D1.1 From EPC schemes gaps and opportunities to SmartLivingEPC requirements, recommendations and market needs

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D1.1 From EPC schemes gaps and opportunities to SmartLivingEPC requirements, recommendations and market needs

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1	Sara Ruffini	21/02/2023	Version for submission

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Executive Summary

The *SmartLivingEPC* project aims to deliver a certificate that will be issued with the use of digitized tools and retrieve the necessary assessment information for the building shell and building systems from BIM literacy, including enriched energy and sustainability related information for the as designed building and its actual performance.

Within the frame of WP1, "Exploration for Smart Living EPCs", the technological and market conditions will be explored to realize the SmartLivingEPC solution, and in particular, this deliverable is aiming to identify the current EPC methodologies, challenges, and opportunities, and to define the market and stakeholder requirements and needs.

This deliverable includes the results from T1.1 and T1.2. T1.1 concerns the current EPC rating schemes and their challenges and opportunities. The results of this task are reported in Chapters 2 and 2.12, which present the identification of the current methodology used at the EU level for the EPC definition, a map of the methodology used for calculation methods, the identification of the barriers in each country, as well as best practices. The analysis is conducted in ten EU countries (Italy, Austria, Greece, Estonia, France, Spain, Belgium, Romania, Germany and Cyprus).

In parallel to this review of the current EPC methodologies employed in Europe, stakeholders have been consulted directly. In a first phase, (i) the different types of stakeholders that can contribute with valuable insight to this project are identified and (ii) a stakeholder map is built, as presented in Chapter 3.1. And in a second phase, a direct consultation with a variety of stakeholders related to these certificates is opened, so that they could share their perceptions, opinions and approaches with respect to the current tools and also the context in which these certificates are used. The aim is to identify the strong points to maintain, but also the weak points to improve and/or rethink, with interesting proposals (Chapter 3.2). In Chapter 3.3, the main suggestions regarding EPCs from the latest European proposals that will be properly incorporated into the new version of the EPBD recast are collected, and the contributions of the European sister programs to the new generation of EPCs are reviewed. Then the factors identified in this chapter are crossed adding academic contributions (since the regulatory level is collected in chapter 2) to configure a diagnosis of strengths and weaknesses, opportunities and threats for energy efficiency certificates, as well as suggestions and contributions for the design of the next-generation of EPCs.

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List of Acronyms and Abbreviations

Term	Description
BPIE	**Buildings Performance Institute Europe**
BRP	**Building Renovation Passports**
CHP	**Combined Heat Power**
CMV	**Controlled Mechanical Ventilation**
DBL	**Digital Building Logbooks**
DEE	**Directive on Energy Efficiency**
DHW	**Domestic Hot Water**
EPN	**Calculation method for all non-residential buildings in Belgium**
EPW	**Calculation method for residential buildings in Belgium**
EVCS	**European Common Voluntary Certification Scheme**
EPC	**Energy Performance Certificate**
EPBD	**Energy Performance of Building Directive**
EU	**European Union**
GDP	**Gross Domestic Product**
GDPR	**General Data Protection Regulation**
GHG	**Greenhouse Gas**

HVAC	**Heating, Ventilation and Air Conditioning**
MEPS	**Minimum Energy Performance Standards**
MPS	**Minimum Performance Standards**
MS	**Member State**
nZEB	**Nearly Zero Energy Building**
PEN	**Non-residential Energy Performance**
PER	**Residential Energy Performance**
PMI	**Project Management Institute**
RES	**Renewable Energy Source**
RD	**Royal Decree**
SMEs	**Small & Medium Enterprises**
T	**Task**
WP	**Work Package**

1 Introduction

The Energy Performance of Buildings Directive (EPBD) was established in the European Union in 2002 with the purpose of promoting the use of energy-efficient and renewable energy sources in buildings, and reducing the overall energy consumption of buildings [1]. It sets out the framework for Member States (MS) to reduce the energy consumption of buildings, including minimum requirements for the energy performance of new and existing buildings, and the use of energy certificates.

Indeed, proper management of the energy performance of the building sector is crucial for achieving the EU's energy and environmental goals. At the same time, better and more energy-efficient buildings will improve the quality of citizens' lives and alleviate energy poverty while bringing additional benefits to the economy and society, such as improved health and indoor comfort levels and green jobs. It is important to note that buildings are responsible for approximately:

- 40% of EU energy consumption;
- 36% of the energy-related greenhouse gas emissions [2].

Buildings are therefore the single largest energy consumer in Europe. Heating, cooling, and domestic hot water account for 80% of the energy that citizens consume. At present, about 35% of the EU's buildings are over 50 years old and almost 75% of the building stock is energy inefficient. At the same time, only about 1% of the building stock is renovated each year [3]. Also, investments in energy efficiency stimulate the economy, especially the construction industry, which generates about 9% of Europe’s GDP and directly accounts for 18 million direct jobs. SMEs in particular, benefit from a boosted renovation market, as they contribute more than 70% of the value-added in the EU's building sector.

The EPBD was reviewed two times, in 2010 and 2018, adding new provisions on smart buildings, building automation and control systems, and the integration of renewable energy sources into buildings. More precisely:

- The **2010 EPBD (Directive 2010/31/EU)** required that all new buildings have to meet the **nZEB Standard** by the end of 2020 and for all new public buildings to meet it by the end of 2018. To achieve this goal, each MS was given the opportunity to use its own metrics, to reflect the national and local conditions. This version of the directive also required the **energy performance certificates (EPCs)** to be displayed in the advertising for all buildings sold or rented across the EU, as well as the production of an EPC as a condition for the sale or rental of buildings [4]. Nevertheless, existing buildings were not required to meet any kind of minimum energy performance standard. The Directive 2002/91/EC introduced the EPCs within a simple and common A-G identification scale. Although the EPCs were introduced by each Member State the parameters and the rating scale are variables between them.

- As part of the Clean Energy package, the EPBD was revised in 2018 by **Directive (EU) 2018/844**. The aim of this revision was to develop a long-term building renovation strategy for all MSs within a roadmap with measures and progression indicators consistent with a reduction of 80-95% in GHG emissions by 2050 [2] The purpose was to include and cover combined systems such as ventilation and heating and consider the performance of building systems under certain typical operating conditions. Also, the directive introduced provisions related to electro-mobility, the smart readiness of buildings and smart technologies, energy efficient renovations, and national financial measures to improve the energy efficiency of buildings.

In this context, the European Commission adopted in 2014 as part of the *Long-term renovation strategies* the use of the EPC [4] [5]. Following actions in favour of the climate, in 2019 the European Commission adopted the European Green Deal as a flagship initiative of the EU for transforming Europe into a modern and competitive economy. The European Green Deal is a package of policy initiatives, which aims to set the EU on the path to a green transition, with the goal of reaching climate neutrality by 2050 (“European Green Deal - Consilium” [6]).

To achieve this goal, the European Commission proposes to raise the EU's ambition on reducing greenhouse gas emissions to at least 55% below 1990 levels by 2030. For this, the 2030 Climate Target Plan [7] sets out the EU's overall strategy for reducing greenhouse gas emissions and transitioning to a low-carbon economy.

The plan includes specific measures to reduce the energy consumption of buildings, among which is the Renovation Wave Strategy (Figure 1), aimed at accelerating the renovation of buildings and improving their energy efficiency. In June 2021, MS of the European Council endorsed the strategy to promote renovations that reduce energy use, curb greenhouse gas emissions, increase the environmental performance of buildings, and generate cost savings. It means doubling energy-related renovation rates in the EU by 2030 [2].

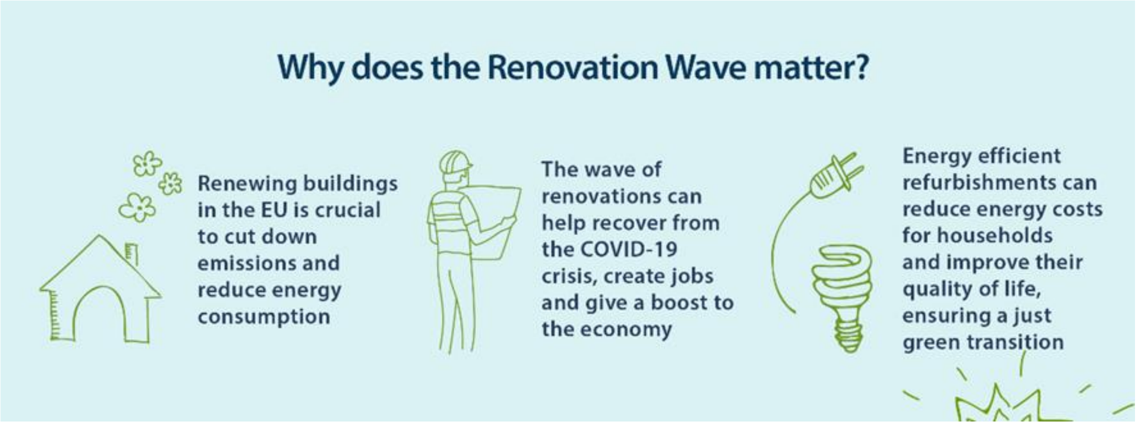

Figure 1 - Highlights of Renovation Wave [8]

In the same way, targeting to translate the ambitions of the Green Deal into law, in 2020 the Commission Work Program "Fit for 55" was adopted. This package is a set of proposals to revise climate-, energy-, and transport-related legislation and put in place new legislative initiatives to align EU laws with the EU's climate goals. It includes a revision of the energy performance of buildings directive, facing two main objectives:

- All new buildings should be zero-emission buildings by 2030 (Figure 2).
- Existing buildings should be transformed into zero-emission buildings by 2050 [9].

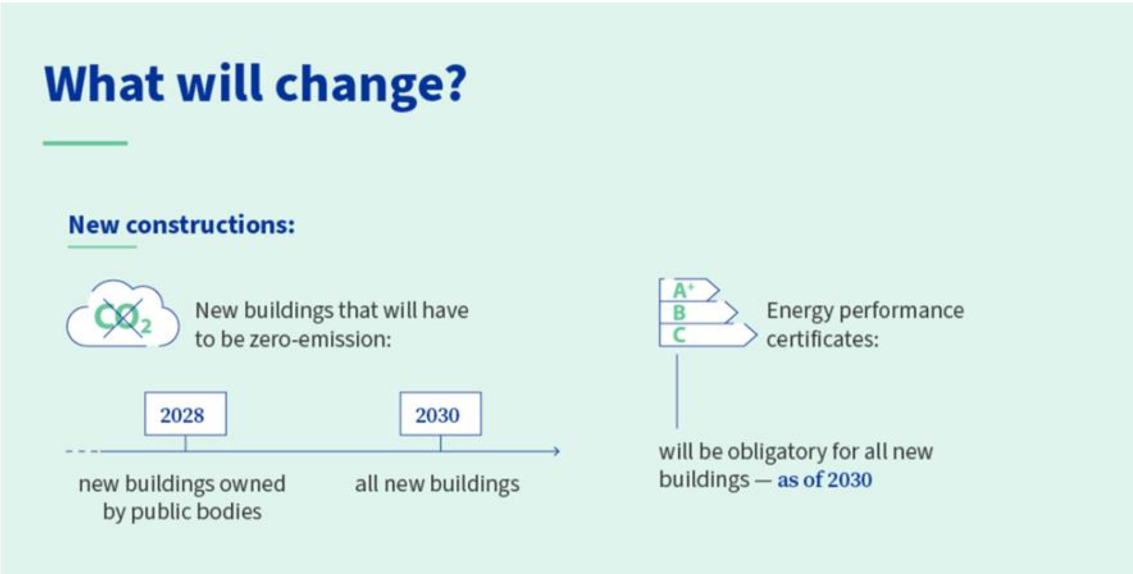

Figure 2 - EPC milestones in Fit-for-55 [10]

Given the need for urgent climate action, as outlined in the European Green Deal [11] (Dec 2019) and to meet the target of reducing GHG emissions by at least 55% by 2030 (and in the long term to be carbon neutral in 2050); the decision was taken to revise the EPBD. Therefore, on **December 15, 2021,** the European Commission adopted a legislative proposal to **revise and recast the Energy Performance of Buildings Directive (EPBD)** as part of the broader overhaul of the 'Fit for 55'' EU climate and energy legislation's package [12].

In October 2022, the EU MSs, meeting within the Council, agreed on a common position on the Commission's proposal for the revision of this directive. The next step will be negotiations with the European Parliament.

As a summary, Figure 3 shows a timeline of the different actions taken in favour of the climate.

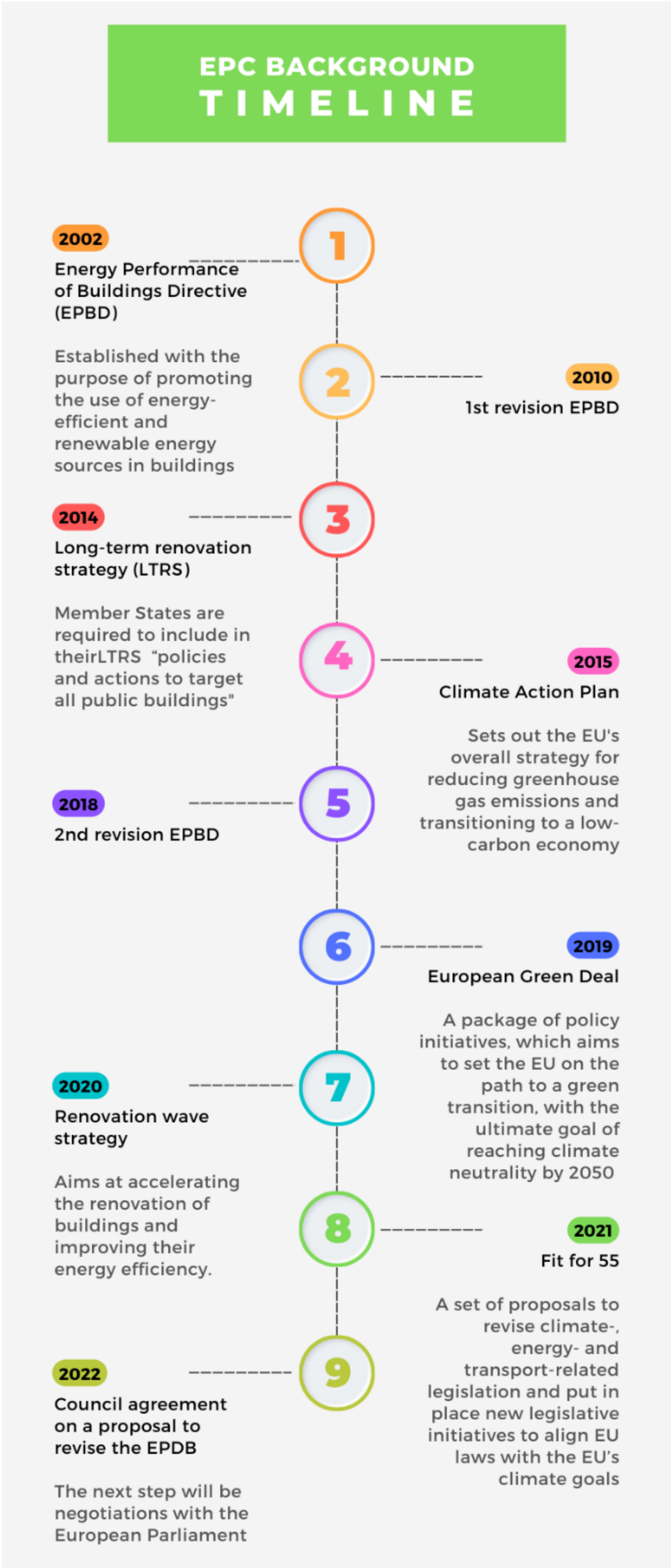

Figure 3 - European timeline for EPC

In this context, the SmartLivingEPC project aims to deliver a certificate that will be issued with the use of digitized tools and retrieve the necessary assessment information for the building shell and building systems from BIM literacy, including enriched energy and sustainability related information for the as designed and the actual performance of the building.

Within WP1, "Exploration for Smart Living EPCs", the technological and market conditions will be explored to realize the SmartLivingEPC solution. The work conducted in the four tasks of WP1 will set out the conceptual and contextual groundwork for the SmartLivingEPC solution envisioned in the project:

- Identify the methodologies currently used for the issuance of EPCs on a European level, and the different methodologies employed in European countries for the definition of the energy performance of buildings. Mapping of the different methodologies, best practices, and gaps in the current practices
- Identify the Stakeholders' needs based on interviews and desk research.
- Define the use cases and scenarios and conduct the demos' surveys.
- Define the specifications and detailed architecture of the project.

1.1 Scope and objectives of the deliverable

D1.1 delivers the identification of current EPC methodologies, challenges, and opportunities and the definition of market and stakeholder requirements and needs. This deliverable includes the results from T1.1 and T1.2.

The outcomes and objectives of the two different tasks are the following:

- **T1.1 Current EPC rating schemes, challenges, and opportunities:** This task first identifies the methodologies currently used for the issuance of EPCs on a European level, including the different methodologies employed in European countries for the definition of the energy performance of buildings. The objectives of this task are to:
    - Identify the current methodology at the EU level used for the issuance of EPCs.
    - Identify the different methodologies in EU countries for the definition of the energy performance of buildings.
    - Map the methodologies used for each country in two categories:
        - Methodologies that are exclusively based on calculated energy consumption (asset rating).
        - Methodologies that use actual energy consumption data (operational rating).
    - Understand the current requirements and the developments expected due to the upcoming revision of EPBD.
    - Identify key features that should be taken into consideration in the design and development of the SmartLivingEPC.
    - Identify effective practices from successful emerging building performance, covering aspects of the smartness of the building, human comfort, its life cycle environmental and economic performance as well as non- energy resources.

- **T1.2 Elicitation of stakeholders' requirements and market needs**: This task defines the stakeholder and market requirements that the SmartLivingEPC system must meet, building on the work from T1.1. The task is based on the design and application of a data collection process that includes the following main activities: (a) Surveys/interviews addressing the project's stakeholders, in order to collect data on the current situation and future trends and needs with the aim of identifying the current market needs as well as emerging future requirements of the market. (b) Desk research: synthesis of current EU framework referred to currently EPC, review of contributions of sister projects with relevance to advanced and innovative approaches for building energy performance and certification, as well as other published scientific works, with the aim of validating the ones identified in the market research. Through this procedure, an accurate and detailed mapping of current status and future trends is recorded. The collected data from both activities are evaluated in close cooperation with the involved stakeholders in order to identify challenges and limiting factors. The output of the task is the development of a report where end-user requirements, recommendations, and guidelines are presented and include the research performed within T1.1 under a unified document.

1.2 Structure of the deliverable

As presented in Section 1.1, this deliverable contains the outcome of two different tasks, T1.1 and T1.2, which have worked in parallel to jointly respond to the project's initial requirements.

Chapter 2 presents the results of T1.1 led by R2M. In Chapter 2, the methodology used to achieve the objective of the task is first presented, and then a detailed analysis of the status of the EPC in ten different countries (Italy, Austria, Greece, France, Estonia, Spain, Belgium, Romania, Germany and Cyprus) is presented. This analysis was based on the questionnaire developed by R2M, for which partners have provided the necessary information in relation to how EPCs are received in each country, the calculation methodology, the gaps and issues, successful cases and suggestions of how EPCs can be improved. While Chapter 2.12 presents the conclusion tables in which the main aspects have been taken into account to get a quick and simple overview of the main topics, such as how the EPBD II is received in each country, the type of calculation methodology applied, the key features, and how each country is planning to implement the new revision of the EPBD.

Chapters 3 and 4 refer to the results of Task 1.2 led by UDEUSTO. In Chapter 3.1, the methodology used to identify stakeholders that each partner has applied in its country to identify the target organizations for the consultation is presented. Once identified, the design of the stakeholder questionnaire is explained. In Chapter 3.2 the results of the consultation are analyzed, according to the five main axes on which the consultation is structured. In Chapter 3.3, the last proposals from the European Union and some related researchs are reviewed, applying those same five axes. In addition, in Chapter 4 the main conclusions are presented, combining the results of the stakeholder consultation with the contributions of the last advances on the subject.

1.3 Relation to Other Tasks and Deliverables

Table 1 summarizes the relation of the present document with other deliverables of the SmartLivingEPC project, which should be considered along with this report for a proper understanding of its contents.

Table 1 - Relation of the current report to other deliverables

Deliverables	Relation
D1.2	D1.2 (and Task 1.4) T1.4 will deliver in detail the technical description of the overall SmartLivingEPC solution and the specifications for each of its key components, modules and functionalities, based on the stakeholder requirements/market needs (T1.2) and the use case scenarios (T1.3).
D2.1	Task 2.1 will examine smart technologies in buildings and analyse SRIs with the aim of integrating them into the energy certification methodology for buildings. Firstly, a detailed overview of the current status of the SRI definition will be realized, exploiting among others the results of T1.1 and T1.2, aiming to identify the level of development, methodologies, and related procedures needed for the issuance of SRI certification.

1.4 Partners contributions

Table 2 - Partners contributions' description

Organization	Contributions
R2M	Responsible and main author of the deliverable. Development of methodology, collection of partners' inputs, and writing of the first part of the deliverable. Input to analysis of the Italian context for T1.1 and stakeholder analysis and market need for T1.2.
UDEUSTO	Co-author of the deliverable. Definition of stakeholders and market needs. Coordination of interviews with stakeholders (T.1.2). Inputs for the Spanish analysis (T1.1)
AIIR	Inputs to the analysis of the Romanian context (T1.1)
FRC	Inputs to the analysis of the Cyprus context (T1.1) and identification of stakeholders (T.1.2)
TalTech	Inputs to the analysis of the Estonian context (T1.1)
ASI	Inputs to the analysis of the Austrian context (T1.1)
ANEC	Inputs to the analysis of the Belgium, German, and France context (T1.1). Identification of stakeholders and consultation in Germany and France (T.1.2)
EUNICE	Inputs to the analysis of the Greek context (T1.1) Identification of stakeholders and consultation in Greece (T.1.2)
CERTH	Inputs to the analysis of the Greek context (T1.1). Identification of stakeholders and consultation in Greece and list of resources in literature and research projects (T.1.2)
QUE	Identification of stakeholders and consultation in Greece (T1.2)

2 Analysis of the EPC across EU countries

In the present chapter, the methodology used to gather information in Task 1.1 is first presented, and then a detailed analysis of ten different EU countries' EPC schemes, methodology calculations, gaps, and issues is presented.

