, by applying the principles outlined in the comparative methodology framework.

The Guidelines give reasonable recommendations on how to carry out calculations of the cost-optimal levels and provide an overview of the input parameters and results. However, some MSs have decided not to use the tables suggested in the Guidelines, but rather adapt the data to the format used in their own national calculation tool in order to make reporting more targeted to their needs.

The use of only one reference building per building type does not cover the wide differences in the real building stock. According to experience from test runs, 3-4 reference buildings for each building type would be necessary in order to get a representative picture of the building stock diversity. When analysing the existing building stock, it is possible to identify a large number of different building types due to differences in construction and use. Based on this, some MSs have defined up to 184 (in the case of The Netherlands) different reference buildings to describe their building stock, while other MSs simply used the minimum number (nine) as described in the Guidelines.

For any reference building, a number of variations on packages of energy saving measures must be calculated in order to identify the cost-optimal level. There is a large diversity in the number of calculations carried out in different MSs. The Flemish region of Belgium, for example, used random variations of energy saving measures and calculated more than 100,000 combinations for each reference building. Other MSs have carefully selected, among logical packages, the variation of energy saving measures to calculate, and have thus limited the number of calculations significantly.

The methodology for calculating cost-optimal levels seems to work well, as it delivers interesting results and the effort needed to make the calculations is manageable. Calculation of numerous variants of energy-saving measures or packages of measures is necessary in order to obtain accurate cost-optimum values. A minimum of ten variants per reference building must be calculated in order to identify the cost-optimal level, but somewhere between twenty and fourty variants seems to be the ideal number in order to more clearly identify the cost-optimal level. Even so, many of the calculated cost curves are quite flat (i.e., they show little difference in energy performance compared to investment levels) and, in many instances, no individual, clear optimal point could be identified. This means that *many MSs find* *a cost-optimal range of measures by combining the building envelope and the technical systems rather than an individual optimal point*. The cost-optimal level is often defined at the lower end of the range to ensure the lowest possible energy consumption within the optimal range of costs (Figure 4).

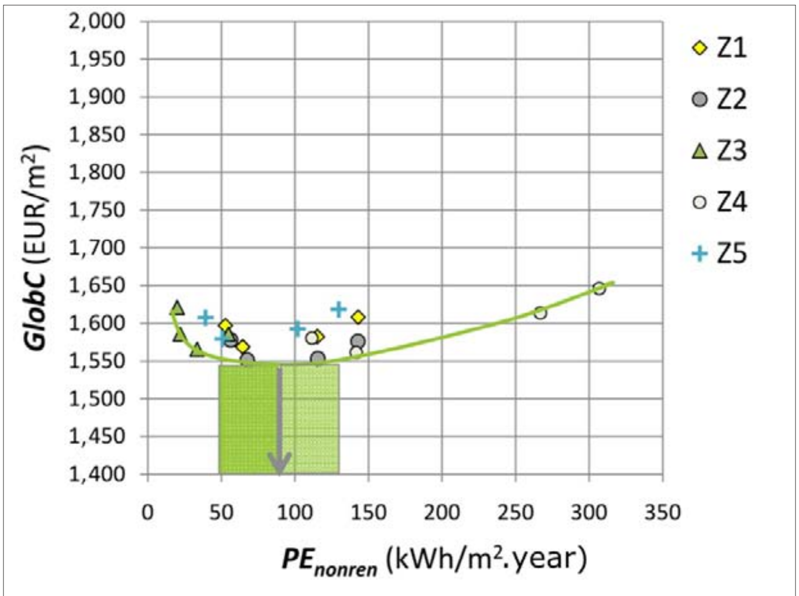
Most MSs (27) have submitted[4] their calculation of their cost-optimal levels. Lessons learned from the cost-optimal calculations vary significantly among MSs. Exchange of experiences and information during CA EPBD discussions (see box on the right) have been of great value for the development of the current Guidelines, and potential further advice provided by the Commission.

Implications of cost-optimality calculations on national energy performance requirements

Examples from selected MS calculations of the cost-optimal levels for new and existing buildings are given next in order to illustrate the huge variety among MSs in setting requirements that are within the acceptable range of 15% from the calculated cost-optimal level.

In *Slovakia*, the 2013 minimum energy performance requirement for blocks of flats was 126 kWh/m².year. Due to the results of the calculation of the cost-optimal levels, these requirements will be tightened to 63 kWh/m².year in 2016. The NZEB requirement, which will be the minimum requirement by 2019 (for public buildings) and by 2021 (for all buildings) is estimated to be 32 kWh/m².year (see Figure 5).

Figure 4: Example graph showing the cost-optimal range of different packages of energy saving measures.



Lessons learned relating mainly to the calculation process

- *The input from experts with experience in this kind of calculation (e.g., development of scenarios for reference buildings) is essential to support legislative changes, and in particular to address real complexities rather than just presenting academic exercises for simple example buildings. This would result in more widely applicable Guidelines and better results.*
- *Minimum energy performance requirements are usually set at the national level and do not take into account the possibilities for RES at the regional, local, district or site level. Therefore, the cost-optimal level is often a compromise, using only those technologies that can be used in all localities. As a result, some real cost-optimal packages with RES may be missed. More flexible minimum requirements with a focus on local conditions should be recommended to trigger the use of RES depending on the specific local conditions, e.g., a local source for small-scale hydropower.*
- *Cost-optimal levels derived from non-renewable primary energy might not always be cost-optimal for individual users because they are based on analyses of reference buildings rather than a specific building, as required by the EPBD. Decisions on energy saving measures for the building owner might need technical-economic analyses that are adjusted to the actual building.*

Wish list for additional advice

- *Provide further guidance on choosing the type and characteristics of reference buildings.*
- *Provide further clarification of economic scenarios.*
- *Improve description of how to establish typologies for new residential buildings.*
- *Define standard forms for reporting on energy management systems.*
- *Define common variants of packages for energy efficiency.*
- *Extend the calculation period to 60 years to reflect the typical economic life of buildings. In particular, the 30-year period does not fully account for the benefit of installing longer-lasting fabric improvements.*

[4] http://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

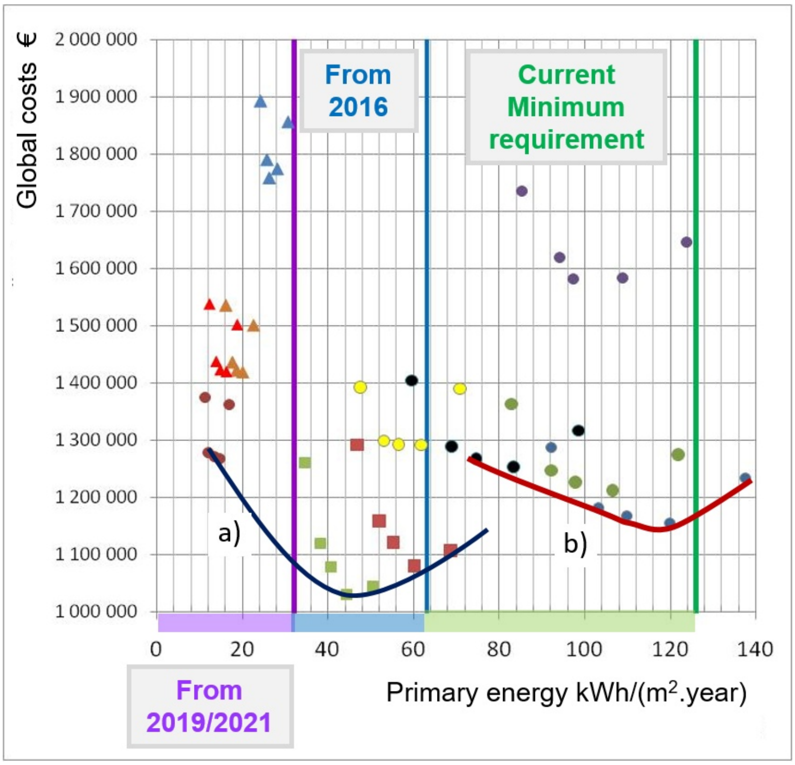
In *the Flemish region of Belgium*, the cost-optimal level for residential and non-residential buildings was calculated in the spring of 2013. In Flanders, the primary energy use (kWh/m².year) is not an indicator used for checking compliance with Flemish building regulations. Instead, the so-called E-level (primary energy consumption divided by a reference value) is used. The results (Table 1) indicate that the cost-optimal level for residential buildings with PV is E50, which should be compared with the 2014 requirement of E60. For offices and schools, the cost-optimal level without PV is E57, which is close to what is already defined in the 2014 Flemish building regulations. Since the E57 level is close to the 2014 requirement, further steps are planned in order to gradually reach NZEB levels by 2021 (and E55 by 2016).

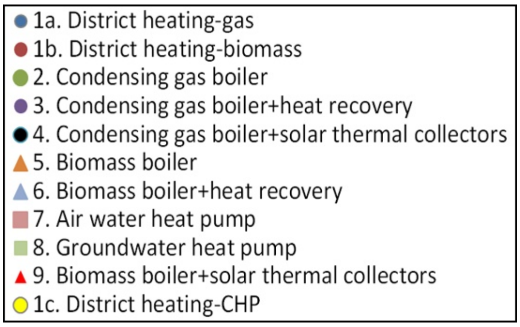
In the expected 2021 Flemish building regulations, the E-level requirements will be E30 for residential buildings, and E40 for offices and schools. These more demanding levels represent the expected future cost-effective levels.

In order to find the cost-optimal point, different packages of energy-saving measures were chosen, reflecting the interaction between various measures. Generation of random combinations of measures is believed to help identify a more accurate optimum. These randomly generated combinations also included improbable and clearly non-optimal packages. Although those were excluded from the calculations, the number of packages calculated per reference building was still more than 100,000.

Table 2 summarises the *Danish* cost-optimal levels in comparison with the energy requirements for new buildings in the 2010 Danish building regulations (BR10). Analyses are based on a financial perspective (i.e., effects on the whole building stock). The gap between the BR10 energy regulations and the cost-optimal levels is shown as a percentage of the cost-optimal level of requirements in kWh/m².year primary energy, inclusive of renewables.
A negative gap indicates that the requirements in the Danish BR10 are tighter than the cost-optimal level.
The BR10 includes the 2010-2015 minimum energy performance requirements in Denmark. Two voluntary classes, LEB2015 (Low Energy class 2015)

Figure 5: Calculation of costs and primary energy use in block of flats with indication of the current requirements level, the requirement level from 2016 and the 2020 level (NZEB) for different heating sources (example from Slovakia). Conversion factors for primary energy used in the calculations are biomass: 0.2; natural gas: 1.36; CHP district heating: 0.7. The blue curve (a) represents heat pumps and biomass solutions while the red curve (b) represents heat sources that are feasible for all locations.





Building type	Heat supply	Cost optimum kWh/m².year	Deviation between cost-optimal and BR10 requirements (%)		
			2010-2015 Minimum requirements	LEB2015 Voluntary class	B2020 Voluntary class
Single-family house	District heating Heat pump	68.7 51.1	-15.7% -2.8%	-44.9% -49.8%	-57.0% -58.0%
Multi-family house	District heating	53.6	-9.2%	-36.1%	-44.7%
Office building	District heating	51.7	31.2%	-16.0%	-37.3%
Weighted average	DK mix.		2.8%	-34.4%	-48.8%

Table 1: Comparison of energy performance levels for new and existing buildings in Flanders, Belgium.

and B2020 (Building class 2020) are both already defined in the BR10 as prospects for minimum requirements for 2015 and 2020 respectively. Only the relevant heat supply sources in relation to Danish heat plans are included in the calculations.

In relation to the new housing examples, the present minimum energy requirements in the BR10 all show gaps that are negative, with a deviation from the cost-optimal point of up to 16%. With the planned tightening of the requirements for new houses in 2015 and again in 2020, the energy requirements can be expected to be tighter than the cost-optimal point in the current price structure. However, it must be expected that the costs for the necessary improvements and for new technologies will decrease, and hence future requirements and cost-optimal points will eventually converge.

In relation to new office buildings, there is a gap of 31% between cost-optimality and the 2010 requirement. In relation to the 2015 and 2020 requirements, there are negative gaps to the point of cost-optimality based on 2014 prices.

If the gaps for all new buildings are weighted on an average, based on a mix of building types and heat supply for new buildings, in Denmark, there is a gap of 3% on average for new buildings, in the current regulations (BR10). The planned tightening of the energy performance requirements in 2015 and 2020, using today's prices, is 34% and 49% more strict than the cost-optimal levels.

Many MSs have noted that one or more building types had more lax minimum energy performance requirements than the calculated cost-optimal levels (resulting in more than 15% difference between the two). In many cases, the identified gap has already been addressed by changing the national legislations, or will soon result in new, tighter national minimum energy performance requirements. A survey showed that nine countries saw a tightening of 11% to 25% on the energy performance requirement between 2011 and 2014.

In most cases, the curve defining the calculated cost-optimal level is almost horizontal over a range of equally cost-optimal combinations of energy saving measures around the cost-optimal level. This means that there is little additional investment required to obtain additional energy savings if the building is within the cost-optimal range. Many MSs have thus decided to define their cost-optimal level at the lower end of the range to ensure the lowest possible energy consumption within the optimal cost range.

Most MSs have experienced that one or more building types have more lax energy performance requirements than the calculated cost-optimal levels (with more than 15% difference between the two).

3.3 Energy performance requirements for new and existing buildings

MSs deal with setting energy performance requirements for new and existing buildings in different ways.

Especially for existing buildings subject to major renovations, the diversity is immense. Some MSs set requirements only for those individual building components that are being renovated or replaced, while other MSs set requirements for the whole building.

Setting requirements for new buildings also differs among MSs, not only in terms of energy performance levels, but also in terms of other properties in the building envelope. For example, there are substantial differences in the units of measure used by MSs (kWh/m^2,

Table 2: Cost optimal requirements for new buildings in the Danish Building Regulations 2010. For the different building types and heat supply, the table shows the cost optimum in kWh/m^2.year primary energy and the percentual gap between the cost-optimal level and the 2010-2015 requirements

	Existing buildings		New buildings	
	Previous levels	Optimal level	Previous levels	Optimal level
Single-family	no E-level, only U-values	(E90)	E70 (2012), E60 (2014)	E50
Multi-family	no E-level, only U-values	(E90)	E70 (2012), E60 (2014)	E50
Office buildings	no E-level, only U-values	(E72 (office), E49 (school))	E70 (2012), E60 (2014)	E57

comparison with reference building, kg CO_2/m^2). There are also differences among the properties of the building envelope. For example, infiltration is handled very differently by MSs (e.g., compulsory tests versus quality certification programmes). On the other hand, most MSs tend to set limits on U-values. There are also very different ways of checking compliance. For example, Sweden set requirements that are verified through comparison with the measured energy consumption two years after taking the building into use. Designers thus need to establish a margin that can absorb the variations caused by user behaviour and different climates.

Compliance checking and setting requirements for new and existing buildings has been one of the focus areas during 2010-2015. Additionally, setting requirements for technical building systems has also been discussed.

3.3.1 Energy performance requirements for renovation of existing buildings

The two main methods for setting requirements for existing buildings subject to major renovation both have advantages and disadvantages (Table 3).

The main advantages of *component requirements* are that they are easy to explain, confirm and enforce, and therefore they offer the possibility for increased user acceptance. On the other hand, this method is difficult to regulate (especially indoor works are difficult or impossible to check) and does not lead to improvements of adjacent areas or components. Moreover, it is not easy to decide which measure to implement first without a holistic approach.

Applying *whole-building requirements* makes it easy to set ambitious energy

Table 3: Pros and cons for the different approaches for setting energy performance requirements to existing buildings subject to (major) renovation.

Building component requirements	
Pros	Cons
• Sets minimum standard for replacement of individual windows/doors/ walls/ boilers/etc. • Requirements direct architects and engineers towards cost-effective solutions • Simple to assess • Stimulates the market and improves supply of energy-saving components • Partially market driven • Easy to explain, and therefore possibility of increased user acceptance • Easy to confirm and enforce in cases where a construction permit is required • Effective for achieving energy and CO_2 savings • Easy to control components' performance	• Difficult or impossible to check when a construction permit is not required (e.g., indoor works) • Does not improve adjacent areas • Requirements might not 'add up' to a low energy building • New materials and solutions can be excluded • Lack of flexibility creates a need for exceptions • Interaction between components is easily missed • Decision what to do first is not so easy without a holistic approach • Improvement of a single component might have negative effects on other parts
Whole-building requirements	
Pros	Cons
• It may set ambitious energy requirements for major renovations, change of use and extensions • There is a possibility of avoiding costly energy measures that only have a small effect on the energy demand of the building • It is possible to achieve the cost-optimal level • Easy and direct connection to the energy performance indicator(s), i.e., overall energy evaluation	• The requirements are often considered difficult to understand by the industry • There are no requirements ensuring the use of energy efficient components (for normal maintenance, minor refurbishments, etc.) • Additional costs due to requirements for the whole building may be a hinderance for implementing energy-saving measures at all
Whole-building and component requirements	
Pros	Cons
• Strengthening of requirements is easier when an alternative is available • In the course of the refurbishment of one building element, a holistic approach might tackle additional measures • It is possible to achieve the cost-optimal level • Easy and direct connection to the energy performance indicator(s)	• Often, the refurbishment of a small building is a matter between owner and craftsmen and no architect is involved to implement a holistic approach • Lack of flexibility • There may be an imbalance between efficient (component) and cost-optimal solutions (whole building) • Architectural limitations • More difficult to administer several requirements

requirements for major renovations, change of use and extensions, and to avoid costly energy measures, which may only have a small effect on the energy demand of the building. However, there are no requirements ensuring the use of energy-efficient components for normal maintenance or minor refurbishments, and there is a risk that additional costs due to requirements for the whole building may be a hinderance for implementing energy-saving measures at all. Moreover, in many cases, especially in the case of refurbishment of small buildings, the owner and craftsmen are the only players involved and there is no architect nor engineer to encourage (or design and calculate) a holistic approach.

A combination of *whole-building* and *component requirements* makes it easier to tighten the requirements, as there are possible alternative solutions that can meet the overall requirement. However, this approach also implies the negative points for each of the individual paths.

Only two MSs/regions have only whole-building requirements in force, while seven MSs/regions rely solely on component requirements. The other MSs/regions require a combination of component and whole-building requirements (Figure 6).

Some MSs, even some of those MSs with combined requirements, have suggested that setting requirements for building components that are being replaced or renovated is sufficient to ensure an optimal energy performance of the renovated building. In an earlier study[5], it has even been suggested that *"compliance with whole-building energy performance requirements may hinder major renovations if the procedure for meeting the regulations is too complicated or too costly"*. It seems that a combination of whole building and component requirements is the optimal solution to ensure a holistic approach for energy savings in the building stock in general.

3.3.2 Requirements for technical building systems in new and existing buildings

The EPBD uses the term technical building system (TBS) in the recitals and Articles 1, 2, 8 and 11. Article 8 calls for minimum standards for energy performance, installation, dimensioning, adjustment and control. These standards are obligatory in existing buildings, and they refer to system performance rather than product performance or whole building performance.

Most MSs have TBS performance regulations of some kind in place and about two-thirds report having the same requirements for TBS for new and existing buildings. The EPBD does not require that MSs set regulations for TBS in new buildings, though most MSs apply TBS regulations to new, as well as existing buildings. In most cases, there are no requirements for carrying out a whole building energy performance calculation to prove compliance, as minimum TBS requirements are considered sufficient.

When TBSs are being installed in new buildings, regulations might require design calculations to be carried out so that system energy performance can be evaluated. However, in existing buildings, the original design information for TBSs will not usually be available, nor will building data (in the form of dimensions, heat loss, etc.). So, in the context of system replacement in existing buildings, it may be too difficult and time-consuming to carry out a rigorous system design and performance evaluation. TBS requirements are thus often limited to performance requirements for each individual component.

More detailed information about TBS regulations is found in the chapter on "Inspections" in this book.

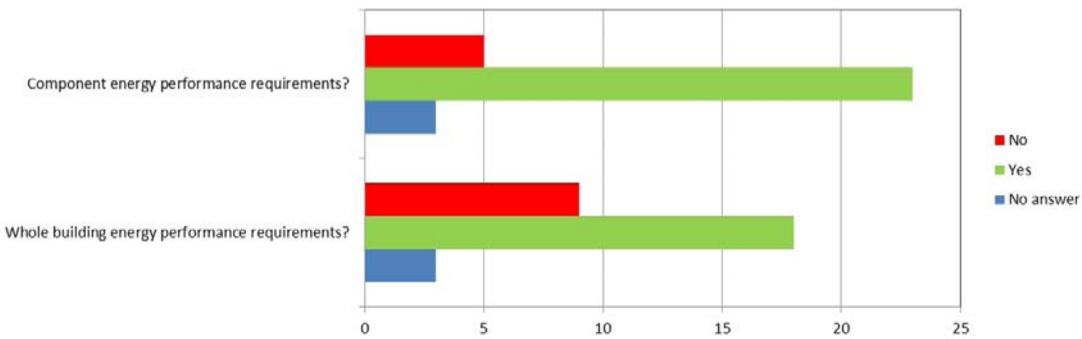


Figure 6: Number of MSs that set requirements for existing buildings subject to major renovation as whole-building or component requirements.

[5] *Thomsen et al (2009). Thresholds related to renovation of buildings - EPBD definitions and rules. SBi 2009:02. Danish Building Research Institute, Aalborg University.*

3.3.3 Checking and enforcing compliance for new buildings

MSs have different approaches to demonstrating compliance with energy performance requirements, and some have adapted their regulations to implement Article 27 of the EPBD on penalties.

With the progressive increase of the energy performance requirements included in national regulations, the issue of checking compliance of energy performance of new buildings becomes increasingly important. An effective compliance scheme becomes a crucial element of regulation, especially in the context of NZEB.

As previously indicated, the requirements set by MSs affect different parameters of the building (e.g., U-values, infiltration, system efficiency, overall performance, etc.). MSs may choose to check different elements at different stages.

Compliance with energy performance requirements is checked at different stages of the building process in different MSs. Some MSs even check compliance several times during the building process (Figure 7).

In addition to the energy performance requirements for new buildings, most countries also set other requirements. Figure 8 shows some of these requirements.

Compliance check and quality control regarding the airtightness, thermal bridges, summer comfort and availability of daylight in new buildings require increased attention, as buildings are moving towards NZEB, since these topics account for an increasing share of buildings' total energy consumption.

A special compliance check philosophy is in place in Sweden, based on an operational rating system applied to new houses or apartments after two years of operation. It is not necessary to measure single parameters as long as the measured value of energy consumption complies with the building code.

A combination of whole building and component requirements seems to be the optimal solution for ensuring implementation of the most effective energy saving measures in existing buildings - not only when undertaking major renovations, but also when renovating minor parts of the building.

Figure 7:
Most countries check compliance with the requirements for new buildings on more than one occasion.

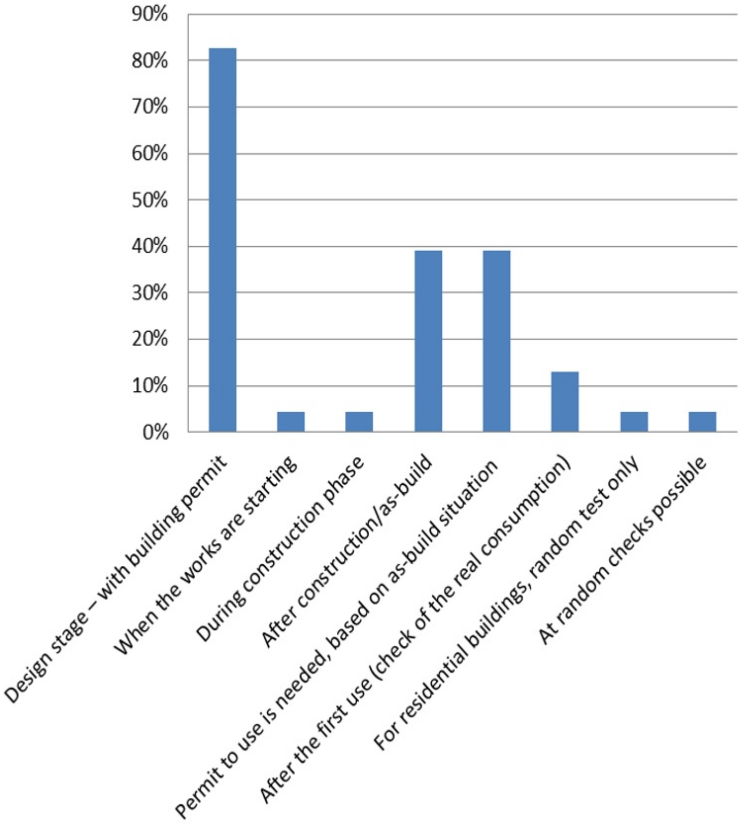
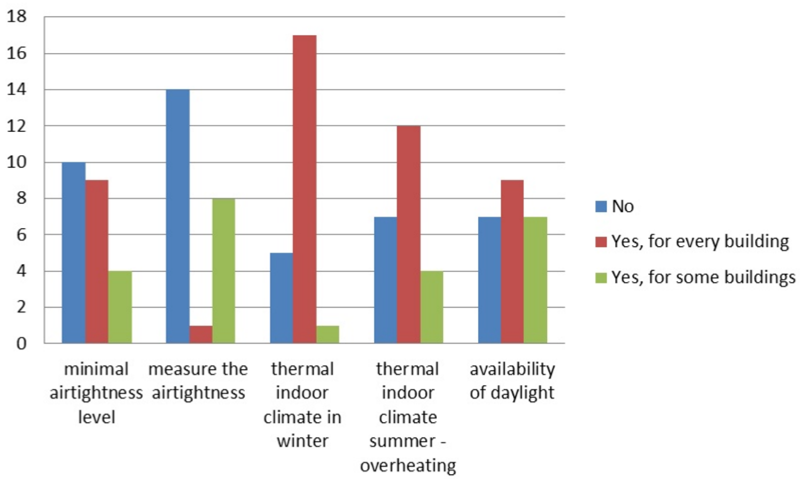


Figure 8: MSs that set requirements in addition to energy performance requirements for new buildings.



Many MSs have chosen to prescribe the same TBS component requirements for new, as well as for existing buildings when replacing TBSs.

With the progressive increase of energy performance requirements included in national regulations, the issue of checking new buildings' compliance with requirements becomes more and more important. An effective compliance scheme becomes a crucial element of regulation, especially in the context of NZEB.

4. Main outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Implications of cost-optimal levels on energy performance requirements	Most MSs had one or more building types with looser energy performance requirements than the calculated cost-optimal levels.	Most MSs planned to tighten their energy performance requirements when necessary.	Energy and component costs will evolve and tighter energy performance levels will presumably become cost-optimal.
Reference buildings and energy saving measures for cost-optimal calculations	There is a large variation among MSs' approaches to calculating cost-optimal levels, ranging from a few combinations of measures per reference building up to 100,000.	Based on these reference buildings, and a sufficient number of variations, sensitivity studies are able to produce cost-optimal levels.	For existing buildings, there is a need to develop a comprehensive and relevant set of reference cases.
Legal framework and Guidelines on calculating cost-optimal levels	Experiences from the first round of calculations highlighted strengths and weaknesses of the Guidelines and suggested areas for improvement.	In many cases, the calculated cost-optimal level varies little over a large range of equally cost-optimal combinations. MSs are encouraged to select their minimum requirements at the lower end (lower energy needs) of the cost-optimal range.	The Guidelines should be continuously updated to reflect lessons learned and best practices from MSs.
Compliance checks for additional performance requirements for new buildings	Most countries have additional requirements for energy performance levels for new buildings, e.g., airtightness, summer comfort, daylight.	Compliance can be checked at different levels, e.g., airtightness can be ensured by careful design and construction, or direct measurements in the completed building.	With the increased energy performance requirements in NZEBs, compliance checking of the performance of new buildings becomes increasingly important.
Setting energy performance requirements for existing buildings	There are pros and cons for setting mandatory energy performance requirements for existing building renovations with either whole-building or component requirements.	A combination of component and whole-building requirements may prove to be the best solution to implement the most energy saving measures.	Requirements should ensure maximum energy savings, while reducing investment costs and not hindering refurbishments due to too rigid, too costly or too complicated requirements.
Requirements for technical building systems (TBS)	Many MSs have chosen to prescribe the same component requirements in new and existing buildings when replacing TBS.	Equivalent component requirements for TBS in new and existing buildings makes it easy for the industry to deliver TBS.	MSs still need to make significant improvements for implementing the requirements for TBS.
Handling exceptions and innovative systems in energy performance calculation procedures	Most MSs' building codes do not handle innovative systems and materials well.	Three fundamentally different ways of handling exceptions and innovative systems were identified, i.e., separate (unofficial) tools; any tool allowed; after implementation in official tool.	It will be increasingly important to enable inclusion of innovative systems and materials in energy performance calculations as requirements approach NZEB levels.
RES in NZEB	There is a large diversity among MSs regarding inclusion of RES and types of RES in the national requirements and NZEB definitions.	Taking different RES sources into account when calculating energy performance strongly depends on the primary energy factors used.	It is important for MSs to ensure that unrealistic low primary energy factors do not hinder deployment of NZEBs and effective energy saving measures in existing buildings.
Calculation of realistic energy savings for building renovation	Standard calculations, as carried out in the EPC, are the best tool for benchmarking buildings without influence of the users.	Estimates of realistic energy savings require additional calculations, taking into account user behaviour.	Cost-effective renovation towards NZEB requires improved methods for estimating accurate energy savings.