2.1 Methodology used for Task 1.1

To fulfil the aim of Task 1.1, a questionnaire was developed with the aim of collecting the same information for each of the countries that are part of the SmartLivingEPC consortium in order to better understand the current requirements and the developments expected due to the upcoming revision of EPBD, as well as to identify key features that should be taken into consideration in the design and development of the SmartLivingEPC.

The questionnaire developed by R2M (Figure 4) was structured in this way: in the first part, there were the WP and task introductions and also instructions to better compile the document, while in the second part there were open questions regarding how EPC is issued in each country.

Instructions for the questionnaire

This document aims to provide the state of the art to identify the following objectives:

- Identify the current methodology at EU level used for the release of EPCs.
- Identify the different methodologies in EU countries for the definition of the energy performance of buildings.
- Understand the current requirements and the developments expected due to the upcoming revision of EPBD.
- Identify key features that should be taken into consideration in the design and development of the SmartLivingEPC.

Therefore, in the following questionnaire you are requested to answer questions that will help us define a map on EPCs across Europe.

Please fill in all selected sections with as much detail as possible.

Questionnaire

1. How is the EPBD II recast being received in your country?
2. What are the minimum energy performance requirements reference for a building?
3. Are recommendations for the cost-optimal or cost-effective included in the EPC? Please elaborate.
4. Which is the validity time of an EPC in your country?
5. When was the EPC issued in your country?
6. What is displayed in the EPC in your country?
   a. Key performance indicators
   b. Other indicator(s) used for energy rating and sustainability rating.
   c. EN reference standards for the indicators
   d. Energy saving measures
   e. Building description
   f. Additional information
7. What is the calculation methodology?
   a. Methodologies based only on calculated energy consumption (Asset rating)
   b. Methodology that uses actual energy consumption data (operational rating)
   c. Other methodologies
8. What are the main gaps/issues within the EPC in terms of EPC results (e.g. the EPi value is not accurate enough)?
9. Are there any examples of Best Practices for EPC that are focused on the smartness of the buildings, human comfort, and its life cycle environmental and economic performance as well as non- energy resources.

Figure 4 - Questionnaire circulated among partners to gather information on EPCs in European countries.

The following partners involved in the task compiled the questionnaire: FRC, AIIR, UDEUSTO, TalTech, ASI, ANEC, EUNICE, and CERTH. After receiving the questionnaire with all the information in it, R2M used it to shape the analysis developed in the following paragraph, divided by country (Italy, Austria, Greece, Estonia, France, Spain, Belgium, Romania, Germany, and Cyprus). The next sections synthesise the key points of the answers received within the questionnaire for ten countries, covered by the SmartLivingEPC partners. The quality of each country's contribution depends on the information gathered and available at the time of writing this deliverable. **The analysis in these sections is based on information collected by the SmartLivingEPC partners and reflects the transposition status as of January 2023.**

2.2 Italy

In Italy, the implementation of the EPBD II has been transposed with the Legislative Decree n.48/2020 that modifies and updates the previous directive EPBD (2010/31UE) and the directive on energy efficiency DEE (2012/27/UE).

The main objective of this directive is to intervene in the Italian building stock with specific actions aimed at improving energy performance through the application of minimum requirements for new buildings, as well as for existing buildings undergoing a major renovation. The goal is to make more effective strategies for restructuring real estate in the long term, which should be clear and measurable for a building sector that is ideally decarbonized and a building-only stock of nZEB by 2050.

The maximum validity of the EPC in Italy is ten years. In case there is a variation in the replacement or improvement of the technical building system installed there is a need to modify it in part or in total.

As of October 2015, the EPC has a standard format throughout the country and provides information on the building's energy performance, i.e., the amount of energy (annually) required to meet the demand for standard use of the services of heating, cooling, ventilation, and domestic hot water production. From 2020, EPC issuing is mandatory in the case of:

- new buildings for which compliance with minimum energy performance requirements is essential to obtain a building permit;
- buildings undergoing a major renovation;
- buildings undergoing demolition and reconstruction;
- extensions to existing buildings with the creation of new air-conditioned volumes, for a minimum of 15 percent of the initial volume or 500 cubic meters;
- buying and selling real estate;
- gratuitous transfer (donations);
- real estate sales announcements.

In contracts of sale and purchase of real estate, deeds of transfer of real estate for consideration, and in new leases of buildings or individual real estate units subject to registration, a special clause shall be inserted whereby the purchaser or the tenant declare that they have received the information and documentation, including the certificate, with respect to the energy performance certificate of the buildings. The EPC shall be attached to the contract, except in cases of leasing individual units' buildings.

In the case of new buildings, the EPC shall be produced by the builder (either the developer of the construction or a construction company operating directly). In the case of the sale or lease of a building prior to its construction, the seller or tenant shall provide evidence of the building's future energy performance and produce the certificate of energy performance within 15 days of the request for issuance of the certificate of practicability. In the case of existing buildings, the EPC (if any) is produced by the owner of the building.

Penalties: In case of failure to declare or attach, if due, the parties shall be subject to the payment, jointly and severally and in equal parts, of the administrative penalty fine of 3-18,000 euros; the penalty is of 1-4,000 euros for leases of individual housing units. Payment of the administrative penalty, however, does not exempt the obligation to submit to the competent Autonomous Region or Province the declaration or copy of the energy performance certificate within 45 days.

A professional who issues the technical report without complying with the schemes and methods established by the regulations, or an energy performance certificate for buildings without compliance with the criteria and methodologies is punished with an administrative penalty of not less than 700 euros and not more than 4,200 euros. The local authority and the region or autonomous province shall notify the relevant professional orders or colleges for consequent disciplinary measures.

The construction manager who fails to submit to the municipality the asseveration of conformity of works and the energy qualification certificate before the issuance of the certificate of agility, shall be punished with an administrative sanction of not less than 1,000 euros and not more than 6,000 euros. The municipality that applies the penalty must notify the relevant professional association or college of any subsequent disciplinary measures.

With the publication of the new Legislative Decree No. 48/2020, the contents that the EPC must mandatorily include have been updated, adding the obligation to also indicate the inspection, including:

- the overall energy performance of the building in terms of both total primary energy and non-renewable primary energy, through the respective indices;
- the energy class determined through the overall energy performance index of the building, expressed in non-renewable primary energy;
- the energy quality of the building (containment of energy consumption for heating and cooling) expressed through the useful thermal performance indices for winter and summer air conditioning of the building;
- the reference values (minimum energy efficiency requirements in force);
- the carbon dioxide emissions;
- the exported energy;
- the recommendations for improving the energy efficiency of the building with proposals for the most significant and cost-effective interventions, separating the provision of major renovation interventions from those of energy upgrading;
- information related to energy performance improvement, such as diagnosis and financial incentives;
- the date of the mandatory inspection and the related report signed by the property owner or his delegate.

The energy class should be determined through the non-renewable global energy performance index ($EP_{gl,nren}$) that is determined as the sum of the individual energy services provided in the building under consideration and is expressed in kWh/m^2/year in relation to the reference useful floor area, as follows:

$$EP_{gl,nrem} = EPH_{,nrem} + EPC_{,nrem} + EPW_{,nrem} + EPV_{,nrem} + EPL_{,nrem} + EPT_{nrem}$$

Where:

$EPH_{,nrem}$ = non-renewable primary energy demand for heating

$EPC_{,nrem}$ = non-renewable primary energy demand for cooling

$EPW_{,nrem}$ = non-renewable primary energy demand for domestic hot water production

$EPV_{,nrem}$ = non-renewable primary energy demand for ventilation

$EPL_{,nrem}$ = non-renewable primary energy demand for artificial lighting in case of non-residential buildings

EPT_{nrem} = non-renewable primary energy demand for transportation of people or goods

Indices:

gl: global

nren: non-renewable

For the purposes related to proper energy certification, and thus the attestation of the energy performance of the building or real estate unit, it is of fundamental importance that the EPC, in addition to providing the overall energy performance index (EP_{gl}), also reports information on the contributions of the individual energy services that contribute to its determination (EPH, EPW, EPV, EPC, EPL, and EPT), in accordance with the definitions and provisions of the legislative decree and Annex 1, paragraph 3.3, of the Minimum Requirements Decree.

The performance ranges that identify the other classes are derived through multiplicative reduction and the majorities coefficients of the above $EP_{gl,nren}$, (2019/21) value.

Table 3 - Building rating scheme

	RATE	
	Classe A4	*≤0.40* $EP_{gl,nren,rif,standard(2019/21)}$<
0.40 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe A3*	*≤0.60* $EP_{gl,nren,rif,standard(2019/21)}$<
0.60 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe A2*	*≤0.80* $EP_{gl,nren,rif,standard(2019/21)}$<
0.80 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe A1*	*≤1.00* $EP_{gl,nren,rif,standard(2019/21)}$<
1.00 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe B*	*≤1.20*$EP_{gl,nren,rif,standard(2019/21)}$<
1.20 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe C*	*≤1.50*$EP_{gl,nren,rif,standard(2019/21)}$<
1.50 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe D*	*≤2.00*$EP_{gl,nren,rif,standard(2019/21)}$<
2.00 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe E*	*≤2.60*$EP_{gl,nren,rif,standard(2019/21)}$<
2.60 $EP_{gl,nren,rif,standard(2019/21)}$<	*Classe F*	*≤3.50*$EP_{gl,nren,rif,standard(2019/21)}$<
	Classe G	*>3.50*$EP_{gl,nren,rif,standard(2019/21)}$<

The building rating scale is based on the overall non-renewable energy performance for index renewable $EP_{gl,nren}$.

The need to provide an energy certificate for buildings has led to the establishment of calculation procedures codified in national legislation, implementing European directives, which have long been very careful and punctual in energy efficiency and savings. Buildings can be evaluated in two main ways, depending on whether they are new or existing constructions.

To determine energy performance, a distinction is made between a "procedure" and a "method" of calculation. Procedures for determining energy performance cover the activities of finding and choosing input data, applying the correct calculation method, expressing energy performance indices in terms of primary energy, and identifying energy efficiency improvement measures.

The calculation methods are established by the relevant technical standards, used to calculate the required numerical energy performance indicators from the appropriate input data.

The decree DM June 26, 2015 identifies the minimum requirements, parameters, energy performance indices, and yields necessary to describe and verify the energy quality of the building.

For the purposes of drawing up the EPC and assigning the energy class, the energy performance index $EP_{gl,nren}$, expresses, as already mentioned, the annual amount of non-renewable primary energy required to meet the various needs associated with a standard use of the building, divided by the useful floor area of the building and expressed uniquely in kWh/m^2 per year.

This index considers energy needs for winter and summer air conditioning, ventilation, domestic hot water production, lighting, and transportation of people or things, as well as auxiliary energy from plant systems, including cogeneration, district heating, and renewable energy enhancement.

In addition to the overall $EP_{gl,nren}$ index, partial energy performance indices are evaluated, relating to the energy performance of individual services in the building.

The resulting parameters are compared with the prepared tables and included in the technical report, which will be issued to the applicant, and which defines the overall Energy Class of the building. For a better understanding of the state of the building and to better identify possible areas of intervention, "subclasses" are also described that summarize the results of the different certified energy services: heating, cooling, domestic hot water, ventilation, lighting, and transportation of people or things.

Finally, it should be noted that it was also considered appropriate to consider aspects that may affect energy performance in the summer: indication of the summer thermal quality of the building envelope should therefore be included in the Energy Qualification and Certification Certificates (AQE - APE).

The design calculation or standardized calculation procedure involves the assessment of energy performance from input data related to:

- the climate and standard use of the building.
- the characteristics of the building and facilities, as detectable from the energy project, after verification that the building meets the design.

The calculation procedure from the building survey involves the assessment of energy performance from the input data collected directly on the existing building, based on which the assessment of energy performance is carried out according to the appropriate calculation method, as specified below. In this case, the methods of retrieval of input data related to the building may be:

a) based on survey procedures, also supported by instrumental surveys, on the building and/or plant devices carried out in accordance with current national or international technical reference standards or, in the absence of such standards, from technical and scientific literature.
b) derived by constructive analogy with other coeval buildings and plant systems, supplemented by national, regional or local databases or abacuses.

Simplified calculation methods may be used as part of this procedure, subject to the limits specified in the decree and these guidelines.

To prepare the EPC, the following criteria for the application of calculation procedures shall be observed:

a) in the case of new buildings or existing buildings undergoing major renovations, the design or standardised calculation procedure referred to in paragraph 3.1 of DM 26/06/2015 (Energy Certification) shall be applied.
b) for existing buildings that have not undergone a major renovation, without prejudice to the possibility of using the design calculation procedure or standardized calculation procedure referred to in paragraph 3.1, the calculation procedure from the survey referred to in paragraph 3.2 of Ministerial Decree 26/06/2015 (Energy Certification) may be applied.

To prepare the EPC, the energy performance certificate shall also be used, where available, after verification of the data. The input data required to carry out the calculation procedure are described in the project report referred to in Article 8, paragraph 1 of the Legislative Decree, considering any changes and variants that have occurred during construction and are subject to verification. If the documentation is not available, the collection of the necessary input data is carried out during the in-situ survey, the results of which are collected in the relevant report.

As part of the calculation procedures, the following methods may be used, subject to the specified conditions.

1. Design calculation method: with regard to the calculation of parameters, energy performance indices, and efficiencies, the following calculation methods shall be used in compliance with Article 11 of the Legislative Decree:
    a) CTI Recommendation 14/2013 "Energy Performance of Buildings - Determination of Primary Energy and Energy Performance EP for Building Classification," or equivalent UNI standard and subsequent technical standards that follow;
    b) UNI/TS 11300-1 Energy performance of buildings-Part 1: Determination of the thermal energy demand of the building for summer and winter air conditioning;
    c) UNI/TS 11300-2 Energy performance of buildings-Part 2: Determination of primary energy needs and efficiencies for winter air conditioning, domestic hot water, ventilation and lighting;
    d) UNI/TS 11300-3 Energy performance of buildings-Part 3: Determination of primary energy needs and efficiencies for summer air conditioning;
    e) UNI/TS 11300-4 Energy performance of buildings-Part 4: Use of renewable energy and other generation methods for space heating and domestic hot water preparation;
    f) UNI EN 15193-Energy performance of buildings-Energy requirements for lighting.

The design calculation method is applicable to all building types, both new and existing buildings, regardless of their size.

2. Calculation method from survey on the building: with regard to the calculation of parameters, energy performance indices and efficiencies, the following levels of in-depth study are provided. On-site survey (analytical method and by building analogy): This method is applicable to all existing buildings, regardless of building type and size.

3. Simplified method: Application software using a simplified method is prepared by ENEA[1] in collaboration with CNR[2], and is made available free of charge on their respective websites. Simplified calculation methods are applicable only to existing buildings or residential building units with a useful floor area less than or equal to 200 m2, except in cases where the EPC is prepared because of major renovation.

Gaps/Issues With the EPC

The main gaps/issues within the EPC in terms of EPC results are due to the fact that the calculation methodology used is asset rating and, hence, is not possible to obtain the real consumption; there is no correlation between the Primary Energy and the operational mode. This is because the input data are simplified and fixed, so it is not possible to modify those data (such as hours of operation, date to switch on and off the heating/conditioning system) and this leads to a non-realistic analysis of the building. Furthermore, one piece of information that is missing now is the presence of energy storage in the simulation, which can affect the results of the EPC.

Best Practices

There are no best practices in use in Italy; the only way to achieve a more advanced building certification is to pursue one of the Green certifications like LEED. However, these are voluntary and do not substitute for the scope of the EPC.

Regulation

In Italy the implementation of the EPBD II has been transposed with the Decreto Legislativo n.48/2020 that modify and update the previous directive EPBD (2010/31UE) and the directive on energy efficiency DEE (2012/27/UE).

The main objective is to intervene on the Italian building stock with specific actions aimed at improving energy performance through the application of minimum requirements for new buildings. The goal is to make more effective strategies for restructuring of real estate in the long term, which should be clear and measurable for a building sector that is ideally decarbonized and a building-only stock of NZEB by 2050.

Building rating scale based on the overall non-renewable energy performance index renewable EPgl,nren.

	Classe A4	$\leq 0{,}40\ EP_{gl,nren,rif,standard\ (2019/21)}$
$0{,}40\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe A3**	$\leq 0{,}60\ EP_{gl,nren,rif,standard\ (2019/21)}$
$0{,}60\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe A2**	$\leq 0{,}80\ EP_{gl,nren,rif,standard\ (2019/21)}$
$0{,}80\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe A1**	$\leq 1{,}00\ EP_{gl,nren,rif,standard\ (2019/21)}$
$1{,}00\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe B**	$\leq 1{,}20\ EP_{gl,nren,rif,standard\ (2019/21)}$
$1{,}20\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe C**	$\leq 1{,}50\ EP_{gl,nren,rif,standard\ (2019/21)}$
$1{,}50\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe D**	$\leq 2{,}00\ EP_{gl,nren,rif,standard\ (2019/21)}$
$2{,}00\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe E**	$\leq 2{,}60\ EP_{gl,nren,rif,standard\ (2019/21)}$
$2{,}60\ EP_{gl,nren,rif,standard\ (2019/21)} <$	**Classe F**	$\leq 3{,}50\ EP_{gl,nren,rif,standard\ (2019/21)}$
	Classe G	$> 3{,}50\ EP_{gl,nren,rif,standard\ (2019/21)}$

EPC Indicators

The minimum requirements decree DM June 26, 2015, identifies parameters, energy performance indices and yields necessary to describe and verify the energy quality of the building. For the purposes of drawing up the EPC and assigning the energy class, the energy performance index EPgl,nren, expresses, as already mentioned, the annual amount of non-renewable primary energy required to meet the various needs associated with a standard use of the building, divided by the useful floor area of the building and expressed uniquely in kWh/sqm per year.

Calculation Methodology

An asset rating calculation method is used in Italian EPC.

The standardised calculation procedure involves the assessment of energy performance from input data related to:

- to the climate and standard use of the building;
- to the characteristics of the building and facilities, as detectable from the energy project, after verification that the building meets the design

Best Practices

There are no Best practices in use in Italy, the only way to achieve a more advanced building certification is to pursue one of the Green certifications like LEED, but those are voluntary and do not substitute the scope of the EPC.

Gaps/issues

The calculation methodology used is asset rating, hence is not possible to obtain the real consumption, there is no correlation between the Primary Energy and the operational mode. This is due to the fact that the input data are simplified and fixed so it is not possible to modify those data (such as hours of operation, date for switch on and off the heating/conditioning system) and this leads to a non realistic analysis of the building. Furthermore, one information that is missing now is the presence of energy storage in the simulation and this can affect the results of the EPC

Figure 5 - Synthesis of the Italian state of the art (as of January 2023)

[1] ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development

[2] CNR National Research Council

2.3 Austria

In Austria, the implementation of the EPBD is mainly carried out by the OIB (Austrian Institute for construction technology) guideline 6 "Energy saving and thermal insulation" [13], which is published every 4 years (2007, 2011, 2015, 2019, 2023, etc.). Thus, the implementation of new versions or amendments of the EPBD can always be updated.

In Austria, there are minimum requirements for new buildings and major renovations, divided into residential and non-residential buildings shown in Table 4.

Table 4 – Minimum Requirements in Austria

	New construction	*Larger renovation*
Residential	$HWB_{Ref,RK,zul} \leq 10 \times (1+3/\ell_c)$ $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$	$HWB_{Ref,RK,zul} \leq 17 \times (1+3/\ell_c)$ $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$
Non-residential	$HWB_{Ref,RK,zul} \leq 10 \times (1+3/\ell_c)$ $KB^*_{RK,zul} \leq 1{,}0\ kWh/m^3a$ $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$	$HWB_{Ref,RK,zul} \leq 17 \times (1+3/\ell_c)$ $KB^*_{RK,zul} \leq 2{,}0\ kWh/m^3a$ $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$

Where:

- HWB: Heating demand
- KB: Cooling demand
- EEB: Final energy demand
- ℓ_c characteristic length

Indices:

- Ref: reference heating demand (calculated with standard residential building use profile).
- RK: reference climate
- Perm: permissible
- Reference equipment: legally specified building services equipment with which the EEB_{zul} is determined.

Note: This may be waived if significant renewable energy revenues are generated on the building.

For new buildings and major renovation of an existing building, the recommendations for the cost-optimal or cost-effective are included in the EPC. For existing buildings, this is also the case through the mandatory indication of measures whose implementation will reduce the final energy demand of the building or through a renovation certificate.

In Austria, EPC is delivered in these cases:

- for new construction: to prove compliance with requirements and to obtain a building permit;
- for major renovation: to prove compliance with requirements in the case of subsidy or in the case of expectation of economic benefits from the improvement in the real estate market and;
- for existing buildings: for cases of real estate transactions or at the end of the 10 years.

In Austria, the EPC's indicators are:

1. Key performance indicators: *Reference heating demand, heating energy demand, hot water heating demand, heating energy demand, energy expenditure figure for hot water, energy expenditure figure for space heating, energy expenditure figure for heating, household electricity demand, final energy demand, primary energy demand, primary energy demand non-renewable, primary energy demand renewable, equivalent carbon dioxide emissions, energy performance factor, photovoltaic export*
2. EN reference standards for the indicators
    - *ÖNORM EN ISO 52000-1 Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures (ISO 52000-1:2017)*

- *ÖNORM EN ISO 52003-1 Energy performance of buildings - Indicators, requirements, ratings and certificates - Part 1: General aspects and application to the overall energy performance (ISO 52003-1:2017)*
- *ÖNORM EN ISO 52010-1 Energy performance of buildings - External climatic conditions - Part 1: Conversion of climatic data for energy calculations (ISO 52010-1:2017)*
- *ÖNORM EN ISO 52016-1 Energy performance of buildings - Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads - Part 1: Calculation procedures (ISO 52016-1:2017)*
- *ÖNORM EN ISO 52018-1 Energy performance of buildings - Indicators for partial EPB requirements related to thermal energy balance and fabric features - Part 1: Overview of options (ISO 52018-1:2017)*

3. Building description:

Gross floor area (GFA), reference area (BF), gross volume (VB), building envelope area (A), compactness (A/V), characteristic length (ℓc), heating days, heating degree days, climate region, standard outdoor temperature, target indoor temperature, average U-value, construction method, type of ventilation, solar thermal, photovoltaic, electricity storage, WW-WB system (primary), WW-WB system (secondary, opt.), RH-WB system (primary), RH-WB system (secondary, opt.)

Note:

- U-value: the value of thermal transmittance
- WW-WB: warm water heat demand
- RH-WB: space heating heat demand

The calculation methodologies are based on the asset rating. In Austria, the methodology is regulated by

- ÖNORM B 8110-5 for usage profiles and climate data;
- ÖNORM B 8110-6-1 for heating and cooling demand;
- ÖNORM H 5050-1 for final energy demand, primary energy demand and GHG emissions;
- ÖNORM H 5056-1 for heating energy demand;
- ÖNORM H 5057-1 for indoor air conditioning energy demand;
- ÖNORM H 5058-1 for cooling energy demand;
- ÖNORM H 5059-1 for lighting energy demand.

All the above refer to national application documents for the current CEN/ISO standards. These standards also contain default values for input parameters for the existing building.

Gaps/Issues with the EPC

On the other hand, within the EPC, in terms of EPC results, there are some gaps/issues for:

- Existing buildings: precise knowledge of component structures and building technology and the effort needed to obtain this information, e.g. accessing and interpreting old construction and design plans, comparison with changes due to any renovation work.
- New construction and major renovation: preparation of the energy certificate for obtaining building permits or subsidies before the actual tendering and awarding of contracts.

Best Practices

The best example of best practices for EPC that are focused on the smartness of the buildings would be Voluntary building certificates e.g. according to ÖGNB (ÖGNB – Austrian Society for Sustainable Building). The rationale for this is, that such voluntary building certification schemes are elaborated in a broad stakeholder dialogue based on compliance with legal requirements, evidence and anticipating the stakeholders' needs and their fulfilment. Another advantage is the flexibility to revise such schemes when needed. The voluntary building certificates from

ÖGNB include further parameters for global sustainability e.g. quality of local supply, quality of the social infrastructure, proximity to recreation areas and leisure facilities, site security, building land quality, etc. These represent a holistic approach to energy savings and sustainability.

Regulation

Implementation of the EPBD in Austria is mainly carried out by the OIB (Austrian Institute for construction technology) guideline 6 "Energy saving and thermal insulation", which is published every 4 years (2007, 2011, 2015, 2019, 2023, ...). Thus, the implementation of new versions or amendments of the EPBD can always be updated.

In Austria, there are minimum requirements for new buildings and major renovations, divided into residential and non-residential buildings.

	New construction	Larger renovation
Residential	$HWB_{Ref,RK,zul} \leq 10 \times (1+3/\ell_c)$ $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$	$HWB_{Ref,RK,zul} \leq 17 \times (1+3/\ell_c)$ $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$
Non-residential	$HWB_{Ref,RK,zul} \leq 10 \times (1+3/\ell_c)$ $KB^*_{RK,zul} \leq 1{,}0$ kWh/m³a $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$	$HWB_{Ref,RK,zul} \leq 17 \times (1+3/\ell_c)$ $KB^*_{RK,zul} \leq 2{,}0$ kWh/m³a $EEB_{RK,zul} \leq EEB_{RK,\ equipment}$

Where:
- *HWB ... Heating demand*
- *KB ... Cooling demand*
- *EEB ... Final energy demand*
- *ℓc characteristic length*

Indices:
- *Ref ... reference heating demand (calculated with standard residential building use profile).*
- *RK ... reference climate*
- *perm ... permissible*
- *Reference equipment ... legally specified building services equipment with which the EEBzul is determined.*

EPC Indicators

Key performance indicators Reference in: heating, heating energy, hot water heating, heating energy, energy expenditure figure for hot water, energy expenditure figure for space heating, energy expenditure figure for heating, household electricity demand, final energy, primary energy, primary energy non-renewable, primary energy renewable, equivalent carbon dioxide emissions, energy performance factor, photovoltaic export.

Calculation Methodology

The calculation methodologies are based on asset rating.
In Austria, the methodology is regulated by:
- ÖNORM B 8110-5 for usage profiles and climate data,
- ÖNORM B 8110-6-1 for heating and cooling demand,
- ÖNORM H 5050-1 for final energy demand, primary energy demand and GHG emissions,
- ÖNORM H 5056-1 for heating energy demand,
- ÖNORM H 5057-1 for indoor air conditioning energy demand,
- ÖNORM H 5058-1 for cooling energy demand,
- ÖNORM H 5059-1 for lighting energy demand

which are to be understood as national application documents of the current CEN/ISO standards.
In particular, these standards also contain default values for input parameters for existing buildings.

Best Practices

Voluntary building certificates e.g. according to ÖGNB (ÖGNB – Austrian Society for Sustainable Building)

Gaps/issues

- Existing buildings: precise knowledge of component structures and building technology or the effort required to obtain this information.
- New construction and major renovation: preparation of the energy certificate for obtaining building permits or subsidies before the actual tendering and awarding of contracts.

Figure 6 - Synthesis of the Austrian state of the art (as of January 2023)

2.4 Greece

The EPBD II is well received in the country, so much so that it is subject to laws. The responsibility for the implementation of the EPBD in Greece lies with the Ministry of Environment and Energy (YPEN). The Greek Parliament approved the adoption of Directive 2010/31/EU in February 2013 under Law 4122/2013. From July 9, 2015, Law 4122, among others, reduces the limit of floor area to attain an EPC in public buildings to 250 m² (in force since July 9, 2015) and sets control mechanisms for quality control of the issued EPCs and inspection reports.

Law 4342/2015 transposes the EED into national legislation and sets the obligation to renovate 3% of the total floor area of heated and/or cooled public buildings each year to meet at least the minimum energy performance requirements. New qualifications and training requirements for energy auditors were included in Law 4409 (July 2016) along with the energy auditors' classification into three categories.

The amendment of Law 4342/2015 with Law 4843/2021 incorporates the EPBD II directive (2018/2002/EE) into the national legislation to achieve the energy efficiency target of 32.5% by 2030.

Management and quality control are performed by the Departments of Energy Inspection (of Northern and Southern Greece) of the Directorate of Environment, Construction, Energy, and Mines Inspections, which are entities within the ministry, established for this purpose.

Also, in Greece, new buildings or building units must meet the minimum energy performance requirements set out in the KENAK, the national building code “Regulation on the Energy Performance of Buildings” [14] (class B) (see Table 5).

Table 5 - Energy Efficiency Categories of Buildings in Greece

Category	Category limits	Category limits
A+	EP ≤0,33 R_R	T ≤0,33
A	0,33 R_R <<EP≤ 0,50 R_R	0,33 < T ≤0,50
B+	0,50 R_R <<EP≤ 0,75 R_R	0,50 < T ≤0,75
B	0,75 R_R <<EP ≤1,00 R_R	0,75 < T ≤1,00
Γ	1,00 R_R <<EP ≤1,41 R_R	1,00 < T ≤1,41
Δ	1,41 R_R <<EP≤1,82 R_R	1,41 < T ≤1,82
E	1,82 R_R <<EP≤ 2,27 R_R	1,82 < T ≤2,27
Z	2,27 R_R <<EP≤ 2,73 R_R	2,27 < T ≤ 2,73
H	2,73 R_R < EP	2,73 < T

Where R_R: primary energy consumption (reference building-Upper limit of category B)

- EP: primary energy consumption (examined building)
- T: EP/R_R

In combination with the obligation set in Law 4122/2013, these regulations ensure that every new building in the public sector, from January 1, 2019, should be an nZEB. This obligation applies also to all new buildings constructed after January 1, 2021.

At the stage of issuing a building permit for new buildings or building units, additional documentation must be prepared and submitted to the relevant Building Office Authority. This documentation accompanies the energy study and contains the technical, environmental, and economic feasibility of the installation of at least one of the following alternative energy supply systems:

- centralised energy supply systems based on RES;
- combined heat power (CHP);
- heating or cooling systems in the region or block;
- and/or heat pumps that meet the minimum eco-labelling requirements.

Stricter minimum energy performance standards for new building components and the building envelope were implemented in the amended KENAK in July 2017. The energy requirements for new buildings are presented in the following Table 6.

Table 6 - Minimum energy performance requirements for building components of new buildings in Greece

Building component	U-value [W/(m².K)]			
	Climatic Zones			
	A	**B**	**C**	**D**
Roof	0.45	0.40	0.35	0.30
External walls	0.55	0.45	0.40	0.35
External walls in contact with the ground	1.30	0.90	0.70	0.65
Floor in contact with unheated space (‘piloti’)	0.45	0.40	0.35	0.30
Floor over ground	1.10	0.80	0.65	0.60
Openings	2.80	2.60	2.40	2.20

Glass façades	2.10	1.90	1.75	1.70

Table 7 presents the 4 climatic zones' maximum allowable thermal transmittance values for the building envelope of new buildings.

Table 7 - Maximum acceptable mean U-value of the building envelope (Um) for new buildings in Greece

F/V (m-1)	Max Um [W/(m².K)]			
	Climatic Zones			
	A	B	C	D
≤ 0.2	1.25	1.13	1.04	0.95
0.3	1.17	1.05	0.96	0.88
0.4	1.10	0.99	0.91	0.83
0.5	1.04	0.93	0.86	0.78
0.6	0.98	0.89	0.81	0.73
0.7	0.92	0.83	0.76	0.68
0.8	0.86	0.77	0.71	0.63

The following are some characteristics that have been newly added to the updated regulation:

- Regarding DHW, a low-demand building concept introduced the use of a pump for DHW recirculation.
- The idea of terminal control using thermostatic valves and space thermostats for each operational space. Additionally, it is noted that calorimetry must be used when cost allocation is required.
- Tertiary sector buildings should comply with the minimum lighting efficiency (60 lm/W) for tertiary sector buildings, as well as the requirement to control the lighting with separate switches.

Furthermore, two new paragraphs cover parts regarding the automation degree of technical building systems and the requirement of each technical building element to comply with the requirements of the EU Eco-design and ecolabel Directives.

For new buildings or building units, it is mandatory, since 2011, to cover part of the hot water needs from solar, thermal or other RES/CHP systems. The minimum percentage of the solar share on an annual basis is set at 60%. Not applying the above rate requires adequate technical documentation in accordance with current legislation and the prevailing conditions.

A cost-optimal study is under preparation and will determine the minimum energy performance requirements for new buildings or building units so that the maximum energy savings are achieved with the lowest cost impact. Part of the study that covers new single-family buildings and multi-family buildings (covering over 75% of the building stock) has been completed and resulted in a proposal for more strict minimum energy requirements for new buildings. Concerning the tertiary sector, the study is expected to be finished before the end of the year.

The energy requirements for existing buildings have not been altered since the end of 2014. The energy performance of an existing building that undergoes major renovation should be of an energy class “B” or better, unless it can be proven, through a technical report, that this is technically, functionally, and economically not feasible. For those building permits that have already been issued from January 1, 2020, to December 31, 2020, and concern either new buildings or additions to existing buildings, there is an obligation to submit an Energy Efficiency Study for energy category B+. The same regime applies to those that will be submitted until the first five months of 2022. The aim is not to damage, even further, the construction industry, which after the "blow" it received during the years of economic recession in Greece, must face a new crisis brought to the building sector by the pandemic of the new coronavirus SARS-CoV-2.

The EPC document is valid for ten years upon its issue date. If the building undergoes a radical renovation or addition in an area that affects its energy performance, the validity of the building’s EPC expires at the time of the renovation or addition’s completion, before the 10-year period has elapsed. In case of renewal of a lease contract, it is not required to issue a new EPC, even if it does not exist or is not valid. On the contrary, in the case of a new lease contract, the issuance of a new EPC is required, even if it exists and is valid. Also, the issuance of the EPC is required for all buildings with a total area of more than 50 m^2, of basic uses (residential, permanent and holiday, temporary, accommodation, education, health, and social welfare, prison, offices, etc.) when the following occur:

- New and radically renovated buildings (upon completion of construction)
- Existing buildings: For every sale-purchase of a single building or part of a building (e.g., apartment) for residential or business premises.
- Existing buildings: For each new renovation of a single building and part of a building (e.g. apartment) for residential or office premises.
- For the inclusion of residential buildings in the «Εξοικονομώ» program, which finances in large percentages the renovation of a home.
- Heritage buildings are not exempt from the obligation of EPC issuance.
- Holiday homes (summer/winter country & recreation houses with accommodation less than 4 months) are not exempted from the obligation to issue an EPC, according to article 28 of Law 3889/2020.

The certificate indicates, among other things, the general data of the building, the annual primary energy consumption of the reference building and the building under review, the annual primary energy consumption by final use and type of fuel, the final energy consumption in total and by use, the amount of the emitted pollutants, as well as suggestions for interventions to improve the energy of a building.

The form of the Energy Performance Certificate issued in Greece is presented in Figure 7.

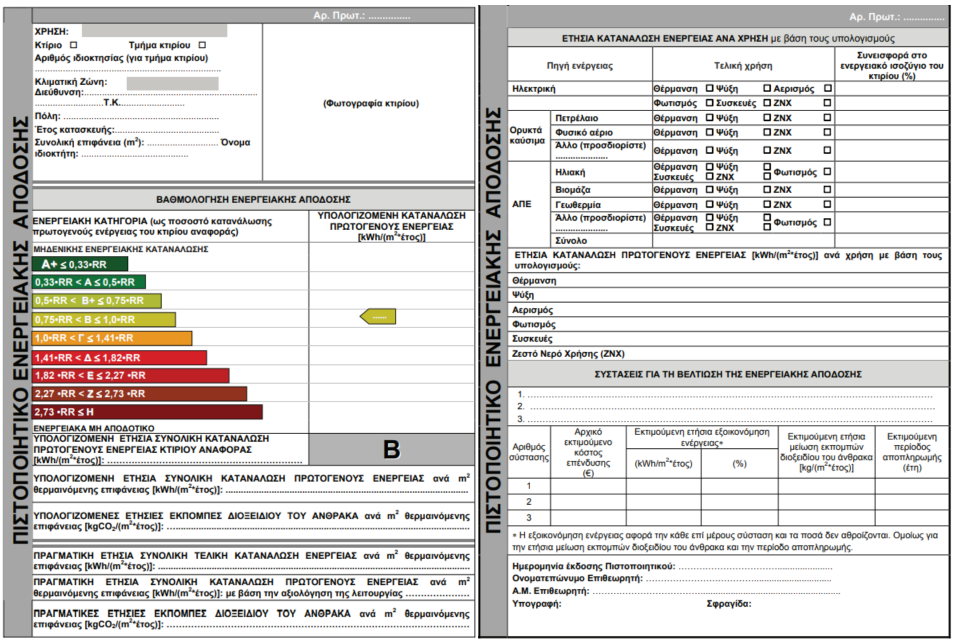

Figure 7 - Results of official two-page EPC in Greece.

The first page of the EPC includes the general building data, ranking label (building class) based on the calculated primary energy consumption (compared to the reference building), the annual calculated and actual (if available) primary and final energy consumption and resulting CO_2 emissions normalized per unit floor area. Finally includes an evaluation of indoor environmental quality to support the interpretation of the actual final energy consumption.

The second page of the EPC includes the breakdown of the contribution of the various energy sources to the final end-uses, annual primary energy consumption for the different end-uses per unit floor area, at least one and up to three of the most cost-effective recommendations for improving the building's energy performance (including initial cost, calculated annual energy conservation and the abatement of CO_2 emissions, and the simple payback period).

The calculation methodology is based on asset rating, comparing the under-study building with a reference building. The reference building and the building under examination share the same geometrical qualities as well as the same location, orientation, usage, and operating characteristics. Except for the system of direct solar gain, the passive solar systems that may be present in the investigated structure are not considered in the energy efficiency calculations for the reference building.

The energy efficiency of buildings is determined based on the methodology for calculating primary energy consumption. The methodology includes at least the following elements:

- The use of the building, the desired indoor environmental conditions (temperature, humidity, ventilation), the operating characteristics, and the number of users.
- The meteorological data of the building area (temperature, relative and absolute humidity, wind speed and solar radiation).
- Geometric characteristics of the structural elements of the building shell (shape and form of building, transparent and non-transparent surfaces, shading, etc.), in relation to the orientation and characteristics of the internal structural elements (partitions, etc.).
- Thermal characteristics of the structural elements of the building envelope (thermal permeability, absorption of solar radiation, reflectivity, and emission of thermal radiation).
- Technical characteristics of the space heating installation (types of systems, distribution network, system performance, etc.).
- Technical characteristics of the installation of HVAC premises (types of systems, distribution network, system performance, etc.).
- Technical characteristics of the lighting installation for the buildings in the tertiary sector.
- Passive solar systems.

In the calculation methodology, the positive effect of the following systems is considered, as the case may be:

- Active solar systems, and other heat, cooling, and electricity generation systems using renewable energy sources.
- The energy produced by combined heat and power (CHP) technologies.
- Central heating and cooling systems on an area or block scale (district heating).
- Natural light.

However, EPCs in Greece face some issues:

- The implementation of the inspection methodology and the quality control of inspection reports are the responsibilities of the Departments of Energy Inspection of Northern and Southern Greece. However, only a very small number of inspection reports have been registered since the inspection methodology's formal introduction (at the beginning of 2016), and as a result, no quality control checks have been performed yet.
- The national plan for increasing the number of nearly zero-energy buildings was released in August 2018 and stipulated, among other things, that a new building can be considered a nearly zero-energy building if it at least falls under energy class A, while an existing building can be considered a nearly zero-energy building if it at least falls under energy class B+. This was incorporated into Greek law through Ministerial Decision YPEN/DEPEA/85251/242 (GoG B' 5447/5.12.2018). However, a choice has yet to be made about the minimum percentage of RES and how it affects the consumption of primary energy.
- The existing framework for assessing the building's energy performance examines only the 'as-designed' state of the building. The methodology is based on the EN ISO 13790 standard, which was issued in 2007 and lacks many of the updates introduced by the newer standard (EN ISO 52000). Moreover, there is no

framework for examining the "as-operated" state of the building, by utilising the data from energy meters installed in the building.

Best Practices

Currently, the two main examples of best practices for EPCs in Greece would be the following:

- Law 4342/2015 foresees that the final customer for electricity, natural gas, district heating, district cooling, and domestic hot water is provided with competitively priced individual metering devices that accurately reflect the final customer's actual energy consumption, providing information on the actual time of use. Such meters shall be provided whenever an existing meter is replaced, or a new connection is made unless this is technically impossible or not cost-effective in relation to the estimated potential savings in the long term.
- According to the provisions of Law 4001/2011, the responsible body for the electricity meters is the Hellenic Electricity Distribution Network Operator (HEDNO S.A). HEDNO S.A. has already installed electronic meters for all medium voltage consumers and around 60,000 meters for low voltage consumers with high consumption (large consumers). Also, HEDNO S.A. has launched an open tender procedure (tender ND207), which, among other things, foresees the installation of 170,000 electronic meters in residential and small commercial buildings, with a total budget of 41 million €. The procedure for the evaluation is still on-going.

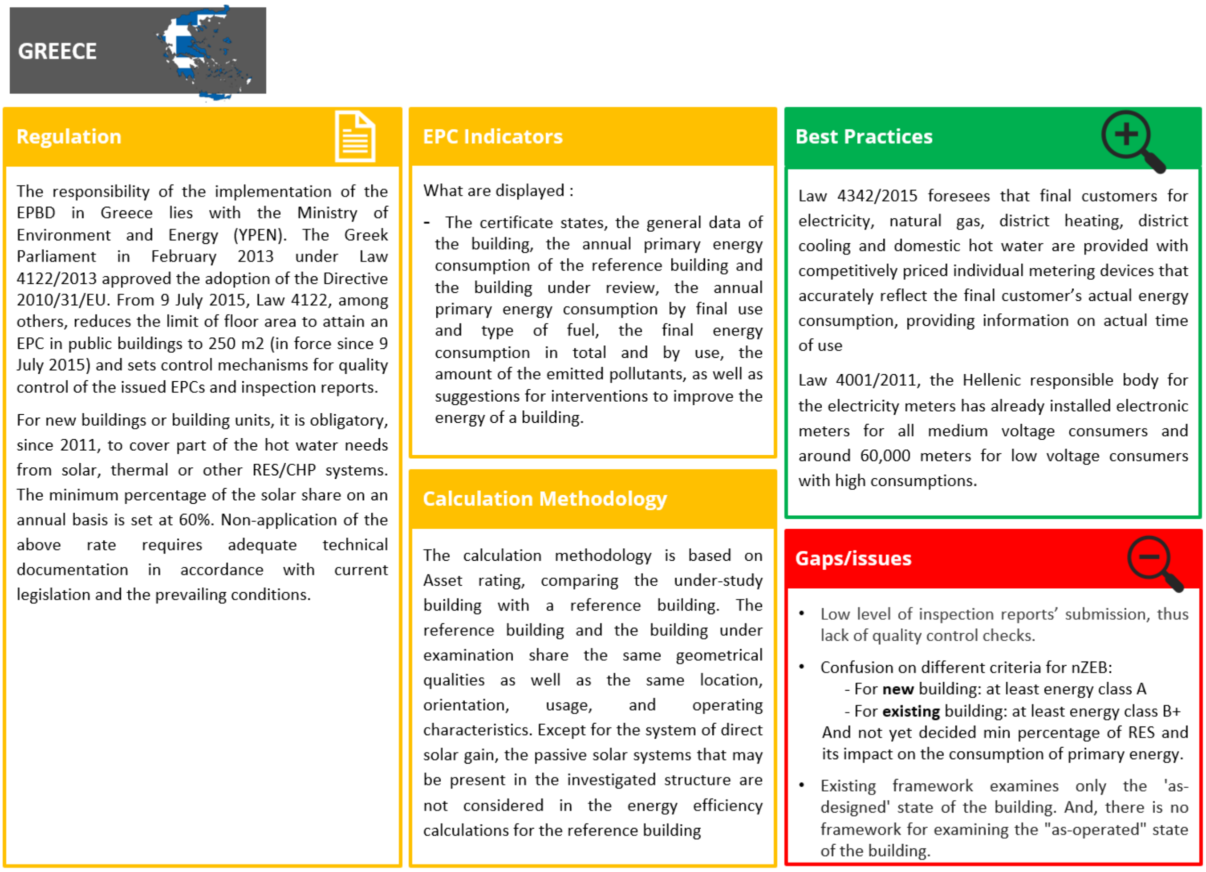

Figure 8 - Synthesis of the Greek state of the art (as of January 2023)

2.5 Estonia

In Estonia, EPCs are set up in force and implemented as nZEB requirements [15]. Table 8 indicates the Energy performance classes for buildings.