5. Lessons learned and recommendations

Energy performance calculation procedures

Innovative and not-commonly-known systems and materials cannot always be handled directly by the national energy performance calculation tools. It is recommended that MSs ensure smooth inclusion of innovative systems in energy performance calculation methodologies in order to promote the design of NZEBs. Development of new energy efficient products is often ahead of the capabilities of energy performance calculaton tools, and there is a need for flexibility to include them in the calculations.

MSs implement different approaches as to how to handle renewable energy sources (RES) in their energy performance calculations and legislation. In some cases contributions from RES, e.g., biomass, are calculated using a primary energy factor of 0, making almost no energy saving measures cost-effective. It is important for MSs to ensure that primary energy factors do not hinder implementation of NZEBs. According to the EPBD, it is required that the RES be located “nearby” the building if it is to be taken into account in the building’s energy performance. Also, there are significant differences among MSs on how far “nearby” is, ranging from “at the building and the building site” to “within the borders of the MS”.

Most MSs use standard inputs for energy performance calculations and thus these results are generally not in line with the measured energy consumption. Calculated energy savings presented in the EPC are therefore often different from the energy savings actually experienced. However, standard calculations, as carried out for the EPC, are the best tool for benchmarking buildings without influence of the users, while a supplementary calculation can provide realistic energy savings. Cost-effective renovation towards NZEB requires improved methods for estimating realistic energy savings. Several MSs have issued different guidelines for calculating realistic energy use and savings, as summarised in a report from CIBSE[6].

Calculating cost-optimal energy performance levels

There is an increased focus on setting out adequate and cost-optimal energy requirements in the national building regulations. Additionally, the cost-optimal calculation exercise resulted in recommendations for an update of the Guidelines to the Regulations for cost-optimal calculations, e.g., more guidance on choosing the type and characteristics of reference buildings, more clarification on economic scenarios and improved Guidelines of how to establish building typologies.

In most cases, the curve defining the calculated cost-optimal level is almost horizontal over a range of equally cost-optimal combinations of energy saving measures around the cost-optimal level. It is recommended that MSs set their requirements at the lower end of the cost-optimal range.

Many MSs have experienced that one or more building types have looser energy performance requirements than the calculated cost-optimal levels. Many MSs are working on closing, or have already closed, this gap by implementing tighter national minimum energy performance requirements for new and existing buildings.

Energy performance requirements for new and existing buildings

With the increased energy performance requirements for NZEB included in future national building regulations, compliance checking of the performance of new buildings becomes increasingly important. Compliance with requirements is not limited to energy performance requirements, but in several MSs also includes other aspects like airtightness, daylight levels, summer comfort, etc. There are different methodologies for compliance checks used in MSs depending on the assessment method and the requirement(s) to be checked.

There are two fundamentally different approaches to setting requirements for existing buildings subject to major renovation, namely whole building requirements or component requirements. Neither of the two methods is ideal and it is recommended that a combination of the two is implemented. The main advantages

[6] *Cheshire D. & Menezes A.C. (2013). Evaluating operational energy performance of buildings at the design stage. CIBSE TM54:2013.*

of a combined approach are: it is easy to strengthen requirements when an alternative is available; the approach is helpful during the setup of funding schemes; it is possible to achieve the cost optimum for each component; and there is an easy and direct connection to the energy performance indicator(s). It is recommended that requirements should ensure maximum energy savings without implementing requirements that are too rigid, too costly or too complicated. Works that do not require a building permit or which are performed inside the building are especially difficult to monitor.

Setting standards for technical building systems (TBS) is obligatory in existing buildings, and it refers to system performance rather than product performance or whole building performance. Even though it is not obligatory to set standards for TBS in new buildings, it is recommended to prescribe the same component requirements in new and existing buildings. This will make it easier for the industry to deliver highly efficient components as only one set of rules apply, and consequently prices will decrease as the market increases.

Towards 2020

Nearly Zero-Energy Buildings

OVERVIEW AND OUTCOMES

AUGUST 2015

1. Introduction

With the adoption of the Energy Performance of Buildings Directive (Directive 2010/31/EU - EPBD) in 2010, both the building industry and Member States (MSs) faced new challenges. One of the most prominent among them is the progress towards new Nearly Zero-Energy Buildings (NZEB) by 2021 (or by 2019 in the case of public buildings), while in parallel supporting the transformation of existing buildings into NZEBs. Thus, since 2010, the Concerted Action EPBD (CA EPBD) has been discussing the issues related to moving 'Towards 2020 - Nearly Zero-Energy Buildings' promoting dialogue and the exchange of best practices among MSs and thereby contributing to a more effective implementation of the EPBD in the MSs.

The work focused on the transposition of the Directive 2010/31/EU into national law, namely on the national detailed application in practice of the framework definition of NZEB, and on the national plans for increasing the number of NZEBs.

This report summarises the main outcomes of the discussions on this topic from March 2011 to March 2015. The successful contribution on MSs progress towards 2020 is based on the active participation of the national delegates (representing national authorities in charge of implementing the EPBD), including information gained from questionnaires, national studies, poster presentations, and study tours.

2. Objectives

Article 9 of the EPBD requires that *"Member States shall ensure that (a) by 31 December 2020 all new buildings are nearly zero-energy buildings; and (b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings"*. MSs shall furthermore *"draw up national plans for increasing the number of nearly zero-energy buildings"* and *"following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings"*.

A NZEB is defined in Article 2(2) of the Directive 2010/31/EU as *"a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby"*.

The specific CA EPBD activities on the topic 'Towards 2020 – Nearly Zero-Energy Buildings' support the MSs through the exchange of experiences regarding already existing high performance buildings, ranging from low energy buildings to passive houses, zero-energy and zero-emission buildings, and even to buildings with an energy surplus.

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Figure 1: Two NZEBs visited by CA EPBD: on the left, a single-family demonstration house in Berlin (Germany); on the right, a renovated multi-family house in Graz (Austria).

The discussion topics included the different national applications of the NZEB definition, the most common building and service system solutions, calculation methods, supporting documents (e.g., guidelines), awareness-raising activities for the general public, subsidies and other available incentives and support policies, etc.

A particularly important objective has been the integration of Renewable Energy Sources (RES) into the NZEB national implementation. This is part of the EPBD requirements, as the nearly zero or very low amount of energy consumed in NZEBs should be covered to a very significant extent by energy from renewable sources, but it also links to the RES requirements from Directive 2009/28/EC (Renewable Energy Sources Directive - RESD). In accordance with the RESD (Article 14(4)), by 31 December 2014 MSs must, in their building regulations and codes, or by other means with equivalent effect, require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation.

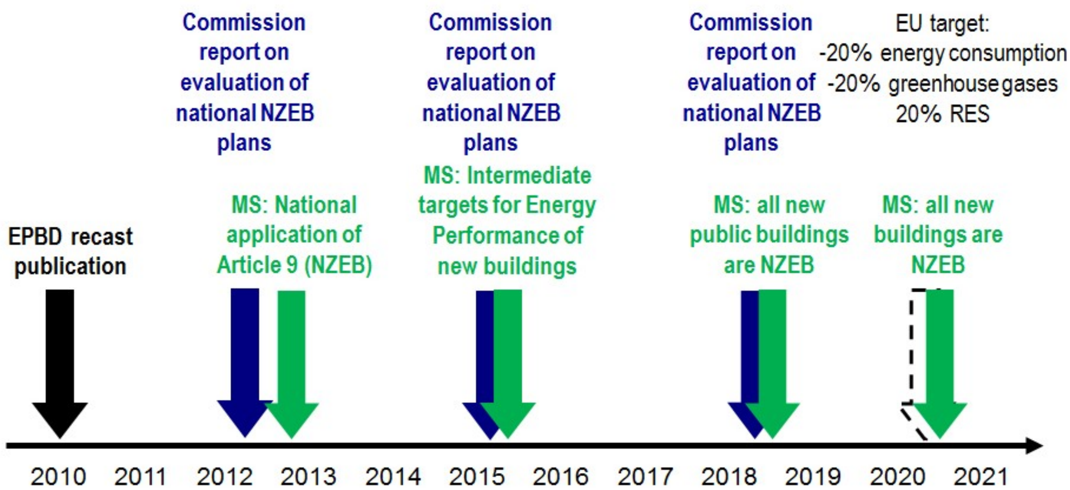
One of the main objectives of this period (for all MSs) has been to ensure that the national application of the EPBD NZEB definition is feasible at both technical and financial levels. For this reason, four study tours have been organised to better evaluate the particularities of NZEB in different environments and applications. These study tours have included visits to already existing buildings (new and renovated) that are close to the performance expected from an NZEB.

There is a very close link between the NZEB discussion and the CA EPBD activities on 'Energy performance requirements using cost-optimal levels', because the cost-optimal minimum energy performance requirements will have to meet the NZEB level by the end of 2018 for public buildings, and by the end of 2020 for all other new buildings. Additionally, both topics involve work on calculation procedures. This has fostered the exchange of views, challenges and ideas between technical and economic experts from the MSs.

Finally, discussions have also focused on the national plans for increasing the number of NZEBs.

The timeline for actions by the MSs and the EC related to NZEBs (Article 9 of the EPBD) is presented in Figure 2.

Figure 2: Timeline of NZEB-related actions according to the EPBD.



3. Analysis of insights

3.1 Mapping of national applications of the NZEB definition

3.1.1 National applications of the definitions in place by April 2015

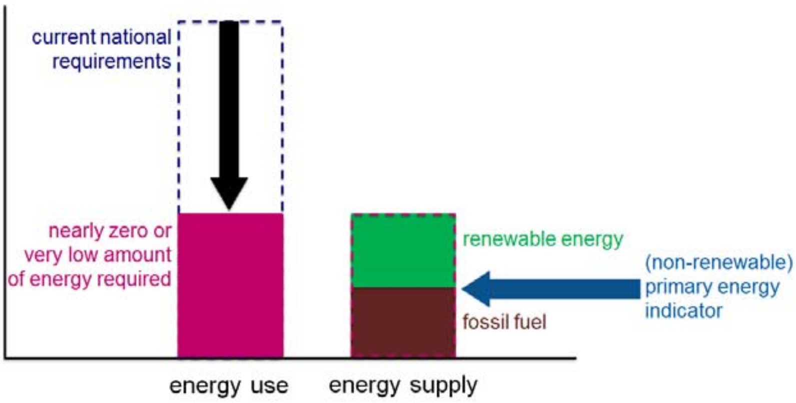
Continuous work and discussions have taken place from 2011 to 2015, gathering and comparing the status of national applications of the NZEB definition in the MSs. Table 1, which is taken from a special CA EPBD report[1], presents an overview of the available information regarding the detailed national definitions in April 2015, based on the national plans for increasing the number of NZEBs and the work within the CA EPBD. Figure 3 presents the main elements of the NZEB definition of the Directive 2010/31/EU Article 2(2).

According to Table 1, which was reviewed by the national representatives of the participating countries, about 40% of the MSs do not yet have a detailed definition of the NZEB in place. Some of them state this clearly in their national plan for increasing the number of NZEBs. About 60% of the MSs have laid out their detailed NZEB definition in a legal document, but a few of them emphasise the draft status of the definition, or that the definition might be updated later on. The relevant legal documents are either building regulations, energy decrees and official guidelines, or the national NZEB plans.

The very high energy performance is expressed in at least nine MSs by requiring that the building must fall into one of the top energy classes of the energy performance certificate. Other countries give specific information about the ratio of the tightening of the energy requirements compared to the 2014 level (or the 2012 level in some cases). These tightening ratios are between 10-25% and 50-60%. Denmark states a tightening of even 75% but relates it to an earlier energy performance requirement (2006).

The vast majority of EU countries (twenty three MSs and one of the three Belgian regions) use a primary energy indicator in kWh/m².year, in line with Annex I of the EPBD, either in their detailed NZEB definition, or in their current energy performance requirements for new buildings. Two additional MSs and the other two Belgian regions use either E-levels (a figure for primary energy use

Figure 3:
Graphical interpretation of the NZEB definition according to Articles 2 and 9 of the EPBD.



divided by a reference primary energy use), or include primary energy as a calculation result, but not as the indicator.

In most MSs, the limits for the nearly zero or very low amount of energy required are placed on more than just primary energy. The additional parameters include U-values of building envelope components, mean U-values of the building envelope, net and final energy for heating, cooling and possibly other energy uses and CO_2 emissions.

While about one third of the countries have only indirect requirements for the recommended 'very significant extent of renewable energy', those with direct requirements set them mostly as an energy share of the primary energy use. The required renewable energy share varies from > 0% to > 50%. A few other countries set specific minimum renewable energy contributions in kWh/m².year. Applying 'indirect' requirements means that, due to the low maximum value of primary energy use allowed for NZEBs, the use of energy generated from RES is implicit, although a specific minimum required amount is not included in the national definition.

By April 2015, about 60% of the MSs have laid out their detailed NZEB definition in a legal document and the vast majority of MSs use a primary energy indicator in kWh/m².year. While many MSs require a renewable energy share of the primary energy or a minimum renewable energy contribution in kWh/m².year, others use indirect requirements, such as a low non-renewable primary energy use that can only be met if renewable energy is part of the building concept.

[1] *Overview of national applications of the Nearly Zero-Energy Building (NZEB) definition, Detailed report, April 2015, available at www.epbd-ca.eu/wp-content/uploads/2016/01/Overview_of_NZEB_definitions.pdf*

Table 1: Overview of the available information regarding the detailed national NZEB definitions (April 2015)

Country		Main points of the NZEB definition				
		Detailed definition	**Very high energy performance**	**Nearly zero or very low amount of energy required Limits placed on:**	**Very significant extent of renewable energy**	**Primary energy indicator in kWh/m².year**
Austria		EPBD text implemented in OIB 6 of 03/2015. Detailed definition included in national plan of 03/2014	Maximum final energy use reduced by ≥ 50% compared to energy performance requirements of 2012	Heat demand, total energy efficiency factor, final energy, primary energy, CO_2 emissions	Direct: Minimum share of the final energy dependent on the implemented RES technology. Examples: • 50% of the final heating energy covered by biomass • 10% of the final DHW energy	Yes
Belgium	Brussels Capital	Included in *Arrêté du Gouvernement de la Région de Bruxelles-Capitale* of 21 December 2007, modification of 26 March 2013	Passive house	Heat demand, primary energy	Indirect *	Yes
Belgium	Flemish Region	Included in Regulation of the Flemish Government of 29 November 2013 regarding the energy performance of buildings	E-level (=primary energy use/reference energy use) ≤ E30 (for residential buildings); ≤ E40 (for offices/schools)	Component U-values, mean U-value of building envelope, primary energy as E-level	Direct: minimum share and alternative of single measure with quantitative requirements (e.g., 0.02 m²/floor area solar thermal (for single-family houses) or 10 kWh/m².year (for houses, apartments, schools, offices))	E-level (=primary energy use/reference energy use); not in kWh/m².year
Belgium	Walloon Region	Interpretation of EPBD text in national plan, study contracted, definition will evolve	Building envelope close to passive house and required E-level (=primary energy use/reference energy use)	Component U-values, primary energy	Under discussion: direct (> 50% of residual consumption of heat + cold + electricity)	Included for residential buildings in current minimum energy performance requirements. E-level used for all buildings
Bulgaria		Draft definition in national plan (BPIE study)	Class A	Primary energy	Direct: minimum share of 20% to 50% depending on building type	Yes
Croatia		Definition for single-family house in national plan. Definition for various building categories in Technical Regulation on Energy Economy and Heat Retention in Buildings (OG 130/14)	E.g., single-family house: 40.9 kWh/m².year primary energy (continental)/ 33.4 kWh/m².year (coastal)	Primary energy	Direct: minimum share of 30% of renewable energy from annual primary energy	Yes
Cyprus		Included in decree ΚΔΠ 366/2014 (issued on 1 August 2014)	Energy class A	Component U-values, heat demand (for residential buildings), installed lighting power (for office buildings), primary energy	Direct: at least 25% of primary energy	Yes
Czech Republic		Included in Regulation No. 78/2013 Coll.	Reference technologies, 30% lower mean U-value, 10-25% lower primary energy compared to current requirements	Mean U-value of building envelope, delivered energy, primary energy	Indirect *	Yes

Country	Main points of the NZEB definition				
	Detailed definition	**Very high energy performance**	**Nearly zero or very low amount of energy required Limits placed on:**	**Very significant extent of renewable energy**	**Primary energy indicator in kWh/m².year**
Denmark	Included in BR10, currently voluntary, to be adjusted	Building class 2020 (75% reduced to 2006)	20 kWh/m².year (for dwellings) / 25 kWh/m².year (for other buildings) primary energy	Indirect *, examples of solar panel sizes necessary to cover deficiencies in combination with district heating/heat pump in national plan	Yes
Estonia	Included in regulation VV No 68:2012 "*Energiatõhususe miinimumnõuded*"	Building class A	Primary energy: 50 kWh/m².year (for single-family houses) / 270 kWh/m².year (for hospitals)	Indirect *	Yes
Finland	The detailed definition will be finalised in the course of 2015 and the aim is to present the legislative proposal to the parliament in autumn 2016	-	-	-	-
France	Included in RT 2012	1/3 of prior requirements	50 kWh/m².year primary energy	Direct: 5-12 kWh/m².year for single- and multi-family houses, more in RT 2020	Yes
Germany	EPBD text implemented in energy saving act, detailed definition is being developed	Probably along KfW efficiency houses	Probably mean U-value of the building envelope and primary energy	Direct requirements included in current minimum energy performance requirements	Requirements included in current minimum energy performance
Greece	EPBD text implemented in Law 4122/2013 of 19 February 2013	-	-	Direct requirements included in current minimum energy performance requirements	Requirements included in current minimum energy performance
Hungary	Draft definition included in Decree about Determination of Energy Efficiency of Buildings of 7/2006 (V.24), detailed definition is being developed	More efficient than cost-optimal level	Specific heat loss coefficient of the building envelope, primary energy	Direct requirements included in current minimum energy performance requirements	Yes
Ireland	Draft definition included in the national NZEB plan	(Primary) energy performance coefficient = 0.302, carbon performance coefficient = 0.302 for typical dwelling: 45 kWh/m².year, for other buildings: 50-60% improvement comared to current requirements; rating A3 or higher	(Primary) energy/carbon performance coefficient	Direct requirements included in current minimum energy performance requirements (RES contribution of 10 kWh/m².year (thermal) or 4 kWh/m².year (electrical)); planned to be introduced for non-residential buildings in 2015	Yes (together with carbon dioxide performance indicator in kg CO_2/m².year)

Country	Main points of the NZEB definition				
	Detailed definition	**Very high energy performance**	**Nearly zero or very low amount of energy required; Limits placed on:**	**Very significant extent of renewable energy**	**Primary energy indicator in kWh/m².year**
Italy	EPBD text in Decree Law no. 63/90 of 2013, new energy decree includes detailed definition near completion	Primary energy significantly lower than current requirements (e.g., 60% tightening for a small multi-family building near Milano)	Primary energy for heating, primary energy for cooling, total primary energy	Direct: planned for NZEB is 50% of primary energy (direct requirements included in current minimum energy performance requirements)	Yes
Latvia	Included in Cabinet Regulation No. 383/2013	Building class A	Energy demand for heating ≤ 30 kWh/m².year; primary energy demand ≤ 95 kWh/m².year	Direct: at least partial use of RES (> 0%)	Yes
Lithuania	Included in Construction Technical Regulation STR 2.01.09:2012	Building class A++	Specific heat loss of the building envelope, efficiency of systems, primary energy	Direct: largest part of energy consumed (> 50%)	Yes
Luxembourg	Interpretation of EPBD text included in national plan and in national legislation (RGD 2014), detailed definition not yet fixed	Probably at least building class A-A	Net heating demand, primary energy	Indirect *	Yes
Malta	Proposed definition included in national plan, consultation process ongoing	Very high energy perfor-mance	Primary energy ≤ 40 kWh/m².year (for houses or apartments), ≤ 60 kWh/m².year (for other buildings)	Indirect *	Yes
Netherlands	National plan: aim to set requirement close to energy performance coefficient = 0 by 2018/2020, at least 2 feasibility studies	Close to energy performance coefficient = 0 (zero-energy building)	Mean thermal resistance of closed building envelope components, U-value of windows, (primary) energy performance coefficient	Indirect *	No. Energy performance coefficient is not in kWh/m².year); primary energy in MJ/m².year calculated as interim result
Norway	No detailed definition available	-	-	Direct requirements included in current minimum energy performance requirements	-
Poland	Translation of the EPBD text in national plan. Detailed definition included in Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location (Journal of Laws No 75, pos. 690), amendment in 2013	No details available	Maximum U-values for the building envelope components, maximum final energy performances indexes for heating, ventilation, hot water, cooling and lighting, maximum primary energy	Indirect *	Yes
Portugal	Translation of the EPBD text in Decree law 118/2013, Article 16. Detailed definition not yet available	-	-	-	Minimum energy performance requirements included in current legislation

Country	Main points of the NZEB definition				
	Detailed definition	**Very high energy performance**	**Nearly zero or very low amount of energy required Limits placed on:**	**Very significant extent of renewable energy**	**Primary energy indicator in kWh/m².year**
Romania	Included in updated national plan of July 2014	Reference technologies with best available technology packages, 13-58% lower primary energy than current requirements	Primary energy, CO_2 emissions	Direct: at least 10% of primary energy	Yes
Slovak Republic	Translation of EPBD text in Act No 555/2012, requirements in MDVRR SR 364/2012 Coll.	Class A0, primary energy 50% lower than current requirements	U-values of building envelope components, final energy use for heating, hot water, cooling and lighting, primary energy,	Direct: at least 50% reduction of primary energy	Yes
Slovenia	Translation of EPBD text in Energy Act of March 2014 (*Energetski zakon, Uradni list RS, št. 17/14*). National plan includes a detailed NZEB definition (approved by the Government on 22 April 2015)	Nearly 50% reduction of heating energy demand, at least 25% reduction of primary energy compared to current requirements. Requirements for public buildings 10% more strict than for other non-residential buildings	Mean U-value of building envelope and U-values of its components; heating energy demand $Q_{h,nd}$ < 25 kWh/m².year; primary energy [kWh/m².year]: 75 (single-family house), 80 (multi-family house), 55 (non-residential)	Direct: 50% RES as share of total delivered energy	Yes
Spain	Translation of EPBD text in RD 235/2013 (pending final approval). Detailed NZEB definition not yet available	-	Probably U-values of building envelope components, heating and cooling energy demand, primary energy (non-renewable and total)	Probably indirect. (Minimum energy performance requirements and direct requirements for certain buildings included in current legislation)	Probably yes. (Minimum energy performance requirements included in current legislation)
Sweden	No detailed definition is available yet. National plan states that there is currently no economic basis for further tightening. Next control planned for 2015	-	-	-	No. (There are stricter requirements for electrically heated buildings, though)
United Kingdom	National plan: no NZEB definition but target of zero carbon for new buildings through incremental changes to Building Regulations	Zero carbon new buildings in England from 2016 (homes)/2019 (non-domestic), other jurisdictions have similar ambitions. Highest EPC rating	Final energy demand, CO_2 emissions	Indirect	CO_2 emission as main indicator; primary energy indicator included in calculation method outputs in most jurisdictions

* Indirect: No specific renewable energy requirement but the low maximum values of primary and/or final energy use cannot usually be met without using renewable energy sources

3.1.2 Number of requirements for NZEB

Work in the CA EPBD and the EC's two progress reports on NZEB[2] have shown that the specific NZEB definitions in the countries vary considerably in the number of requirements used. The following CA EPBD analysis from October 2013 takes into account a sample of fifteen MSs. Not all of them had already officially fixed NZEB definitions, thus the plans of MSs that were still then working on this topic are also included. On the other hand, not all countries with legally fixed NZEB definitions, as pointed out in 3.1.1, have been part of this study.

While two countries set, or planned to set, only one specific NZEB requirement, namely primary energy, the other countries use, or planned to use, up to six additional requirements. Those additional requirements included CO_2 emissions, final energy, mean U-values, maximum transmission losses, efficiency factors of the whole building service system or part of it, etc.

General energy performance requirements for buildings, but also those specifically for NZEBs, are linked to historical background in most countries. Requirements enacted by early energy legislation are retained and tightened, but rarely abandoned completely. Thus, there are:

> countries that use many different requirements for new buildings in general, and tighten most of these requirements or define additional ones specifically for NZEBs, e.g., Denmark and Germany;
> countries that use many different requirements for new buildings in general and use few specific requirements for NZEBs, e.g., Belgium-Flemish Region, Cyprus, Estonia, The UK England & Wales, and the Czech Republic;
> countries that use few requirements for new buildings in general and many specific ones for NZEBs, e.g., Latvia.

In the sample of fifteen countries, 80% have set primary energy requirements, 53% have set requirements for using renewable energy, and 33% have set final energy use requirements as specific NZEB requirements.

Additionally, many countries limit transmission losses for NZEBs (40%) and/or demand certain building services efficiencies (40%). Ventilation loss requirements are used specifically for NZEBs in 20% of the sample countries. Heating energy limits for NZEBs are set in 27% of the countries. Only one country includes both final energy use limits and heating energy use limits in its NZEB definition. There are two countries in the sample with CO_2 emission requirements, of which one sets no primary energy requirement. It is interesting to note that two countries have set specific NZEB indoor comfort requirements.

The main arguments in support of either few or many NZEB requirements were as in Table 2.

MSs have adopted a wide range of detailed definitions of NZEB. While some countries set or plan to set only one requirement, which is typically primary energy, CO_2 emissions or delivered energy, other countries use or plan to use many additional requirements. Those additional requirements include mean U-values, maximum transmission losses, minimum efficiency factors of the whole building service system or parts of it, etc.

Table 2: Main arguments in support of either few or many NZEB requirements.

Few NZEB requirements	Many NZEB requirements
> easier to explain what a NZEB is > easier to prove what a NZEB is > easier to check what a NZEB is > easier to reach a cost-optimal solution (due to a higher flexibility in the approach)	> easier to adequately accommodate different building types > draws attention to important design phases through detailed, transparent design rules > draws attention to the construction phase (together with additional checks) > accelerates innovations for various products

[2] *available at ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings*

3.2. Convergence between the concepts of NZEB and cost-optimal energy performance requirements

Based on EPBD Article 5 'Calculation of cost-optimal levels of minimum energy performance requirements' and Article 9 'Nearly Zero-Energy Buildings', the beginning of the years 2019 (for new public buildings) and 2021 (for all new buildings) will be the convergence point between the cost-optimal calculations and the definition of NZEB: by 2019/2021, NZEB shall have a cost-optimal combination of building envelope and building service systems.

As a result, the cost-optimal calculations for 2012 have to be reviewed for 2019/2021[3], since there are certain factors like prices, technological developments and primary energy factors that will change between now and 2019/2021. Ten MSs reported in March 2013 that they have performed studies that take into account estimated changes in the following parameters:

> primary energy conversion factors: eight MSs;
> energy prices: nine MSs;
> investment costs: five MSs;
> technology and efficiency developments and innovations: three MSs.

Three countries have studied all four factors listed above. Other factors that were examined (but only one factor per MS) were CO_2 reduction costs and discount factors.