Table 8 - Energy performance classes for buildings in Estonia

Building type	EPI value requirement, kWh/(m² year)[34]			
	nZEB (class A) EPBD scope*	**nZEB (class A)**	**Low energy building (class B)**	**Renovation of existing building (class C)**
Small residential buildings (detached house, row house): a) net heated area <120 m² b) net heated area 120-220 m² and row house c) net heated area >220 m²	89.4 73.4 **59.5**	145 120 **100**	**165** **140** 120	185 160 140
Multi-apartment buildings	**45.9**	**105**	125	150
Military barracks	**85.9**	**170**	200	250
Office buildings, libraries and research buildings	**62.1**	**100**	130	160
Accommodation building, hotel	**138**	**145**	170	220
Commercial buildings	**118**	**130**	150	210
Public buildings	**135**	**135**	160	220
Commerce buildings and terminals	**154**	**160**	190	230
Educational buildings	**82.6**	**100**	120	160
Pre-school institutions for children	**90.0**	**100**	120	165
Healthcare buildings	**83.7**	**100**	130	170
Warehouse	**54.0**	**65**	80	100
Industrial building	**68.7**	**110**	140	170
Buildings with high energy consumption	**Na**	**820**	850	950

Requirements are also set for summer thermal comfort in buildings:

- For residential buildings, this requirement is defined as the hourly mean indoor temperature is more than the maximum limit of 150 degree-hours (ºCh) over +27°C during the summertime period (from 1 June to 31 August).
- For non-residential buildings, this requirement is defined as the hourly mean indoor temperature above the maximum limit of 100 degree-hours (ºCh) over +25°C (+27°C for warehouses, industrial buildings) during the summertime period (from 1 June to 31 August, educational buildings from 1 May to 15 June, and from 15 August to 30 September).
- For compliance assessment, detailed procedures are described in the regulation [13].

In Estonia, there are two calculation methodologies:

[3] ** EE EPI values in other columns include appliances in non-residential buildings, and lighting and appliances in residential buildings that are not included in EPBD energy uses. As being tabulated fixed values, EPI values for EPBD scope can be reported*

[4] *Primary energy requirements for buildings (bold values denote minimum requirements for new built structures).*

1. A methodology based only on calculated energy consumption (asset rating) –for a new building, dynamic energy simulation with validated commercial software.
2. A methodology that uses actual energy consumption data (operational rating) for existing buildings. Climate dependent part of metered energy is estimated, and climate is normalized with heating degree days. It is allowed to reduce non-EPBD uses if equipped with separate energy meters (however, appliances and lighting are included in Estonia in EPCs).

Temperature simulations are needed for typical living rooms and bedrooms that are most likely to encounter overheating. Temperature calculations for non-residential buildings are needed for typical room types. The verification is to be conducted by considering rooms as single zones, and by using dynamic simulation software.

New buildings must achieve EPC class A (nZEB) and major renovation of existing buildings EPC class C (may also be called major renovation nZEB) which both are seen as cost-optimal performance levels.

It is also important to note that the validity time of EPCs in Estonia is different: 2 years for new buildings and 10 years for existing buildings. For new buildings, the main issue for EPC would be the updated/recalculated for a use permit and for existing buildings as required in EPBD.

In the Estonian EPC the main indicators are:

- **Key performance indicators**: primary energy indicator.
- **Other indicator(s) used for energy rating and sustainability rating**: delivered, exported, and on-site generated energy.
- **EN reference standards for the indicators**: generally, follows EPB standards.
- **Energy saving measures**: included in the existing building EPC, so that recommendations can be selected from the drop-down menu. EPC is not a renovation passport with detailed recommendations.
- **Building description**: basic data in EPC and more detailed in a digital logbook.
- **Additional information**: input data and energy calculation result data tables and energy performance design documentation as a required part of the design documentation.

For new buildings, the main issues with EPCs would be:

- to establish a requirement to update/recalculate EPC issued in the building permit stage so that it would be recalculated by using as-built data in the use permit stage
- to establish a requirement that input data and results tables would be uploaded together with EPC, to provide an easy option for quality control – to assess the validity of the results

For existing buildings: there are no issues and performance gaps seen because actual energy consumption data is used in EPC calculation, and the system is very robust.

The best practice ongoing would be the official position in Estonia (responsible ministry) stating that EPC must stay as a simple and short document, reporting energy use /generation in an easy-to-understand fashion to the end customer. In the longer run, it is planned to automate the existing EPC calculation in the building registry, based on real-time main energy meters data already available today in the cloud data store.

ESTONIA

Regulation

Estonia implemented NZEB requirements 2020:

- EPC class A (NZEB) for new buildings (corresponding to cost-optimal performance level)
- EPC class C for major renovation (is also called major renovation NZEB)

Energy regulation includes requirements for summer thermal comfort:

- For residential buildings limit of 150 degree-hours (ºCh) over +27°C during the summertime period (from 1 June to 31 August)
- For non-residential buildings, limit of 100 degree-hours (ºCh) over +25°C (+27°C for warehouses, industrial buildings) during the summertime period

EPC Indicators

1. Key primary energy indicator is non-renewable primary energy
2. Delivered, exported, on-site generated energy, energy uses and needs also reported in EPC
3. EPB standards principles used in energy calculation
4. Energy saving measures included in the existing building EPC
5. Building description, basic data in EPC and more in a digital logbook

Calculation Methodology

1. Asset rating –for a new building, dynamic energy simulation with validated commercial software.
2. Operational rating for existing buildings climate normalised measured energy data is used. It is allowed to reduce non-EPBD uses if equipped with separate energy metres (however appliances and lighting is included in Estonia in EPCs).

Best Practices

In the longer run, it is planned to automate existing EPC calculation in the building registry, based on real time main energy meters data already today available in the cloud data store.

Gaps/issues

- New buildings: Input data and results tables, to be uploaded together with EPC, provide an easy option for quality control to assess the validity of the results
- Existing buildings: there are no performance gaps because actual energy consumption data is used in EPC calculation.

Figure 9 - Synthesis of the Estonian state of the art (as of January 2023)

2.6 France

The EPBD II recast received mixed reactions from consumer organizations. Although some measures were welcomed in essence, the timing of implementation was criticized by some as it arrived too late and spans over too many years. It also has been criticized regarding the costs of renovation on tenants. Since November 2006, EPCs are mandatory (with some exceptions) for the sale and since 2007 for the rent of housing. Since July 2021, EPCs are no longer only indicative but legally enforceable, and they can be legally opposed. In mainland France, dwellings must have an energy consumption, evaluated according to the EPC, of less than 450 kWh/m^2/year for new buildings and rentals from 2023. From 2025 on, the poorest performing housing will be banned from the housing stock; the next poorly performing range will be banned in 2028, and the next range by 2034. Also, the EPC is valid for 10 years, except in the case of substantial changes to the property.

The rating scale for EPCs realised before 1 July 2021 can be found in the guideline for the production of the Energy Performance Diagnosis (DPE). Below are the new rating scales [16] for EPCs performed after that date:

- Class A: less than 70 kWh/m^2 per year and less than 6 kg CO_2/m^2 per year
  - Class B: 70 to 110 kWh/m^2 per year and 6 to 10 kg CO_2/m^2 per year
  - Class C: 110 to 180 kWh/m^2 per year and 11 to 29 kg CO_2/m^2 per year
  - Class D: 180 to 250 kWh/m^2 per year and 30 to 49 kg CO_2/m^2 per year
  - Class E: 250 to 330 kWh/m^2 per year and 50 to 59 kg CO_2/m^2 per year
  - Class F: 330 to 420 kWh/m^2 per year and 70 to 99 kg CO_2/m^2 per year
  - Class G: more than 420 kWh/m^2 per year and 99 kg CO_2/m^2 per year

The diagnosis of the EPC includes recommendations to encourage improvements in the energy performance of the building, but they are not legally binding to tenants, who are not obliged to implement them.

The recommendations concern:

- **use:** summer/winter set point temperature, hot water consumption (they show the impact of virtuous on the amount of theoretical energy expenditure for heating, cooling and domestic hot water production, by showing a reduction in the dwelling's energy bill);
- **good management and maintenance of equipment**: CMV, boiler, glazing, etc.;
- **renovations**: the distinction between essential renovations *(e.g. priority work packages to get out of the energy sink class)* and other renovations *(e.g. work packages to achieve an efficient level class A or B)*. In the case of an energy sink (classes F and G of the EPC), both packages of work must be proposed.

It contains two labels:

- The EPC must specify the characteristics of the dwelling and its equipment and indicate the annual energy consumption: that’s the ENERGY label.
- The EPC must also indicate the impact of this consumption on greenhouse gas emissions: that’s the CLIMATE label.

The calculation methodology is based on the asset rating schema and it estimates the theoretical annual bills and is unified for all dwellings.

Gaps/Issues With the EPC

Problems have been reported regarding the uniformity of the calculation methodology and the scarcity / lack of certified professional assessors.

Best Practices

French EPCs include an **indicator of summer comfort**, which makes it possible to judge whether the comfort in the building is good, average or insufficient and specifies the characteristics of the dwelling that are favourable to summer comfort and the means to improve it. It appears on the second page of the EPC. A visual can be found in the guideline ‘’Understanding my EPC’’ of the French Ministry of Ecological transition [17].

Only passive summer comfort is assessed, active cooling systems, i.e. those that consume energy (excluding air movers) are not taken into account in the indicator. It is therefore possible to have a building considered uncomfortable in summer in the ECD although having a cooling system installed. To improve this indicator in the DPE, passive solutions should be proposed (external solar protection, roof insulation, insulation from the outside to maintain a high level of inertia, and installation of fixed air fans).

The **indicator for the performance of the envelope** appears on the second page of the ECD. The distribution of heat loss can be used as a guide to the priority work to be carried out. Potential buyers or tenants of a property can thus judge the performance of its envelope very easily.

Some consumer housing associations also advocate for energy certificates to be complemented by electrical and gas safety diagnosis. As the renovation of a building often involves the electrification of functions or components, it is necessary to ensure that electrical and gas safety levels are upgraded accordingly.

FRANCE

Regulation

In mainland France, dwellings must have an energy consumption, evaluated according to the EPC, of less than 450 KWH/m2/year for new buildings and rentals from 2023.

As of 1 July 2021, they are legally enforceable and can be legally opposed (except for the renovation recommendations) as they classify housings in performance categories from A to G, which corresponds to Kw/m2/year

The law on combating climate change and enhancing resilience to its effects, enacted on 22 August 2021, also makes it compulsory to carry out a regulatory energy audit, in addition to the energy performance diagnosis, for all sales of single-family houses and collective housing buildings in single-family homes, classified as F or G.

EPC Indicators

It contains two labels:

The EPC must specify the characteristics of the dwelling and its equipment, and indicate the annual energy consumption, that's the ENERGY label

The EPC must also indicate the impact of this consumption on greenhouse gas emissions, that's the CLIMATE label

Calculation Methodology

The calculation methodology estimates the theoretical annual bills and is unified for all dwellings.

Best Practices

French EPCs include an indicator on summer comfort, judging the comfort in the building

Also there is the indicator on the performance of the envelope. The distribution of heat loss can be used as a guide to the priority work to be carried out. Potential buyers or tenants of a property can thus judge the performance of its envelope very easily.

Gaps/issues

Problems have been reported regarding the uniformity of the calculation methodology and about the scarcity / lack of certified professional assessors.

Figure 10 - Synthesis of the French state of the art (as of January 2023)

2.7 Spain

The Royal Decree (RD) 390/2021 [18] is in force in Spain, which transposes into Spanish law the regulation on the energy certification of buildings provided in the Directive (EU) 2018/844 of the European Parliament and of the Council of May 30, 2018. The title of the Spanish regulation is ''Procedure for approving the basic procedure for the certification of the energy performance of buildings'' (*''Procedimiento por el que se aprueba el procedimiento básico para la certificación de la eficiencia energética de los edificios''*). This standard repeals the previously in-force regulation from 2013 (RD 235/2013) and 2017 (RD 564/2017).

Within the existing political model in the Spanish Constitution of the distribution of competences between the State and the Autonomous Communities, this general regulation corresponds to the State. However, each Autonomous Community has a competent body in this area whose function will be to control the quality of the certificates of each region and their registration.

In 2015, the IDAE[5], a public body under the Ministry for Ecological Transition and Demographic Challenge published a technical guide, called Building Energy Efficiency Rating (Calificación de la Eficiencia Energética de los Edificios) [19]. The document was prepared with the collaboration of the Eduardo Torroja Institute of Construction Sciences – IETcc-CSIC and the Andalusian Association for Research and Industrial Cooperation, AICIA.

This document establishes the methodology to carry out an energy rating that can be expressed in the form of letters and indicators that provide relevant information to the end users of the buildings. The energy efficiency of a building is determined by calculating the energy consumption necessary to satisfy the building's energy demand annually under normal operating and occupancy conditions and is expressed qualitatively or quantitatively by means of indicators, indices and ratings, or letters of a conventionally determined scale that varies from greater to lesser efficiency.

The main or global energy efficiency indicators are:

- Annual CO_2eq emissions.

[5] Institute for Diversification and Saving of Energy; Instituto para la Diversificación y Ahorro de la Energía

- Annual consumption of non-renewable primary energy.

These main indicators include the impact of heating, cooling, domestic hot water production and, in uses other than private residential (housing), lighting, as well as the reduction in emissions or consumption of non-renewable primary energy resulting from the use of renewable energy sources.

Complementary energy efficiency indicators are:

- Annual energy demand for heating.
- Annual energy demand for cooling.
- Annual non-renewable primary energy consumption disaggregated by services.
- Annual CO2e emissions disaggregated by services.
- Annual CO2e emissions disaggregated by electricity consumption and other fuels.

The services considered in the supplementary indicators are heating, cooling, and domestic hot water production, in buildings other than those for private residential use (housing), also lighting.

The units used to express these indicators are kWh per m^2 of the usable floor area of the building, for demand or consumption values, and kgCO_2eq per m^2 of the usable floor area of the building, for emission values. Table 9 and

Table 10 contain examples of rating scales in Spain. The scale values vary according to climatic zones.

Table 9 - Rating scale for buildings for private residential use (housing) in Spain

Rating	Index				
A			C1	<	0,15
B	0,15	≤	C1	<	0,50
C	0,50	≤	C1	<	1,00
D	1,00	≤	C1	<	1,75
E	1,75	≤	C1		
			C2	<	1,00
F	1,75	≤	C1		
	1,00	≤	C2	<	1,50
G	1,75	≤	C1		
	1,50	≤	C2		

Table 10 - Rating scale for buildings for other uses in Spain

Rating	Index				
A			*C*	<	0,40
B	0,40	≤	*C*	<	0,65
C	0,65	≤	*C*	<	1,00
D	1,00	≤	*C*	<	1,30
E	1,30	≤	*C*	<	1,60
F	1,60	≤	*C*	<	2,00
G	2,00	≤	*C*		

As part of the content of the Energy Performance Certificate, there should be a mention of recommendations for possible interventions for the improvement of cost-optimal or cost-effective levels of the energy performance of a building or part of a building (Art. 8 of Royal Decree (RD) 390/2021). The recommendations included in the energy performance certificate may address, among others:

1. The recommended interventions for the improvement of the building envelope, taking into consideration, where appropriate, the building's level of architectural protection.
2. Measures to improve the building's technical installations, including, where appropriate, the recommendation to replace fossil fuel-fired equipment with more sustainable alternatives. Measures to reduce thermal losses in the heat transfer fluid distribution networks may also be included.
3. The incorporation of automation and control systems.
4. The most appropriate time sequence for carrying out the proposed measures.

The recommendations included in the energy efficiency certificate shall be technically feasible, include an estimate of the payback periods for the investment, and may also include estimates of improvements in comfort, health, and well-being conditions.

The recommendations do not need to be included when there is no reasonable potential for cost-effective or cost-optimal energy performance improvement. In this case, a technical justification for the lack of improvement potential must be provided.

The recommendation made in the certificate shall contain information addressed to the owner, developer, tenant, maintenance company, energy auditor or energy service provider on the cost-effectiveness of the recommendations. The assessment of cost-effectiveness shall be made based on a set of standard criteria, such as the assessment of energy savings, underlying energy prices and a preliminary cost forecast. It shall also provide information on the actions to be taken to implement the recommendations.

The owner/tenant may also be provided with information on other related topics, such as energy audits, financial or other incentives and financing possibilities. For this purpose, the relevant criteria of Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodological framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements may be applied. This Regulation allows the calculation of cost-optimal levels of cost-optimal minimum energy performance requirements for buildings and building elements.

According to Art. 13. of the Royal Decree (RD) 390/2021, which refers to **the validity of EPCs,** renewal and updating of the energy performance certificate, the following is established:

1. The energy performance certificate shall be valid for a maximum of ten years, except when the energy rating is G, which shall be valid for a maximum of five years.
2. The competent body of the Autonomous Community for the energy certification of buildings shall establish the specific conditions for renewing or updating the certificate.
3. The owner of the building shall be responsible for renewing or updating the energy performance certificate in accordance with the conditions established by the competent body of the Autonomous Community. The owner may voluntarily proceed to its update when he/she considers that there are variations in aspects of the building that may modify the energy performance certificate or parameters used in the procedure for calculating the energy performance rating of the building.

Art. 3 of Royal Decree (RD) 390/2021 **indicates the scope of application of this regulation**. It establishes that it must be applied to the following cases:

1. Newly constructed buildings.
2. Existing buildings or parts of buildings that are sold or rented to a new tenant.
3. Buildings or parts of buildings belonging to or occupied by a Public Administration with a total useful surface area greater than 250 m^2.

4. Buildings or parts of buildings in which alterations or extensions are carried out that comply with any of the following assumptions:
    a. Replacement, installation, or renovation of thermal installations that need a project to be carried out or modified, in accordance with the provisions of Article 15 of the Regulation on Thermal Installations in Buildings, approved by Royal Decree 1027/2007, of July 20.
    b. Intervention on more than 25% of the total surface area of the final thermal envelope of the building.
    c. Extension in which the surface area or built volume of the unit or units of use on which the work is carried out is increased by more than 10%, when the total useful surface area of the extension exceeds 50 m^2.
5. Buildings or parts of buildings with a total useful surface area of more than 500 m^2 intended for the following uses:
    a. Administrative.
    b. Sanitary.
    c. Commercial: shops, supermarkets, department stores, shopping centers and similar.
    d. Public residential: hotels, hostels, residences, pensions, tourist flats and similar.
    e. Educational.
    f. Cultural: theatres, cinemas, museums, auditoriums, conference centers, exhibition halls, libraries and similar.
    g. Recreational activities: casinos, amusement arcades, nightclubs, discotheques and similar.
    h. Catering: bars, restaurants, cafeterias and similar.
    i. Passenger transport: stations, airports and similar.
    j. Sports facilities: gyms, sports centers and the like.
    k. Places of worship, religious and similar uses.
6. Buildings that are obliged to undergo a Technical Building Inspection or equivalent inspection.

The same article in paragraph 2 establishes the cases in which this regulation does not apply:

a) Buildings are officially protected for being part of a declared environment or by reason of their architectural or historic value, provided that any energy efficiency improvement action would unacceptably alter their character or appearance, with the authority issuing the official protection determining the unalterable elements.
b) Temporary buildings with an expected period of use of two years or less.
c) Non-residential industrial, defence and agricultural buildings, or parts thereof, with low energy demand. Areas that do not need to ensure comfortable thermal conditions, such as workshops and industrial processes, shall be considered to have a low energy demand.
d) Free-standing buildings, i.e. not in contact with other buildings and with a total useful floor area of less than 50 m_2.
e) Buildings that are purchased for demolition or for the purpose of renovation. These buildings shall be exempt from obtaining the energy performance certificate of the existing building, until, in the case of renovation, the renovation is completed and complies with the requirements of art. 3.1 (d) (vid. Supra)

Art. 8 of Royal Decree (RD) 390/2021 sets out the **Content displayed in the Energy Performance Certificate**, which is made up of the following elements:

a) Specific document Energy Efficiency Certificate of the building.
b) Energy Efficiency Label.

c) Energy assessment report of the building in electronic format (XML).

d) Documents or digital files necessary for the evaluation of the building in the calculation procedures used.

e) Annexes and supporting calculations that may be necessary for the correct interpretation of the energy assessment of the building.

f) Recommendations for use by the user.

The Energy Performance Certificate referred to in paragraph a) shall contain at least the following information:

a) Identification of the building or part of the building being certified, including its cadastral reference and, where applicable, the existence of special architectural cataloguing circumstances.
b) Indication of the recognized procedure used to obtain the energy efficiency rating.
c) Indication of the regulations on energy saving and efficiency applicable at the time of construction.
d) Description of the energy performance characteristics of the building: thermal envelope, technical installations, normal operating and occupancy conditions, comfort conditions and other data used to obtain the energy performance rating of the building.
e) The energy performance rating of the building is expressed in accordance with the recognized Energy Performance Rating for Buildings document.
f) Recommendations for possible interventions for the improvement of cost-optimal or cost-effective levels of the energy performance of a building or part of a building. The recommendations included in the energy performance certificate may address, among others:
    1. The recommended interventions for the improvement of the building envelope, taking into consideration, where appropriate, the building's level of architectural protection.
    2. Measures to improve the building's technical installations, including, where appropriate, the recommendation to replace fossil fuel-fired equipment with more sustainable alternatives. Measures to reduce thermal losses in the heat transfer fluid distribution networks may also be included.
    3. The incorporation of automation and control systems.
    4. The most appropriate time sequence for carrying out the proposed measures.

    The recommendations included in the energy efficiency certificate shall be technically feasible and shall include an estimate of the payback periods for the investment, and may also include estimates of improvements in comfort, health, and well-being conditions.

    The recommendations do not need to be included when there is no reasonable potential for cost-effective or cost-optimal energy performance improvement. In this case, a technical justification for the lack of improvement potential must be provided.

    The recommendation made in the certificate shall contain information addressed to the owner, developer, tenant, maintenance company, energy auditor or energy service provider on the cost-effectiveness of the recommendations. The assessment of cost-effectiveness shall be made on the basis of a set of standard criteria, such as the assessment of energy savings, underlying energy prices and a preliminary cost forecast. It shall also provide information on the actions to be taken to implement the recommendations.

    The owner/tenant may also be provided with information on other related topics, such as energy audits, financial or other incentives and financing possibilities. For this purpose, the relevant criteria of Commission Delegated Regulation (EU) No 244/2012 of 16 January 2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodological framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements may be applied. This Regulation allows the calculation of cost-optimal levels of cost-optimal minimum energy performance requirements for buildings and building elements.
g) Date of the visit to the building and description of the tests and checks carried out by the competent technician during the energy rating phase.

Articles 4 and 5 of Royal Decree (RD) 390/2021 **establish this issue of calculation methodology** which is Asset rating. Art. 4 indicates which are the recognized documents for the certification of energy efficiency, defined as those documents of a technical nature drawn up to facilitate compliance with the basic procedure for the certification of the energy efficiency of buildings, and which have the joint recognition of both the Ministry for

Ecological Transition and the Demographic Challenge and the Ministry of Transport, Mobility and the Urban Agenda. The documents recognized for energy performance certification may consist of the following:

1. Calculation procedures for the energy efficiency rating. These procedures may be simplified or general, and to optimize the quality of the certificates, their use shall be limited according to their scope of application in their corresponding recognized documents.
2. Specifications and technical guides or comments on the technical-administrative application of the energy performance certification.
3. Models of the building energy performance label, of the building energy assessment report (in XML format) and of certificates in physical or digital format that specify the information to be provided in each case.
4. Any other document that facilitates the implementation of the energy performance certification, excluding those that refer to the use of a particular product or system or under patent.

If components, strategies, equipment and/or systems are used that are not included in the available procedures, the procedure established in the informative document "Acceptance of unique solutions and additional capacities to the general and simplified procedures for an energy efficiency rating of buildings" [20] shall be used (art. 5-2).

In general, the methodology consists of solving C_1 and C_2 in the following set of equations.

$$C_1 = \frac{(R \cdot I_o/\bar{I}_r}{2(R-1)} + 0{,}6$$

$$C_2 = \frac{(R' \cdot I_o/\bar{I}_s}{2(R'-1)} + 0{,}5$$

where:

- I_o: denotes the annual emissions, annual primary non-renewable energy consumption, etc. of the building. These values must be estimated using one of the validated methodologies implemented in different certificated software.
- I_r: denotes the reference value for the new buildings of the same typology on the weather zone. These values are pre-computed and are publicly available.
- I_s: denotes the reference value for the current buildings of the same typology on the weather zone. These values are pre-computed and are publicly available.
- R: the ratio between Ir and the 10th percentile of the reference value for the new buildings of the same typology on the weather zone. These values are pre-computed and are publicly available.
- R': the ratio between Is and the 10th percentile of the reference value for the current buildings of the same typology in the weather zone. These values are pre-computed and are publicly available.

The final label is obtained by looking for the interval that fits C_1 and C_2 in Table 9 and

Table 10.

Gaps/Issues with the EPC

There is no single calculation system in place, but several approved ones and it can even not be used as long as the different calculation system used is indicated. It provides flexibility, but on the other hand, the results may differ.

The mechanism of proposing recommendations has a good objective and could have positive effects in the medium term, but the reality is that owners seek to obtain the certificate and as they are not obliged to carry out any recommendations, in most cases they are not carried out. Moreover, there is a lack of trust in the real impact that the proposed interventions could produce.

The specific procedures and registers are the responsibility of the Autonomous Communities, so these may vary from region to region, although this does not affect substantive issues, which have been regulated at the state level.

Best Practices for EPC

In general, in European countries the EPC must stay as a simple and short document, reporting energy use /generation in an easy-to-understand fashion to the end customer.

There are public and private organizations that elaborate decalogues or, in general, indications for the public that make suggestions to improve energy efficiency. For example:

- NGOs like Intermon-Oxfam [21]
- Public Administrations, like IDAE (Institute for Diversification and Saving of Energy; Instituto para la Diversificación y Ahorro de la Energía), a public body under the Ministry for Ecological Transition and Demographic Challenge [22].
- Regional Public Administrations, like in the Basque Country EVE (Basque Energy Agency; Ente Vasco de la Energía), provide energy-saving and efficiency measures [23].

Some of these good practices collected by these organizations:

- Use of energy-efficient systems in both light bulbs and household appliances, as well as intelligent use (complete filling of washing machines and dishwashers, use of residual heat in ovens and hobs, refrigerators, etc.) and rational use (heating and air conditioning temperature, reduced use of hot water in bathrooms and kitchens).
- Adapting use to real needs (adjusting contracted power, closing taps, switching off lights), making use of natural resources (natural light, air draughts) or simple resources (use of blinds and weather sealing of shutter boxes and window slits) or easily achievable resources (keeping lamps and bulbs clean, diffuser mechanisms on taps, etc.).

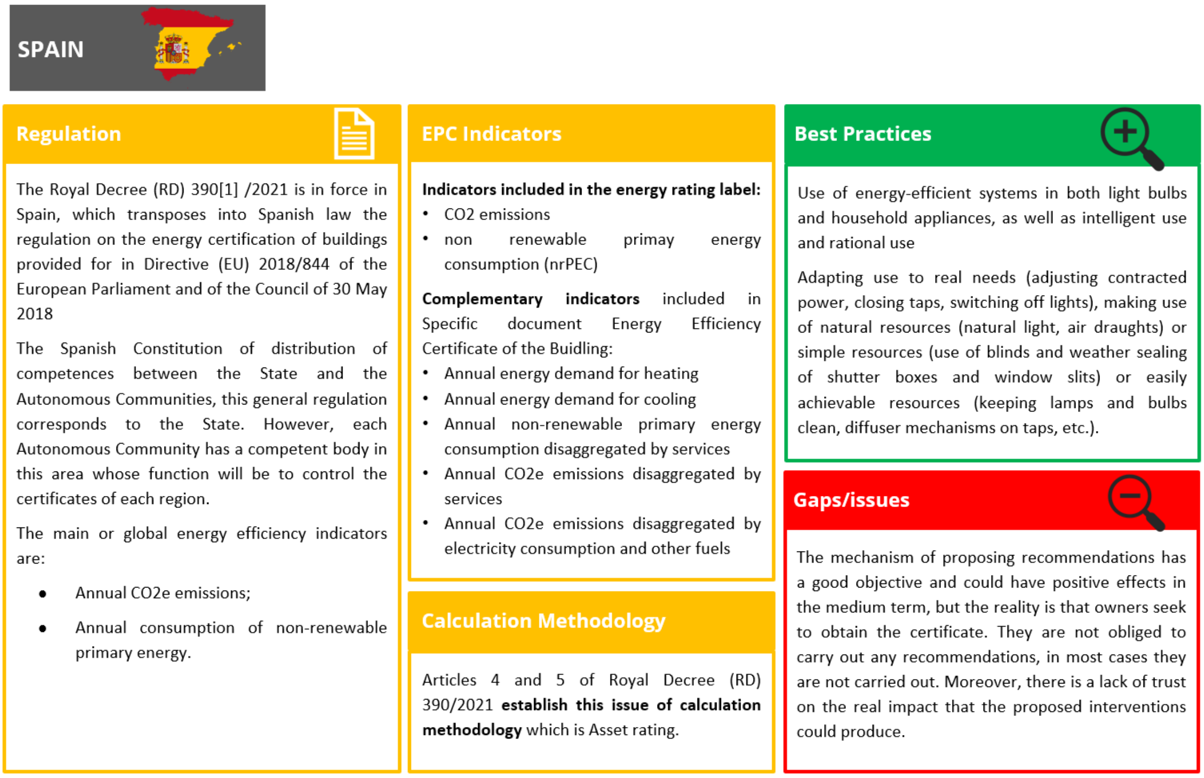

Figure 11 - Synthesis of the Spanish state of the art (as of January 2023)

2.8 Belgium

In Belgium, regulations on building energy performance are set at the regional level, each region is therefore free to define its own requirements. However, the three regions cooperate to establish a common methodology for new and refurbished buildings, and they use a jointly developed single software tool.

When an existing house is put up for sale or rent, an energy performance certificate must be provided beforehand. There are some exceptions which vary depending on the Region:

- **In the Brussels Region**, this is regulated by the ordinance of 2 May 2013 relating to the Brussels ordinance of air, climate and energy. In an amending ordinance of 18 December 2020, the Brussels legislator made a whole series of adaptations aimed at implementing Directive 2018/844, another update of the Energy Efficiency Directive [24]. If, since then, renovations have been carried out that have an impact on energy performance (insulation, replacement of windows, new boiler, etc.) and if the property is put up for sale or rent, Brussels Environment considers that the certificate is no longer representative and therefore no longer valid. You will then have to ask for an update, either from the old assessor (if it is still active) or from another one. If you choose a new certifier, then all the data needs to be re-entered into the software, whereas the old certifier can simply note the results of the work carried out and update the data he had previously entered. This may of course have an impact on the fee charges.
  - **In Flanders**, In Flanders, the legal basis for the transposition of the EPBD is established in the *energy decree* of 8 May 2009 and the *energy decree* of 19 November 2010. In October 2020, the decree of the Flemish Government amended the energy decree of 19 November 2010, with regard to the transposition of Directive 2018/844/EU and various provisions relating to energy efficiency [25]. They must be renewed when there is a change of tenant or owner. If the energy performance has improved since the certificate was issued, a new certificate can be issued, but this is not mandatory.
  - **In the Walloon Region**, the *Decree relating to the energy performance of buildings* of 28 November 2013, followed by an implementing order adopted on 15 May 2014 by the Walloon Government, is the basis. The latest update in Wallonia: The 2018 Directive completes the existing measures with requirements for electromobility. The PEB decree of November 28, 2013, was amended accordingly on December 17, 2020 [26]. A new certificate has to be issued if the building put up for sale or rent has undergone work requiring a building permit: extension, renovation, reconstruction, etc. In other cases, such as the installation of (additional) insulation or a boiler offering a higher efficiency, an updated EPC can be issued, but this is not compulsory.

In general, the EPC certificate must be established before the property is put up for sale or rent. Sale and renting advertisements must mention the energy performance of the property put up for sale or rent. The EPC certificate must be communicated to the purchaser or the tenant before the signature of the sale or rental agreement. Penalties are foreseen in case of the absence of the certificate or case of non-communication of the certificate through publicity or directly to the purchaser/tenant.

Depending on the allocation of EPC units, two EPC calculation methods exist to determine the primary energy consumption of new EPC units and equivalent to new: one applies to individual dwellings (residential units), and another one applies to non-residential units.

In the Brussels Region

- The PER method (Performance Énergétique Résidentielle) for “individual dwelling” units described in appendix XVII (“appendix PER”) of the decree of the Government of the Brussels-Capital Region relating to EPCs of 21/12/2007 (“Requirements decree” *or AGRBC*). *This appendix replaces Annex XII for projects for which the application for planning permission has been submitted on 01/01/2019;*
- The PEN method (Performance Énergétique Non-Résidentielle) for “non-residential” units is described in *appendix XVIII (“appendix PEN”) of the Requirements decree. This appendix replaces appendix XIII for projects for which the planning permit application was submitted on 01/01/2019*.

The energy consumption calculated by the PEB method is theoretical and determined for an average weather year with standardized occupant behaviours. Depending on the PER/PEN method, different usage assumptions are applied.

In Flanders

Most buildings in Flanders must meet a minimum level in terms of insulation, energy efficiency or energy performance and ventilation. Which requirements exactly apply depends, among other things, on the purpose of the building, the nature of the work and the date of the building application or notification. For new homes, for example, there may be EPB requirements for insulation, energy performance (expressed in an E-level), ventilation, minimum share of renewable energy, etc.

- The calculation method for residential buildings, i.e. single-family houses, and apartments, is called the EPW method. Annex V to the Energy Decree contains the E-level calculation for EPW units.
- the calculation method for all non-residential buildings is called the EPN method. This applies to all non-residential buildings (offices, schools and others such as hotels, care centers, etc.). Annex VI to the Energy Decree contains the E-level calculation for EPN units.
- Innovative building concepts or technologies cannot always be assessed based on the imposed calculation method. The Energy Decree, therefore, provides that you can use an alternative calculation method, via the equivalence procedure.

Due to continuous further developments in the calculation methods, the content of these appendixes depends on the date of application for the urban planning permit and the time at which the EPB declaration is submitted.

In the Walloon Region

The same dual system applies in Wallonia: one method targets residential buildings (Annex A1, PER method) and one target non-residential and collective dwellings (Annex A3, PEN method).

The Order of the Walloon Government of the 15 Mai 2014 implementing the decree of 28 November 2013 relating to the energy performance of buildings determines the calculation method, requirements, procedures, approvals and sanctions.

Both PER and PEN methods are regularly updated by orders of the Walloon Government, the last one dated 19 January 2022.

In general, EPC certificates are valid for 10 years.

The energy performance certificate of a dwelling evaluates, by means of a dedicated software, the theoretical consumption of the heating, hot water, cooling and/or ventilation installations of the dwelling (expressed in kWh per m² per year) based on heat losses through the walls (roof, facades, floor). Own production of renewable energy is also considered.

The consumption of household appliances or lighting is not considered, nor is the impact on users and their habits.

- The Brussels EPC consists of two parts:
    - The first part contains a summary of the results for the dwelling and the three main recommendations for improving its energy performance, with a series of points of attention and some useful information. There is no specific assessment of the building envelope, heating or hot water system, although this information would allow you to identify the critical elements of the house.
    - An annex to the EPC certificate lists the heat loss areas, their composition and insulation value (U or R-value), as well as the main characteristics of the technical systems installed (heating, ventilation, etc.). But it does not provide a specific value or an evaluation via, for example, a colour code for each heat loss surface.

- The Flemish EPC assesses each wall (roof, walls, floor, windows and doors) and each system (heating, hot water, ventilation, renewable energy) of the dwelling and indicates their degree of energy efficiency, using a colour code.
- The EPC also communicates the recommendations generated by the software to improve each component. For the roof, walls and floor, among others, a short description of the value to be achieved (U-value) by 2050 is presented, with guidelines for the thickness of the insulation (number of cms depending on the type). The EPC also provides a cost estimate for the different renovations.
- The Walloon EPC displays the surface area for each wall, the insulation material observed, if any, air leakage and ventilation losses and any comments from the certifier.

On another hand, the use of EPCs in Belgium is deeply criticized depending on their efficacy in the different regions.

Gaps/Issues with the EPC

Critique of the Brussels EPC: Concretely, the EPC certificate gives three main recommendations. It seems to give priority to the largest areas, although, in reality, these are not necessarily the parts of the building that should be treated first. In fact, the certificate does not indicate which areas are efficient and which are not.

Critique of the Flemish EPC: The main criticism is that it does not provide an order for the execution of the renovations: suggestions are only marginally tailored as the information provided remains fairly generic. The order in which the points are dealt with (first the roof, then the windows and doors, then the floors, then the techniques) implies a certain hierarchy, but the exact order should also depend on the specificities of the building.

Critiques to the Walloon EPC: *The* Walloon EPC only contains some general recommendations, e.g: no indication of the insulation value of a wall, nor of the energy gain that additional insulation could bring, nor of the thickness to choose for the insulation. Air leakage and ventilation losses are addressed, but no tailored indication about potential improvements is provided and there is no visual representation of the energy gains after such improvements.

As a general rule, recommendations do not indicate the impact of the renovation or its magnitude (no comparison with average levels or desirable levels), they also do not give estimates of the costs of possible improvements.

Best Practices of EPC

In Wallonia, there is a good example of Best Practice for EPC. Indeed, the region provides an additional tool to evaluate the energy performance of a house: the housing audit. This identifies a house’s weak points and determines the priority work to be carried out to improve the comfort and health of the inhabitants and to reduce energy consumption. It also indicates the potential gain from each measure, an estimate of the costs and incentives available and a roadmap for achieving an A-label energy rating.

BELGIUM

Regulation

In Belgium, regulations on building energy performance are set at the regional level, each region is therefore free to define its own requirements

In **Flanders**, In October 2020, decree of the Flemish Government amending the energy decree of 19 November 2010, with regard to the transposition of Directive 2018/844/EU and various provisions relating to energy efficiency.

In **Brussels**, In an amending ordinance of 18 December 2020, the Brussels legislator made a whole series of adaptations aimed at implementing Directive 2018/844, another update of the Energy Efficiency Directive.

In **Wallonia**, The 2018 Directive completes the existing measures with, in particular, requirements for electromobility. The PEB decree of November 28, 2013 was amended accordingly on December 17, 2020.

EPC Indicators

Brussels EPC: contains a summary of the results for the dwelling and main recommendations for improving its energy performance, with a series of points of attention and some useful information.

Flemish EPC: assesses each wall and each system of the dwelling and indicates their degree of energy efficiency, using a colour code.

Walloon EPC: displays the surface area for each wall, the insulation material observed, if any, air leakage and ventilation losses and any comments from the certifier.

Calculation Methodology

Is different for all region but they are all Asset rating.

Best Practices

Wallonia has a housing audit tool which:

- identifies building's weak points;
- priorities work to be carried out;
- improves inhabitant's comfort and health;
- reduces energy consumption;
- indicates potential gains from each measure;
- estimates the costs and incentives available, and a roadmap for achieving an A-label energy rating.

Gaps/issues

Brussels EPC: the certificate does not indicate which areas are efficient and which are not.

Flemish EPC: does not provide an order for the execution of the renovations, suggestions are only marginally tailored as the information provided remains fairly generic.

Wallon EPC: general recommendations, do not indicate the impact of the renovation or its magnitude they also do not give estimates of the costs of possible improvements.

Figure 12 - Synthesis of the Belgian state of the art (as of January 2023)

2.9 Romania

Until last October 2022, nobody (public or private institutions) talked about EPBD II recast in Romania. Romanian authorities still have many issues with the implementation of the EPBD I recast provisions.

The topic (EPBD recast II) was addressed for the first time in Romania during the AIIR's National Conference, on 14-15th of October 2022.

According to the new Romanian regulation in the field (code Mc001 recast version) which entered into force on 16 of January 2023, the minimum energy performance requirements are two-folded:

- for nZEB building, according to Figure 13for refurbished buildings, according to Figure 13

Climatic zone	Starting with	Office buildings		Education buildings		Residential multifamily buildings		Individual residential buildings (houses)	
		Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]	Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]	Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]	Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]
I	2022	113.5	15.4	72.5	10.9	116.4	17.9	143.2	22.1
II	2022	117.3	16.5	78.2	12.0	121.2	19.1	149.1	26.3
III	2022	116.9	17.2	82.7	13.1	123.1	19.9	156.8	25.5
IV	2022	117.7	18.2	88.6	14.4	126.4	21.1	164.1	27.5
V	2022	119.3	19.2	94.4	15.6	130.0	22.3	171.6	29.5

Climatic zone	Starting with	Health buildings		HORECA buildings		Commercial buildings (shops …)		Sport buildings	
		Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]	Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]	Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]	Total primary energy [kWh/m²,an]	Equiv CO_2 emissions [kg/m²,an]
I	2022	191.9	28.4	113.0	17.4	113.1	16.5	111.2	15.7
II	2022	198.4	30.1	117.8	18.5	121.1	18.3	116.2	16.9
III	2022	199.6	31.3	120.4	19.4	125.8	19.7	117.9	17.9
IV	2022	202.9	32.9	124.3	20.6	132.7	21.6	121.3	19.1
V	2022	206.8	34.5	128.4	21.7	139.8	23.5	124.6	20.3

Figure 13 - Minimum energy performance requirements in Romania

This calculation methodology is **based only on calculated energy consumption (Asset rating),** using around 32 references from the new set of EPB standards from CEN/ISO.

In the new Romanian EPC described by the new regulation Mc001 (recast version from the former Mc001 in 2006), the first annex to the EPC includes data about the total estimated value of the investment and the estimated simple payback period.

The EPC validity in Romania is 10 years from the releasing date mentioned on the EPC form, or until the next major intervention on building and building systems, which requires a construction permit from the local authority (the mayor-house) and a new EPC released, according to the Romanian legislation, at the works reception time.

It is also important to note that in Romania, EPCs can be issued:

- for new buildings, at the reception time of construction works;
- for refurbished buildings which require a construction permit, at the reception time of construction works;
- for sales/purchases of buildings/building units (including apartments);
- for renting buildings/ building units (including apartments).

In the Romanian EPC the Key performance indicators such as Total primary energy consumption, RES energy use, CO2 equivalent emissions, etc and other indicator(s) used for energy rating and sustainability rating such as Final energy consumption etc are all displayed in the EPC certificate (see Figure 14), while all the information regarding Energy saving measures, Building description and Additional information are all displayed in the Annex 1 and annex 2 of the EPC.

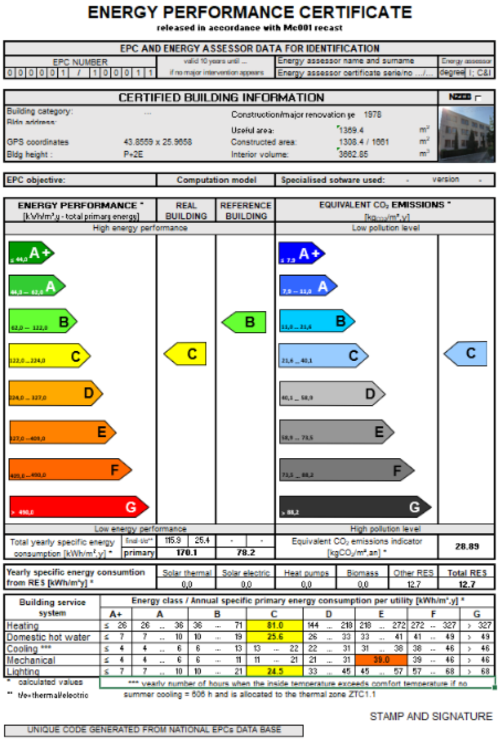

Figure 14 - Romanian EPC certificate

Best Practices of EPC

About Best Practices, there is a lack of information. However, the new Romanian EPC can indicate on a voluntary basis the SRI value for the building assessed (see the annex 1 to the EPC). Additionally, if a building is not cooled, a comfort indicator (i.e. the number of hours in a year when the inside temperature exceeds the reference value of 26grdC) must be computed and listed in the EPC.

The Romanian EPC indicates as well in its annex 1 the approximate total value of the investment needed for the implementation of the renovating solutions, and the approximate simple return on investment.

Gaps/Issues with the EPC

On another hand, there are a lot of issues within the EPC in terms of EPC results (e.g. the EPi value is not accurate enough).

- Total primary energy consumption is not close to the real (measured) consumption of the building/building unit.
- Very complex calculation methodology based on EPB standards; it can be used only with the help of a digital tool.
- Calculation based on a monthly climatic date; no hourly data available for Romania (except 9 main towns).
- There are no security elements integrated into the EPC form (calculated values can be very approximative, not really calculated based on the official methodology); the authority in charge to check the EPCs doesn't have options to do it properly, they check only the EPC format and if the EPC author (the energy assessor) has sent the EPC to the national database of the ministry in charge.
- The building owner doesn't react after the reception of the EPC in the sense of implementing some of the renovation measures indicated by the energy assessor.

- There is no official procedure regarding how to send the EPCs to the national database, there is no study made with data from EPCs recorded in that database.