The primary energy conversion factors, or more precisely the non-renewable primary energy factors for the national electricity mix and for district heating energy will decrease because higher rates of RES will be integrated into their generation systems in the near future. Applied estimations included e.g., in Denmark electricity primary conversion factors of 2.5 in 2012 and 1.8 in 2020, and district heating conversion factors of 1 in 2012 and 0.6 in 2020. Hungary used values of 1.12 for the 2012 primary energy conversion factor for district heating based on combined heat and power (CHP), and 0.65 for 2020.

The estimated increases of the energy prices that were used in the calculations were between 2-3% per year and 5-6% between 2012 and 2020 in total.

The development of loan interest rates and of financial incentives might be additional factors that can be also analysed in the cost-optimal calculations. However none of the ten countries have claimed to have studied these evolving factors so far.

MSs reported that, using the present costs, technologies, and primary energy conversion factors, the currently available national applications of the NZEB definition are not fully in compliance with the cost-optimal requirement, because there is no certainty about the evolving influence factors for the calculations for the year 2019/2021, see Figure 4. Only one country (Denmark) reported that it has used the study on evolving factors to adjust its national application of the NZEB definition. Other countries might follow.

Figure 4: Strong fluctuation of the crude oil price complicates the prediction of 2019/2021 NZEB boundaries.

[3] *This is coherent with the EPBD Article 4(1) timeline for cost-optimal reports, whereby the first report was due by June 2012 and the following five years later (June 2017). Due to the actual date of adoption of the Delegated Regulation on the cost-optimal methodology, a formal extension was granted to MSs for submitting the first reports by March 2013, which in practice brings the five-year review to be done before March 2018.*

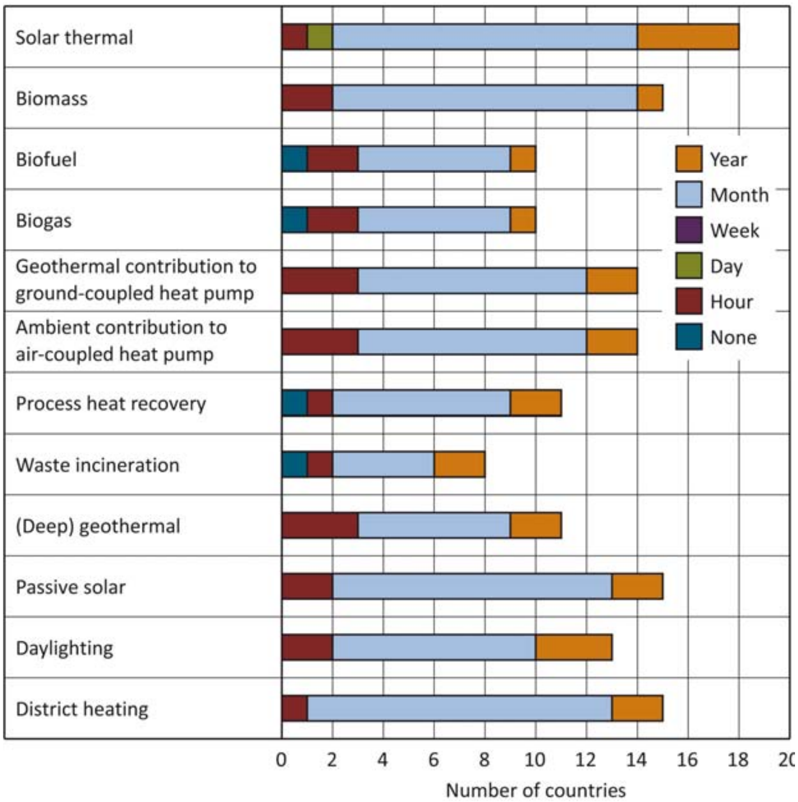
Therefore, the topic is certainly worth revisiting in the future when developments in existing and new technologies, as well as the cost of these technologies, may change the picture, and hence initiate new calculation results and new discussions. Updated cost-optimal calculations using expected evolving influence factors can give indications of the changes necessary for the detailed national application of the NZEB definitions in the coming years. In 2020 they can be used to fix the final requirements for NZEBs.

Ten MSs performed a cost-optimal study for 2019/2021 (e.g., for NZEBs), taking into account evolving parameters such as primary energy conversion factors, estimated energy prices, investment costs, and technology efficiency developments and innovations. The update of cost-optimal calculations with expected values of evolving influence factors in the coming years might allow for iterations of the national NZEB definitions.

3.3. MS approaches to introduce renewable energy sources (RES) in NZEB

The CA EPBD has continously discussed national boundary conditions for the use of RES in buildings in general, but also specifically for NZEBs. The analysis described in this section of the report was produced in May 2014 based on input from twenty MSs.

Figure 5: Balancing period for heat production from various RES sources in MSs national calculation tools.



MSs allow for almost all forms of RES to be taken into account, but there are differences in how electricity is accounted for in the national calculation procedures (for more details see the chapter on Energy Performance Requirements Using Cost-Optimal Levels, in this book), as well as in the primary energy factors which MSs use. For example, two MSs (Estonia and Malta) allow for an annual balancing of electricity production, but most of the other MSs balance electricity production on a monthly basis – primarily due to the overall balancing period of the national calculation tools, which in most cases is monthly. More or less the same differences and approach apply for heating and cooling production using RES. The thermal RES strategies used in most MSs are solar thermal, 'green' district heating (both are used in eighteen MSs) and biomass (in seventeen MSs). The applied balancing periods for thermal RES are presented in Figure 5.

The EPBD recommends that the nearly zero or very low amount of energy consumed in NZEBs is to be covered *"to a very significant extent by energy from renewable resources, including energy from renewable sources produced on-site or nearby"*. In the national definition of 'nearby', there are significant differences among MSs, ranging from at the building itself (e.g., The UK and France for photovoltaic (PV) panels) and the building site (e.g., Austria, Slovenia, Slovakia), to within the borders of the MS (e.g., Malta). Belgium-Flemish Region defines 'nearby' as on-site, except for district heating and participation. The Netherlands and Bulgaria have defined it as RES installed at a maximum distance of 10 and 15 km respectively. In Denmark, RES is considered 'nearby' as long as the building owner has an economic interest (e.g., investment) in the RES system and the RES system is located in the same municipality or a neighbouring municipality of the building site. Lithuania has not defined 'nearby', but accepts all RES regardless of where the energy source and power generation equipment are located. More than half the MSs have not yet outlined a definition of 'nearby'.

Taking into account different RES must be discussed further in the future in order to verify the boundary between the building and the surrounding utility grids, and to avoid double counting of RES production on the MS level.

MSs have different approaches on how to handle RES in their energy performance calculations and legislation. Moreover, the primary energy factors used for renewable energy sources and technologies differ considerably among MSs. Energy from RES can include both those located on-site or nearby the building. 'Nearby' has so far been defined only by some countries and rather differently, ranging from 'on the building itself' to 'within the country'.

3.4. NZEB in energy performance certificates (EPC)

The CA EPBD collected Energy Performance Certificate (EPC) layouts that have been adapted to include NZEBs. The examples from the MSs show that there are widely different methods for including NZEB in the EPC. Often no adaptation is needed, or only small adjustments or additional energy performance classes; a scale may be suitable for including NZEBs and even the 'plus energy' building level (a building that produces more energy than it consumes over an annual period). Many MSs chose not to show the NZEB level explicitly on the EPC front page. The approaches can be distinguished as follows (the list of countries is indicative and meant only to illustrate the various approaches):

> no change at all: use of existing layout, no adaption, a NZEB is class A (or A+ or similar): the Czech Republic, Italy, Hungary;
> no change in the layout but addition of guidelines for NZEBs: France;
> addition of one or several classes in order to present NZEBs: Croatia, Denmark, Lithuania, Luxembourg, Portugal, Slovakia, The Netherlands;
> small changes in the layout regarding indicators or design: Austria, Estonia;
> new layout, change from scale to classes, NZEB is class A or A+: Germany (for residential buildings), Latvia;
> addition of a NZEB indicator to the existing scale (e.g., an arrow similar to the current minimum energy performance requirements): Germany (for non-residential buildings), Malta.

The survey showed that in most cases adaptations to present the NZEB-level on the EPC are rather insignificant. However, not all countries foresee integrating an NZEB indicator on the EPC at this stage. They want to make EPCs as user-friendly as possible, and point out that an additional indicator will render the EPC less understandable for the building owners, tenants and other building users. If the possible advantages of an indication of the NZEB-level, e.g., better communication of the 2019/2021 minimum requirements, are to be exploited in all MSs, the requirement to include this indicator may need to be added to the next version of the EPBD.

3.5 Practical experiences with NZEB

3.5.1 Selected examples of NZEB in the countries

The CA EPBD identified examples of existing buildings that have an energy performance level in the expected range of NZEB (or approaching NZEB level) in the different EU MSs. In total thirty-two practical examples of NZEB-like buildings from twenty different MSs have been collected and published in a specific CA EPBD report[4].

Though the selected buildings cover a wide range of climates, building types and sizes, the cross analysis gives a good overview of what kind of buildings are expected to be NZEB in the different countries and EU regions. For example the average U-values in the buildings are 0.29 W/m².K (walls; range: 0.065–1.97 W/m².K), 1.16 W/m².K (windows; range: 0.70–4.5 W/m².K), 0.14 W/m².K (roof; range: 0.06–0.55 W/m².K) and 0.29 W/m².K (ground/cellar ceiling; range: 0.68 – 2.19 W/m².K). The realised U-values can be as low as 0.065 W/m².K for walls and roofs and 0.70 W/m².K for windows, and demonstrate the highest level of energy efficient building technologies currently available. On the other hand there are a few examples presented with more conventional U-values of up to 1.97 W/m².K for walls, and even 4.5 W/m².K for windows, in one of the Southern European countries. The higher U-values are partly acceptable due to the warmer climatic conditions, but also show that some of the technical developments for energy efficient building components are not yet available and/or used in all EU MSs. In addition, the more conventional U-values and building components result in lower costs.

[4] *Erhorn, H. and Erhorn-Kluttig, H.: Selected Examples of Nearly Zero-Energy Buildings. Report of the Concerted Action EPBD. 2015, available at www.epbd-ca.eu/wp-content/uploads/2011/05/CT5_Report_Selected_examples_of_NZEBs-final.pdf*

The buildings are often heated by heat pumps, followed by gas boilers and connections to a district heating net. Hot water is mostly generated in combination with the heating system. Where cooling systems are used, these often involve thermally activated building components[5] in the cooling strategy.

About three quarters of the buildings use a mechanical ventilation system with heat recovery. Only three of the buildings in the report rely on natural ventilation (window opening) for fresh air.

In terms of RES, PV panels are the most common option, with nearly 70% of the NZEB examples using them. Solar thermal panels are part of the energy concept in more than half of the buildings. Other renewable energy used in the buildings is geothermal (from ground source heat pumps), biomass and district heating with high shares of renewable energy. The average percentage of the total final energy use that comes from RES is 70% for the thirty-two buildings, but can be as high as 216% in one of the so-called ‘plus energy’ houses included in the collection.

The improvement compared to the current national requirements is between 21% and 202%, with an average of 74%. A (net) zero energy building has an improvement ratio of 100%. An improvement ratio of more than 100% is possible if the building is a ‘plus energy’ building. The average of the additional costs compared to the current national requirements is 208 €/m² or 11% of the total costs. However there are also buildings with zero additional costs and buildings with up to 473 €/m² or 25% of the total construction and technology costs. It must be noted though that some of these buildings are special demonstration projects or prototypes, and they may not really be representative of the future typical costs of NZEBs when these technologies become standard.

Nearly all MSs have started to gather experience from practical examples of NZEB-like buildings. The case studies show a wide range of building envelope qualities and types of building service systems and included RES. The most dominant technologies are: increased insulation and high performance windows, as well as mechanical ventilation systems with heat recovery, heat pumps and PV applications. There are differences between climatic conditions, though, and some of the solutions are less frequently adopted in Southern European MSs.

The average of the additional costs is 11% of the total cost, or 208 €/m². However one NZEB case study resulted in no additional costs.

3.5.2 NZEB apartment buildings

NZEB apartment buildings (new buildings and renovations) have been the focus of a detailed comparison between eight available documented examples in six MSs (Austria, Croatia, Denmark, Finland, Germany and Spain) with the following main results:

- The average U-values of the building envelope components are 0.20 W/m².K (external walls), 0.12 W/m².K (roofs), and 0.33 W/m²K (cellar ceilings/ground slabs). Windows are mostly triple-glazed and result in an average U-value of 1.0 W/m².K.
- The building service systems are often connected to the district heating unit, sometimes with solar support. Other systems include heat pumps, gas boilers and combined heat and power units. Domestic hot water (DHW) is mostly generated centrally by the generator(s) of the heating system. Only one case study includes a cooling system, and uses a reversible heat pump for generation and a floor heating system as distribution system.
- The most frequently applied RES systems are on-building solar thermal and PV systems. In all cases with district heating systems, the district heating generation also includes RES: biogas and geothermal via a heat pump are each applied in one system.
- During the construction phase, a few projects had difficulties with workforce quality regarding new technologies and airtightness. Other projects had no such difficulties.
- While two projects reported an energy consumption that meets or even undercuts the predicted energy use, a few projects will need another monitoring year to take care of systems and automation that did not work according to plan.
- Most of the projects reported that the costs were affordable or financially attractive to the tenants. Additional

[5] *Thermally activated buildings components are ceilings, floors or walls that include pipes or ducts with water or air for either heating or cooling, thus activating the building mass of the component and reducing the heating or cooling load.*

costs compared to conventional buildings were as low as 0 €/m² for the Croatian and one Finnish example, 20 €/m² for the Danish example, 27 €/m² for the Spanish example and 25 €/m² for the second Finnish example.

> Under ‘experiences with the project’, several projects specifically reported user satisfaction and improved quality of life.

A detailed analysis of renovated apartment blocks in Austria focused on the technologies used for renovating multi-family houses into NZEBs or even ‘plus energy’ houses. One innovative technology that was identified is a prefabricated facade system that also contains the installations and several renewable energy measures. The CA EPBD also studied financing methods for such deep renovation projects in Austria. Besides identifying an interesting financing method that uses the money of private investors (with acceptable paybacks) for the renovation of certain buildings in combination with governmental and local subsidies, discussion also focused on whether the support of some pilot projects with high subsidies could help meet the targeted high renovation rate in general.

Apartment buildings are an interesting building type when it comes to the implementation of NZEBs, as they are rather similar in all EU MSs and represent a significant portion of the building stock. The CA EPBD has analysed several examples of NZEB-like apartment buildings and found comparable building concepts in many countries, as well as interesting financing approaches. Most of the projects reported that the costs were affordable or financially attractive to the tenants. Several projects specifically reported user satisfaction and improved quality of life.

3.5.3 Single-family houses used as pilot projects

In the EU, single-family houses are the most common building type, and thus attract the most MS interest. Thus the CA EPBD collected various MS experiences with high-performance single-family houses.

British experts reported that there is often a difference between the predicted (calculated) energy performance and the measured results of the buildings. It should be noted though, that this is relative. While the absolute amount of deviation in energy use is often smaller in high performance buildings, the deviation percentage increases with the reduction of energy needs. The following reasons for these differences have been determined, based on experience with high performance buildings:

> deviations between design and as built;

> significantly lower seasonal efficiency of boilers and heat pumps than predicted and expected;

> problems with mechanical ventilation systems, including draughts, noise, faults and poor performance;

> poor workmanship on the installation of solar thermal systems;

> different user behaviour in reality than assumed in the calculations;

> use of control systems that are too complicated for the users.

Some countries, e.g., Austria and Germany, have good practical experience with high performance houses. In those countries, fewer failures at the construction site are found, and houses with a higher energy efficiency than that required by national regulations have a dominant share in the market of new residential buildings.

Finally, the experience in The UK shows that it is difficult to introduce NZEBs in countries in which the average time which people stay in a purchased home is about seven years before a new home is bought and the old one is sold. This makes investment in energy efficient technologies rather difficult, as they rarely pay back within that short timespan.

There is often a significant difference between the predicted (calculated) energy performance of buildings and the measured results. There are countries with good practical experience with high performance houses, where this type of house already has a dominant share in the market of new residential buildings. In these countries, the differences between the predicted and the actual performance are smaller.

3.5.4 Public buildings as leading examples

In Article 9, the EPBD sets earlier implementation dates for NZEB for new buildings occupied and owned by public authorities. Public buildings shall be used as leading examples for the process of moving towards NZEB. There is already a variety of high performance public buildings in several countries, some of which are presented in the catalogue of selected examples of NZEBs produced by the CA EPBD (see footnote 3). Germany, the focus of a CA EPBD study tour on this issue, uses prominent buildings like the 'Reichstag' (the Federal Parliament building), several ministry buildings, and community buildings e.g., schools and kindergartens, as lighthouses for the general development in the building sector. School buildings can be used as a special means of communication with pupils and their families, and can thus reach many different groups of the society. This approach is also applied in several other countries, such as Ireland, The UK, Denmark, Italy and Norway. The national approaches are supported by several EU projects, e.g., the EU FP7 School of the Future[6] and the IEE ZEMedS[7].

In Germany and Latvia, there are specific research and funding programmes for new and retrofitted community-owned buildings at NZEB level. There are several communities in different countries (e.g., Denmark, Germany and Belgium-Flemish Region) that have implemented their own energy decree, with energy performance requirements that are further tightened in comparison to national minimum requirements. The requirements apply to community buildings and buildings built on community land. The German Federal Government has committed to build its own new buildings at NZEB level already since 2012. An interesting measure is the installation of an energy commissioner responsible for the energy efficiency of all federal buildings of Germany.

The use of public buildings as leading examples is already in place in several MSs. Various instruments, e.g., financial support for communities, specific research programmes, tighter energy performance requirements, etc., are in use.

3.5.5 NZEBs in Southern Member States

A key challenge for NZEB in Southern MSs is to ensure the environmental comfort without the use of significant energy for cooling. The technologies most frequently used to reduce the cooling energy demand in the MSs are solar control features (e.g., mobile or fixed shading devices and structures, including verandas), night ventilation, ground-coupled heat exchanger for pre-cooling of ventilation air, and ventilation systems with summer mode (bypass of heat exchanger). Reversible heat pumps are a common solution where mechanical cooling is needed.

According to practical experience, the following conclusions can be drawn:

> The use of shading and night ventilation are the most important passive cooling strategies.

> Thermal mass can only be used effectively in climates with significant differences between day and night outdoor air temperatures.

Additional experience in warm climate countries shows that ground-coupled heat exchangers for ventilation (earth cooling tubes) work well in France, Portugal and Greece and that insulation is effective in warm climates, as it can reduce energy needs for both heating and cooling.

The experience with high performance buildings in France led to NZEB requirements combining energy performance and comfort by limiting the primary energy use, the new bioclimatic indicator (relating heating, cooling and artificial lighting demand) and the indoor temperature accounting for the intensity of discomfort.

In countries with a warm climate, a combination of NZEB requirements for energy performance with specific comfort criteria might be advisable. The essential issue is to create indoor conditions that allow occupants to feel comfortable without air-conditioning during warm periods, or to reduce the cooling load where cooling is still necessary.

3.6. National plans to increase the number of NZEB

Article 9, paragraph 1 of the EPBD indicates that *"Member States shall draw up national plans for increasing the number of nearly zero-energy buildings"*. The article also includes further information on what must be included in the national plans, namely: the detailed application in practice of the NZEB definition (including a numerical indicator of primary energy use expressed in kWh/m^2.year), intermediate targets (by 2015) and information on policies and financial measures to increase the number of NZEB.

[6] *EU FP7 demonstration project School of the Future (260102), available at www.school-of-the-future.eu*
[7] *IEE project ZEMeds (IEE/12/711), available at www.zemeds.eu*

In order to support MSs in this work, a possible structure for the national plans was developed. In general, there seem to be two ways to structure the national NZEB plans: either with the focus on the content topics, as defined in the EPBD Article 9, i.e., a report topic by topic, or by concentrating on the building type (new/existing/public/residential/non-residential).

The drafts of the national NZEB plans have been discussed during this CA EPBD period. Three key aspects of the national plans have been specifically analysed by the CA EPBD:

> intermediate targets for improving the energy performance for new buildings by 2015;
> policies and financial or other measures adopted for the promotion of NZEBs;
> national requirements and measures concerning the use of energy from RES in new and existing buildings.

The intermediate targets indentified were not all planned for 2015, as stipulated in the EPBD. Instead, MSs are developing these targets over the whole period between 2013 and 2019/21. Several countries plan to set more than one intermediate target between 2013 and 2019/21. However there are twelve countries that foresee a tightening of the energy performance requirements within the year 2015, as shown in Figure 6. The targets can be grouped into the following headers (see Figure 7): envelope quality, building service system efficiency, passive house standard, net energy demand, final energy demand, primary energy demand, CO_2 emissions, renewable energy sources, earlier implementation of NZEBs and lower building energy performance classes.

The policies and financial or other measures for the promotion of NZEBs, including measures for using RES, demonstrate a wide variety. They include:

> policies and requirements, e.g., requirements for integrating RES, renovation roadmaps, including in the context of Article 4 of the Directive 2012/27/EU (Energy Efficiency Directive - EED), green deals, etc.;
> using the public sector as a frontrunner, e.g., retrofit programmes for local authority-owned buildings, model contracts for Energy Service Companies (ESCOs), financial subsidies for RES measures in public buildings, etc. For example, Ireland's National Energy Efficiency Action Plan (NEEAP) and the Energy End Use Efficiency and Energy Service Plan include specified aims for energy efficiency improvement (in GWh of savings) by 2015 and 2020. In both plans, the public autorities play an exemplary role. They are only allowed to buy or lease buildings rated at least A3 from 2015 onwards, purchase energy efficient equipment and vehicles (Triple E register), display EPCs in buildings over 500 m², and apply green tenders;
> financial incentives, e.g., loans with reduced or 0% rates, tax credits, third party financing, revolving funds, the use of EU Structural and Investment Funds, etc.;
> demonstration programmes and buildings, e.g., exemplary NZEBs, educational excursions, exhibitions of energy saving technologies, etc. For example, Germany runs several demonstration programmes for new buildings up to the level of plus energy houses and energy efficient renovation of existing buildings;

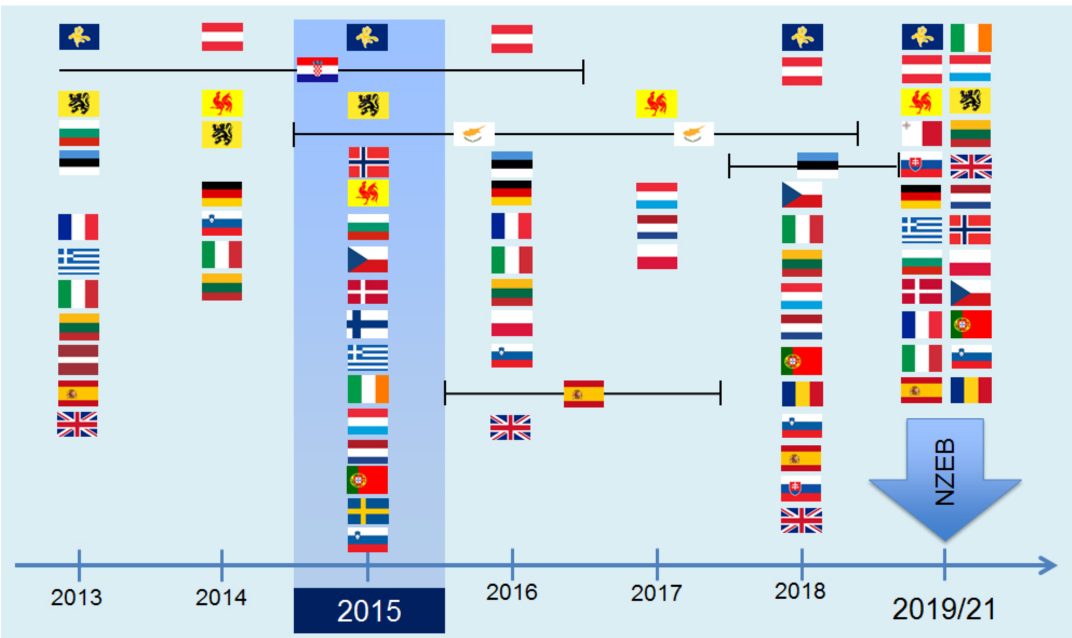


Figure 6: Timing of planned intermediate targets for energy performance requirements in the different MSs as stated in the national plans for NZEBs, and the deadline for NZEBs in 2019/2021. The black lines show foreseen time spans in which a tightening of energy performance requirements is planned in a country.

Envelope Quality

- Minimum Rc – value for all building envelope parts NL
- Maximum transmission heat losses (H'T) D
- Minimum transmittance values required for building elements I
- K (Global Insulation Level) BE-W
- U_{max}-values for spec. components BE-W, IR, BE-FL, PT

Building service system efficiency

- Minimum efficiencies for specific building service systems (heating, DHW, cooling, ventilation, lighting, lifts) PT
- Energy performance factor „$f_{GEE,max}$“: indicator for techn. building systems related to the overall final energy demand A

Passive House Standard

- Construction to comply with 'passive' standard BE-W

Net Energy Demand [kWh/m².year]

- Maximum space heating demand A Maximum heating needs BE-BR, PT
- Maximum cooling needs BE-BR, PT

Final Energy Demand [kWh/m².year]

- Overall final energy demand A

Primary Energy Demand [kWh/m².year]

- Maximum primary energy demand A, D, BE-BR, EE, F, D, IR, LX, PL, RO
- Primary energy framework for residential and non-residential buildings DK
- Ew (Global Energy Performance Level – Calculated PE consumption divided by calculated PE consumption of a reference building) BE-W

CO_2 [kg/m².year]

- Maximum CO_2 emissions A, BE-W, IR, RO, UK

Renewable Energy Sources (RES)

- EP consumption covered by RES [%] BE-W, I
- Renewable energy (RE) kWh/m².year total useful floor area BE-FL
- Incorporating RES that will contribute as minimum percentage to the building PE needs CZ

Earlier implementation of NZEBs

- Share of all/public NZEBs of all new built buildings [%] PT
- Au - Useful floor area [m²] of all new buildings in specific years already built as NZEB (new + renovated) SL, (HR: SFH only)
- Percentage of total floor space of new buildings occupied by central/local government with an EP corresponding to nearly zero-energy use BG

Lower Building Classes

- Minimum energy performance tightened by requesting a lower building class LT, LX, PT, SK

Figure 7: Type of planned intermediate targets for improving the energy performance of new buildings in the different MSs as contained in the national plans for NZEBs (not an exhaustive list).

> research work, e.g., virtual and real energy research centres, data studies, building material research, etc.;
> communication with and education of various target groups, e.g., central databases with information for the public, information and training of builders, communication campaigns, energy agencies, etc. For example, an interesting approach from Belgium (Flemish region) is to position the NZEB as a brand with practical guide on how to build a NZEB, lists of NZEB frontrunners (architects, energy experts, construction companies, installation companies, manufacturers and banks), demonstration buildings, TV programs and cheaper loans.

By presenting specific interesting national examples as best practices, inspiration has been shared with all countries participating in CA EPBD from 2010-2015.

MSs have planned intermediate targets towards NZEBs, not only for 2015 but also over the whole period from 2013 to 2019/2021.

The CA EPBD activities supported the MSs in developing their national plans towards NZEBs by giving inspiration through the presentation of interesting examples for financial incentives and demonstration programmes, as well as communication and education, etc.

4. Main outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
National applications of the NZEB definition	By the end of April 2015 about 60% of MS have laid out their detailed NZEB definition in a legal document.	'Very high energy performance' is introduced in different ways, including X% less than current requirements, top building classes, or zero carbon buildings. Not all definitions contain direct requirements for renewable energy contributions.	Several MSs are still working on the detailed application in practice of the NZEB definition. Existing applications will have to be reviewed and may be adapted prior to the target dates of 2019/2021.

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Convergence between the concepts of NZEB and cost-optimal energy performance requirements	There are uncertainties in predicting factors like energy prices, component costs and technical innovations.	Ten countries performed cost-optimal studies for 2019/2021, taking into account estimates of evolving factors.	Cost-optimal calculations towards NZEB must be repeated closer to 2019/2021 to account for technological developments and better cost estimates.
Introduction of RES in NZEB	MSs take various different approaches to accounting for renewable energy contributions.	Primary energy (weighting) factors and available definitions of 'nearby' vary among MS.	There is a need for further national and CEN work to converge on how to account for renewable energy and how to express passive contributions.
NZEB in EPC	Examples of EPC layouts that include NZEB show widely different approaches in MSs.	NZEB can be expressed with no or small adjustments (e.g., a certain top energy performance class) or by introducing a new indicator (e.g., an additional arrow on an energy performance scale).	To increase the visibility of NZEBs, the specific presentation of this energy performance level on EPCs in all MSs will be helpful.
Examples of practical experiences with NZEB	Nearly all MSs have started to gather experience by constructing examples of NZEB-like buildings. The case studies show a wide range of building envelope quality, types of building service systems and RES.	Most dominant technologies are insulation, high performance windows, mechanical ventilation with heat recovery, heat pumps and PV applications. The average additional cost of the prototypes was 11% of the total costs (ca. 200 €/m^2).	Further experience with innovative technologies and control strategies is needed, as are studies on user acceptance and influence and indoor comfort. Reduction in additional costs must be sought.
Practical experiences with NZEB: apartment buildings	The CA EPBD has analysed several examples of NZEB-like apartment buildings and found comparable building concepts in many countries, as well as interesting financing approaches.	Apartment buildings are an interesting building type for the implementation of NZEBs. They are rather similar in all EU MSs and represent a large proportion of the building stock.	With more national NZEB definitions and example buildings available, the comparison between examples will lead to more representative average costs and experiences.
Practical experiences with NZEB: single-family houses	In some MSs, there is a significant difference between the predicted and the measured energy performance.	In MSs with a dominant share of high performance buildings in the market of new residential buildings, fewer failures are reported.	The workforce needs to be trained for installing certain more advanced technologies (BUILD UP Skills).
Practical experiences with NZEB: public buildings as leading examples	Several countries use public buildings as lighthouses for the general development of high performance buildings.	A list of instruments to support the use of public buildings as leading examples towards NZEBs was compiled.	Financial support programmes for community buildings are important in the future (e.g., for NZEB retrofit).
Practical experiences with NZEB: Southern Member States	Successful technologies for reducing cooling energy use include good solar shading, night ventilation, ground heat exchangers, and reversible heat pumps.	A combination of NZEB requirements for energy performance and comfort criteria might be advisable.	More examples and further information on successful technologies and their costs are needed.
National plans to increase the number of NZEBs	MSs have planned intermediate targets towards NZEBs not only for 2015, but also for the years between 2013 and 2019/2021. Several countries plan to realise more than one tightening of requirements during this period.	There are several good examples for financial incentives, demonstration programmes, as well as communication and education measures.	The first national NZEB plans were sent in September 2012. The plans will have to be updated every three years and new versions should be prepared based on the best practices that were identified.

5. Lessons learned and recommendations

With many details in the national applications of the Nearly Zero-Energy Buildings (NZEB) definition still under development in a significant number of Member States (MSs), the exchange of information in the Concerted Action EPBD (CA EPBD) has proven to be very helpful for those responsible for the implementation of the EPBD in MSs.

A major challenge is the convergence point between the NZEB definition and the cost-optimal energy performance requirements. Several major parameters cannot be easily predicted over the next five years. These parameters include future performance of new technologies and existing technologies that will be further improved in the coming years, cost developments of technologies, future primary energy factors (mainly for electricity, as well as for district heating and cooling), due to changes in the infrastructure, cost developments of energy carriers, labour and planning, as well as boundaries like changing climate and lifestyle. Therefore, NZEB levels will perhaps need to be based on the updated cost-optimal calculations due by March 2018, at the latest.

The national applications of the NZEB definition need to show a clear direction, although the exact values might still have to be adjusted by the MSs at a later stage, when costs and the other influencing factors become predictable with a higher degree of certainty. However, a clear indication of the tightening range (e.g., 30-50% better energy performance compared to the current requirements) is necessary for the building industry, investors and planners to stimulate timely technological innovations and developments.

NZEB pilot and demonstration projects have been realised in the MSs, along with promotion and subsidy programmes to support their early market implementation. Despite the current financial crisis in Europe, these kinds of projects and programmes should be continued and extended to all European countries and to more types of buildings (many MSs only have experience with one or just a few building types). Experience in some MSs shows that state investment in financial incentive programmes is a win-win situation, because of the payback from the increased number of jobs and tax revenues.

Rehabilitating the existing building stock into more energy efficient buildings remains one of the main difficulties to be overcome, even more so when the targets are as high as they are with the NZEB. MSs must improve their national plans for the gradual tranformation of existing buildings into NZEBs and their long-term strategies for mobilising investment in the renovation of the national building stock, and quicken the pace of implementation. Initial experiences show that it may be difficult to reach the same level of NZEB minimum energy requirements for new and renovated buildings with equivalent timelines, because the cost-efficiency is different. The requirements regarding primary energy use and renewable energy contribution will also have to take into account the resulting costs. A life cycle assessment approach should be considered for the future. This is in accordance with the EPBD NZEB requirements for existing buildings, which refer to the need for continuous policy and financial support, without target dates (contrary to the NZEB provisions on new buildings).

A major focus should be on motivating building owners to renovate buildings to the NZEB level. Therefore, successful examples without subsidies are needed, while unsuccessful examples or negative press articles are significant barriers that have to be overcome. Roadmaps for renovation in several steps might also be helpful.

As stimulation instruments, tax reductions have been suggested together with special programmes for buildings under multi-ownership, pilot projects and a database of successful examples.

Compliance and Control

OVERVIEW AND OUTCOMES

AUGUST 2015

1. Introduction

The Energy Performance of Buildings Directive (EPBD) emphasises compliance and control as vital elements for its successful implementation. This report contains information, statistics, outcomes and conclusions from the dialogue on national approaches to compliance and control during the period 2011-2015.

The discussions within the Concerted Action EPBD (CA EPBD) focused mostly on compliance with the energy performance requirements and control of the Energy Performance Certificates (EPCs). As Member States (MSs) implemented the EPBD, experience of enforcing energy performance requirements and of EPC quality control has grown significantly, but it seems that there are still quite a few substantial challenges preventing the EPBD from being fully implemented and thus acheiving its goals.

Compliance and control issues for inspections have also been addressed. Fourteen countries opted to replace heating system inspections with alternative measures, while seven countries did the same for AC systems, therefore, issues of compliance and control of inspections and inspectors do not apply in those cases. The other countries have, by the end of 2014, already implemented a working approach to monitor and ensure the quality of inspections of heating and cooling systems (sixteen MSs implemented an inspection approach for controlling heating systems and twenty-one for cooling systems). However, not all of them have yet established an active control system for inspectors and/or for inspections and reports.

This report attempts to obtain the relevant information from every MS in the EU. However, as this was not possible for every aspect, the total number of countries covered in some statistics may be less than twenty-eight (or twenty-nine including Norway).

2. Objectives

Directive 2010/31/EU introduced two new obligations for the MSs, in order to improve the quality and effectiveness of its implementation:

> MSs shall lay down the rules on penalties for infringement of the national provisions adopted pursuant to the Directive (Article 27).
> MSs shall implement an independent control system for EPCs and for inspection reports (Article 18). The requirements for the control system are specified in Annex II of the EPBD.

2.1 Enforcing compliance with requirements and rules

The delivery of regulatory outcomes is not only based on how regulations are designed. Experience with the EPBD in recent years showed that regulation without enforcement leads to lack of compliance, while the effective use of sanctions increases compliance with the regulations.

The Organisation for Economic Co-operation and Development (OECD) underlines in its report entitled

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'Regulatory Enforcement and Inspections'[1] that ensuring effective compliance with rules and regulations is an important factor in creating a well-functioning society and trust in the government, and is necessary to effectively achieve a government's goals. The major challenge is to apply enforcement strategies that deliver the best possible outcomes by achieving the highest levels of compliance, while keeping regulatory costs and administrative burdens as low as possible.

The CA EPBD focussed on enforcement strategies, actions to improve the compliance rate and sanctions to penalise infringements.

2.2 Independent control system

In order to maximise the potential benefits of the EPBD and to achieve credibility in the market, not only compliance checks but also quality control of the issued certificates are both essential. The CA work focussed on:

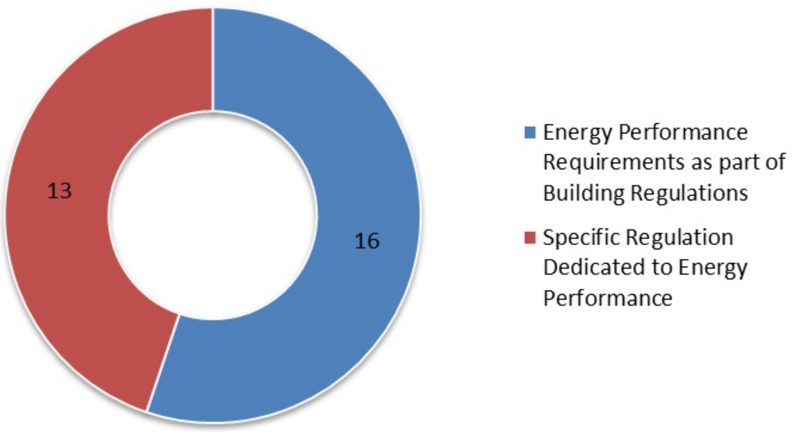
> how to set up and run an independent control system;
> the necessary sample size, both for random and targeted controls;
> quality monitoring and analysis of the control results.

3. Analysis of insights

3.1 Checking compliance with the energy performance requirements for new and renovated buildings

The energy performance requirements for new and renovated buildings are one of the key elements of the EPBD (Articles 4, 6 and 7 of Directive 2010/31/EU).

Figure 1: Types of legislation for energy performance requirements in new and renovated buildings.



Moreover, MSs should tighten requirements in the coming years to reach Nearly Zero-Energy Buildings (NZEB) by 2021 (Article 9).

Many MSs focused compliance checks on energy performance requirements before the introduction of Directive 2010/31/EU, although the establishment of sanctions was only formally required by Article 27. Since January 2013 at the latest, MSs must apply penalties to infringements of their regulations implementing the EPBD.

3.1.1 Two different approaches

In general, two different approaches to energy performance requirements exist in the legal frameworks (Figure 1):

1. The approach through building regulations. Building regulations contain requirements in different areas like fire safety, structural safety, acoustics, waste disposal, building accessibility, electrical safety, ventilation and energy performance. With this approach, energy performance is just another requirement included in the general building regulations. The UK, Ireland or The Netherlands are typical examples of this approach.
2. The approach, adopted e.g., in Belgium and in Portugal, of a dedicated regulation for buildings' energy performance requirements.

This difference in legal frameworks can influence the rules on proof of compliance, the framework for sanctions for infringements and the duties of the controlling authority. If the energy performance regulation is part of the building regulation (as in the first approach), the sanctions are in most cases the same for all kinds of infringement. If the legislation is separate, the control system and sanctions can differ from those for other infringements related to new or renovated buildings.

Experience shows that it is often more challenging to enforce energy performance requirements if they are part of a global building regulation or if one authority is in charge of controlling all building requirements. As resources and budget for enforcement are limited, some MSs have to make a difficult choice between different requirements to enforce.

[1] *OECD (2014), Regulatory Enforcement and Inspections, OECD Best Practice Principles for Regulatory Policy, OECD Publishing http://dx.doi.org/10.1787/9789264208117-en*

3.1.2 Responsibility for compliance

The holder of the building permit is, in general, the person responsible for compliance with energy performance requirements. However, special provisions to protect private builders and buyers of new buildings may exist, as is the case in Belgium: the legislation appoints the developer and/or the professional advisors (e.g., designer, architect, energy expert) as (co)responsible for the building's compliance with energy performance requirements. The relevant energy expert (e.g., architect or engineer) is in charge of calculating the energy performance, and is responsible for the accuracy of this calculation.

3.1.3 When to check compliance

There has been significant evolution in the way MSs check compliance with building regulations. Where calculations in the design stage were, in the past, the most important proof of compliance with energy requirements, the majority of MSs now undertake a double check:

1. During the design stage, the fulfilment of the requirements is checked for the first time. This usually takes place when obtaining the building permit. This check is essential to ensure that the construction specifications take into account all measures necessary to reach a certain level of energy performance.
2. When the construction phase is finished, a second calculation and proof of compliance is undertaken. This second check is crucial to ensure that the building, as it has been built, complies with the requirements. In three MSs, the regulations include provisions to check the building's real energy consumption after it comes into use.

In 2014, twenty-one MSs (up from ten MSs in 2010) asked for proof of compliance at a certain point after construction was complete. The other countries check compliance at different phases or even only through random checks (see Figure 2).

3.1.4 Instruments used to check and demonstrate compliance

The calculation methodology for new and refurbished buildings is described in national and/or regional legislation, or by means of a national standard. Seventeen countries have public software. In four countries, the public software must be used exclusively, while the remaining countries have a mixed system with public software for some building types and commercial software for other building types. Twelve MSs have a free market with only commercial software. In most cases, commercial software is required to pass a validation test before it is recognised by the MS.

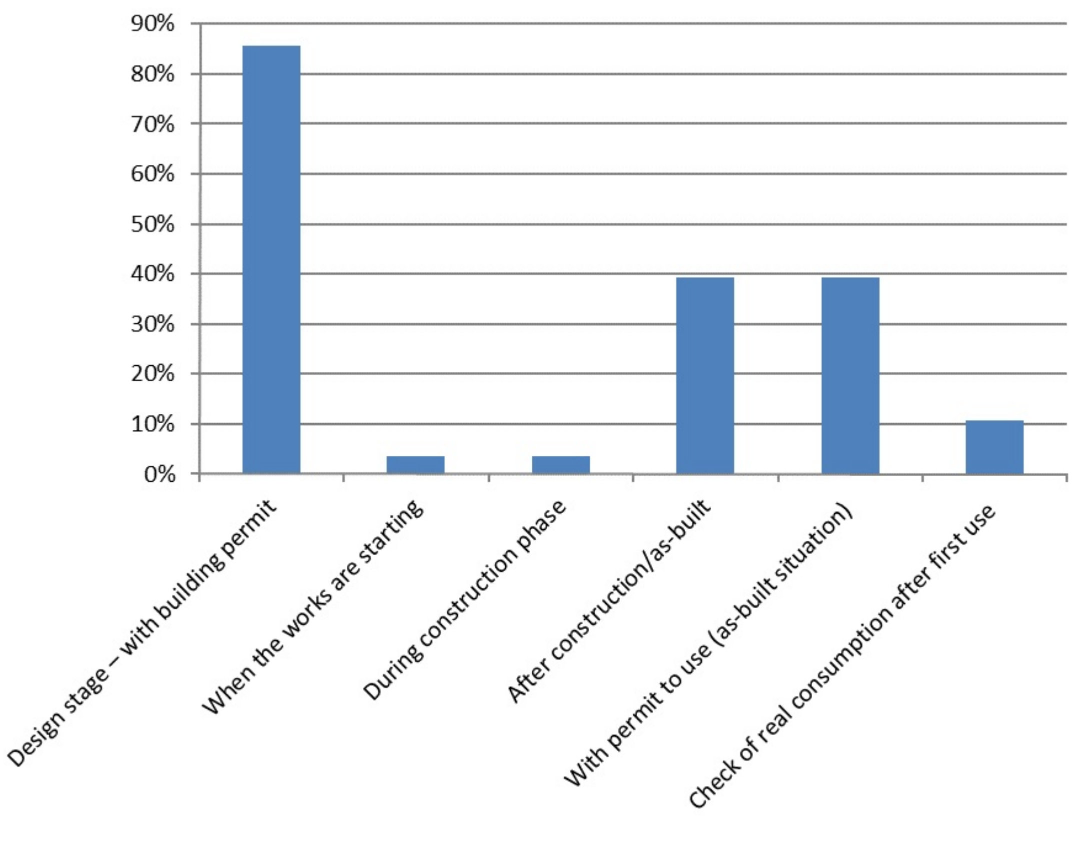


Figure 2: When is compliance with energy performance requirements checked for new buildings? (2014)

The first step to check compliance should be built into the software, which can give quick feedback to experts and builders and generate documents containing the relevant information. In some MSs, e.g., in Belgium, where fines are used as a sanction, the software immediately calculates the fine for a non-compliant building project (Figure 3). Knowing the amount of the fine is useful feedback for the expert and builder, and it can also be key to a smooth infringement process.

For the as-built proof of compliance, MSs use the Energy Performance Certificate (EPC) or other specific forms (Figure 4).

A central database or registry of EPCs for new or renovated buildings is available in twenty-four countries. In the five remaining countries, this kind of tool is either under development or planned for the future. A central database makes it possible to build an efficient compliance checking process and system. In certain countries, the database is restricted so that buildings that do not comply with energy performance requirements are unable to send in their results. This is a delicate decision, as it could trigger fraud: when the building does not meet the requirements, the expert could submit a deliberately false calculation that complies with the requirements, simply to obtain the EPC.

Although not specifically mentioned in the EPBD, an independent control on the energy performance calculations for new and renovated buildings is necessary in order to verify that the expert has made a correct calculation of the 'as-built' situation. As this control is very similar to the independent control on EPCs for existing buildings, it is addressed in 3.2.

Checking compliance with energy performance requirements is crucial to achieve energy efficiency in buildings in practice.

Checking compliance in the planning phase is necessary to ensure all provisions are taken into account before construction begins.

Checking compliance with the requirements after the construction phase is necessary because a large number of building projects change between the planning phase and the actual construction.

The first step is a check for compliance using the software. The EPC of a new building should contain an indication of its compliance with energy performance requirements.

The inclusion of information about new and refurbished buildings' compliance in a central database enables the operation of a smart enforcement scheme and monitoring of the compliance rate. The existence of such databases is now widespread.

3.2. How do MSs make the EPC reliable through independent controls

The EPBD requires the introduction of an independent control system for the EPC and for inspection reports on heating and AC systems (Article 18). When 'EPC' is mentioned in this chapter, this also refers to the control of the 'energy performance calculations' for both new and renovated buildings, which is very similar to or in some cases the same as the control on the EPC.


Scheidingsconstructies eisen (U/R)

Eisen zijn niet gerespecteerd

Boete

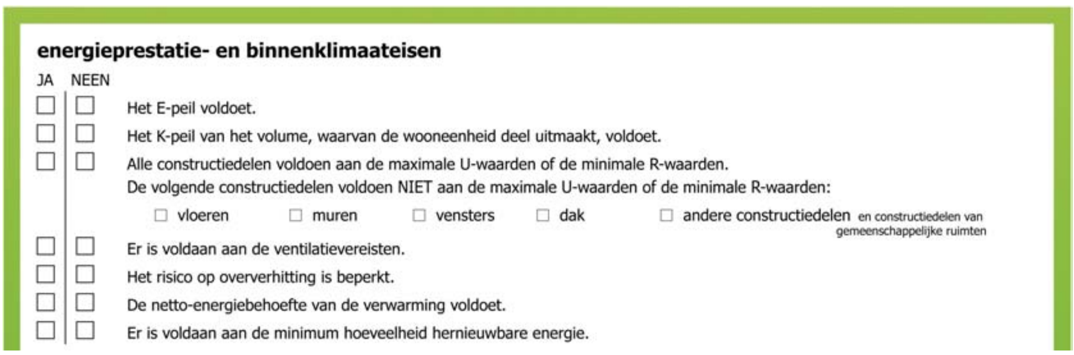
De totale oppervlakte die onderworpen is aan de 2% regel : **383,79m²**.

Voor ten hoogste 2% van de oppervlakte die hierboven vermeld wordt, moet niet voldaan worden aan de eisen, dit is **7,68m²**.

Indicatieve boete na het toepassen van de 2% regel : **696,54 EUR**.

Indicatieve boete: **696,54 EUR**

Figure 3: Example of a warning in the software in Belgium, which appears if required levels are not met, and with calculation of the administrative fine.


energieprestatie- en binnenklimaateisen

JA	NEEN	
☐	☐	Het E-peil voldoet.
☐	☐	Het K-peil van het volume, waarvan de wooneenheid deel uitmaakt, voldoet.
☐	☐	Alle constructiedelen voldoen aan de maximale U-waarden of de minimale R-waarden. De volgende constructiedelen voldoen NIET aan de maximale U-waarden of de minimale R-waarden: ☐ vloeren ☐ muren ☐ vensters ☐ dak ☐ andere constructiedelen en constructiedelen van gemeenschappelijke ruimten
☐	☐	Er is voldaan aan de ventilatievereisten.
☐	☐	Het risico op oververhitting is beperkt.
☐	☐	De netto-energiebehoefte van de verwarming voldoet.
☐	☐	Er is voldaan aan de minimum hoeveelheid hernieuwbare energie.

Figure 4: Example of part of the EPC of a new building where compliance with energy performance requirements for new buildings is displayed (Belgium - Flemish Region).

Independent control systems on EPCs were already introduced for implementation of Directive 2002/91/EC in twelve MSs before 2010, when it became a requirement with the adoption of Directive 2010/31/EU. In eleven MSs, EPC quality control systems appeared more recently (from 2010-2013). By 2014, twenty-seven countries (out of twenty-nine) had an operational independent control system for EPCs (Figure 5).

The control systems situation for inspections, however, is different. Among the sixteen MSs where heating systems inspection is undertaken, only seven have established a control system. Among the twenty-one MSs that have opted for AC inspections, six MSs organised a control system and two others have it ready but have not yet begun implementation. The other MSs are still in the preparatory phase and do not yet have control systems in operation.

3.2.1 The responsible authority

MSs can delegate implementation of the control system to third parties according to Article 18 of the EPBD. Seven countries have appointed a third party to run the EPC control system. These third parties are often the same as the accredited bodies responsible for expert certification. In the other twenty-two countries, the central or regional government, or a governmental agency, runs the EPC control system. Some MSs, including Denmark and The UK, ask that the certified companies run an internal quality assurance system, in parallel to that of the government.

Of the six MSs that have an operational control system for AC inspections, two MSs entrusted this task to a third party and four have a public control system in place. For system owners who do not comply with the obligation to undertake regular maintenance in countries where it is compulsory, there is a fine (e.g., Italy). The chimney sweepers (in countries where they are responsibile for heating inspections) oblige the occupant to submit the boiler for inspection. None of the MSs engaged in heating inspections opted for third party quality control.

3.2.2 The control sample

The EPBD states that a statistically significant percentage of all EPCs or inspection reports issued annually must be controlled through a random sample.

Figure 5: The year when MSs began to apply the independent control system.

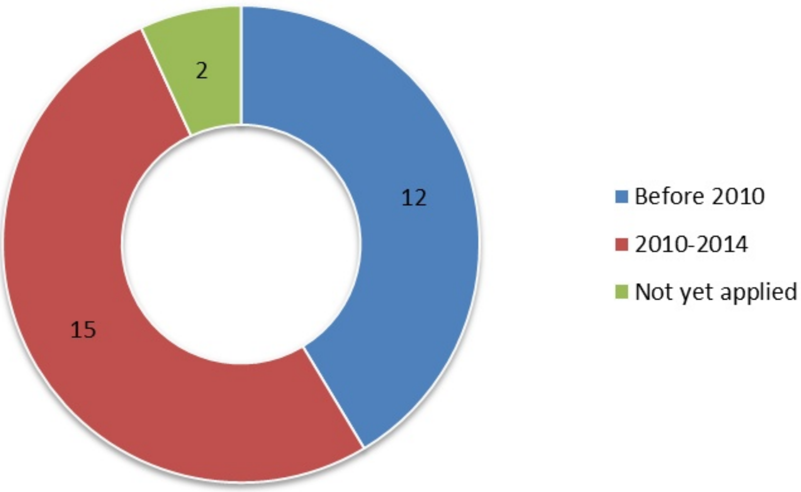


Table 1: Random sample size necessary to ensure statistical confidence (Source DG Energy).

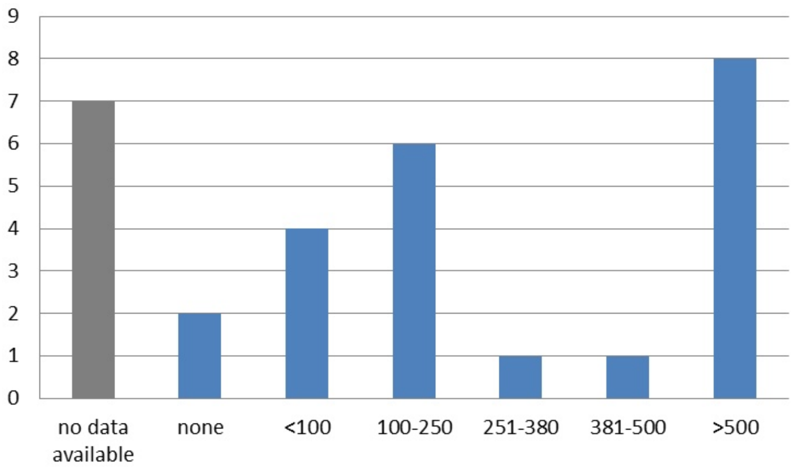
Population size	Sample size	Significant percentage
100	80	80.000%
200	132	66.000%
500	217	43.400%
1,000	278	27.800%
2,000	322	16.100%
5,000	357	7.140%
10,000	370	3.700%
20,000	377	1.885%
50,000	381	0.762%
100,000	383	0.383%
200,000	383	0.192%
500,000	384	0.077%
1,000,000	384	0.038%

This random sample is used to provide an understanding of the overall quality of the EPCs or inspections. In statistics, both the confidence interval and the confidence level are needed in order to define a statistically significant percentage. In the context of the Energy Performance of Buildings Committee, the EU Commission services estimated that a confidence interval of 5% with a confidence level of 95% would be suitable for this type of independent control. This means that the result has a 95% probability that the sample gives a compliance rate at ±5% of the actual population compliance rate (which is unknown). The control of a sample of randomly selected EPCs shown in the table (Table 1) ensures that the control results for the sample can be trusted as an accurate estimate of overall EPC quality.

Many MSs note that the cost of and workload for the independent control system is a significant factor that leads to a possible random sample that is not large enough. In practice, one MS did not control a random sample and one MS did not control at all. In 2014, at least eleven MSs used a random sample that was too small, especially when the sample is split up into subsamples (e.g., new/existing buildings or residential/non-residential buildings (Figure 6).

Subsampling can be necessary to establish compliance rates when the method (calculation procedures, inspection protocol) differs, as between residential and non-residential buildings. Also a different sample for new and renovated versus existing buildings seems necessary, as there are risks of fraud. For existing buildings, there is a risk of fraud in order to obtain a better EPC and thus influence the sale price or the speed of the buying/selling process. For new or renovated buildings, there is a risk of fraud when buildings do not comply with the requirements. In that case, the owner can put pressure on the expert to make false calculations to avoid the penalties for not fulfilling the requirements.

Figure 6: Size of the random samples in MSs.



Eighteen MSs use a type of targeted control in addition to the random sample, based on several criteria (Figure 7). The targeted control enables MSs to have the most significant impact on experts who deliver poor quality EPCs with the available resources (cost-efficiency). MSs use it to check the correct application of the EPC and the energy performance requirements and also in some cases to check compliance with different requirements. A random control is useful in order to evaluate the quality of the whole body of EPCs, while a targeted control is better suited to detect bad EPCs and experts who produce problematic EPCs.

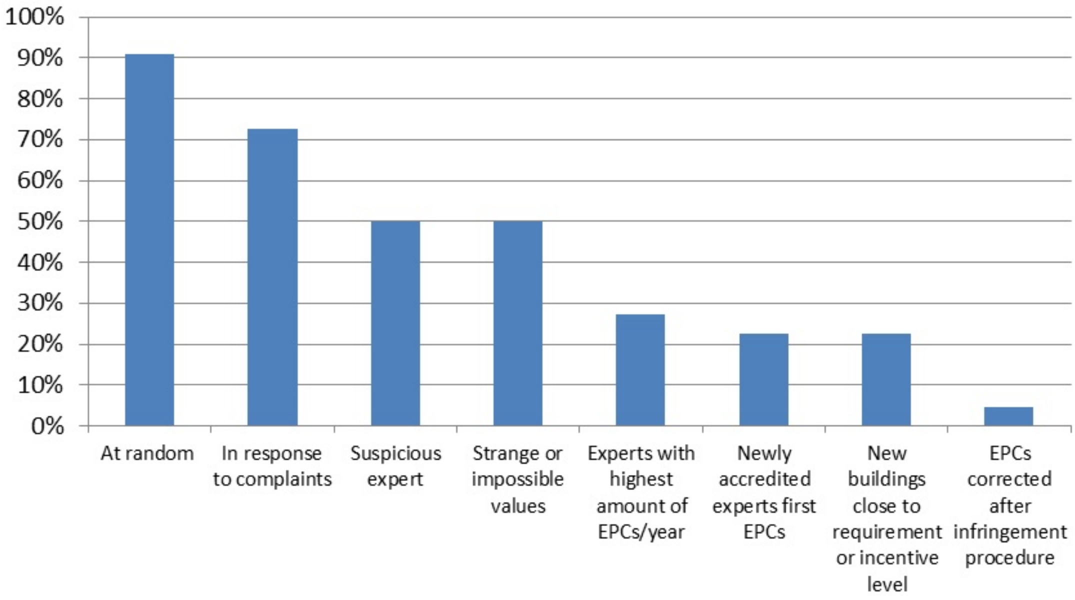
Some MSs believe that each certificate should be randomly subject to controls irrespective of the expert, while other MSs prefer that the expert rather than the certificate be subject to control.