ROMANIA

Regulation

Romanian authorities still have many issues with the implementation of the EPBD I recast provisions. The topic (EPBD recast II) will be addressed for the first time in Romania during the AIIR National Conference, on 14-15 of October 2022.

According to the new Romanian regulation in the field which will enter into force until the end of 2022, the minimum energy performance requirements are two-folded in for NZE building and in for refurbished buildings (explained in annex)

When informations about EPC are displayed:

- for new buildings, at the reception time of construction works;
- for refurbished buildings which requires a construction permit, at the reception time of construction works;
- for sales/purchases of buildings/building units (including apartments);
- for renting buildings/ building units (including apartments).

EPC Indicators

IN THE ROMANIAN ANNEX

Calculation Methodology

Methodologies based only on calculated energy consumption (Asset rating), using around 32 references form the new set of EPB standards from CEN/ISO.

Best Practices

Romanian EPC can indicate on a voluntary basis the SRI value for the building assessed

Additionally, if a building is not cooled, a comfort indicator must be computed.

Also indicates the approx. total value of the investment needed for the implementation of the renovating solutions, and simple return on investment.

Gaps/issues

- Total primary energy consumption is not close to the real building's consumption.
- Calculation methodology based on EPB standards used only with the help of a digital tool.
- Calculation based on monthly climatic date, no hourly data available for Romania.
- There are no security elements integrated in the EPC form.
- Weak concerning of the building owner about EPC.
- There is no official procedure regarding how to send the EPCs for the national database.

Figure 15 - Synthesis of the Romanian state of the art (as of January 2023)

2.10 Germany

There are different perceptions in Germany from various stakeholders about EPCs and moreover EPBD II:

- Architects, the building industry, craftsmen and commerce tend to support the proposals because it will boost their business.
- Building owners do have different views whereas tenants mainly do not support the recast with respect to the affordability of the measures.
- However, from an environmental point of view, there is basic support for the aims of all groups.

It is important to note that in Germany, there is a special political framework about things you can do in a residence. To start with the latter:

- If a landlord owns a detached or semi-detached residential home, it is solely up to the owner to decide what to do with the property (unless there will be an obligation to renovate existing buildings).
- If a landlord owns an apartment in a building block, the community of owners decides (basically by majority) if there will be renovation works. The respective law changed two years ago and there are more detailed exceptions to this rule, but the principle basically remained.

When it comes to financing the measures, tenants are obliged to participate in the costs by an increase in the rent they must accept. This percentage was recently reduced from 11% to 8% yearly of the share of the costs that impact the energy performance of their apartment expenses due to maintenance of the building which cannot be forwarded to the tenants by the landlord. The percentage was reduced to offset the excessive rise in rental fees experienced in metropolitan areas during the last decade.

In Germany, there are new laws about energy requirements for buildings. In 2020 a new law came into force[6] that combines and succeeds different national laws and directives. A reference building with the relevant heat transfer coefficients for certain building components (walls, ceilings, windows) is defined. The new law stipulates a maximum value of 70% of this reference building. Altogether, this corresponds to 45 kWh per m² for residential buildings. The new law also embraces the requirements for EPC.

In the energy certificate for residential buildings, the issuer, e.g. the energy consultant, can indicate "recommendations for cost-effective modernization". These recommendations can serve as a certain basis for refurbishments and are helpful if the energy certificate must be issued anyway. Also, Methodologies based only on calculated energy consumption are applicable for new buildings and for small buildings (up to 4 dwellings) built before 1977.

Methodologies that use actual energy consumption data are most common for existing buildings because it is inexpensive. All these specifications are counterbalanced by the fact that EPCs in Germany can last 10 years, and they are issued only if there is a change of owner or tenants in buildings. Also, key performance indicators are displayed only for new buildings with EN references, energy-saving measures, building descriptions and all additional information needed. There are no other indicators displayed.

Gaps/Issues with the EPC

The major issue about EPCs results lies still in the fact that both operational and asset rating EPC are allowed. Hence, tenants can hardly compare the energy performance of two different building offers using EPC from two different methodologies. Moreover, people tend to misinterpret the operational rating EPC and mistake it for their expected heating bill, without realizing that they may have a completely different use scenario than the user before.

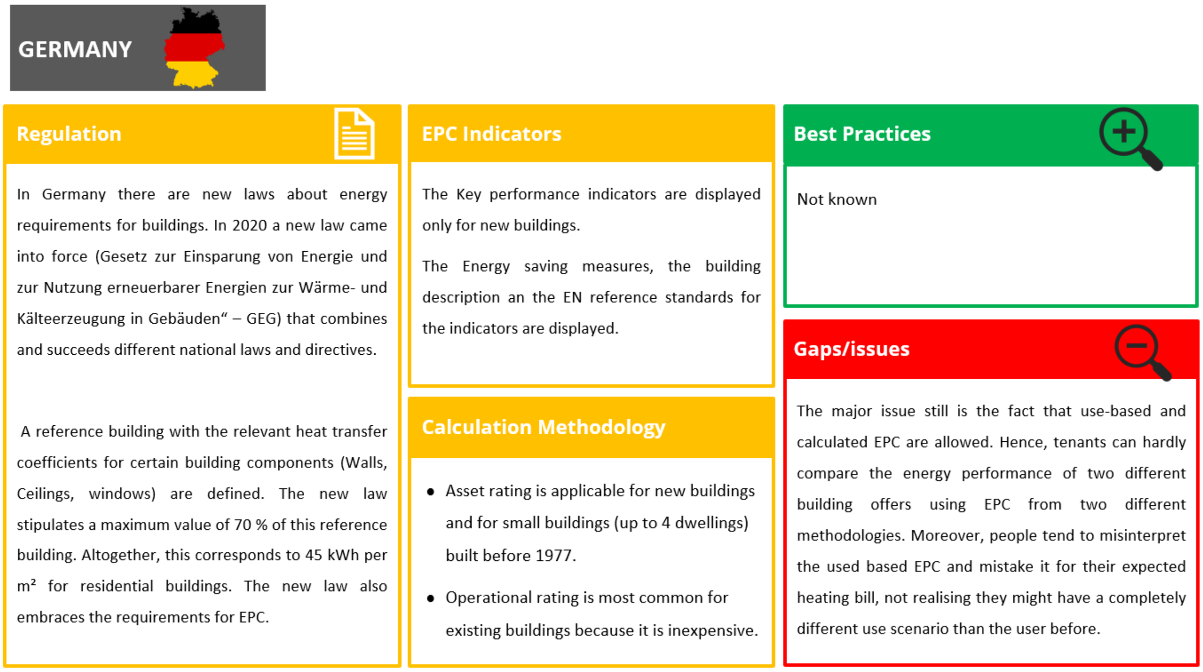

Figure 16 - Synthesis of the German state of the art (as of January 2023)

[6] Gesetz zur Einsparung von Energie und zur Nutzung erneuerbarer Energien zur Wärme- und Kälteerzeugung in Gebäuden“ – GEG

2.11 Cyprus

Cyprus transposed the EPBD into national legislation by issuing the law that regulates the Energy Performance of Buildings in 2006, which has since been amended three times in order to transpose Directive 2010/31/EU and better adjust the EPBD to national circumstances. The EPBD II recast was welcomed by Cypriot stakeholders but is not in use yet.

From 2020, the new minimum requirements for energy performance will require an nZEB level in new buildings. The requirements defined in nZEB regulation are also identical for both new builds and for that part of the existing building stock which undergoes a major renovation. Below you can see the minimum energy requirements for a building according to the Regulation of the Energy Performance of Buildings Law 122/2020:

1. Energy performance category in the Building Energy Performance Certificate → **A**
2. Maximum primary energy consumption as calculated by the methodology for calculating the energy performance of a building for buildings and building units used as dwellings. = **100 kWh /m² per year**
3. Maximum primary energy consumption as calculated by the methodology for calculating the energy performance of a building for buildings and building units that are not used as dwellings, not including hotels. = **125 kWh /m² per year**
4. Maximum primary energy consumption as calculated by the methodology for calculating the energy performance of a building for buildings and building units used as hotels. = **220 kWh /m² per year**
5. Maximum average U value coefficient of walls and elements of the load-bearing structure (columns, beams and walls) that are part of the building envelope = **0,40 W/m²K**
6. Maximum average U value coefficient of horizontal structural elements (floors in gated, floors in a cantilever, roofs, roofs) and floors that are part of the building's shell. = **0,40 W/m²K**
7. Maximum average U value coefficient of frames (doors, windows) that are part of the shell of the building = **2,25 W/m²K**
8. In order to be permissible to exceed the maximum coefficients of points (5), (6), (7) the maximum average coefficient of all the elements of the building envelope must not be greater than = **0,65 W/m²K**
9. The maximum average shading coefficient in frames (windows) that are part of the building's shell. = **0,63**
10. Maximum energy demand for heating for buildings and building units used as dwellings = **15 kWh/ m² per year**
11. Maximum average installed lighting power for buildings and building units used as offices = **10 W/ m²**
12. The maximum average installed lighting power referred to in point may be exceeded where the building should be equipped with an automation and control system, which must allow:
    - the continuous monitoring, recording, analysis and ability to adjust the energy consumption for lighting and
    - benchmarking the energy performance of the building, identifying losses in the efficiency of the building lighting systems and informing the person in charge of the premises or the technical management of the building about the possibilities of improving energy performance.
13. A minimum percentage of the total primary energy consumption derived from renewable energy sources as calculated by the methodology for calculating the energy performance of a building = 9% for hotels and 25% for all other types of building

Recommendations for the cost-optimal or cost-effective are included in the EPC. The methodology used or the cost-optimal calculation of the energy performance minimum requirements for Cyprus, in accordance with regulation 244/2012 and Article 10 of the EPBD in the article written by FRC [28]

The period of validity of an EPC currently issued in Cyprus is 10 years and it is required to be issued at the Design Stage, as part of the building permit. Also, EN reference standards for the indicators, Energy saving measures, building description are displayed in Greece for EPC. And finally, they have calculation methodologies based only on calculated energy consumption (Asset rating).

Gaps/Issues with the EPC

The main gaps within the EPCs include the following:

- The EPC certification is issued at the “design stage” and not at the “as-built stage”. As a result, in the case of deviations in the construction, the EPC is not representative.
- A large gap exists between the average value of the calculated and the measured energy. Thus, due to the occupants’ behaviour, an important impact on the measured energy performance of the buildings is not taken into consideration [29].

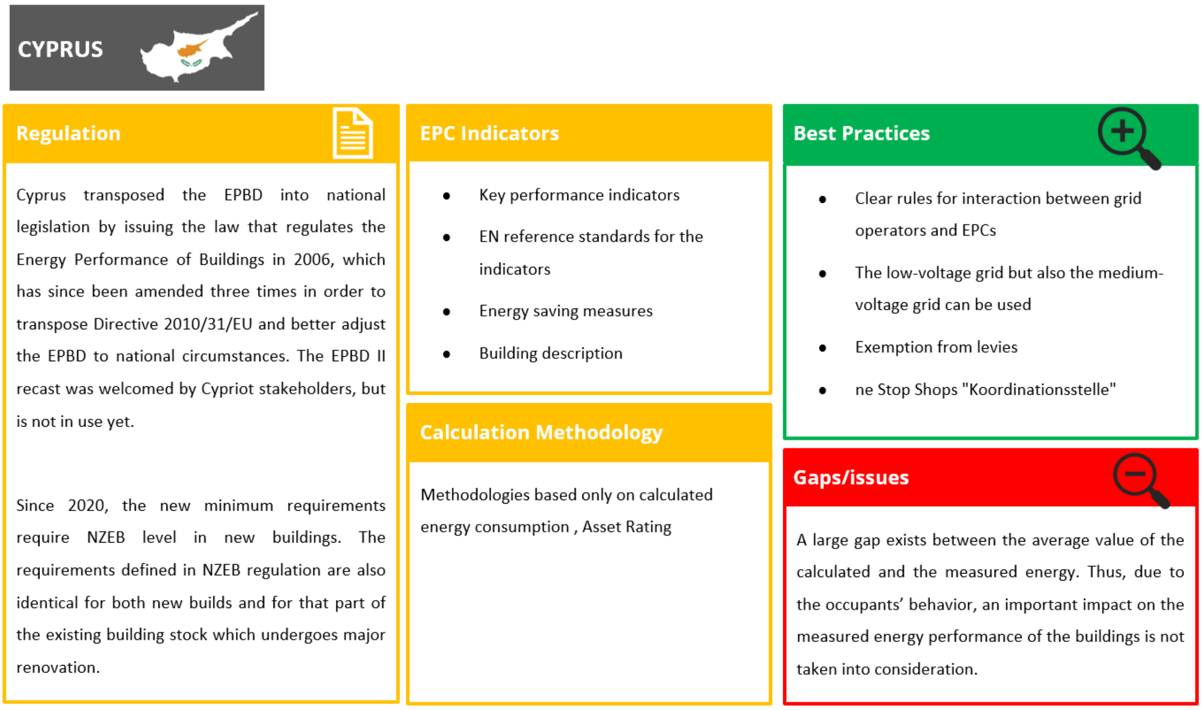

Figure 17 - Synthesis of the Cyprus state of the art (as of January 2023)

2.12 Conclusion on the analysis conducted in EU countries

The analysis of EPC for the ten EU countries conducted at an early stage of the process enabled the understanding and identification of EPC and EPBD implementation the state of the art, the main used methodologies, as well as, the main barriers and best practices in each of the selected countries of the SmartLiving EPC project. The outcome can be considered as a basis for the assumptions and consideration that will be made in this project. *It has to be noted that the information gathered represent the situation occurring in January 2023 at it can change in the near future after the EPBD revision and its transposition in different EU countries*.

Figure 18 shows a summary of the analysis conducted highlighting four main points for each country:

- the status of the EPBD implementation (if it was received and its law reference);
- the calculation methodology (if asset rating or operational or both);
- what are the measures in the expected revision of the EPBD (if known);
- and what are the key features that have to be considered for the SmartLivingEPC development.

In general, it can be stated that most of the countries have implemented the EPDB except for Cyprus and Romania, and this last one is expected to be transposed soon. The calculation methodology mostly used is the asset rating apart in a few cases (Germany and Estonia) where the operational rating is used for existing buildings.

In all ten countries, there are plans to update the actual version of the EPBD with the new one, but at the time of writing this report, no actual real information is known. For instance, in Estonia the expected revision should update the EPC scale, class A according to new cost-optimal calculations and class G as 15% of worst-performing buildings, while in Austria the revision of the new version of EPBD is scheduled for Autumn 2023 (not confirmed); a first draft was submitted to public comment in summer 2022, as well as in Italy where the government wants to be in line with the "Fitfot55" package.

For instance, in Estonia, the expected revision should update the EPC scale (class A according to new cost-optimal calculations and class G as 15% of worst-performing buildings), while in Austria the revision of the new version of EPBD is scheduled for Autumn 2023 (a first draft was submitted to public comment in summer 2022), as well as in Italy where the government wants to be in line with the "Fitfot55" package.

Concerning the key features that should be taken into consideration in the design and development of the SmartLivingEPC solution, the following can be identified from Greece, Estonia and Austria:

- Incentives to roll out the development of almost carbon neutral (Super Low Energy) buildings in Greece:
    - In general, for buildings which are placed in the highest energy efficiency rank, in agreement with the Greek EPC, the build-surface ratio of the building can be increased by 5%.
    - For both residential and commercial buildings with primary energy saving ratios above 16% of the energy performance of the Reference Building Scenario based on the greek law (KENAK), an increase in the build-surface ratio of 10% can be achieved. For commercial buildings, an extra requirement must be fulfilled: that the building can present at the same time excellent environmental performance according to national standard protocols such as LEED, DREAM and DNGB.
- In the building registry/digital logbook using machine-readable formats and automated calculation for existing building EPC (Estonia).
- Use the Heat storage system and heat supply systemin for the EPC calculation (Austria).

	SPAIN	ITALY	AUSTRIA	GREECE	ESTONIA	FRANCE	BELGIUM	ROMANIA	GERMANY	CYPRUS
Status of EPBD II transposition	Enforced with Royal Decree (RD) 390/2021	Enforced with Decreto Legislativo n.48/2020	Enforced by OIB Guideline 6	Enforced with Law 4843/2021	Enforced since 2020	Enforced since 2021	Enforced in all three regions from 2020	not enforced yet (end of 2022 ?)	Enforced in 2020	Not yet enforced
Calculation Method	Asset rating	Asset rating	Asset rating	Asset rating	Asset rating for new building Operational rating for existing ones	Asset rating	Asset rating	Asset rating	Asset rating for new building Operational rating for existing ones	Asset rating
EPBD Expected Revision	tbd	Italy seems to want to be in line with the "Fit for 55" package	Scheduled in Autumn 2023	tbd	Revision should update the EPC scale	tbd	tbd	tbd	tbd	tbd
Key Features for SLE development	N/A	N/A	Use Heat storage system and heat supply system in EPC calculation	Incentives to roll out the development of almost carbon neutral (Super Low Energy) buildings	Using machine readable formats and automated calculation for existing building EPC in Blogbook	N/A	N/A	N/A	N/A	N/A

Figure 18 - Summary of the analysis conducted in each country (as for January 2023)

3 Consultation with the market and stakeholders involved

In parallel with the presented review of current EPC methodologies and legal frames in Europe, this project opens a consultation process to collect the point of view of stakeholders and experts in relation to energy efficiency and the EP as an instrument for measuring it.

3.1 Methodology used for Task 1.2

The methodology used for this task is based on two parallel working lines with five main questions structuring the whole analysis for the research. As can be seen in Figure 19, on one side, a direct consultation process (surveys and interviews) is launched with selected stakeholders, identifying them in the first stage in order to interview them later. On the other side, a research process of the latest written sources (desk research) is developed, to complete the elements not collected in task 1.1 with respect to legal regulations, tools, and methodologies applied. Based on the information collected, a mapping is constructed to identify the current situation, challenges and drivers, as well as future trends. All this is to serve as an informative basis for the following tasks, mainly T.1.4.

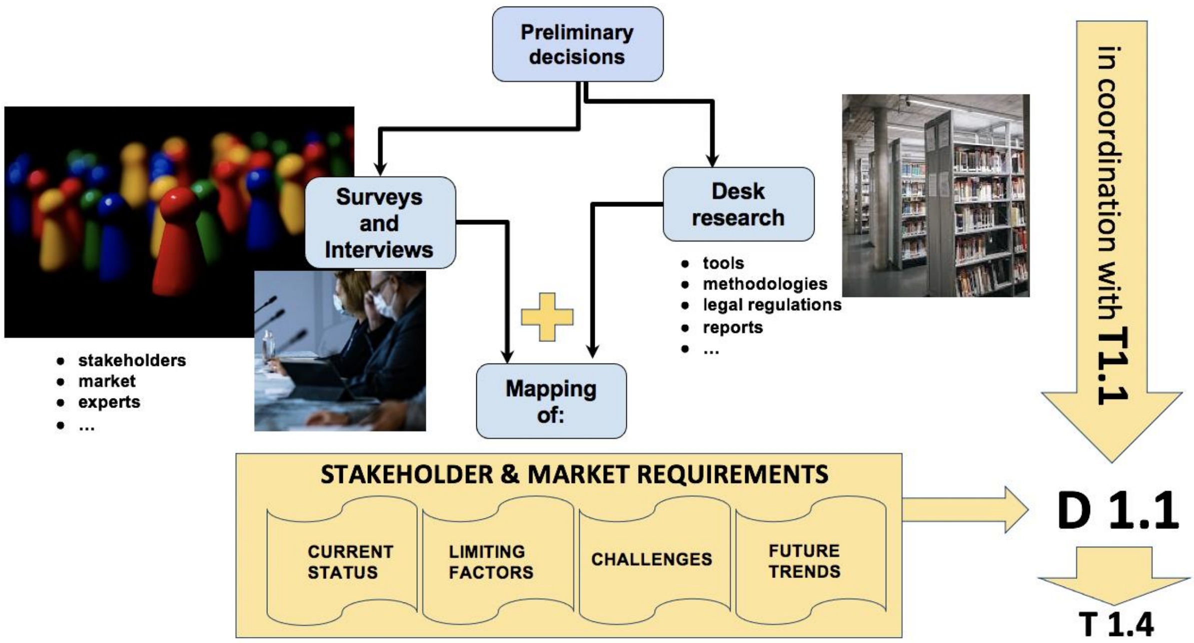

Figure 19 – Methodology scheme for Task 1.2

3.1.1 Identification of target stakeholders

The first step in this process of consultation was to agree on the procedure for identifying relevant stakeholders for this project, which are understood to be "an individual, groups, or organizations, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project" [27].

As the Energy Performance Certification is an EU-wide scale market, it is important to define the main world entities/stakeholders involved in this market. Following the methodology adopted for the recognition of relevant stakeholders specified by the Project Management Institute (PMI), the SmartLivingEPC project has defined three key target groups:

1. Stakeholders who affect the EPC assessment and certification, including stakeholders participating in the delivery of EPCs and those who determine the context of the EPC: organizations and companies implementing EPC assessments and developing EPC software, entities who set the legal framework and specific rules. Part of the vision of those stakeholders has been already compiled, country by country, in the first part of this deliverable.
2. Stakeholders who are affected, directly or indirectly, by the EPC assessment and certification, such as users and owners of the buildings, facility managers, the general public, local community groups such as resident associations, or other community-based groups.
3. Stakeholders who are interested in the EPC assessment and certification, such as researchers and Academia, environmental/social campaigning organizations, or potential users/clients for future projects.

In this phase of the research, the perspective of the second group becomes particularly interesting to be known. Following this pattern, each partner has analysed his country's context in order to identify stakeholders whose views could enlighten the project by providing new elements to be considered in the future design of EPCs.

As a result, a map of stakeholders has been designed and classified on the basis of these two criteria: on the one hand, the setting of the organization as public, business, representative and, on the other hand as a social organization. These criteria have been combined/matched with their role in the housing market, distinguishing between energy suppliers, builders and technicians related to construction, real estate managers, construction financiers, housing users and their advocates. The map below in Figure 20 shows the resulting framework:

Map of stakeholders

	PUBLIC BODIES	ENTERPRISES	REPRESENTATIVES	SOCIAL ENTITIES
ENERGY PROVIDERS				
BUILDERS & TECHNICS				
REAL STATE SECTOR				
FINANCIAL SECTOR				
END USERS				
DEFENDERS				

Figure 20 – Framework for classifying stakeholders

As a result of the joint effort done by the partners involved, a total number of 24 stakeholders were identified, from which to obtain their views and visions on the current EPC and their proposals for future designs that are reported in Figure 21.