3.2.3. Smart options for quality control

Even if an effective independent control system can be organised with or without a central EPC database, the MSs using such databases recognise them as an essential element of their EPC scheme and an important factor for high compliance rates. Statistics regarding the availability of central EPC databases in the MSs are mentioned under 3.1. These databases are used to issue certificates, to perform control checks, to crosscheck specific certificates, and for datamining and statistical purposes.

Recent developments in MSs show that interconnected databases can be a powerful tool for the control process. One such application enables an investigation

Figure 7: Reasons to perform a targeted check.



of whether a building with renewable energy installations (information from the EPC database) has effectively applied for green certificates (information coming from a second database) and vice versa.

The energy performance calculation and often also the inspection methodology are implemented through software. Experience shows that if there are no validation rules in the software, experts make a number of avoidable mistakes that can have a huge influence on the EPC rating. Integrating validation rules into the software is an excellent and easy step to avoid most inaccurate or incomplete input data. In 2013, nine MSs had implemented a scheme to validate input data. The control system can identify the validation rules, e.g., frequent errors made by experts. A good set of validations in the software or the database can replace the validity check according to option A of Annex II of the EPBD (see 3.2.4). Implementing validation rules in the software is an easy and very cost-efficient measure to improve the quality of every EPC or inspection report. Typically, out-of-range values (e.g., surfaces, volumes), or specific parameters below or above a threshold or expected value (e.g., efficiency, performances of installations) are used as validation rules (Figure 8). Linking different parts of the calculation procedure also allows the identification of impossible or improbable values (e.g., energy use for fans is necessary for mechanical ventilation).

3.2.4 The different means of controlling quality

Annex II of the EPBD indicates different means of control and defines different options as presented in Table 2. Only four MSs control only according to Option A of Annex II (validity checks of input data used to issue the EPC and of the results stated in the certificate). Most MSs (nineteen) indicate that they combine options A, B and C. Only two MSs indicate that they use option C alone (the most complete option). However, in practice, thirteen MSs have not implemented any kind of control yet, in spite of having defined the control mechanisms in legal documents.

In addition to desk audits, on-site controls are also used. On-site controls are in general used less frequently than desk controls, as they are more time consuming and it is often difficult to get access to the building or building site. Only fifteen MSs reported undertaking on-site controls. Of eight MSs that published figures on the kind of control they use, four MSs do on-site controls in less than 2% of all control cases, one MS in around 8%, and two MSs in 17%. Only one MS reports on-site control as the most common type among the various control types they use. The other MSs only do desk control.

In some MSs, authorities visit the building at the same time as the expert. This avoids the problem of access to the building, but takes away some of the control possibilities. If the control officer and the expert visit the building at the same time, the expert is warned and will thus not commit a fraud that he might otherwise in cases where there was no control officer present.

A review of the reports made in the office can reveal inaccurate or false data at a lower cost, although on-site control is the

Figure 8: Types of validation rules implemented in EPC software or in the central database.

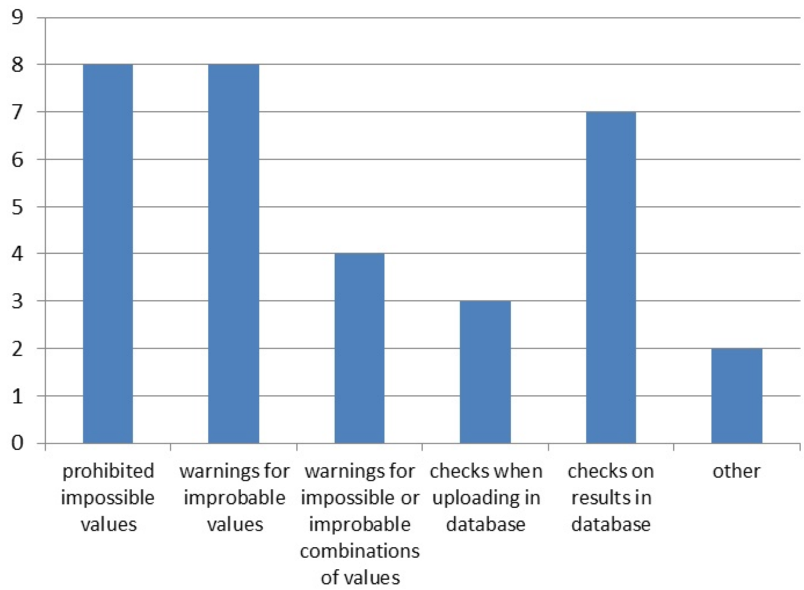


Table 2: Control options as defined in Annex II of Directive 2010/31/EU.

EPBD-recast Control Option	Input data	Calculation results	Recommendations	On site visit
A	Validity check	Validity Check	-	-
B	Check	Verification	Verification	-
C	Full check	Full verification	Full verification	-
C*	Full check	Full Verification	Full verification	Check correspondance
E(quivalent)	...	...	...	...

most thorough, and often the only way to identify bad, false or incongruous figures or cases of fraud. In both cases, the level of detail of the control can vary significantly - from a limited investigation of very specific elements to full control of all elements. Specifications of the evidence for input data is made in most MSs and is linked to verification possibilities and methods.

Surveys of the relevance of controlling different areas revealed that the control system should evaluate not only the input data, the heating or AC system information, the accuracy and the relevance of the recommendations, but also the completeness of the report and the independent nature of the recommendations.

MSs apply both random controls to assess the compliance rate, as required by the EPBD, and targeted controls to enforce the quality and compliance of the EPCs and inspections.

Several interpretations of the statistically significant percentage of EPCs to control, as described in the EPBD, exist in Europe. The control samples in MSs are generally below the target guidelines defined by DG Energy.

Smart options for control, through linking different databases and validation rules, were developed by several MSs. The majority of controls are desk-based and do not include a site visit, although this is often the only way to detect fraud.

Figure 9: Year when the requirement for the inclusion of the EPC in advertisements came into force in MSs.

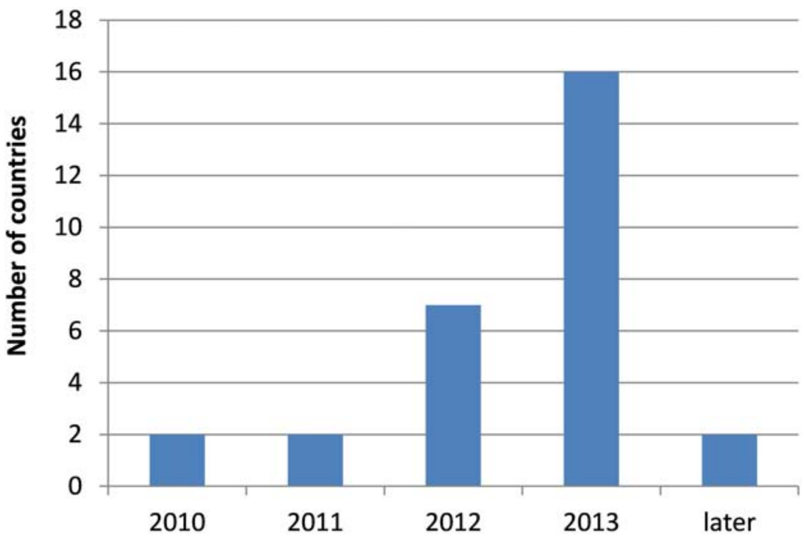
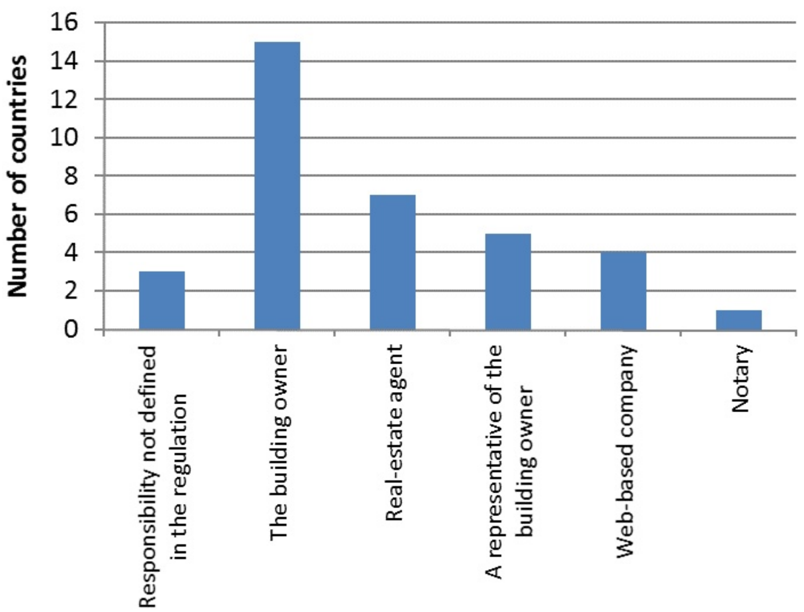


Figure 10: Actors responsible for compliance with the advertisement requirement.



3.3 Checking the requirement of including the energy rating in the advertisings

The EPC is used to provide insights into a building's energy performance for potential buyers or tenants. In order to play this role, the EPC has to be available at an early stage. The EPBD mandates the publication of the EPC in advertisements in commercial media (Article 12 §4). In the majority of MSs, this requirement came into force in 2012 - 2013 (see Figure 9).

3.3.1 Responsibility for placing the information in the advertisement

Several actors can be considered responsible for compliance with the advertisement requirement. The building owner is mentioned as one possibility in most MSs (fifteen MSs, see Figure 10). Other actors, such as real-estate agents, representatives of the building owner, web-based companies or notaries are also mentioned in the regulations as responsible for compliance with this requirement. Three MSs did not define who is responsible for compliance and thus, in these cases, enforcing this requirement is nearly impossible.

3.3.2 Controls

In 2013, responsibility for controlling compliance with the advertisement requirement was not clearly defined in five Member States, where it is practically impossible to enforce compliance. In the MSs where controls are undertaken, random checks (in eight MSs), as well as targeted controls in response to complaints (in ten MSs), are the most common methodologies.

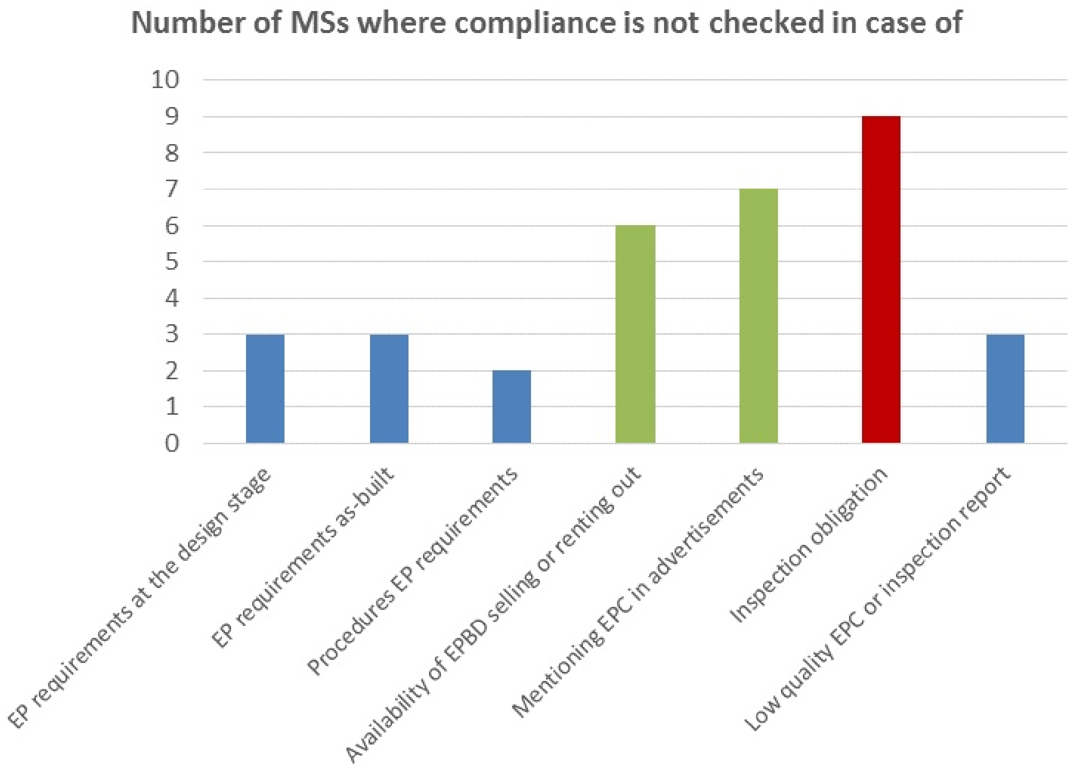


Figure 11: Number of MSs where compliance with the different obligations under the EPBD was not checked in 2013 (twenty-four MSs, March 2013).

The compliance rate for this requirement was known in only one MS, where communication with and control of real estate agents has led to an improvement in the compliance rate from 47% in the first year to 95% three years later.

Although the obligation to include the energy rating in advertisements exists in most MSs, there is very little enforcement. In a few MSs, the regulation does not even define who is responsible for enforcement, nor does it include penalties for non-compliance.

Even if overall there is a general compliance with this obligation in many MSs, in 2014 figures on the effective compliance rate were available in only one MS.

3.4 Sanctions

The imposition of sanctions is an essential part of an enforcement system. There is no point in checking compliance if infringements are not sanctioned. Penalties should be used in cases of non-compliance with the regulation, e.g., in reaction to severe neglect by the builder or developer (compliance checking), the owner (failure to issue an EPC, absence of the energy label in advertisements and failure to display the EPC in public buildings frequently visited by the public), or to false reporting of actual energy performance or other severe instances of non compliance by the expert (independent control).

Most MSs have accounted for sanctions in their legislation, but it must be noted that some MSs do not have explicitly defined sanctions. Reference to sanctions in the legislation does not necessarily mean that compliance with requirements of availability and display of the EPC is monitored and that sanctions are laid down in practice. An enquiry in 2013 revealed that a number of MSs do not check compliance with one or more of the EPBD requirements (Figure 11). Several examples of sanctions in the case of non-compliance with several EPBD requirements are discussed in the rest of this section.

3.4.1. Non-compliance with energy performance requirements

For new and renovated buildings, it is necessary to lay down sanctions in practice to discourage non-compliant builders from deriving a commercial advantage, relative to compliant builders, by avoiding the investment needed to ensure compliance.

The difference in legislation approaches (building regulation or separate legislation) influences the framework for sanctions on infringements (see 3.1.1).

Penalties for non-compliance are generally imposed on the builder or the developer. When a building does not meet the energy performance requirements in the design stage, the usual sanction is that the building permit is not granted.

Figure 12: Sanctions in case of non-compliance with energy performance requirements in the design stage (from a sample of twenty-four MSs, March 2013).

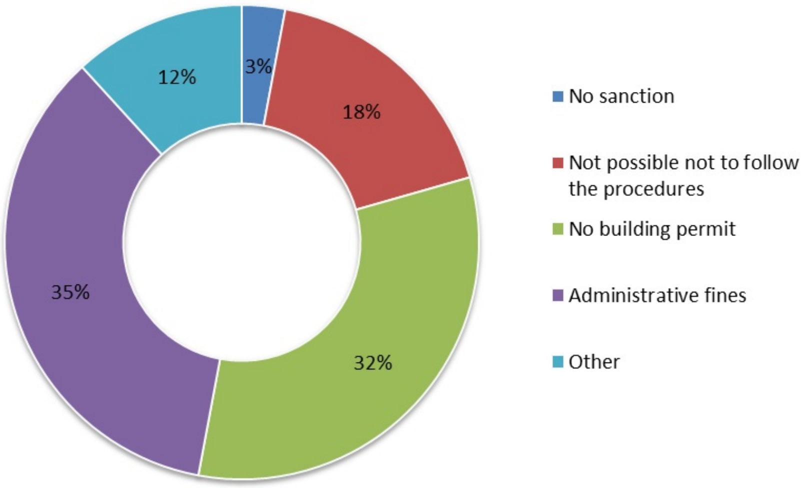
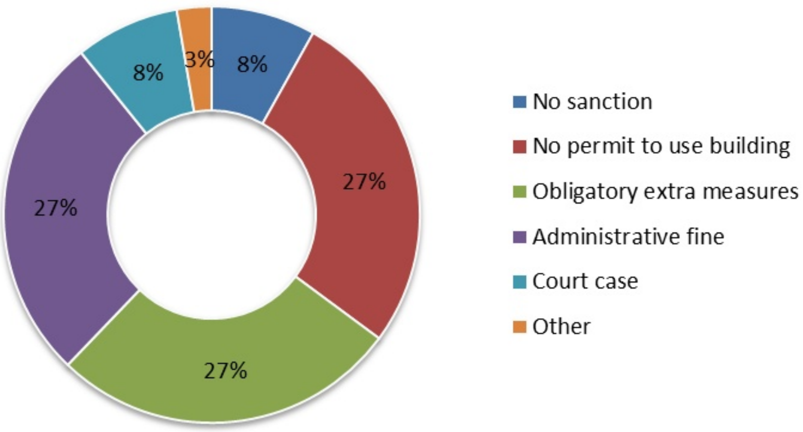


Figure 13: Sanctions in case of non-compliance with energy performance requirements in the 'as-built' stage (from a sample of twenty-four MSs, March 2013).



The design must be adapted until the building complies (Figure 12).

When the building does not meet the energy performance requirements as-built, one or more of the following types of sanctions are commonly laid out in MSs regulations (Figure 13):

> the use of the building is prohibited (with the implicit obligation to take extra measures until the building complies);
> the obligation to take extra measures until the building complies, within a certain period;
> administrative fines;
> court cases.

The experiences of some MSs showed that the type of sanction has a significant impact on the effectiveness of enforcement and on the compliance rate. In the design phase, necessary adaptation of the project is quite effective. During construction, the obligation to implement extra measures can also be an appropriate sanction. In the as-built phase, the obligation to take extra measures is sometimes not an appropriate sanction. Some requirements (e.g., ventilation, airtightness of slab insulation), cannot always be corrected through mandating extra measures. In that case, other types of sanctions, e.g., administrative fines, are more appropriate.

Sanctions during the design stage are quite effective, as in 75% of the MSs non-conformity in the design stage leads to rejection of the building permit. Sanctions during the as-built stage are less commonly laid down in pratice. A number of MSs have arrived at a system where proof of compliance is required for all buildings during the as-built stage (see 3.1.3).

Some MSs, like Belgium, have extensive successful experience with imposing administrative fines. Some MSs effectively sanction non-compliance by not granting the permit to use the building. Other MSs only control compliance in the as-built stage, based on a random sample of all or only one requirement. Random sampling seems inappropriate as a means to detect and sanction non-compliance because the likelihood of inspection can be very low. The low probability of being checked can lead to a sense that fulfilment of the requirements is not important at all and the result will be similar to the situation in MSs where there is no control at all in the as-built phase, or where every citizen is assumed to act according to the rules, without enforcement.

3.4.2 Sanctions in case of non compliance with other EPBD requirements

The most frequent sanctions in cases where the EPC is not provided at the point of sale or rent are administrative fines (in ten MSs). In one country, the building cannot be sold or rented (without an EPC). It must be noted that seven MSs did not define sanctions in their regulation. However, in practice, only two MSs actually apply sanctions in cases of non-compliance.

When the EPC is not included in advertisements, the most common sanction is a fine (in ten MSs). Eight MSs did not explicitly define the type of sanction in their regulations. In practice, by 2014, sanctions for non-compliance had been applied in only two MSs.

The most common sanctions for the absence of an inspection report are fines (in twelve MSs). In some MSs, a court case is possible, in theory, if the inspector reports false irregularities in the system, in view of getting money from repeated inspections. In several MSs, no sanction is laid out in the legislation.

The most frequently used sanctions for low-quality EPCs are administrative fines (in eleven MSs), temporary (in fifteen MSs) or definitive (in seventeen MSs) withdrawal of the accreditation of the expert responsible for the EPC data, or the obligation to produce a correct EPC at no cost to the owner.

The most common sanction for poor quality inspections is the removal of an inspector's accreditation, in the event of malpractice.

The quality control of inspections requires sanctions when reports do not comply with the necessary level of accuracy in reporting results and recommendations. In extreme (and rare) cases, an inspector who violated the requirement of independence or the correctness of behaviour with the client was sanctioned through the cancellation of his/her authorisation to make inspections. The inspection then must be repeated by another inspector.

The imposition of sanctions is an essential part of the enforcement system. For specific types of non-compliance, some MSs did not define the sanction in their regulation. According to the type of non-compliance, the sanction can be imposed on either the building owner or on the experts.

Sanctions for experts are applied in most MSs as a result of non-conformity detected by the independent control system. Compliance during the design stage is effectively ensured by linking it with the building permit.

Sanctions for other EPBD-related infrigements are either non-existent or negligible in almost every MS. Much improvement is needed, and this is one of the important topics for the future.

Non-compliance with requirements when a building is assessed 'as-built' should be sanctioned in every case.

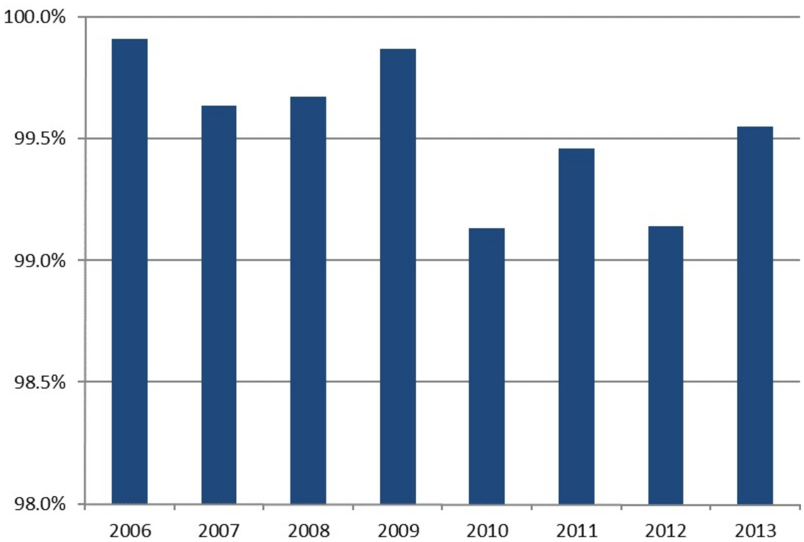
Much improvement is also needed in the monitoring and sanctioning of non-compliance with EPC issue and display and the issuing of the inspection reports.

3.5 Monitoring the quality of the EPC and compliance rates

Monitoring the compliance rate is essential in order to evaluate the efficiency of the regulation. The compliance rate of the different EPBD obligations should thus be a key performance indicator for every ministry, agency or organisation in charge of EPBD implementation.

The examination of compliance and control from 2007-2010 revealed that only a few MSs had a clear understanding of compliance rates or the quality of EPCs or inspections, or even tried to obtain such information. From 2010-2014, this scenario has not improved much: only half of the twenty-four MSs that reported on this issue indicate that they have figures on the compliance rate of new buildings ('as-built') with energy performance requirements. In some MSs, e.g., France, the 'as-built' compliance rate concerns compliance with all building requirements (i.e., also fire safety requirements), or is derived only from a limited control sample. Other MSs, e.g., Greece and Cyprus, monitor the compliance rate, but do not publish this information. Some MSs, e.g., Denmark and Latvia, plan to obtain information on the compliance rate by adding analysis tools to their database or linking/building new databases. Most MSs have no plans to get a picture on compliance rates.

Figure 14: The compliance rate of new buildings with the energy performance requirement 'E-level' during the 'as-built' phase in the Flemish region of Belgium.



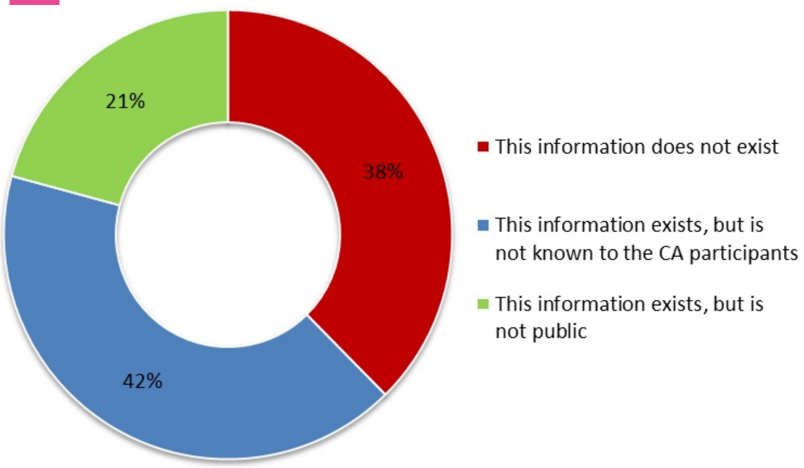


Figure 15: Number of MSs that have information on the percentage of good quality EPCs as result of the independent control of a random sample.

The few MSs that report compliance rates indicate figures around 80%, with one MS indicating compliance for new residential buildings between 94% and 98%, and from 75% to 85% for new, non-residential buildings. Figure 14 shows an example of new buildings' rate of compliance with energy requirements during the 'as-built' phase in the Flemish region of Belgium. The Flemish region lays down administrative fines for infringements of the energy performance requirements. This leads to very high rates of compliance with energy performance requirements 'as-built.' The compliance rate with all requirements (including ventilation rates) has been around 97% since 2010.

A defined percentage of good quality EPCs is one of the essential outcomes of the independent control system. Knowing this percentage is essential in order to monitor the quality of the EPC scheme and to efficiently manage the independent control system. Actions to improve the overall quality of the EPC scheme or to apply sanctions in a more effective way will result in a higher percentage of good quality EPCs. Many MSs still do not have an understanding of EPC quality (based on a random sample) (Figure 15). As MSs use different criteria to define EPC quality, it is difficult to compare the overall quality of the EPC scheme among MSs, but some MSs indicate that 60% to 80% of the controlled EPCs are of good quality.

Significant progress is needed in most MSs. Monitoring the compliance rates with all EPBD requirements and the percentage of good quality certificates or inspection reports should be required for all MSs. This information is vital to analyse the efficiency and efficacy of the schemes and of their enforcement, and to improve the system, if MSs seriously intend to implement a credible, effective system rather than just putting some requirements into law in order to satisfy the EPBD but without making real efforts to make it work and produce the intended benefits.

In 2014, only half of the MSs monitor the rate of compliance with the requirements for new and refurbished buildings, with some monitoring a very limited sample or monitoring compliance with all building requirements (not just energy performance). Even fewer have an accurate view of EPC quality derived from a random sample.

As the compliance rate and a clear picture of the quality of EPCs and inspections are essential information to evaluate the efficacy of the regulation, this remains a challenge in many MSs.

4. Main outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Timing of compliance checks	MSs can check compliance with building regulations at the design stage and/or at the end of the construction phase ('as-built').	The final check at the end of the construction phase is crucial to ensure actual compliance with requirements. A number of MSs made progress in this direction.	Compliance checks at the end of building works ('as-built') make the regulations more efficient and should be encouraged for all MSs.
Objectives of the independent control system	The control system is used to assess and ensure the quality of the EPCs, of the inspection reports and of energy performance calculations.	Two types of control are needed to achieve these goals: randomly selected controls (required by the EPBD) and targeted controls (not mentioned in the EPBD). Many MSs have yet to recognise the benefits of the combination of both types.	Many MSs still need to further develop the implementation of randomly selected controls.

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
The size of randomly-selected control samples	The EPBD allows for interpretation of “a statistically significant percentage of randomly selected controls”. Guidelines have been provided by DG Energy.	The minimum sample size will substantially increase if MSs want to obtain information on sub-samples (e.g., regional differences, new versus existing buildings, etc.).	The size of random samples is too small in most MSs, and most MSs need to make substantial improvements.
EPC quality	In 2014, quite a few MSs still do not have an idea of the percentage of ‘good’ quality certificates.	Knowing the percentage of ‘good’ quality EPCs is necessary to evaluate the EPC scheme and to develop action to improve it.	All MSs should have a clear definition of a ‘good’ quality EPC. They should know the overall quality of EPCs, based on a random sample.
Inspection controls	Very few MSs have adopted systems to control the quality of inspection reports.	Quality control performed by public authorities could increase citizen confidence in the relevance of MS-imposed inspections.	Wider collaboration among MSs is necessary to identify cheap and effective forms of quality control.
Sanctions	Effective, proportionate and dissuasive sanctions and their practical application could still be further developed in several MSs.	The application of sanctions is essential for enforcement, and checking compliance is pointless if infringements are not sanctioned. Effective sanctioning leads to better compliance.	Very few MSs have applied sanctions in EPBD-related issues. Strong action is needed, otherwise compliance and quality cannot be ensured.
Monitoring the rate of compliance with minimum building requirements	In 2014, only half of the MSs monitor the rate of compliance with regulation requirements, some based on a very limited sample.	Monitoring the compliance rate is essential for understanding the efficacy of regulations and for improvement.	MSs should be required to monitor compliance rates and to publish the results.

5. Lessons learned and recommendations

Directive 2010/31/EU drew attention in many MSs to compliance and to independent quality and compliance control systems through its specific requirements for independent control systems and the implementation of related rules on penalties applicable to infringement of the national provisions adopted pursuant to the Directive. Many MSs introduced legislation for compliance and control systems, or adapted existing legislation in recent years. Many MSs experienced similar challenges and used lessons learned to improve or implement solutions. Further exchange of successes is desirable to improve the performance of the EPC scheme and the control system, and to curb fraud.

Athough effective compliance is essential to achieve an improvement in energy performance of the European building stock, compliance and control systems were often overshadowed by efforts by governments and stakeholders to reduce regulatory impact, including sanctions, and to remove ‘unnecessary burdens’, resulting in far from ideal and less effective regulations. Moreover, regulators in many MSs are increasingly under pressure to do ‘more with less’ which leads too often to very poor compliance checking or to very limited or light control systems with very limited resources. There is certainly much room for improvement to check compliance with the EPBD requirements in most MSs, as well as with issuing sanctions.

For checking requirements in new buildings, compliance checks in the ‘as-built’ phase of all buildings should be the standard. Experience with effective sanctioning shows that very high compliance rates in all new and refurbished buildings can be attained while keeping the burden on citizens and the government at a reasonable level.

Almost every MS developed an independent control system for EPCs. As the control system is a measure to ensure quality and is described in the EPBD in more detail, the political will and the resources to implement it are usually greater than those for compliance checking. There are some examples of innovative approaches and best practices in control systems, e.g., validation rules and the use of databases. Validation rules in the software or when uploading the EPC to the database could even substitute type A checks as defined in Annex II of the EPBD. These best practices are worth further exploration and wider application.

Clear guidance on the random sample size and the necessary subsamples, as well as recognition of the additional benefits from targeted controls would help MSs to allocate sufficient budgetary resources to exploit a qualitative independent control system.

For the issuing of the EPC or inspection reports and for the display of the EPC, a compliance check of a broad random sample is necessary while the compliance rate is low, as in most MSs at the end of 2014.

Unbiased monitoring of compliance rates is vital to determine the impact of the regulations on the energy performance of new and refurbished buildings, for inclusion of the energy rating in advertisements, for the availability of the EPC at the moment of sale or rental, for the correct display of the EPC in public buildings, and for the availability of inspection reports. Monitoring and publishing the rates of compliance with all EPBD requirements and the percentage of good quality certificates or inspection reports should be required for all MSs. This information is vital to analyse the efficiency and efficacy of the schemes and of their enforcement, and to improve the system, if MSs seriously intend to implement a credible, effective system rather than just putting some requirements into law in order to satisfy the EPBD but without making real efforts to make it work and produce the intended benefits.

Most MSs still perform too weakly on all, or at least a few of these points. This must be a priority action area in the future.

Effectiveness of Support Initiatives

OVERVIEW AND OUTCOMES

AUGUST 2015

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1. Introduction

Finance, information and coordination are vital elements for the implementation of the EPBD Directive 2010/31/EU and within the roadmaps to NZEB, for both new and renovation construction, in order to deliver on policy targets.

This report summarises the main findings of the Concerted Action (CA) on the Energy Performance of Buildings Directive (EPBD) around the topic 'Effectiveness of Support Initiatives' for the implementation of the EPBD Directive 2010/31/EU up to the end of 2014, including conclusions and indications about future directions. It excludes shared detailed topics relating to certification, training and Nearly Zero-Energy Buildings (NZEB), which are addressed in other chapters in part A of this book.

The activities aimed at identifying, developing and assessing approaches and options relevant to EPBD implementation by Member State (MS) authorities. The focus of the work has been towards ensuring the impact of the directive as an effective instrument of change in the building construction and property marketplace.

Arising from our work on these topics, two sets of key issues have consistently emerged.

Firstly, there remains a need to address a lack of awareness and understanding of the scale and nature of financial and related instruments available to mobilise the market. Related to this, national authorities and energy experts working on technical building codes and other issues often do not possess in-depth knowledge and understanding of the language and processes of the financial services community. Similarly, the finance and banking sector is usually unfamiliar with the challenges of many energy efficiency measures. Addressing this gap has been - and remains - an essential issue in order to enable national authorities and energy experts to engage more effectively with the finance and banking sector.

The report by the Energy Efficiency Financial Institution Group (EEFIG), which was published on 26 February 2015, contains recommendations on a range of actions that could help overcome the current challenges to obtaining long-term financing for energy efficiency. This work could lay the basis for further work with the financial challenges related to building renovation across Europe.

Secondly, there remains a need and opportunity for improved coordination systems and synergies among the various national institutions responsible for implementing energy efficiency policy, and notably two other EU Directives, the Energy Efficiency Directive (Directive 2012/27/EU - EED) and the Renewable Energy Directive (Directive 2009/28/EC - RESD). MS need to develop long term plans to drive the deployment of energy efficiency measures and renewable energy sources, and these directives include many requirements relating to buildings. A key issue in this period has therefore been to help to develop these long-term strategies in a more structured and cohesive manner.

2. Objectives

In tackling the strategic EPBD goal of transforming the EU building stock, MSs face many barriers - technological, skills related, economic, informational, financial, legal or regulatory, organisational and marketing related. Within this arena, the focus of

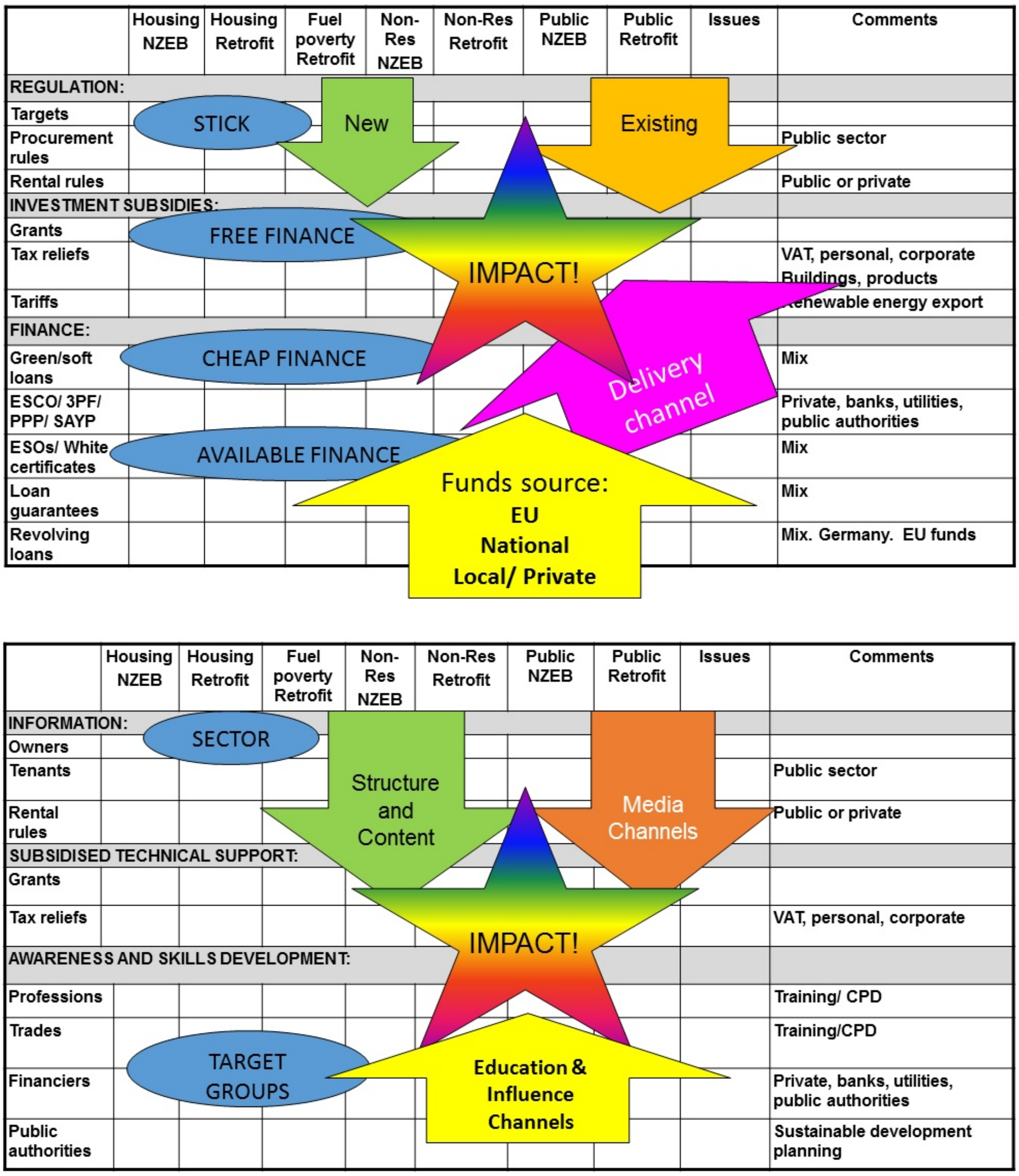
‘Effectiveness of Support Initiatives’ has been on tackling the financial and informational barriers to energy efficiency action by building owners, investors and users. Its specific role was to assist the implementation of Articles 10 and 20 of the EPBD (Directive 2010/31/EU), including highlighting opportunities and synergies with the EED and the RESD.

Article 10 is concerned with financial incentives and market barriers, and includes a periodic reporting requirement by MSs to the EC. It also sets complementary obligations on the EC to assist MSs in setting up financial support programmes and to analyse the effectiveness of the national supports listed in National Energy Efficiency Action Plans (NEEAPs)[1].

Article 20 relates to the provision of information to owners and tenants of buildings on the different methods and practices for improving energy performance. MSs shall ensure that guidance and training are made available to those responsible for implementing the EPBD, and the EC is invited to improve its information services.

The aims of CA EPBD dialogue on these two articles have been to identify and explore the array of financial and informational instruments available, to assess their effectiveness, and thus help to inform national authorities and the EC in considering policy action options within their jurisdictions. It has also sought to raise awareness on areas of potential synergy in transposition and implementation between the EPBD, the EED and the RESD.

Figure 1: Frameworks of financial and informational initiatives.



[1] *A number of EC reports on financial supports, particularly for building energy renovations, can be viewed on: ec.europa.eu/energy/en/topics/energy-efficiency/buildings/financing-renovations*

3. Analysis of insights

The outcomes of the CA EPBD discussions are now summarised from the following selection of topics addressed over the period 2011 - 2014:

1. Overview and mapping of barriers and available support initiatives.
2. Developing strategies for mobilising upscaled investment in deep energy efficiency renovation.
3. Accessing, mobilising and leveraging complementary EU, national/regional and private sector finance.
4. Communicating and working with financial institutions.
5. Experiences with Energy Service COmpanies (ESCOs).
6. Experiences with Energy Efficiency Obligation initiatives.
7. Monitoring and evaluation of policies, programmes, schemes and projects.
8. Exploiting interactions and synergies with the EED and the RESD.

3.1 Overview and mapping of barriers and available support initiatives

A strategic overview of both financial and informational support initiatives, as summarised in Figure 1, allowed the identification of priority areas that MSs need to address.

Support initiatives can be categorised in several ways:

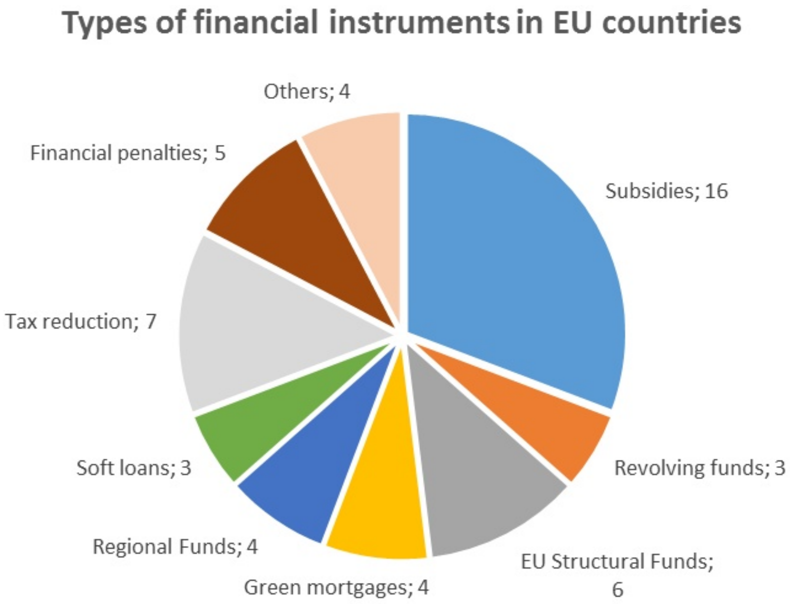
> by policy instrument: regulatory (rules, legislation and penalties), financial (incentives/disincentives), and promotional/informational/ developmental (EPC, public information campaigns, media success stories, engaging key influencers, training and other capacity building in the supply chain, etc.);
> by target sector: by age of the building (newbuild versus renovation), by building type (single house, apartment building, commercial, public), by ownership (owner occupied, social housing, private rented), by economic condition of the owner and/or occupant (level of income, access to capital);

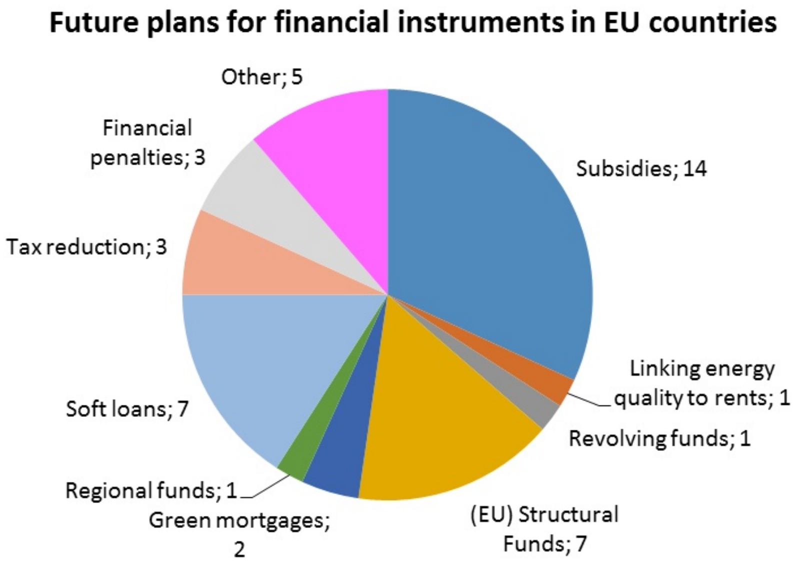
and in the important case of financial instruments:

> by grade of financial instrument: 'free finance' (grants, subsidies, tax breaks), 'cheap finance' (favourable loan levels, interest rates), accessible finance (banks, Energy Service Companies (ESCOs) and other Public Private Partnerships (PPPs), third parties), accompanying confidence building measures (guarantees, official securities);
> by source of the financial instrument: EU, national, regional, local authorities, suppliers of energy services or products, private financial institutions.

These numerous circumstances and potential policy tools highlight a strong need - and opportunity - for combined actions across multiple actors. A survey of twenty two MSs indicates that each MS has typically more than one type of incentivising financial instrument. As shown in Figure 2, subsidies/grants, EU funding and soft loans are the most common current (and likely future) types of financial instruments, followed by tax reliefs, guarantees, etc. Germany, Estonia and Lithuania provide incentives for renovating apartment buildings related to

Figure 2: Present applications and future plans for financial instruments among MSs.





certified energy performance. Grants and soft loans are the leading financial instruments for residential and commercial buildings, whereas for public buildings ESCOs/third party finance initiatives are leading, closely followed by grants/subsidies, as shown in Figure 3. However, there is a recognised need to migrate from capital grant based supports to more sustainable market based alternatives, highlighted further in 3.3 below.

It has been estimated that the annual investment in the energy renovation of the building stock will need to grow from 12 B€ (~30 € per capita) to 60 B€ (~150 € per capita) in order to meet the EU target of a 20% energy efficiency improvement by 2020, including the associated EED requirement regarding energy renovation of buildings. Such a market transformation and upscaling of activity requires an unprecedented mobilisation of policy and market actors, in order to tackle the various barriers to decision and action in a co-ordinated way. Comparable challenges apply to the delivery of NZEB standards for new buildings. Figure 4 summarises these barriers, for each of which there are corresponding ingredients for success, including the key role of policy co-ordination and interventions to stimulate and sustain market confidence and commitment. The resources outlined in 3.2 and 3.3 highlight many case examples of how such barriers have been tackled by MSs.

To achieve NZEB and deep renovation uptake on a large scale, two particular requirements have been identified as vital: firstly, insight and understanding of the attitudes and motives of building owners and investors, and secondly, the

Figure 3: MSs views on the most important financial instruments according to building type.

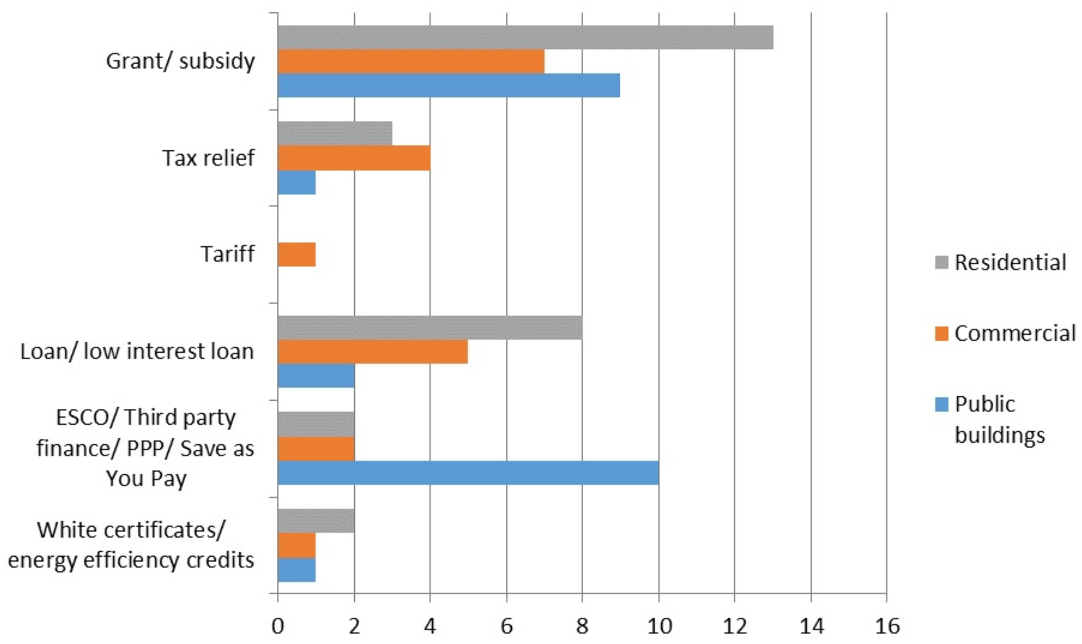
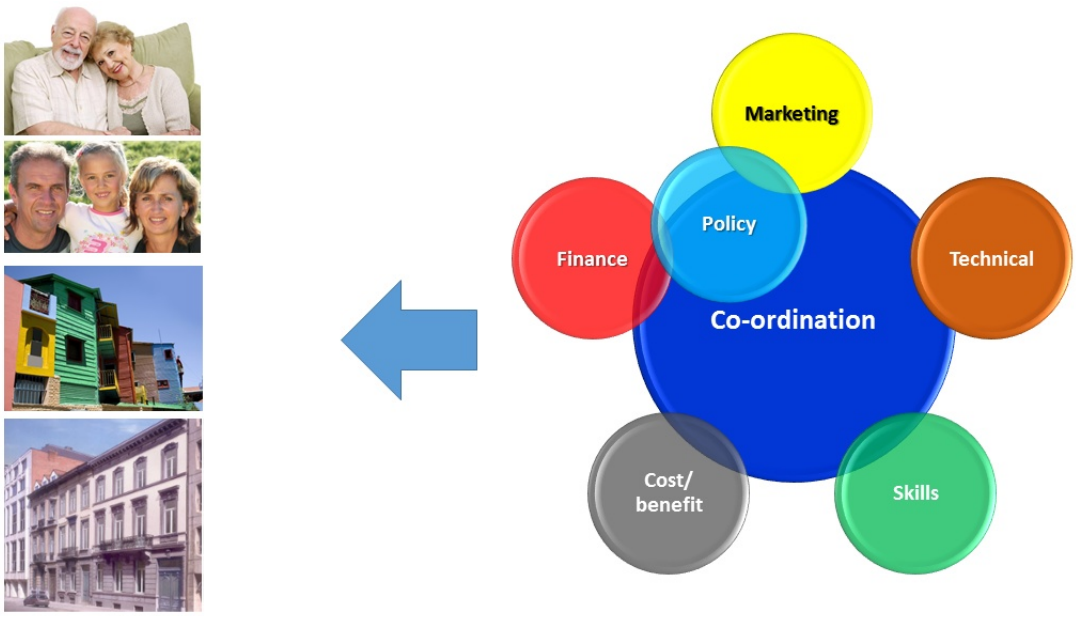


Figure 4: Mobilising and transforming the market: Barriers vs ingredients for success.



availability of suitable finance. Regarding the motives and decision-making processes of these parties, energy efficiency is not often the main argument and there are different perspectives from different stakeholders. Thus, there is a need for information to be configured in a versatile way for different decision makers. For building owners, it may be an overall upgrading of building quality and asset value, improved productivity or comfort, while for governments it may be employment content or health benefits, as well as climate policy advancement. A useful illustration of the multiple benefits of energy efficiency is given in Figure 5.

Among the particular ingredients proposed for stimulating the market (in terms of suitable finance) are:

> one-stop-shops – providing practical information, advice and guidance to assist decision makers (building owners or investors) in relation to procurement, installation and service;
> packaging of measures – clear and attractive energy efficiency product offerings, and highlighting the benefits – including energy efficiency as a key quality and value factor;
> financing options – favourable loans/ green mortgages, ESCOs/ PPPs, Energy Performance Contracting, guarantees, tax reliefs.

The complex arena of support measures is a formidable challenge. A key success factor is the role of policy authorities in providing the focus, coherence and specific interventions to stimulate and sustain market confidence and commitment.

Typically, each MS has more than one type of financial instrument to stimulate energy efficiency in buildings. While MSs still see an important role for grants and subsidies, there is a need to migrate from capital grant based supports to more sustainable market based alternatives.

3.2 Developing strategies for mobilising upscaled investment in deep energy efficiency renovation

Article 4 of the EED obliges each MS to establish a long-term strategy or roadmap for mobilising investment in the energy efficient renovation of the national stock of residential and commercial buildings, both public and private. Responding to this policy priority, which calls for a major upscaling in the volume and depth of renovation, the three Concerted Actions for the EPBD, EED and RESD joined forces and produced a document pack[2] to provide practical assistance to MS authorities.

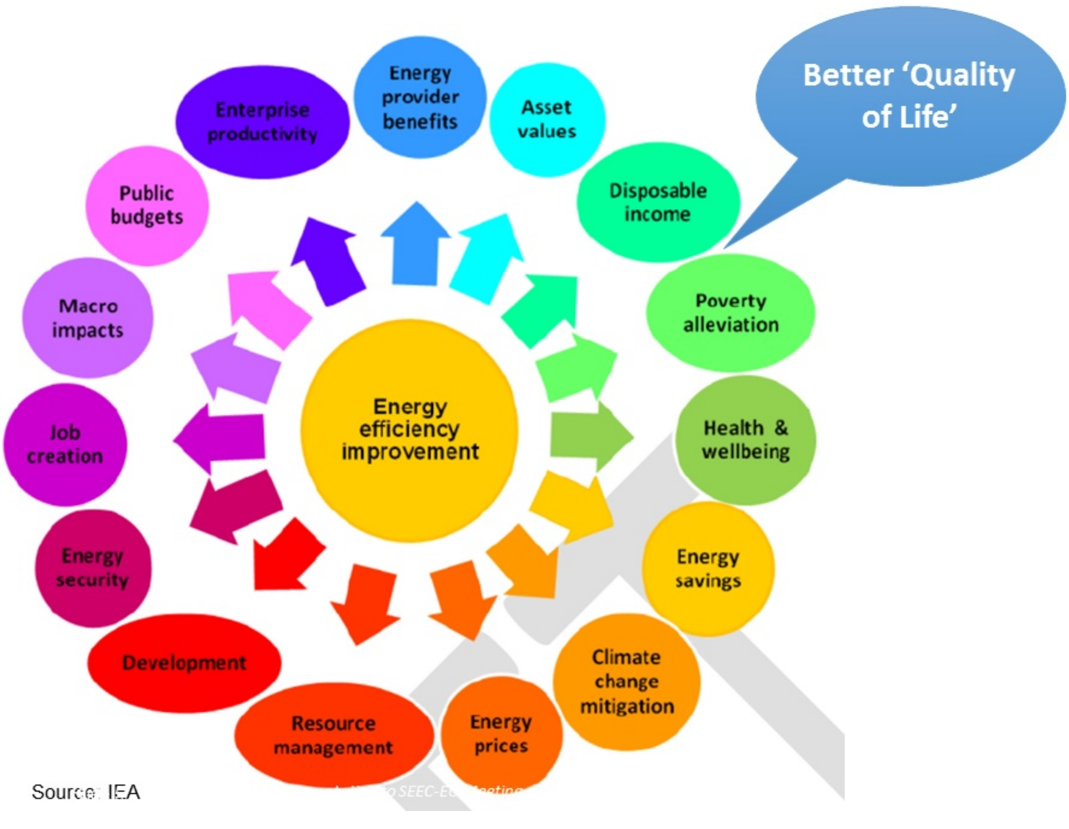


Figure 5: Multiple benefits of energy efficiency (Source: IEA).

[2] *The full documentation is available at www.epbd-ca.eu/outcomes/EED-Article4-composite-document-final.pdf*

It consists of a main document and two annexes. The main document takes the form of a series of nine steps, each containing an introductory narrative that describes the context, role, and a checklist of indicative issues and outcomes sought in that step. This is followed by hyperlinked signposts to two other documents: Annex 1, which contains a selection of 69 case examples of potentially useful approaches (policies, programmes, projects, studies, methodologies), and Annex 2, which offers possible detailed expansions on the checklist of 61 primary questions, which can be regarded as an extended menu.