Map of stakeholders

	PUBLIC BODIES	ENTERPRISES	REPRESENTATIVES	SOCIAL ENTITIES
ENERGY PROVIDERS		ENERGY SERVICE COMPANIES (ESCOs) ENERGY COOPS		
BUILDERS & TECHNICS		QUALITY ASSURANCE TECHNICS BUILDING MATERIAL INDUSTRIES CONTRACTORS SUPPLIERS BUILDING INDUSTRY BUILDING COOPS	PROFESSIONAL ASSOCIATIONS OF ENGINEERS PROFESSIONAL ASSOCIATIONS OF ARCHITECTS	
REAL STATE SECTOR	PUBLIC SOCIAL HOUSING PROVIDERS & MANAGERS	REAL STATE RENTING ENTREPRISES HOUSING COOPS	PROFESSIONAL ASSOCIATIONS OF MANAGERS IN REAL STATE	SOCIAL HOUSING PROVIDERS & MANAGERS
FINANCIAL SECTOR		MORTGAGE & CREDIT PROVIDERS ENERGY COMUNITIES ETHICAL BANKS		
REGULATORY BODIES	PUBLIC ENERGY AGENCIES CONTROLLER BODIES MUNICIPAL ENERGY OFFICES MUNICIPAL ONE-STOP SHOPS	STANDARDIZATION BODIES		
END USERS & DEFENDERS	MUNICIPAL ONE-STOP SHOPS MUNICIPAL ENERGY OFFICES ENERGY COMUNITIES	QUALIFIED EXPERTS HOUSING COOPS CONSUMER COOPS ACADEMIA ENERGY COMUNITIES	RESIDENT ASSOCIATIONS CONSUMER ASSOCIATIONS ENERGY COMUNITIES ACADEMIA	SOCIAL NGOs ENVIRONMENTAL NGOs LOCAL COMMUNITY GROUPS

Figure 21 – Map with the type of stakeholders

After the application of various strategies to reach the target stakeholders, 19 responses were obtained, representing the following typologies summarized in Figure 22 below.

Map of stakeholders consulted

	PUBLIC BODIES	ENTERPRISES	REPRESENTATIVES	SOCIAL ENTITIES
ENERGY PROVIDERS		ENERGY COOP		
BUILDERS & TECHNICS		SUPPLIER OF INSULATION MATERIALS PERFORMANCE PROGRAMMERS SUPERVISOR OF TECHNICAL ENERGY PROJECTS QUALITY ASSURANCE TECHNICIAN RECICLYING ELECTRIC&ELECTRONIC WASTE	PROFESSIONAL ASSOCIATION OF ARCHITECTS	
REAL STATE SECTOR	PUBLIC SOCIAL HOUSING PROVIDER & MANAGER PUBLIC SOCIAL HOUSING PROVIDER & MANAGER		PROFESSIONAL ASSOCIATION OF MANAGERS IN REAL STATE	SOCIAL HOUSING PROVIDER & MANAGER
FINANCIAL SECTOR		SEED INVESTMENT FUND FOR STARTUPS & INCUBATOR		
REGULATORY BODIES	MUNICIPAL ONE-STOP SHOP			
END USERS & DEFENDERS		QUALIFIED EXPERT	RESIDENT ASSOCIATION HOUSING ASSOCIATION CONSUMER ASSOCIATION	

Figure 22 – Map with interviewed stakeholders

With the level of responses obtained, every established profile was accomplished. Thus, both the vision of public entities which provide public housing and manage public and private rental housing, as well as of municipal-based citizen service offices for participatory urban renewal has been achieved.

From the private business perspective, contacts have been established with: a) companies representing various stages of the housing cycle and its services, b) a cooperative company that generates and distributes energy, c) private companies dealing with the manufacture of insulating materials, programming applied to energy, the supervision of energy projects, as well as electronic recycling, and also with a company dedicated to EPC processing. Furthermore, for the financing phase, opinions from an incubator of technological projects with its seed capital fund have been achieved.

With regard to associations representing the various stakeholder profiles involved, responses were received from a professional association of architects (including those committed to certifying EPCs), as well as from an association of housing managers, and from several consumers and specifically from housing users´ associations.

With regard to housing management, different points of view from various fields have been compiled, including two public companies, a professional association of real estate managers and a social entity dedicated to providing housing for people with inclusion difficulties.

Although no perspective of regulatory bodies has been analyzed, it will be outlined with the current regulatory situation analysed in detail in Task 1.1 and it will be combined with the answers from the rest of the stakeholders on the new approaches and discussion at the European level that probably, in the near future, will become mandatory with respect to EPC in all European countries.

3.1.2 Questions to research

Once the stakeholders have been identified, the second phase has focused on identifying the main factors to be considered related to EPC. Therefore, this is an exploratory study with the goal of building a map of key factors to consider in the next steps of SmartLivingEPC project. So, the idea is to launch five open-ended questions to allow each interlocutor to give us his/her opinion on the subject.

These are the following five open-ended questions:

1. Which is your opinion about the **efficiency and level of public knowledge about the current** Energy Performance Certificate (EPC)?
2. Which are the **main opportunities and drivers (propellers)** of the current EPC?
3. Which are the **main barriers /obstacles** of the current EPC?
4. Which are the **risks of** EPC to be a **factor of exclusion of vulnerable population**? If there is a risk of exclusion, how can it be avoided?
5. The EPC collects a large amount of information, what part of this **information** do you consider is **not necessary** for the current situation? What **new information** should **be included**?

The answers were analyzed accordingly, combining the opinions of the different stakeholders. In this way, the coincidences and discrepancies in some issues among the interviewees could be better observed. And later these results were cross-checked with those obtained from desk research.

3.2 Analysis of collected answers

The abovementioned five questions are the main axes that structure this consultation, as can be seen in Figure 23 which presents the research itinerary organized on the basis of these axes. First of all, opinions about the current EPC are collected, distinguishing between **positive and negative opinions**, about the tool and its use in practice. After this initial overview, the questions are focused on investigating the **drivers and barriers** that can be detected. The third axis is spot on the potential **spillover effects** related to EPC. And as a conclusion, the questionnaire gathers the **recommendations** received from the stakeholders, as well as the suggestions for **improvement** proposed by them.

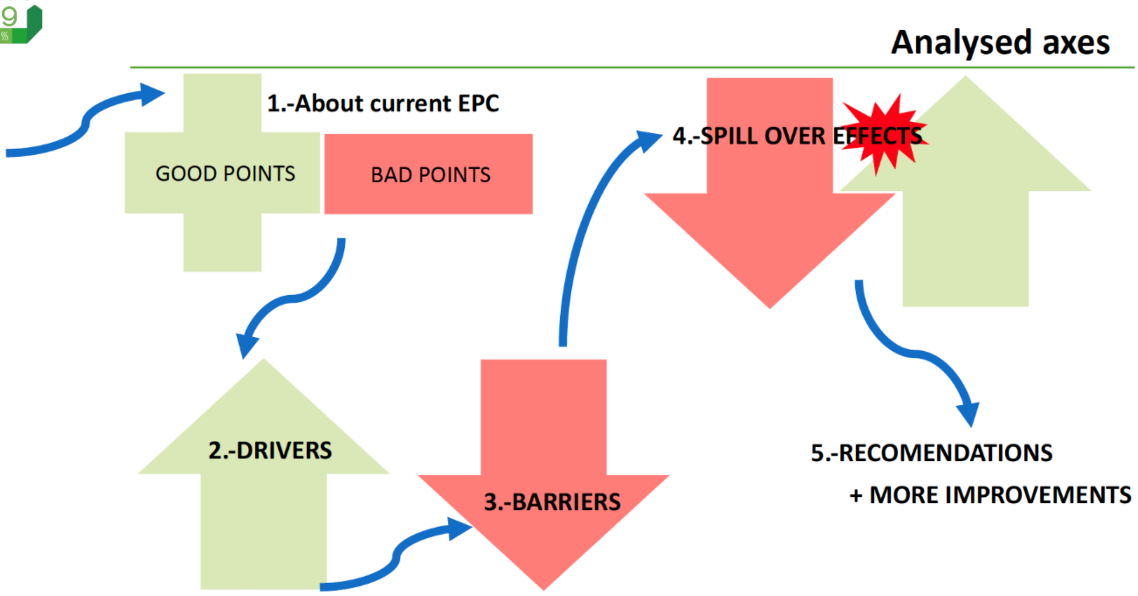

Figure 23 – Classification of axes

3.2.1 Responses related to the use and knowledge of the current EPC

Considering what has already been pointed out in chapter 2, several interviewees indicated that the tool is well-known among the public and is useful for various stakeholders. However, by looking deeper into the above, it becomes clear that those stakeholders are technicians, planners and policy makers, but not the general public. Those that need to sell, buy or rent housing, are required by law to have an energy assessment of that home (which has to be attached to the contract). They know the existence of the EPC but in general, they don't understand it. This lack of understanding about the implications of the score provided by the certificate is the point mentioned by most of the interviewees, regardless of the profile of the interviewee. And this issue will have a significant impact on many questions, as will be seen.

Adding to the above, energy efficiency is not a concept used by the general population, although the current energy crisis will probably help to change this fact. Consequently, is it important to recognize a very low knowledge ("catastrophically low", for one of the agents consulted, "fairly known" for another, "negligible current effectiveness" for a third respondent) in non-expert public and perhaps they can read the final score with letters because it's similar to the one domestic devices. But the rest of the information contained in the document is a complete mystery for normal people.

Considering also the lack of knowledge about the information contained with the lack of understanding of the real implications of the score, the result is a lack of trust in the certificate, especially when they perceive an inconsistency with their real consumption data, measured in money, not in kW/h. One of the interviewees pointed out that there is concern that the current mentality has not yet changed to prioritize reducing consumption, taking the necessary steps for consumers to ask themselves: "What can I do to make what I consume cheaper, instead of how can I reduce what I consume?". So, the idea of energy savings is catching on, but perhaps not yet that of energy efficiency. This suggests the need for awareness raise and education to achieve citizen commitment to energy efficiency.

In short, the public considers the EPC as a costly administrative requirement with no real value for them. This fact explains that, although the law requires it in real estate transactions, if the transaction is not carried out through a real estate agency, but directly between private individuals, the transaction is not carried out or is simply marked as pending.

All of this means that the existence or not of such a certificate and the valuation obtained hardly influences the purchase/rental decisions of individuals and families. It is symptomatic that in real estate agencies, this information appears in the advertisements because it is mandatory, but it appears in a small box because it is not taken into consideration when choosing a house, although other characteristics such as location, nearby services, etc., are valued. This is probably also influenced by the fact that much of the housing stock is of similar age and therefore similarly rated in terms of energy efficiency.

Another negative aspect mentioned is the failure to incorporate any consideration of the actual use being made by the building. Thus, some of the interviewees stated that the certificates are designed with theoretical scenarios based on consumption that are not aligned, for example, with the reality of public social housing. In short, "if it does not adjust to the usage profile of your home, it will not adjust to your consumption either".

In brief, the bad points detected about the current EPC are those:

- Very low knowledge of non-expert public
- Only identify the letter in all the documents, with lack of:
    - knowledge of information contained
    - understanding about implications of the score
- Lack of trust: confused by the inconsistency with their REAL consumption data
- Without considering the actual use of the building
- As a costly administrative requirement with no real added value
- Lack of usefulness as most houses have the same evaluation
- Today no real informative value for decision making
- Only when regulations require it

Technical profiles are the ones that have most valued the usefulness of all the information contained in the certificate, recognizing it as a powerful working tool, widespread as it is compulsory in certain activities. They also emphasize that EPC is issued by an external agent as a guarantee of neutrality. The architects recognized the change in thinking in the profession over the previous trend of tearing down and building up again: now the efforts are aimed at renovating the existing building stock and the EPC will become a positive tool to foster those renovation politics, for example, by recovering traditional neighbourhoods and old city centers.

Those technical profiles also identify the EPC as an opportunity to generate and extend a standard vocabulary in relation with energy efficiency among different agents involved especially in new construction or integral rehabilitation projects.

And some interviewees mention the possibility that EPC gives to recognize efficiency value of a building, which may have economic consequences in the valuation of the property or in the rent to be charged. This point will be analyzed again later in the report.

Summarizing, the good points detected about the current EPC are the following:

- Widespread as it is compulsory in certain activities
- Issued by an external (and neutral) party
- Useful for several stakeholders (experts)
- Positive tool to foster renovation (vs new construction)
- Could be used to increase the rent/value of the house
- Opportunity to generate standard vocabulary

A fundamental question in the answers obtained refers to the real addressee of the tool: Who is the end-user of the tool? Some respondents suggest that if the end-user is the public administration for urban planning purposes, it should bear the costs of obtaining the information, freeing citizens from having to finance this certificate. And if the end-user are owners and tenants, the certificate must be redesigned according to them and their necessities, as a first step in the process of fostering public engagement with this tool.

3.2.2 Responses related to opportunities and drivers (propellers) of the current EPC

Most of the interviewees point to the strong boost EPC receives from being connected to public support with financial help (Next Generation funds…) that appeared to be strong incentives for the people. So, Public Administrations are highlighted as the main propellers at this moment and the European leadership is underlined in fostering urban renovation.

In those financial support programs having an objective measurement is critical, and EPC becomes a crucial tool to demonstrate the real improvement in energy efficiency as a requirement for receiving those public funds or to get tax breaks and benefits. At the same time, EPC contributes to increasing the efficiency of renovation actions carried out.

Certain events are also mentioned as propellers of energy efficiency and EPCs, which may be of a temporary nature. One of them is the greater awareness of increased energy expenditure that combines geopolitical events (such as the invasion of Ukraine) with climatic instabilities (record heat waves followed by storms and Siberian cold waves). At the same time, the forced confinement for so long in homes due to the COVID pandemic has made us realize the importance of comfort and quality of space in our homes, not only as a place to sleep but also as a place to live.

And with a slower maturation period, the recognition of higher levels of sensitivity and knowledge regarding energy efficiency in newer generations must be acknowledged. As they become more involved in decisions related to housing, this sensitivity will drive the concern for energy efficiency in day-to-day life, as they are already doing in recycling issues, for example.

In summary, these are the main propellers detected by the interviewees:

- Greater awareness of increased energy expenditure (geopolitical events…)
- Search for comfort (after COVID experience)
- Increase knowledge of new generations
- Support from stakeholders (especially public authorities + Europe)
- Being linked to funds as a very powerful incentive
- Interest in fostering urban renovation
- Need the certification for taxing purposes (explicating cost, minimum performances, etc.)
- Searching objectivity: need to measure.
- Increase efficiency of renovation actions carried out

3.2.3 Responses related to barriers /obstacles of the current EPC

Along respondents almost unanimously refer to the administrative process and the bureaucracy involved as a hindrance. They also point out the complexity of the process to access public funds, describing it as "added complexity in the procedures".

Additionally, respondents emphasize that the lack of usefulness for the public is leading to a focus on finding the cheapest service provider, even if the quality is poor. This is hurting the market for experts in EPC certification, as certificates are now being issued based solely on photos of a building or apartment, without an on-site inspection. Certifications like these are causing the EPC tool to lose credibility and trust. At the same time, good professionals are leaving the industry because they are not being paid competitively or valued for their quality. This is resulting in a shortage of trained professionals and demotivating expert professionals.

This lack of professionalism, combined with the diversity of instruments or the lack of unanimity in their application, means that the same building evaluated by two different technicians and/or even two different tools can potentially give rise to different results. Inevitably, the aforementioned points contribute to the discredit of the certificate itself as a tool for achieving objectivity in the measurement of energy efficiency.

The EPC is connected with improvement measures but most of those measures, especially passive measures for energy efficiency, need to be applied by all the residents of the building to be really effective, also including the common areas. And that necessary agreement is not an easy task in a society as individualistic as ours, although one of the interviewees sees a positive dimension in this to the extent that the climate urgency is going to force us to necessarily explore community solutions, better sooner rather than later.

Another barrier mentioned refers to the fact that the requirement of the certificate is also mandatory for low-income people. Certainly, the public administration can establish economic support to finance these certificates, but the greatest threat to this group does not come from the price of the certificate, but from other derived consequences, as it will be seen later when analyzing spillover effects.

Two interesting paradoxes have also been mentioned among the barriers. On the one hand, the “A label paradox” is identified. Normally, the best-positioned buildings in energy efficiency have more automatization levels and more shared solutions (e.g. central heating). This results in a higher fixed cost than other buildings not so efficient, and the cost of those facilities is a disadvantage for frugal people who do not take advantage of all these facilities due to budget constraints. One of the respondents suggest thinking about the cost of starting up a highly energy-efficient building: “The cost of starting up a highly energy-efficient building is much higher than in other buildings simply because the degree of complexity of the installations is higher and if we go to centralized solutions, in individualized consumption this is penalized. In addition, with our level of non-payments, what some do not pay, others pay, and this also generates problems of coexistence”.

Connected with this paradox, there is the second paradox, namely the ‘’Frugal Paradox’’, which underlined the strategic importance of passive solutions for frugal persons, reducing maintenance costs and the energy needs of the house. The managers of a public social rental company pointed out to us that: “We prefer to be less efficient in facilities and more efficient in management (…) In our case, it is very clear that people are not going to interact in the right way with a building that is technically very complex. Passivity and things to work in a way that is not very automated from the user's point of view are needed, but very automated from the point of view of the building manager, which is us.” And they ended with a very clear request: “Innovation whatever you want, but at no extra cost”.

In summary, those are the main barriers detected:

- Additional cost/bureaucracy
- The complexity of the process
- The price war has led to the certification of bad quality (without in situ inspection)
- Lack of trained professionals
- De-motivation of expert professionals
- Lack of replicability: comparable?
- Individualist society: Problems to reach consensus at the building level
- Being compulsory (for low-income people)
- A label PARADOX (increase efficiency has more fixed cost than no efficiency and this hurts frugal people)
- Frugal PARADOX (for a frugal person will be a better passive house)

3.2.4 Responses related to risks of EPC as a factor of exclusion of vulnerable population

This has been the question where the answers have diverged the most. When asked about the risk of exclusion that the certificate could cause, in general, the technicians did not detect any risk and at most referred to the economic effort to pay for the certificate in the cases of being obliged to present it. But what about the improvement measures, especially if they could be mandatory too?

Most of the respondents mention the high investments needed to improve the old houses and suggest better public programs of grants for taking certifications and performing the recommendations. Some respondents mention the lack of interest of some populations (for example, retired people) in the renovation of the house by the impossibility of aspiring to it. Some more mention the digital divide, related to automatizations for energy efficiency: “Smart buildings and Smart living create an IT gap between generations”.

But the two main challenges are focused on low-income people, that may suffer double or even triple penalties. Double penalized when they live in an inefficient house but cannot afford the improvement of it. Triple penalized if to the above, the obligation to assume increases in green taxes and fees is added.

And the second challenge for low-income people is the gentrification threat as a result of a massive increase in the energy rating in a neighbourhood. This improvement of the neighbourhood sooner or later translates into a renegotiation of rents, usually with steep increases, which may be unaffordable for tenants, who find themselves evicted from their neighbourhoods. And in general, energy efficiency is becoming a source of tension and conflict between landlord/owner and tenant.

In summary, the negative spillover effects detected are the following ones:

- Low-income people could be:
    - DOUBLE PENALIZED (inefficient house + impossibility to improve) or
    - TRIPLE PENALIZED (inefficient house + impossibility to improve + increase taxes / tariff)
- A massive increase in the energy rating could probably lead to a neighbourhood GENTRIFICATION process / increase of the rent
- Landlord-tenant conflict around energy efficiency
- DIGITAL GAP
- Need of high investments
- Lack of interest for impossibility to aspire to renovate the house (for example, retired people)

So, this type of programs needs to take in account those challenges, and develop shield mechanism for low income people related with increasing rents and housing costs due energy efficiency improvements. It has also been suggested the creation of one-stop-shops at municipality level, as in the OpenGela project [28]: “proximity offices that are installed in the neighborhood where an energy rehabilitation intervention is to be carried out and that accompany and listen to citizens step by step. This relationship of proximity makes citizens participate in a process that you gradually take over. That is the key.”

However, the respondents also detected positive spillover effects deriving from the extension and application of EPCs: fostering sustainability and recovering the existing housing stock instead of demolishing them. And all this urban regeneration will generate new economic activity and employment.

Of course, to the extent that these energy renovations lead to savings in energy consumption and also include self-generation solutions (individual or collective), they will contribute to reducing demand and, consequently, energy dependence.

In short, those are the positive spill over effects detected:

- Foster sustainability
- Creating new jobs
- Reducing suppliers (after installation of self-generation)
- Improving housing stock already built, avoiding temptation of demolition

3.2.5 Responses related to current level of information and new information to be included

The answers collected suggest that the presentation of data in the tool could be improved by dividing it into two parts, one for each end-user. The first part, aimed at the non-expert public, should present information in a more qualitative way, using graphics and schematics, and giving more space to explain the recommended improvement measures. The respondents suggest maintaining the use of color and letter codes, similar to those used for household appliances, to make the information more intuitive. The second part of the EPC, as a separate document, would provide all the raw data and technical information.

Another group of recommendations are focusing on other information of environmental impacts, such as noise protection, indoor air quality, location and orientation of the building, the use of materials and energy in all stages of the building (construction, use and dismantling), also picking up information about actual performance of the building, the comfort levels, the quality of spaces (so sought after and valued in times of pandemic confinement), transports and connection needs. Especially, taking into consideration the part of the total energy consumption expenditure of a household (as the next graphic represent, with data referring to the Spanish case) that is currently collected in the Energy Performance Certificates, forgetting all the transport implications which contributes more than 40% of the total.