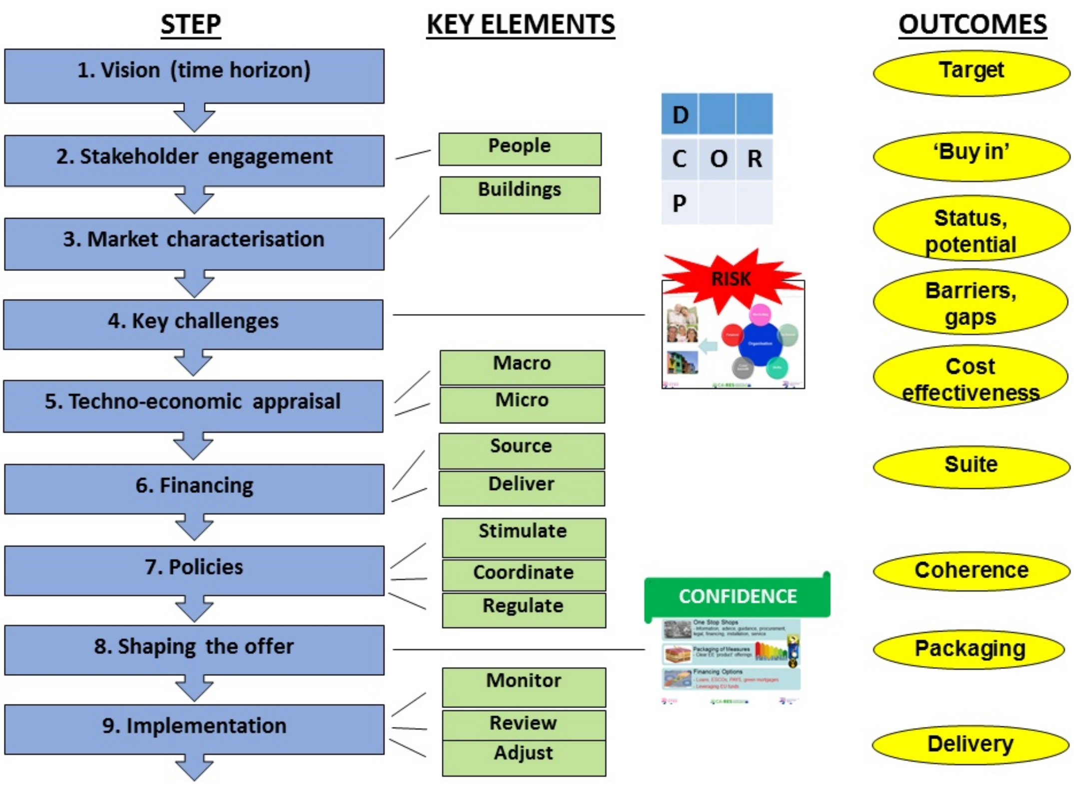
The indicative nine steps are shown in blue boxes in Figure 6. For each step, the green boxes show the corresponding key elements and the yellow boxes show the corresponding outcomes sought. As an example, issues covered in Step 4 (assessing and overcoming key challenges and barriers) include the following: Have you identified actual and possible barriers to the upscaling of building energy renovation in your country? How do you resolve the dichotomy between societal and private investment perspectives? What are your particular challenges with older buildings? Do you have a national code of practice for building energy renovation? Do you have a national skills plan for building energy renovation? Is there a suitable support system for developing new products/services for building retrofit? Do you have a monitoring and verification system or guidelines for energy efficiency programmes? Is there a forum to co-ordinate the different ministries involved in building energy retrofit?

As examples of the later steps, 'Policy measures' cover issues to consider in assessing options to stimulate, coordinate and regulate large scale marketplace delivery of quality renovation activity in each market segment. 'Shaping the offer' covers issues to consider in developing actions to create investor trust and confidence across the market segments and is the integrating response to the set of barriers and risks assessed in earlier step 4. Such measures are particularly necessary to attract investors and close the gap between long-term societal cost/benefit and private cost/benefit.

The essence of a successful ongoing renovation strategy is strong, consistent policy leadership and co-ordination with stakeholders to tackle barriers and risks, including addressing the dichotomy between longer term societal vs shorter term investor cost/ benefit.

National strategies need to include a twin approach, which stimulates a major upscaling in the volume of demand by building owners for energy efficiency renovation works, and builds a matching delivery capacity across the building industry supply chain, including finance supply.

Figure 6: Suggested 9 steps, key elements and outcomes in renovation strategy formulation.



3.3 Accessing, mobilising and leveraging complementary EU, national/ regional and private sector finance

Reflecting the seriousness of policy intent in this arena, extensive attention has been paid to the mobilisation of finance for energy efficient buildings, both to newbuild NZEB in its development phase and especially to renovation. The focus has been on three aspects: sources and scale of finance (particularly at EU level), mechanisms for leverage, and design of instruments for delivery to different market segments. This framework, together with accompanying confidence-building measures to tackle various barriers, is reflected in summary form in Figure 7. The process entails a flow of funds between 'wholesale' financiers, 'retail' financiers and building owners/investors.

EU level financial sources cited in recital 18 of the EPBD, and particularly the expansion in Cohesion Funds, can play a vital role. Over 38 B€ is available over the period 2014-2020 to support the shift to a low carbon economy, of which one third is applicable to energy efficiency in buildings. The conditions of co-funding can be seen as presenting a considerable opportunity to leverage national, regional, institutional and private sources and amplify the overall impact of national instruments. This is illustrated in Figure 8, showing a potential to mobilise investment in excess of 100 B€. But it is important to note that, as a pre-condition for using EU Cohesion Funds for building rehabilitation, certain articles of the EPBD must be correctly transposed by MSs.

A study on the status of these instruments in terms of scale of funds, terms of

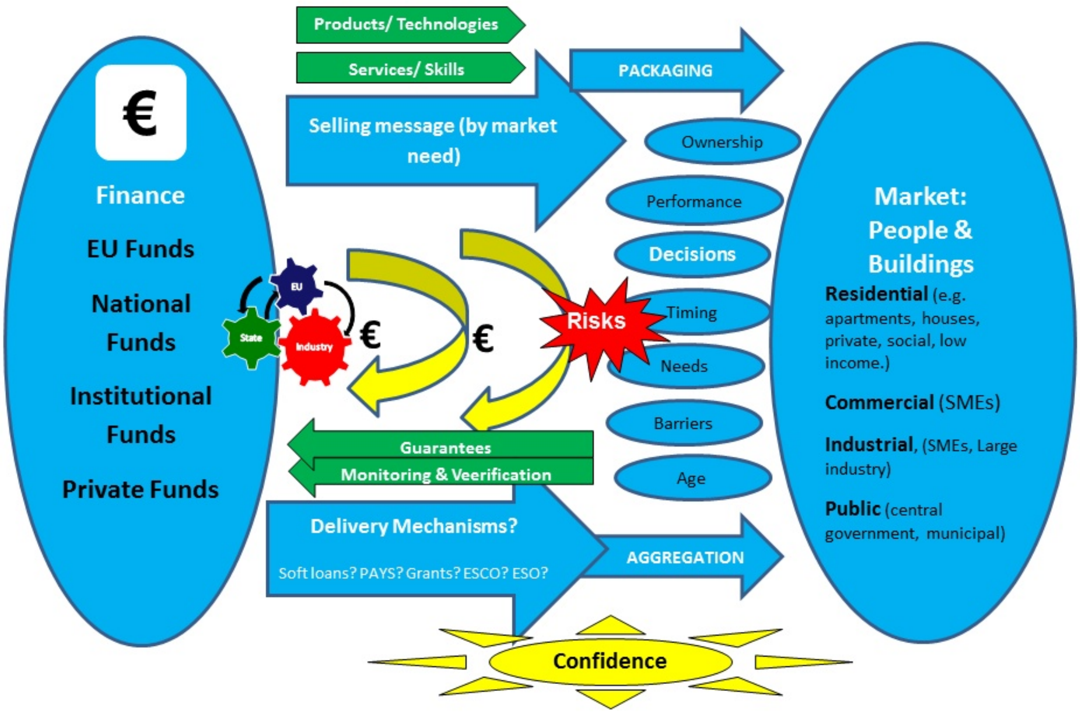


Figure 7: Bringing Finance from Sources to People and Buildings.

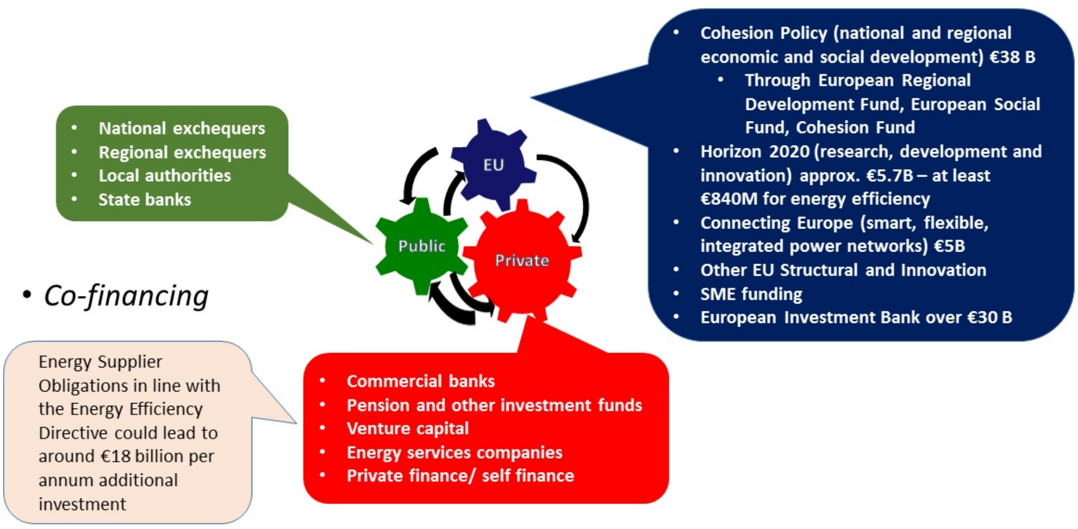


Figure 8: Sources of EU funding and leverage for energy efficiency investment 2014-2020.

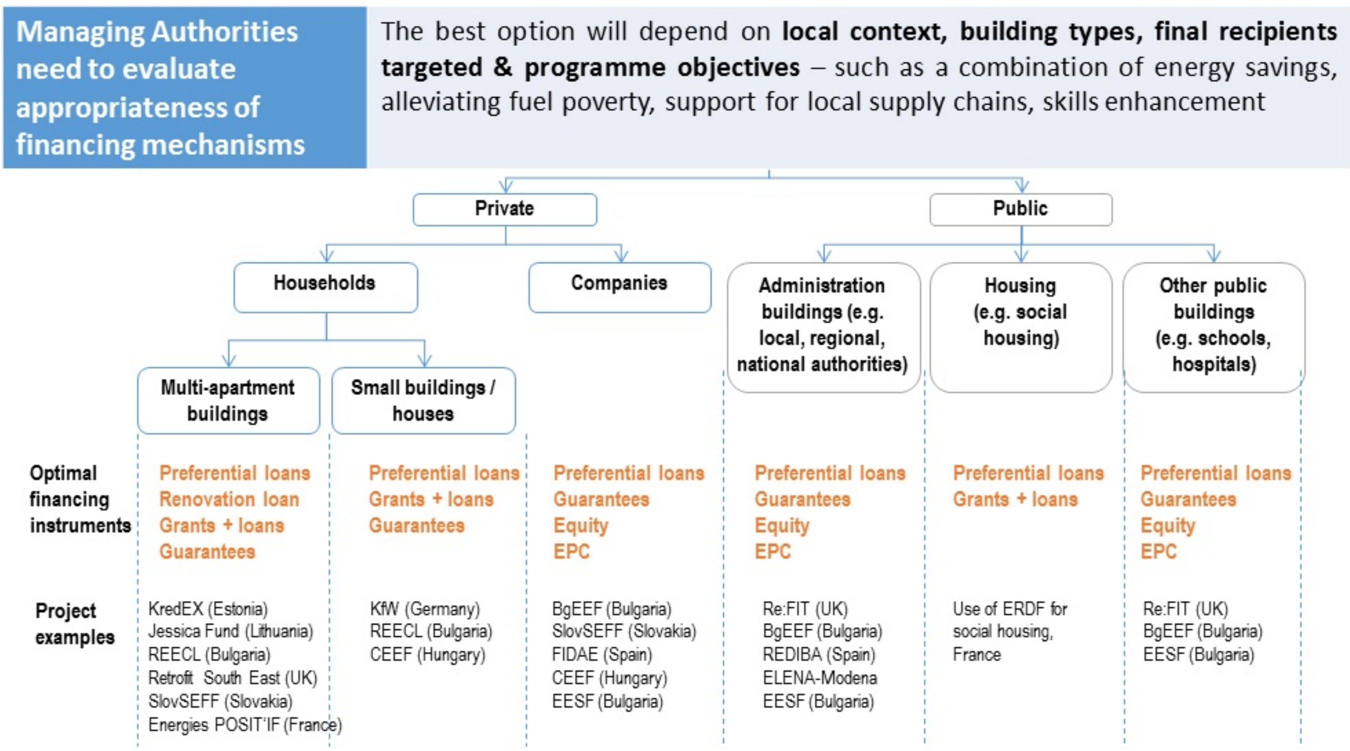
support, sectors and regions of application and experience and impact of applying these funds on the basis of evidence and case examples showed that there was a strong appetite for EU funding in many MSs, but a less strong awareness as to what funds are available, and accompanying conditions. Close liaison between the ministries responsible for energy/economy and structural funds (usually for enterprise, finance or similar) is necessary to avail of this opportunity at MS level.

At least fourteen MSs are using EU or European Investment Bank (EIB) funds to co-finance energy efficiency programmes or schemes in building construction or renovation, in housing or non-residential buildings, principally through preferential loans, grants, and associated 'technical assistance' (TA) (e.g., for training, marketing and procurement set-up) to public authorities, building owners or ESCOs. Despite difficulties caused in some MSs by banking and public finance crises, these initiatives have achieved good results and most are working well. The most common format for success is preferential loans, possibly complemented with a grant and/or TA package.

Experience has shown that it is necessary for financial instruments to be customised to regional/local socio-economic, legal and banking conditions. Frequently, these include the establishment of new legal and administrative mechanisms to administer and leverage the flow of funds from the various co-funding entities, which can involve revolving funds. Typically, these consortium members have included some combination of EU funding bodies, regional governments, energy agencies, municipalities, state banks, merchant banks, local retail banks, energy companies, installers, housing agencies and associations, home owners, ESCOs and project consultants.

Regarding mechanisms for delivery, grants act as a catalyst, but ultimately there needs to be a sustainable market dynamic for energy efficiency, e.g., revolving loans and ESCOs, and there is a gradual move in that direction. Initiatives such as the KredEx model in Estonia and Energies Posit'if in France highlight how central funds can be successfully leveraged. The KfW model in Germany has supported the renovation of over 9 million homes and each 1 € of subsidy has leveraged 9 € in retail bank loans and private investment. Analyses in Germany, France and Ireland of the net financial gain to the state show a typical 5:1 benefit to cost ratio, mainly as a result of the employment and economic benefits stimulated by public funds and resultant tax revenues. The EIB is an important source of leverage for at least eleven MS, partially funding up to 50-75%, mainly in public and social sector building renovation. An example is the renovation of 270 buildings with 23,000 apartments in Bucharest achieving 50% average energy savings through an investment of 140 M€, for which EIB provided a 50% loan. Its normal investment leverage or multiplier is 20:1, but can exceed 50:1.

Figure 9: Extract from guidance report on design of financial instruments.



Buildings' authorities in most, if not all, European countries are in need of guidance on the key challenge of using finance, from whichever source, into well designed financial instruments suitably customised to particular market segments. An example of a useful guide is "*Technical guidance: Financing the energy renovation of buildings with Cohesion Policy funding*", available online[3], which illustrates how many of the funding mechanisms work. Figure 9 indicates how the process of such design can lead to a variety of instruments targeted at different parts of the buildings sector.

Another significant reference is a study by the EU Energy Efficiency Financial Institutions Group (EEFIG), comprising over 120 expert participants, on "*How to drive finance for energy efficiency investments, Part 1: Buildings*", available online[4]. Their report recommends a range of market, economic, financial and institutional actions to help overcome the current challenges to obtaining long-term financing for energy efficiency. These recommended actions are addressed to policy makers and market actors, and include: articulating the benefits to key decision makers, strengthened processes and standards for EPC/energy performance code enforcement, quality generation and presentation of key data to decision makers, and the role of standardised protocols/contracts to assist the investment process.

This work could lay the basis for further work with the financial challenges related to building renovation across Europe. The report specifically recommends measures for better communication between the financial sector and the projects in need for financing - a topic discussed further in 3.4 below. Such measures include the creation of energy and cost databases for buildings and the development of a project rating system to provide a transparent assessment of the technical and financial risks of energy renovation projects for buildings. Furthermore, it emphasises the need to improve building certification methodologies and EPC standards and standards needed in the underwriting process. This partly reflects a need to strengthen the standing of the EPC in MSs, where in almost all cases financing and investment schemes do not yet use the EPC in a formal way. When used, its most common role is to verify energy savings on a 'before versus after' basis.

The EEFIG report also says that barriers to expanding the green mortgage market should be addressed and that there should be a review ensuring that current state aid rules do not unnecessarily burden accelerated energy efficiency investments.

EU level funding has the potential to mobilise investment of over 100 B€ by 2020, but often MSs lack awareness on the required conditions of appropriate programmes and schemes.

There is guidance available on how to develop schemes to trigger measures on energy efficiency in buildings on the ground. A common format for success is preferential loans, possibly complemented with a grant and/or TA package, administered by a well-administered consortium of complementary public and private sector partners.

Energy efficiency support schemes typically yield a net financial gain to the state. But most MSs are not yet taking advantage of these opportunities, often due to lack of familiarity with them.

Important enablers to investment are quality generation and presentation of key data to decision makers and the role of standardised protocols/contracts.

3.4 Communicating and working with financial institutions

A key weakness in the expert technical community (whether employed in the market or by public authorities) seeking to promote investment in building energy efficiency projects and programmes is an inability to understand the perspectives, language, processes, rules and other needs of decision makers and investors in the banking/financing sector (and indeed in engaging with ministries of finance). The success of the energy efficiency mission depends vitally on the ability of this technical community to 'speak the language' and understand the processes necessary to gain the confidence and commitment of the financial community - i.e., to succeed in securing the necessary levels of investment finance from that community. Consideration of this issue, including input from bankers, has provided significant learnings.

[3] ec.europa.eu/energy/sites/ener/files/documents/2014_guidance_energy_renovation_buildings.pdf
[4] ec.europa.eu/energy/en/news/new-report-boosting-finance-energy-efficiency-investments-buildings-industry-and-smes

In seeking funding for a programme, scheme or project, the fundamental need is to present a professional and successful ‘business case’. From the bank’s perspective, the emphasis is often less on the reward to risk relationship than it is on the need to identify, explain and satisfactorily mitigate all sources of perceived risk. An analysis of a range of project proposals submitted to a particular (sympathetic) bank was instructive. It showed that short payback proposals did not necessarily receive finance and that long payback proposals did not necessarily fail, as other motivating factors may be more important than energy savings. Often more important than the predicted savings or return on investment is the strength of the project team – which may only be considered to be as strong as the credit risk rating of its weakest member. Thus, the status of the people can be more important than the projected return on the project. This can be a barrier for Small Medium Enterprises (SMEs), which may have difficulty convincing banks of their viability beyond, say, a 5-year time horizon.

The predicted energy savings and the technical methodology used to compute these savings is of course significant. In this regard, banks often like to rely on ‘technical assistance’ in the form of independent expertise on which they can draw to evaluate the technical energy performance risks. This may entail an ‘investment grade’ energy audit, in the case of building renovation proposals. To be secure regarding the cash flow and ‘bankability’ of a project, a bank may also wish to obtain some form of energy performance guarantees (which might be accompanied by a monitoring and verification protocol). Likewise, the use of products or systems that are accredited by independent authorities (for example, with performance listed on a public register) is a source of confidence. It is noteworthy that in general across MSs, the information in EPCs regarding cost effective improvement options is not considered by financiers to provide a sufficiently clear and reliable basis for committing investment finance. This EPC information might possibly play a role if it were produced by a process, and adapted to a format, that is acceptable to financiers. However, it would still need to be supplemented with other information relevant to banks.

Banks tend to prefer simplicity over complexity as the latter is perceived as risk, so significant effort may need to be applied by proposal teams in making the complex simple. In particular, banks employ standardised documentation and adminstrative procedures and it is wise to minimise deviations from such systems. To minimise transaction costs, projects of larger scale may be more attractive to a bank than small-scale projects – provided this avoids undue complexity and risk. In some instances, bundling or aggregation of projects may be appropriate, in which case intermediaries may be required to co-ordinate and synthesise the overall project (e.g., there is a government ‘insurance’ scheme in Bulgaria that takes this type of perspective, and is reported to be working well). This might apply, e.g., to projects being assembled by an ESCO or an energy utility (e.g., under EED energy supplier obligations). A potential benefit with aggregation is to reduce risks of an individual project failing to deliver, and a loan could be based on a pre-set failure rate that is considered realistic and tolerable.

Overall, it is also advantageous to try to establish a performance record with a particular banking institution, which again will gain confidence. In this regard, if possible, it is beneficial to choose and work with an institution that has prior experience of funding the type of project or scheme being proposed.

In almost all MSs, national authorities and agencies responsible for energy efficiency in buildings have been active over the past five years in engaging with banks, and in understanding and resolving these issues. This has been happening in the process of seeking to establish specific energy efficiency funds, including jointly developing special purpose fund administration mechanisms, and risk sharing or mitigation measures. This needs to continue.

Energy experts need to engage, educate and persuade the financial community on the case for investing in energy efficiency in buildings. Establishment of shared training initiatives would be beneficial.

Banks favour ‘standardised’ administrative and technical methodologies to maximise confidence and minimise transaction costs.

National authorities need to continue to work deeply with the banking sector to achieve mutual goals and understanding of energy efficiency investment requirements.

For example, EPCs are not sufficient to meet bank needs but steps could be taken to adapt or supplement them to provide the necessary evidence and declarations to meet those needs.

3.5 Experiences with Energy Service COmpanies (ESCOs) initiatives

Development and promotion of systems by MSs to support ESCOs (as required by EED Article 18) has an important potential to stimulate significant activity in improving the energy efficiency of buildings.

ESCO markets in Europe are at diverse stages of development, so MSs have much to learn from each other in supporting these markets. Some countries have many ESCOs (e.g., over 500 in Germany, over 300 in France, 80 in Italy) but most have typically less than 20 ESCOs established (14 countries each have 10 or less), complemented by engineering consultancies and technology providers offering solutions with elements, e.g., equipment leasing and performance guarantees. Steady growth took place from 2007-2013 in Denmark, Sweden and Romania and to a lesser extent in Spain, Italy, France and Ireland, with very few countries showing a decline[5]. On average, ESCO markets have been developing in volume and complexity when compared to 2010, driven by regulatory frameworks, financial incentives and increasing awareness. The inclusion of an energy (cost) saving guarantee in the offer is considered particularly important.

However, for a high proportion of ESCOs, revenues from energy supply contracting and/or Energy Performance Contracting still represent less than half of their business revenue. For example, for about 60% of Germany's 540 ESCOs, such revenues are less than 5% of their total turnover, and only around 10 of its ESCOs are exclusively focused on these forms of contracting.

Therefore, while energy efficiency related activity of this sector is estimated at up to 1,6 B€ in 2013, it is far from reaching its estimated 50 B€ potential. There are only a few mature markets, e.g., Germany, the Czech Republic, France, and Austria, and these are expected to grow substantially in the future. The markets are driven as much by market forces (e.g., energy prices, impact of the financial crisis, client interest, developing partnerships between demand side and supply side players, and between the companies and subcontractors), as by dedicated policy measures, regulations and financial solutions. Among the indicators and facilitators of success are the availability of model contracts, standards and/or intensive information dissemination carried out by third parties/market facilitators or intermediaries, engagement of a wide array of companies, including energy supply utilities, consultants, etc., indicating an open and competitive market, and the establishment of ESCO associations. Many governments offer tax reduction and/or some form of funding to support the energy services market, most have legislation to promote the market, but one third of MSs have no financial support.

The motivation for energy supplier involvement may not be extra profit from their ESCO projects directly (although that can be the case), and they are often driven more by regulations on Energy Efficiency Obligations (EEOs) or Demand Side Management (DSM) programmes (e.g., Denmark, Latvia, Slovenia), and/or they offer energy services to attract new customers and increase loyalty of current ones. The perceived complexity of the business model, including Energy Performance Contracting and the associated procurement and verification processes, is a deterrent to many potential clients and financiers, which highlights the value of model contracts and facilitators who can offer specialised knowledge in technology, financing, management and communication. A small number of MS authorities have developed model contracts, and specialist facilitation is being provided by national (or local) energy efficiency agencies, private energy audit companies, procurement advisors and some legal advisors.

Because of the transaction costs, larger scale projects are preferred, which are mainly in the public and commercial sectors. Gaining the awareness and confidence of banks is also a challenge. While, in principle, availability of finance might not be a constraint, a significant difficulty can exist in relation to the credit risk status of the client company or of particular suppliers, particularly for contracts extending beyond 5 years (similar to the SME risk mentioned in 3.4 above).

Public bodies are expected to take a lead in using the ESCO model. While this market is perceived to be relatively well-developed in public administration buildings, hospitals and schools in a few countries, it can still face significant

[5] *Energy Service Companies Market in Europe - Status Report 2013 JRC Scientific and Technical Reports: publications.jrc.ec.europa.eu/repository/handle/JRC89550*

challenges with national exchequer or treasury accounting rules and procurement rules. In the commercial sector, the ESCO market is most developed in buildings such as hotels and large retail premises. Barriers to uptake in office buildings have included the split incentive problem and a mismatch between the long-term nature of an ESCO project and the volatile nature of companies that own office buildings.

It is perceived that to date, ESCOs and Energy Performance Contracts have been applied mainly to improving the energy efficiency of technical systems such as lighting and HVAC systems, and in energy supply solutions such as Combined Heat & Power (CHP), with relatively short payback periods compared with building envelope investments, and thus have not been applied to very deep renovation. The main intervention by MS authorities has been to use national or EU funds to support preferential loans (lower interest rates) for ESCO projects.

The ESCO instrument is least developed in housing for many reasons – diverse ownership, fragmentation/lack of scale, low energy intensity, split incentive problem, etc. However, this sector has been given attention in the form of pilot initiatives in at least Italy, France, Norway, Denmark, Hungary, Estonia, France, Poland, Latvia, The Netherlands, Sweden, Germany and The UK. These projects are usually in the social housing sector and combine some form of national or EU financial incentive with the ESCO finance. An example is the FRESH project[6].

For ESCOs to grow successfully as a force for energy efficient investments in building, independently recognised monitoring and evaluation systems are crucial.

MS need to continue developing model contracts, guarantee mechanisms, opening credit lines, working with public banks and inviting tenders to apply competitive private investment in ESCO services in public sector buildings. Procurement and accounting rules can still be a barrier.

If ESCOs continue to grow in MSs in their present target markets and measures, they can be extended to deep renovation and possibly to housing. But this will require new financing structures and models to be led by MS authorities.

3.6 Experiences with Energy Efficiency Obligation initiatives and alternative measures

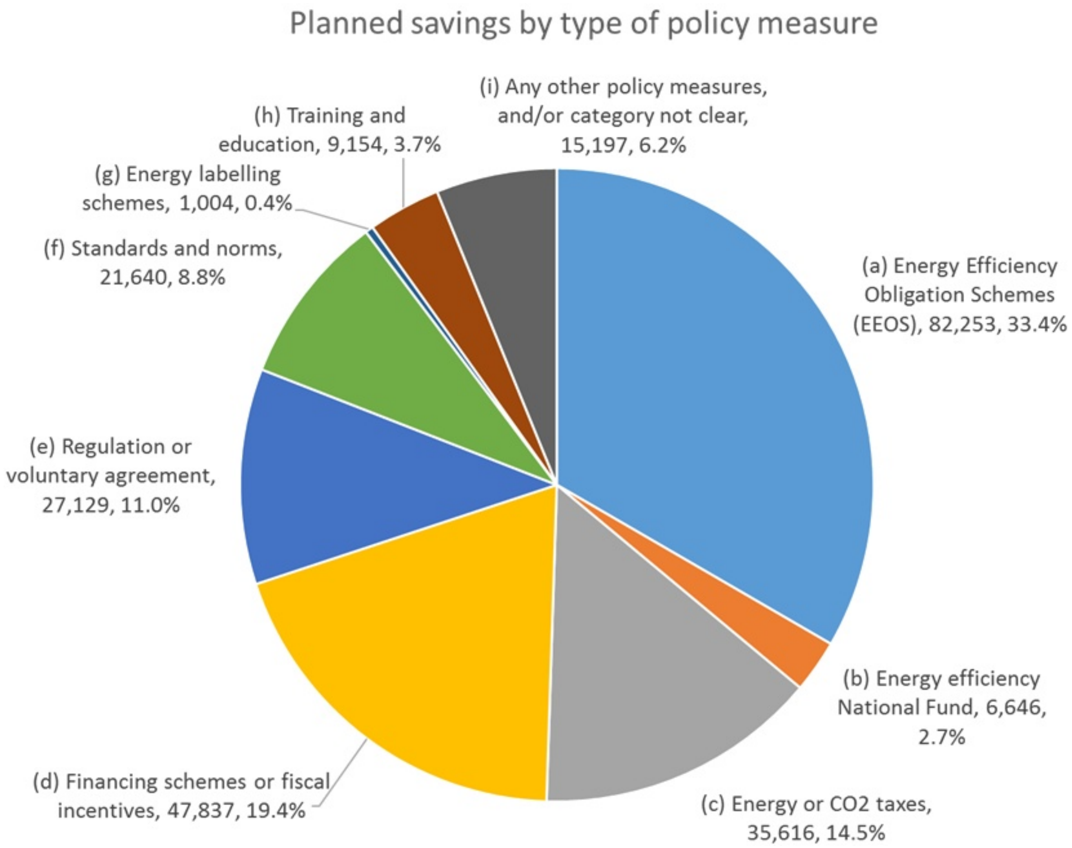
Another important requirement for MSs under the EED (Article 7) is the establishment and operation of an Energy Efficiency Obligation (EEO) scheme or alternative measures that achieve the same amount of energy savings. This has a potential to support significant activity in improving the energy efficiency of buildings. Under the EEO schemes 'obligated parties' (energy companies) are required to achieve new energy savings of 1.5% of annual sales to final consumers, or MSs may choose instead alternative policy measures (e.g., taxes, financial incentives, regulations, voluntary agreements or labelling, training, education and advice) with equivalent effect. MSs are required to lay down the rules on penalties applicable in case of non-compliance with the national provisions adopted in relation to EED Article 7. To date, only Austria is known to have specified the level of such penalties.

EEO schemes have varied from one MS to another, in scope, design features and institutional arrangements at national level. In six MSs (Denmark, France, Ireland, Italy, Poland and The UK), they have transitioned from a voluntary status to a legislated status. In most cases, the obligated parties are the financing source of the measures, and the costs are passed to the final consumer via the energy price or tariff. Careful market analysis, including assessing the most effective channels for energy efficiency investment uptake and savings impact, is important to informing the design of an EEO scheme. Figure 10 is an example of how such a scheme works in The UK, including government oversight, the role of intermediaries and 'counter parties', and provision for trading energy efficiency credits between different energy suppliers.

Schemes are currently in place in eleven MSs (Austria, Bulgaria, Denmark, France, Italy, Ireland, Luxembourg, Poland, Slovenia, Spain and The UK) with good evidence of cost-effective savings, and a further five MSs plan to establish such schemes. As shown in Figure 11, for MSs as a whole, EEO schemes represent 33%, and buildings represent 42% of targeted energy savings under all National Energy Efficiency Action Plans[7] required by the

[6] *www.fresh-project.eu/project*

[7] *This data set contains further information and updated notifications received from the Member States. The target amount of 42% savings generated in the buildings sector combines both EEO schemes and alternative measures.*



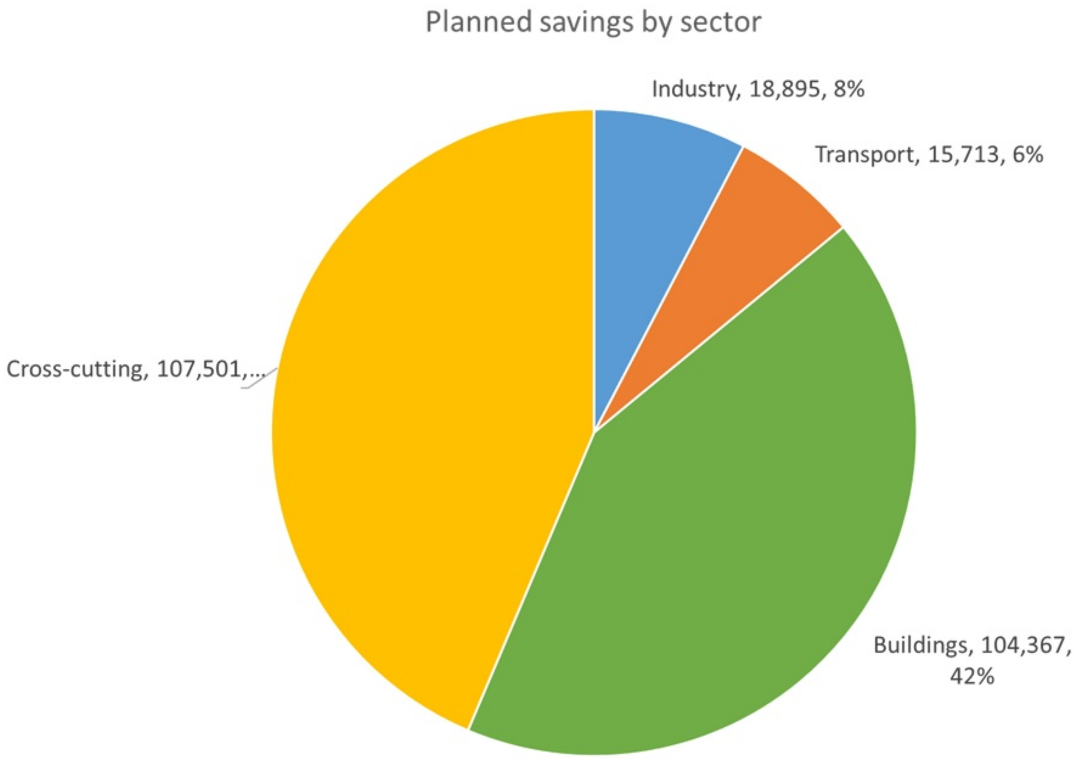


Figure 10: Energy Efficiency Obligation scheme and buildings in the EU: significance and potential.

EED. To this end, EEO schemes can play an important role in meeting shared EPBD goals, and to some extent accelerate the renovation rate. The main focus of existing schemes in relation to buildings has been on retrofitting of Heating, Ventilation and Air-Conditioning (HVAC) and lighting, with few applications to new buildings, innovative technologies or behaviour change. They target low-cost 'shallow' renovation measures for a number of reasons: these are usually the most economically attractive and can be technically standardised more easily than high-cost/complex measures, which enables a streamlined monitoring and verification regime often using 'deemed' savings benchmarks based on representative samples. This approach keeps administrative cost low (less than 0.1% of total cost in The UK).

In their design and evolution of EEO schemes, MSs need to look beyond shallow retrofit actions and set up systems to encourage deeper renovation measures. One initiative reported from two of the active MSs which can help towards this goal is to assign higher credit weightings for 'deeper' and more durable measures.

Based on MSs experience in designing EEO schemes, targets need to be set sufficiently high to mobilise measures that are additional to the baseline market activity, and avoid the risk of 'free riders' and, e.g., excessive distribution of low cost disposable energy efficiency products (e.g., efficient lamps) into households. In the early years of (voluntary) EEO schemes, such rigour was not always the case. A graduated approach to target setting (year 2020 or beyond) is recommended, to allow time for the industry supply chain to develop the capacity to deliver the eligible technologies at the scale required. And as with ESCO initiatives, the operation of suitable systems for monitoring and verification of savings is crucial. Penalties are also seen as an essential component of EEOs, which need to be sufficiently serious to act as a deterrent, and need to be clearly specified and communicated. However none have yet been applied.

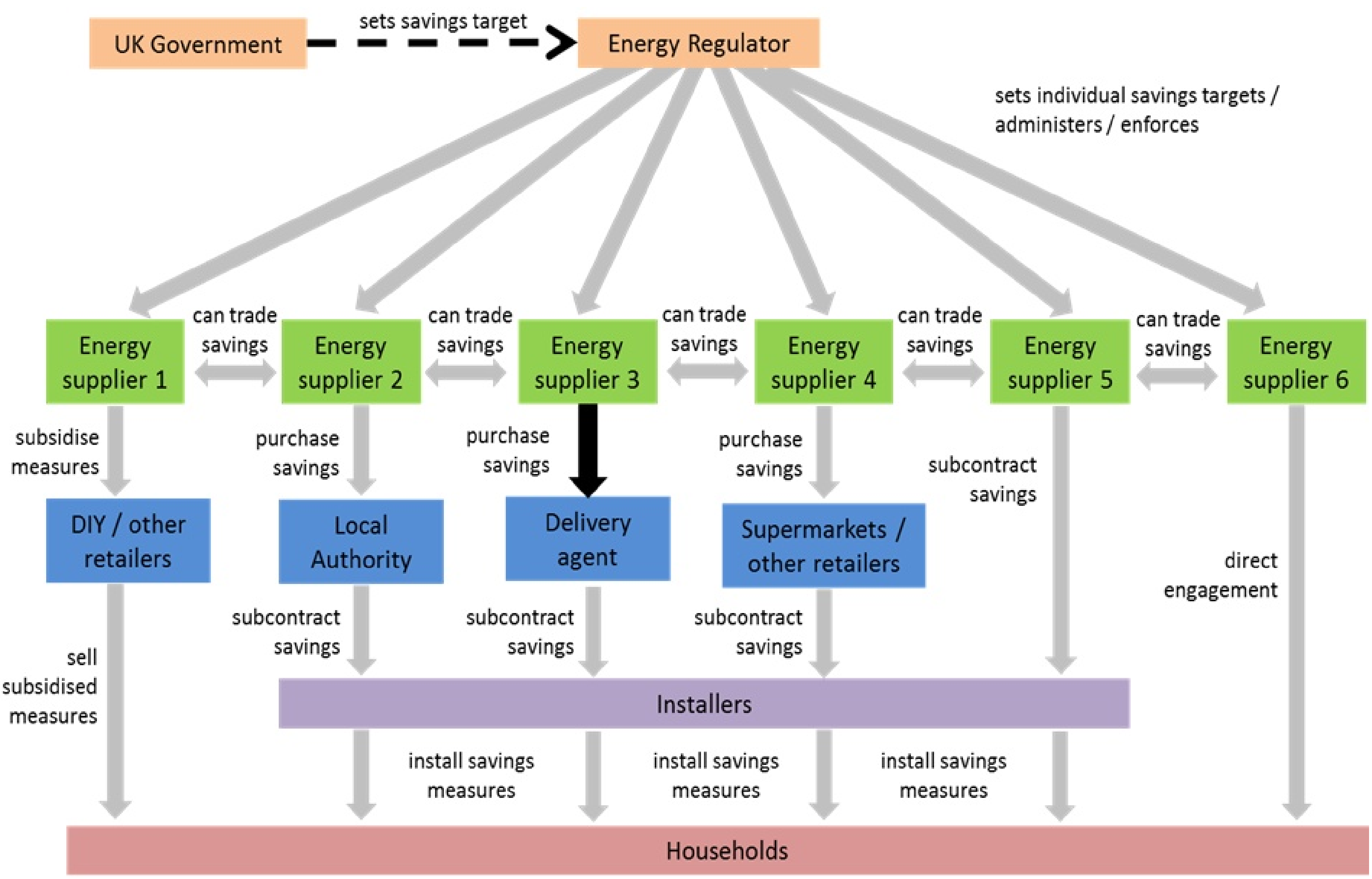
EEO schemes are targeted by MSs to meet 33% of energy savings required under EED Article 7, contributing to the EU 2020 energy efficiency target. Experience shows that with realistic targets and sound monitoring, they can work well and be very cost effective.

MSs need to design the EEO schemes to take careful account of the market conditions.

While EEO schemes have high potential, the limits of their application to 'shallow' measures are likely to be reached in the near future.

MSs need to prepare for EEOs to address deep renovation, e.g., by building incentives into the energy efficiency credits system to reward deeper measures.

Figure 11: Example of how an EEO scheme functions in The UK. Source: Rosenow (AEA-Ricardo) 2012



3.7 Monitoring and evaluation of policies, programmes, schemes and projects

Well designed systems by MS authorities for monitoring and evaluation of policies, programmes and schemes at ‘macro’ level, and of projects at ‘micro’ level, are important for ensuring progress to targets, assessing effectiveness and value for money of different schemes and instruments such as EEO schemes, Energy Performance Contracts, subsidy schemes, funds and tax incentives. This is also important in order to gain the trust and confidence of decision makers: investors, financiers, building owners and ESCOs – and indeed ministries in relation to introducing market stimulus policies.

The certification and inspection programmes developed in the process of implementing the EPBD have the potential to yield a comprehensive data source on the energy performance quality of buildings. To exploit this potential, central registers of certificates and reports should be equipped with interrogation functions to determine the effectiveness of policy interventions. As example of such data enabling policy action, in Denmark, it was used to calculate scenarios for potential energy savings in different building types and ages, plus the necessary investments, informing the government’s energy saving strategy established in 2012. Similarly, Ireland in 2008 launched a pilot grant scheme for home energy efficiency upgrades, which then entered full operational mode in 2009. Evaluation was based on ‘before and after’ Energy Performance Certificate (EPC) data, calibrated with EPC data modelling, assessment of energy bills from a sample of participants, to inform the final design and evaluation system of a full grant scheme which has supported measures in 15% of the housing stock to date.

At individual project level, the scope of the EPC and perceived quality of the recommendations in its present form is not considered sufficient evidence for an ‘investment grade’ energy audit. However, a positive development is the emergence of a number of standardised, versatile international protocols to assist the ex ante and ex post evaluation of energy savings, e.g., the International Protocol for Measurement & Verification of Performance (IPMVP, www.evo-world.org) and the Investor Confidence Project (ICP, www.eeperformance.org). These constitute an integrated set of existing standards, practices, and documentation in order to create the data necessary to enable underwriting (guarantee) or managing of energy performance risk. The EC Joint Research Centre (JRC) recommends that performance-based projects are subject to ‘measurement & verification’ protocols, and regards the IPMVP as a good instrument to be used.

If good data exists on investments in energy efficiency in buildings and energy efficiency improvements, it will be possible to link the effects of policies, programmes, schemes and projects to the energy efficiency improvements. This could be valuable in the evaluation process. However, evidence from MSs suggests that public authorities do not evaluate interactions among policy and programme impacts. Less attention tends to be paid to ex-post performance verification than to ex-ante evaluation of proposed schemes and projects. Few MSs have a protocol for energy efficiency evaluation applied consistently by all agencies, and data collection and evaluation capacity is low. To establish effective evaluation regimes, there is a need to build a monitoring & evaluation culture, methodology and capacity so that impact, process, market and cost are built into the design and implementation of the policy instrument, matching the evaluation approach to the policy objectives and programme design, and with adequate funding for evaluation. At least ten MSs have such solutions already in place or planned. European Bank for Reconstruction and Redevelopment (EBRD) schemes in Slovenia (SlovSEFF) and Bulgaria (REECL) and an EIB scheme in Lithuania (Jessica Holding Fund) could be learning examples for other schemes.

Monitoring & evaluation practice across MSs seems relatively weak at both macro (policy) and micro (project) level. There is a need to normalise the monitoring & evaluation culture in order to determine effectiveness and value for money.

Whether at programme, scheme or project level, there is a need for standardised systems, which balance cost with accuracy – in terms of being simple and workable, and sufficiently rigorous and robust.

Central EPC registries can play a potentially useful role in policy analysis, tracking and targeting.

At project level, protocols such as IPMVP provide useful tracking and evaluation tools and are increasingly used in energy performance contracts.

3.8 Exploiting interactions and synergies with the EED and the RESD

Figure 12[6] shows nine identified areas of potential synergy between the EPBD, the EED and the RESD. In addition to topics covered above (financial instruments, building renovation, EEOs and ESCOs) these include energy certification/auditing, training and accreditation schemes, the exemplary role of the public sector, smart metering/building monitoring, information campaigns, and financial instruments.

A common opportunity exists to deliver information campaigns via energy supply utilities. Targeted financial actions could include tax incentives/reliefs for purchasers of energy-efficient products and grant schemes that facilitate renewable technology deployment.

Training and accreditation schemes are an area of potential synergy, and of significant public/private sector cooperation as almost all MSs have delivered schemes through a combination of government/national agency defined rules, commercial training providers and/or construction professional bodies.

Regarding requirements for training/qualification/accreditation/registration of experts across the three Directives, Europe lacks appropriate training on energy efficiency issues for architects, engineers, auditors, craftsmen, technicians and installers, notably for those involved in refurbishment. MSs are beginning to respond to this need by developing training courses for professionals and actions arising from the BUILD UP Skills initiative (which aims to boost the energy skills of buildings craftspeople and on-site workers and installers across all MSs).

There is clear scope for co-ordinated systems for EPC energy assessors and energy auditors under the EED. Sometimes EPC assessors may have skills in calculation and certification, but may need extended skills in recommending e.g., renovation investments. While there can be administrative efficiency benefits, most MSs do not yet appear to have implemented approaches to benefit from these synergies. Typically, different ministries and institutions are involved, and these and emerging EN/ISO standards can entail lengthy consultative processes. In Poland, Slovakia and Finland, energy auditor schemes link with the EPC

Figure 12: Areas of potential interaction between the EPBD, EED and RESD.

Action area	EPBD Recast	EED	RESD
Target	No	Indicative/ Binding	Binding
Scope	Heat, power	Heat, power, transport	Heat, power, transport
Action Plan required	No	Article 24	Article 4
Reporting	Yes	Article 24	Article 22
Building renovation	Article 7	Article 4	No
Public/ visited buildings	Articles 9, 11, 12	Article 5, 6	No
Information & training	Article 20	Articles 16, 17	Article 14
Energy certificates/ audits	Articles 11, 12	Article 12	
Competent persons/ auditors	Article 17	Articles 8, 16	Article 14
Funds and financial instruments	Article 10	Articles 9, 11, 20	Some
Energy Efficiency Obligations	No	Article 7	Yes
Energy Services/ ESCOs	No	Article 18	No
Metering/ monitoring, billing, information	Articles 8, 20	Articles 9, 10, 11, 12	Some

[6] *Note that a 'no' entry in this table means 'no mention' in the Directive concerned, but it does not mean that the item has no relevance to that Directive.*

schemes for buildings and are good examples to follow. The scheme in Finland has also undergone successful evaluation, highlighting the benefits of including training, monitoring, quality control, tools and models as central elements from the start. Slovenia has a common training/certification article in its legislation for all three Directives and is achieving synergies by implementing a co-ordinated modular training approach.

Suitable systems to enable cross border mutual recognition have also been slow to emerge. There are important barriers and it could be useful to investigate opportunities for a framework allowing transnational recognition of specialists (as mandated by the RESD). The analyses from the BUILD UP Skills initiative in individual MSs could also be a powerful resource to assist implementation and deliver common benefits, given the importance of buildings in the EED and e.g., in relation to installation of technologies such as solar thermal and electric systems, heat pumps and biomass systems (RESD).

The exemplary role set on the public sector in both the EED and EPBD aligns well with the EU policies and national actions on Green Public Procurement (GPP). Such plans typically include the goal of a minimum life cycle cost, and can include elements such as setting ambitious energy performance standards for buildings and products, use of EPCs, ESCOs and registers of energy efficient products (boilers, lighting, etc.). While there appears to be limited exploitation of this synergy within MSs, there are some positive examples of actions being stimulated by GPP policies, e.g., advisory services, manuals, databases and training of procurement officials in Finland, Sweden and Spain. It is recommended that EPBD authorities investigate and pursue possible synergies with colleagues responsible for GPP policies within their national administrations.

Coordination between government ministries and agencies responsible for transposition and impementation of the three Directives will improve policy coherence, stakeholder communication, and the effectiveness of delivery of measures.

A 'one stop shop' type service integrating and offering a full suite of information and guidance on energy efficiency improvements for buildings may be a useful mechanism.

Nine main topics of synergy between the three Directives have been identified (Figure 12).

4. Main Outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Support initiatives	The variety of sources and types of financial and information support initiatives offer strong opportunities for combined actions by multiple actors, targeted to specific sectors.	MSs still consider grants and soft loans as leading instruments for residential and commercial buildings. Policy authorities must provide the leadership, focus, coherence and specific interventions to tackle barriers, and stimulate and sustain market confidence and commitment.	Migrate from capital grants to more sustainable market based instruments. One stop shops and packaging of technical and financial solutions - including favourable loans, tax reliefs, ESCOs and guarantees could help markets develop.
Developing strategies for mobilising upscaled investment in deep energy efficiency renovation	Annual investment in building energy renovation needs to grow by a factor of 5. There is useful guidance documentation to assist MSs in developing effective holistic strategies.	The essence of a successful strategy is strong, consistent policy leadership and co-ordination to tackle barriers and risks, including addressing the dichotomy between long-term societal versus shorter term investor cost/benefit.	National strategies need to include a twin approach, which stimulates an upscaling in demand by building owners, and builds a matching delivery capacity across the building industry supply chain, including finance supply.

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Accessing, mobilising and leveraging complementary EU, national/regional and private sector finance	Energy efficiency support schemes yield a net financial gain to the state. EU level funding has a potential to mobilise investment of over 100 B€ by 2020, but MSs sometimes lack awareness on the required conditions of appropriate programmes and schemes.	There are huge opportunities for leverage of EU level funding. Good guidance and best practice examples are available on the sources of 'wholesale' finance, design and administration of financial instruments customised to different sub-sectors, including risk sharing mechanisms.	Important elements to trigger action are quality generation and presentation of key data to decision makers. Standardised protocols/contracts to assist the investment process are needed.
Communicating and working with financial institutions	National authorities and energy experts need to engage, educate and persuade the financial community on the case for investing in energy efficiency in buildings. They must learn and apply bankers' language and frameworks of risk assessment and decision making.	Banks favour 'standardised' administrative procedures and technical methodologies for project evaluation, monitoring and verification to maximise confidence and minimise transaction costs. Trust in a project team is based on the credit risk rating of its weakest member.	Shared training initiatives between banks, energy experts and national authorities would be beneficial. Proposers should ensure projects are comprehensively synthesised and address all risk factors.
Experiences with ESCOs	The ESCO sector in MSs is growing gradually, at varying stages of development. While relatively well-developed in public buildings, accounting and procurement rules can be a barrier. Monitoring and evaluation are crucial.	ESCOs are seldom being applied to deep renovation or to housing. Extending to these areas will require new financing structures and models to be led by MS authorities.	MSs need to promote model contracts, guarantee mechanisms and invite tenders for ESCOs. The public sector needs to continue taking an exemplary role.
Experiences with EEO	EEO schemes are designed by MSs to meet 33% of the 2020 energy efficiency targets. They are so far established in less than a quarter of MSs. But experience shows that with realistic targets and monitoring, they can work well and be very cost effective.	EEOs are being applied to shallow renovation only. While they have much potential, the limits of their application to shallow measures are likely to be reached in a short number of years.	National EEO schemes should be carefully designed to employ most effective channels for investment uptake and savings impact. MSs also need to prepare for EEO schemes to address deep renovation, for example by using the credits system to reward deeper measures.
Monitoring and evaluation of policies, programmes, schemes and projects	Monitoring & evaluation practice across MSs seems relatively weak at both macro and micro level. Few countries follow a consistent approach in assessing the energy savings from their energy efficiency measures, to verify effectiveness and value for money.	It is crucial to build a monitoring & evaluation culture and tools into a programme or project from concept stage. Central EPC registries can be useful for policy analysis, tracking and targeting - but, for project investors, an EPC is unlikely to be seen as sufficient evidence.	Whether at programme, scheme or project level, there is a need for robust, affordable monitoring & evaluation systems. Project protocols such as IPMVP provide tracking and evaluation tools, are increasingly used and are encouraged.
Interactions and synergies with the EED and the RESD	Areas of potential synergy include certification/auditing, training/accreditation, information, building monitoring, public sector, EEOs, ESCOs and financial instruments. Where responsibility for Directives is led by different agencies, synergy to date seems limited - but improving.	More coordinated approaches between ministries and agencies are needed at national level to exploit synergies, improve policy coherence, stakeholder communication, and delivery effectiveness.	Encourage ministries/agencies to facilitate synergies. A 'one stop shop' type service integrating and offering a full suite of information and guidance on energy efficiency improvements for buildings may be a useful mechanism.

5. Lessons Learned and Recommendations

Three key objectives continue to inform the work on the topic of ensuring the effectiveness of the EPBD implementation regarding provision of financial instruments and information services in the EU construction and property marketplace.

> Firstly, it is vital that MS authorities show leadership in articulating goals, clear roadmaps and adopting robust arrangements (regulatory, financial and promotional) to catalyse the necessary transformation of both new buildings and the existing building stock towards NZEB levels, addressing gaps and mobilising the range of institutional and professional actors. Examples of this are the assistance documentation developed on (deep) building renovation strategies, and on translating 'wholesale' finance such as EU Cohesion Funds into well-designed and targeted stimulus instruments.

> Secondly, it is desirable that all possible opportunities are identified and pursued in exploiting the potential synergies between the EPBD, the EED and the RESD, for example through the work required on financial instruments, ESCOs, EEOs and expert training.

> Thirdly, a priority area is that of ensuring that the energy efficiency community is well acquainted and skilled in communicating and working effectively with the financial community - particularly because, while a role will remain for grants, the scale of the challenge requires more sustainable market based instruments.

In general, positive (but not rapid) progress appears to be continuing in most MSs in terms of improving the focus, leverage and impact of informational and financial initiatives. There is a consistent need to emphasise to the general public and all stakeholders that a building cannot be 'high quality' unless it is an energy efficient building. Further insight into the decision-making process and motives for building owners and consumers is needed, and more experiences and learnings would be valuable. Often energy efficiency is not the main driver and there are different stakeholder perspectives, so instruments need to be sectorally differentiated.

It has been demonstrated that subsidies for building renovation investment frequently yield a net financial gain to the state. However, a significant weakness is that monitoring the results and effectiveness of policies and programmes remains underdeveloped among most MSs. Incorporating the need for both ex ante evidence base and ex post evaluation into policy and programme planning will help identify data needs and collection approaches, and there is scope for standardised systems to minimise administration costs.

To date, comprehensive knowledge of the building stock is limited in many MSs. However, the certification and inspection programmes implemented under the EPBD have the potential to yield extensive data on the energy performance quality of buildings. To maximise the potential of this data source, central registries of certificates and inspection reports should be equipped with interrogation functions to determine the effectiveness of policy interventions.

The public sector is required to take an exemplary role in leading the transition to low-energy buildings but is in a climate of limited public sector capital. It therefore needs to employ the third party financing available through the energy performance contracting/Energy Services COmpany (ESCO) model and to highlight the benefits in order to stimulate similar action in commercial buildings, but there are barriers to this model extending to deep renovation on a wide scale. Barriers to ESCO application are relatively severe in the residential sector, because of its often moderate energy intensity, higher transaction costs (e.g., for metering and allocation), fragmentation of ownership and small scale, the split incentive problem etc. But useful findings may emerge from a series of pilot projects underway in the social housing sector and using national or EU financial incentive in conjunction with the ESCO finance.

Recommendations to improve the effectiveness of support initiatives by MS authorities:

> Actions to facilitate a deepening structured engagement by national authorities and technical experts with financial institutions as vital players in the investment arena, to understand

and inform their perspective, secure their confidence, and develop suitable risk sharing and mitigation measures, especially in relation to funding energy efficiency renovation of buildings.

> Active use of guidance on the leveraging and alignment of financial instruments - according to type, target group and institutional framework - with the different needs of different building type and ownership sectors.
> Making the business case for prioritisation relative to competing (non energy) investments, by consistently highlighting that building energy renovation investment, whether through subsidy or market instruments, justifies itself through a short term net financial gain to the state as well as wider private and societal gains.
> Improved awareness and leverage of EU level funding by relevant MS authorities for the improvement of the new and existing building stock. A growing volume of good examples can help MSs to become more active and ambitious in this regard.
> Enhanced operation of awareness, information, training and confidence building initiatives to stimulate building owners to improve the energy efficiency of their buildings.
> Adoption of unified/standardised methodologies for monitoring and evaluating the effectiveness of policies and programmes (guidelines, principles, strategies) – possibly in liaison with the CA EED.
> Promotion of the ESCO sector, including model contracts, performance protocols, guarantees and other confidence building measures, in commercial and public sector buildings, and exploration of whether and how it can be extended to deep renovation.
> A more coordinated approach to exploit the potential synergies within the three Directives (EPBD, EED and RESD), such as modularisation of training and registration of experts.
> Active sharing with the BUILD UP Skills as a significant resource in implementing common practical on-site delivery actions necessary to successfully implement the three Directives.

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