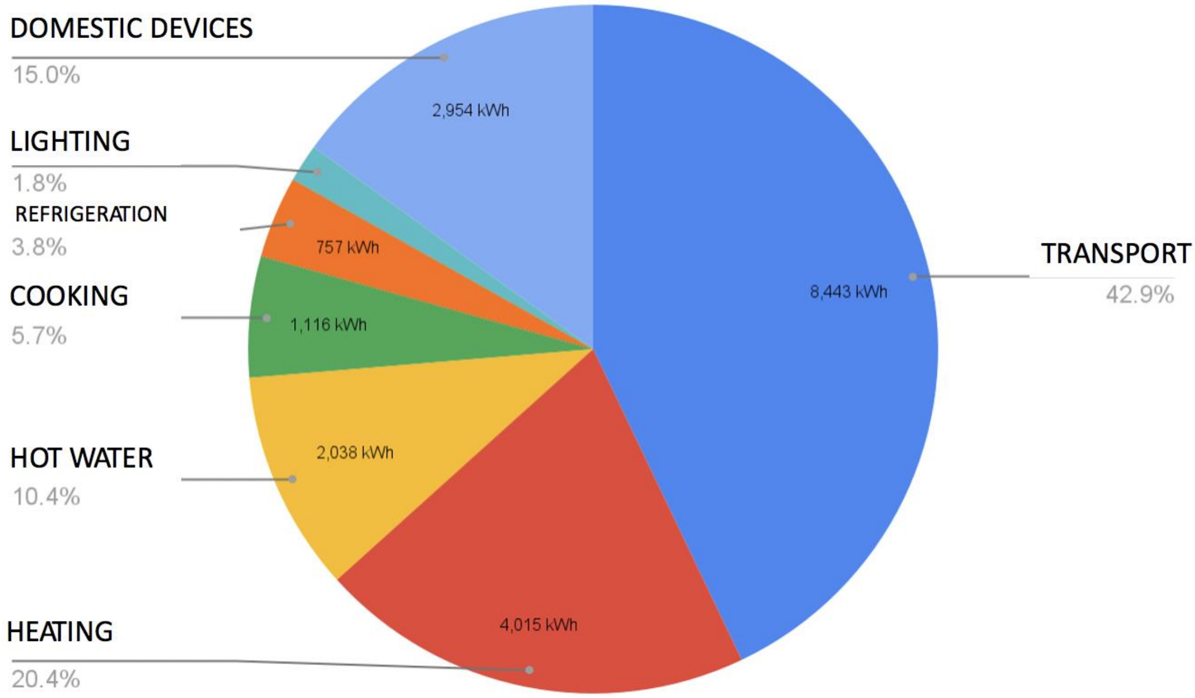

Figure 24 – Distribution of energy consumption in the Spanish household (Source: WHY project [29] with IDEA data [30])

Some respondents are concerned about the emergence of new certificates focusing on other environmental impacts, but which collide with the EPC, since improvements in one of them imply lower ratings in the other. For this reason, they advocate a more integrated approach that seeks to balance these objectives.

The interviewees have detailed a whole series of improvements for the new generation of EPCs, advocating for a clearer estimation of actual energy cost, and making the assessment over real data. And ask for ensuring that the suggested recommendations are adequate (tailored) and calculating clearer estimations of the potential cost of living in the house before and after any suggested improvements, with consequences as penalizations if the promised improvement does not become real.

It is suggested to do the calculations not only thinking in a “standard” user, with a “standard” comfort level but also considering frugal people and wasteful people, in terms of energy consumption. And it is recommended to design the tool looking for the robustness of the solution, to survive in the face of possible bad use of dummies users.

They insist also on more focused tool on behaviour change of the public and passive solutions in the buildings than in smart and sophisticated devices, looking for an adequate balance between automation and user autonomy. In the same line, they recommend boosting collective and shared solutions, in a communitarian perspective, considering the impacts of living in a society with others: noises, convivence problems, unpaid community fees…)

To prevent further degeneration of the market of EPC producers, the experts suggest more control of assets, best governance methods and reviewed business models for the certificate.

And finally, some stakeholders remind the importance of looking beyond the concern for “buildings that protect the climate” to “buildings that also protect people ''. Only in this way will Europe's dual green and digital transition become a real fair transition, as the Three MuskEUteers [31].

3.3 European perspective: from European Building Directive to recent proposals

In the following sections, the latest proposals under discussion regarding EPCs at the EU level will be reviewed, since these results, when they become definitive, must necessarily be incorporated into the new generation of EPCs.

3.3.1 EPC in the 2022 EPBD recast proposal

The EPBD recast proposal introduces a much-needed definition for deep renovation: a renovation transforming a building into an nZEB (before 2030) and into a ZEB, i.e., to EPC class A (as of 2030). But, to obtain an accurate measure of this achievement, it is necessary to introduce positive and comprehensive improvements to the EPC framework.

According to ARTICLES 16 TO 19; ANNEX V of the EPBD recast proposal, it requires MSs to ensure that, as of 2026, all EPCs comply with a common EU template, which includes indicators on primary energy use, operational greenhouse gas emissions and the share of renewable energy in energy use.

By the same date, EPCs will have to be based on a harmonized scale of classes, with A representing zero-emission buildings, and G equating to the 15% worst-performing buildings at a national level. Buildings Performance Institute Europe (BPIE) applauds the proposal for an increased scope of indicators and the push for ensuring more comparability. One additional class (A+) should be added to account for positive energy buildings, which have an even higher performance level than ZEBs.

The EPBD recast proposal also states that EPCs from G to D class have a validity period of five years, while EPCs from C to A class are valid for 10 years. The new text requires MSs to ensure that EPCs are digital and issued by independent experts following an on-site visit.

However, all the improvements made on rescaling, design and additional indicators might only apply to a small proportion of EPCs, since not all buildings would be required to get a new EPC by an established date. Besides the current obligation to issue an EPC when a building is constructed, sold, or rented to a new tenant, the EPBD recast proposal rightly widens it to other situations, such as the renewal of an existing rental contract and major renovation.

In addition, buildings owned or occupied by public bodies must all acquire an EPC. These modifications, although welcome, will not drastically expand the coverage of the building stock with EPCs. It is also unclear whether EPCs issued before the end of 2025 would have to be reissued according to the new provisions, or if they would still be valid for another 5 or 10 years, leading to two different types of EPCs on the market.

This is a critical point when considering that the implementation of other provisions, like minimum energy performance standards (MEPS), will be based on an EPC rating.

A different point of view is added by the BPIE in its police briefing “The make-or-break decade: making the EPDB fit for 2030”. The briefing proposes to increase the use of and access to quality data, notably in the form of EPC databases, to design relevant strategies and track the progress of implementation.

Specifically, the EPBD should:

- Require all MSs to have a national, easy-to-access EPC database, including in a digital format.
- Set quality principles for data management for EPC databases beyond recommendations to increase the quality of EPCs per se. They should be user-friendly with facilitated access; interoperability with other databases, such as cadastral databases, can help with planning renovation interventions, benchmarking, and comparability.
- Clarify the objectives of data gathering (what data to gather and in what format) and design of data governance (clarifying obligations of different actors at different stages of the process – collection, storage, processing, sharing, access, and reporting). One area that could be explored is to grant differentiated access to EPC databases depending on who the user is (prospective buyer, owner/tenant, bank, notary, construction company, one-stop-shop manager, etc.). In this context,

a clarification of General Data Protection Regulation (GDPR) rules in relation to building-relevant data would be welcome.

The EPBD should also introduce a definition and requirement for MSs to make use of Building Renovation Passports (BRPs) and Digital Building Logbooks (DBLs), which provide common data templates facilitating data collection, organization, visualization, and comparison. Finally, the EPBD should design an overarching system for data collection and management that functions coherently to collect and provide the best and most reliable information, whether to building owners or to policymakers. This means that existing EPC databases should be fit for upcoming data from BRPs or DBLs, and data systems governing EPCs, BRPs and DBLs should be designed in a coordinated way.

Overcoming non-financial barriers to renovation will be essential for increasing the renovation rate and depth. Owners and tenants should have easy access to information and guidance facilitating investment decisions. Some instruments exist already, but they need improvement, as well as broader acceptance and dissemination to have a meaningful impact on renovation activities.

3.3.2 Increase the quality of the EPC framework

EPCs were introduced in the EPBD in 2002, with the aim of:

- Giving information at a certain point in time (linked to selling or renting a building) about the energy performance of the building, and
- Laying out some (general) recommendations about which steps to undertake to improve it.

According to these aims, EPCs could play a decisive role in the transformation of the building stock, but for this to happen, a thorough update and upgrade on both aspects is needed. This would enable EPCs to:

- Be recognized as a reliable information tool across all MSs, and
- Fulfil new purposes linked to other policies, such as minimum performance standards (MPS), building renovation passports (BRP) or financing measures.

Nowadays, the coverage of the building stock with EPCs is still rather low, and there are concerns related to the quality of issued EPCs, which are not acting as reliable information tools. This becomes even more important as a successful rollout of MPS will depend on EPCs whose quality and reliability have to be improved ahead of the first MPS compliance date. The EPBD should therefore require that all buildings get an EPC by a certain date, to increase the coverage.

However, improving EPCs means going beyond their design (e.g., common template). While harmonization in the design might boost the usefulness of the tool amongst real estate investors at the cross-border level, what is crucial is that the EPBD ensures all MSs comply with requirements and establishes key quality principles for each aspect of the EPC framework:

- The design should display useful information to the different types of EPC users (prospective buyers, public authority, bank) – finding the right balance between readability/attractiveness on one side and quality/reliability on the other, while always ensuring trust.
- The calculation methodologies should be harmonized and improved, such as by adding complementary indicators like validated actual energy performance, GHG metrics, and indoor air and environmental quality (the latter being especially important for occupants). Overall, the quality of input data should be improved.
- The performance assessment should be based on an on-site audit executed by a skilled certifier.
- Recommendations should be more specific and tailored, include information on costs and benefits, and be linked with advisory services.
- The allowed lifetime of 10 years is too long for the EPC to be considered up to date and should be shortened to five years.

Regarding the quality control of EPCs, a holistic approach should be adopted to improve every stage of the certification process, from training/upskilling of auditors, quality checks of methodologies/software, more frequent ex-post quality controls, and more stringent penalties. Some of these recommendations can be implemented using digital tools.

3.3.3 Sister projects provisional contributions

The European Commission is creating a critical mass of projects on Energy Performance Certification that will serve to inform future policymaking as well as improve the current implementation of the EPBD. Table 11 presents a list of UE funding projects studying several aspects of EPCs.

Table 11 - List of European sister projects

PROJECT ACRONYM	PROJECT DESCRIPTION	PROJECT LINK
U-CERT	U-CERT project is looking at enhancing the new certification schemes to be more practical, reliable, and clearer for a wide range of users and stakeholders, fostering a wider application by activating EU interest groups and national certifying and standardization bodies.	https://u-certproject.eu/
X-tendo	The X-tendo project aims to support public authorities to transition to next-generation energy performance assessment and certification schemes, including improved compliance, reliability, usability and convergence.	https://x-tendo.eu/
QualDeEPC	The project will increase the quality and convergence of EPC schemes and accompanying control and verification systems within the EU. The project will also develop a concept for Deep Renovation Network Platforms, providing one-stop-shops for deep renovation linked to EPCs, including administrative, energy advice, financial, and supply-side information to building owners.	https://qualdeepc.eu/
ePANACEA	The objective of the ePANACEA project is to develop a holistic methodology for energy performance assessment and certification of buildings. It comprises the creation of a prototype (the Smart Energy Performance Assessment Platform) making use of the most advanced techniques in dynamic and automated simulation modelling, big data analysis and machine learning, inverse modelling or the estimation of potential energy savings and economic viability check.	https://epanacea.eu/
E-DYCE	The project finds to increase the reliability of the energy performance assessment process. It will support communication between labelling professionals and building owners, to cultivate benefits in both indoor climate and energy savings. It is complimentary to the current EPC labelling method and not competitive, bringing and standing for all the value of the next generation of certification and building energy assessment.	https://edyce.eu/

EPC RECAST	The project aims to support the development, implementation and validation of a new generation of Energy Performance Assessment and Certification, with a deliberate focus on residential buildings, more specifically existing ones, for which retrofit is one of the most challenging and pressing issues. By enhancing EPCs usability, reliability, and comparability, and by linking them to renovation roadmaps and building digital notebooks, EPC RECAST find achieve unprecedented user-friendliness and user awareness of building performance.	https://epc-recast.eu/
TIMEPAC	TIMEPAC find help to improve existing energy certification processes and move from single, static certification to more holistic and dynamic approaches. At five demonstration sites, the project is developing new methods and tools to provide an improved basis for data collection and analysis. As a result, EPCs will be enriched with concrete retrofitting solutions and experts can be better trained to make our homes fit for the future.	https://timepac.eu/
iBRoad2EPC	The project aims at exploring, designing, developing and demonstrating the concept of individual building renovation roadmaps. This project focuses on the evolution of existing energy audit products and EPCs in order to become a real driver for deep renovations. Representing an evolution of the Energy Performance Certificates (EPCs) and energy audit systems, building renovation roadmaps will serve as a tool outlining a customized renovation plan with a long-term horizon for deep step-by-step renovation of individual buildings (iBRoad-Plan), combined with a repository of building-related information (logbook, iBRoad-Log).	https://ibroad-project.eu/
EUB SuperHub	The project finds a common way to look at buildings, assess their energy performance and work on how to make them more sustainable. Their objectives are: 1- Development of an EU common framework based on European Common Voluntary Certification Scheme (EVCS), Smart Readiness Indicators (SRI) 2- Listing the common smart dimensions of buildings to eventually provide remote inspection and assessment 3- Creation of a digital logbook for market actors after finding a methodology to collect heterogeneous data for building intelligence 4- Setting up a digital one-stop shop where it's possible to find assessment schemes, local databases and guidelines which will improve trust and transparency of EPCs 5- Reporting case studies from different locations, building types, climatic conditions and field practices	https://eubsuperhub.eu/
crossCert	The project is developing a product testing methodology for the new energy performance certificate for buildings. It is based on: 1. Performs cross-testing between the current energy certificates and the new approaches/concepts/initiatives using more than 140	https://www.crosscert.eu/

	buildings in 10 European countries and creates a public benchmarking database of test cases 2. Compares and analyses the results of the different approaches 3. Prepares policy recommendations that include potential improvements in accuracy, usability and harmonization 4. Involves networks and alliances for analysis and outreach.	
D^2EPC	The proposed framework sets its foundations on the smart-readiness level of the buildings and the corresponding data collection infrastructure and management systems. It is fed by operational data and adopts the 'digital twin' concept to advance Building Information Modelling, calculate a novel set of energy, environmental, financial and human comfort/ wellbeing indicators, and through them the EPC classification of the building in question. D^2EPC proposes a digital platform that will enable the issuance and update of new EPCs on a regular basis, integrate a GIS environment and provide, on top, value added services including user-centered recommendations for energy renovation, benchmarking and forecasting of buildings' performance as well as performance verification services.	https://www.d2epc.eu/en
CHRONICLE	CHRONICLE will deliver a holistic, life-cycle performance assessment framework and tool-suite for different building variants, supporting sustainable design, construction and/or efficient renovation and investment decision making. It will be methodologically integrate ongoing initiatives, like EPCs, Level(s), SRI, under the umbrella of the Digital Building Logbook concept. Continuous monitoring and analysis of the actual building performance over its lifetime will allow all stakeholders to realise in quantified terms the short- and long-term impact of the project activities, from policy to practice, and across the whole building life cycle.	https://www.chronicle-project.eu/

After the review of the current public results of those sister-projects, at this moment there is no special suggestion for the SmartLivingEPC project. Could be interesting to review periodically future deliverables of those projects.

4 Conclusions: Stakeholders vs EPBD recast proposal analysis

From the above analysis, it is possible to observe coincidences but also differences between the vision of the EPBD recast proposal and the answers of the stakeholders. In conclusion, the following table crosses the perspectives of both, highlighting consensus and differential elements, organized on the basis of the five axes of analysis applied in the previous chapter.

Table 12 - Crossing perspectives

Issue	STAKEHOLDERS	EPBD recast proposal
Knowledge of the public about current Energy Performance Certificate (EPC)	All the stakeholders consulted agree that educational actions are necessary for the population. On the one hand, it is important that people can read and understand the information contained in the EPC, and on the other, it is essential that this information is linked to the concept of energy saving. Today, the energy certificate for buildings is perceived as a bureaucratic requirement that must be fulfilled to carry out certain operations on real estate (purchase, sale, rental, etc.). But both tenants and owners are not aware of the impact on energy savings, the reduction of carbon emissions and the economic benefits that a high energy rating represents for a building.	The EPBD recast proposal expresses in several of its points the need to make improvements to the EPC. Some aspects to improve are the use of a common EU template, the inclusion of indicators on primary energy use, information about operational greenhouse gas emissions and the share of renewables in energy use. The recast proposal does not contemplate the design of educational policies around the interpretation of the EPC, in terms of its environmental and economic benefits.
	Stakeholders & EPDB recast proposal	
	Both the stakeholders and the EPDB recast proposal agree that the mandatory policies have been an impetus for the adoption of the EPCs. The recast proposal also proposes to deepen this policy, by making the energy certificate mandatory in new situations, such as the renewal of an existing rental contract and major renovation.	

<table>
<tr>
<td rowspan="3">Main opportunities and drivers of the current EPC</td>
<td>According to the interviewees, among the main drivers of the current EPCs are some critical aspects, such as the increase in the price of services, and others bonded to public policies such as economic subsidies for building renovation.

In the first case, the economic crisis or the war in Ukraine was highlighted, referring to them as factors that make us aware of the real cost of the energy we use in our homes.

On the other hand, the value of the aid for the rehabilitation of houses destined to an improvement in the qualification of the energy certificate was highlighted.</td>
<td>The current obligation to issue an EPC when a building is constructed, sold, or rented to a new tenant has been a driver for the adoption of the certificate. Besides, the EPBD recast proposal rightly widens it to other situations, such as the renewal of an existing rental contract and major renovation.

Opportunities for improvements are identified, as:
• Finding the right balance between readability/attractiveness on one side and quality/reliability on the other, while always ensuring trust in the EPC.
• Adding complementary indicators like validated actual energy performance, GHG metrics, and indoor air and environmental quality. Overall, improve the quality of input data.
• Basing the performance assessment on an on-site audit, executed by a skilled certifier.
• Making more specific and tailored recommendations, including information on costs and benefits, and be linked with advisory services</td>
</tr>
<tr>
<td colspan="2">Stakeholders & EPDB recast proposal</td>
</tr>
<tr>
<td colspan="2">Advances in legislation are drivers on which both stakeholders and the EPCB recast proposal agree. On the one hand, the promulgation of mandatory laws that establish the EPC as a requirement for housing procedures has promoted its adoption and will continue to do so. On the other hand, specific laws are necessary to guarantee the homogeneity of energy evaluations to obtain EPCs, ensuring their reliability.</td>
</tr>
</table>

Main barriers and obstacles of the current EPC	The lack of clear legislation that regulates the performance assessment of the buildings when carrying out the certificate is a non-financial barrier to rehabilitation. Today there is no homogeneity in certification services, being able to find both professionals who carry out the evaluation in situ, and those who offer the EPC by sending photos by mail. On the other hand, a certainly added complexity is perceived in the procedures to obtain subsidies from programs for renovation buildings. Stakeholders relate this difficulty to the requirement to measure the impact of the subsidy granted: how many kilos of CO2 are we going to stop emitting into the atmosphere because we have spent x investment on building rehabilitation. Finally, the fact of starting up a building with high energy efficiency has a much higher cost than in other buildings. This is because the degree of complexity of the installations is greater.	The difference in the quality of the EPCs is a barrier for the public to trust them as a tool. EPCB recast proposal recommends a holistic approach to be taken to improve each stage of the certification process, from auditor training/upgrading, methodologies/software quality checks, more frequent ex-post quality checks and more stringent sanctions.

Risks of the EPC as factor of exclusion of the vulnerable population	At this point, there seems to not be a coincidence in the opinion of the different stakeholders. Three groups of responses can be identified: • In the first place, those stakeholders identify possible scenarios in which the EPC could be a factor of social exclusion due to the significant costs that rehabilitation requires. The most vulnerable populations (from an economic and energy point of view) could be subject to living in homes with high energy consumption, with the consequent associated economic costs, without the possibility of making the necessary adaptations to access an EPC, and could even be doubly penalized if taxes associated with carbon emission levels are implemented in the future. • Secondly, there are stakeholders who analyze vulnerability from a strictly economic point of view and associate it with the high costs of renovating spaces as the only barrier to access to the EPC. This risk factor can be easily avoided through state subsidies to make the necessary home improvements. • Finally, a group of stakeholders considers that there is no direct relationship between the EPC and social exclusion, pointing out in some cases that the label itself is not a problem, but that it is a transparent means to indicate the energy performance of the building and therefore the probability of facing high energy costs if user behaviours do not adapt.	The recast proposal of the EPBD does not directly identify the EPC as a factor of social exclusion. However, it recognizes that in order to achieve its 2030 and 2050 climate goals in a socially just way, it is necessary to lift people living in the worst-performing buildings out of energy poverty. Otherwise, they will be locked in the "second worst" buildings for decades to come. The EPBD recast proposal requires MSs to support compliance with the MEPS, from a financial point of view. It recognizes the importance of technical assistance, including one-stop shops, but also postulates that the link should be established with renewal passports, which are useful tools to support deep renewal. The EPBD recast proposal requires MSs to pay attention to vulnerable households, but setting the monitoring and verification framework is largely left to the national level.

EPC information and data collection	The stakeholders will focus their responses on the quantity and quality of the information contained in the EPC. Among the comments, on the one hand, is that the EPC is too focused on technical aspects related to active measures and not so much on passive solutions, which could introduce errors when evaluating them, for not considering factors such as the environment or orientation. On the other hand, suggestions on information that could be added to the label, related to environmental factors such as noise, air quality or carbon footprint, and human factors linked to the use of the building. Finally, there is a concern to overcome the language barrier to be able to express technical terms in EPCs in a simple and accessible way for the general public.	The revised proposed EPBD addresses the issue of data and information contained in the EPC from a computer security perspective. It proposes to increase the use of and access to quality data, notably in the form of EPC databases, in order to design relevant strategies and track the progress of implementation. Specifically, the EPBD should: • Require all MSs to have a national, easy-to-access EPC database, including in a digital format. • Set quality principles for data management for EPC databases. They should be user-friendly with facilitated access; interoperability with other databases, such as cadastral databases, can help with planning renovation interventions, benchmarking, and comparability. • Clarify the objectives of data gathering and design of data governance. One area that could be explored is to grant differentiated access to EPC databases depending on who the user is. In this context, a clarification of General Data Protection Regulation (GDPR) rules in relation to building-relevant data would be welcome.

In conclusion, the analysis reveals several points of contact between the opinions of the stakeholders and the perspective introduced in the EPBD recast proposal. Among them, it is remarkable the concern to standardising the quality of the labels [32], [33], [34], both in the amount of information they provide [35] and in the methodology used to issue the certificate [36] [37], the implementation of a legal framework that makes mandatory certification as a strategy for its widespread adoption [38], the need for a holistic approach for all EPC in the EU [33], [39], [40], [41], the opportunity to create databases with information from the European building energy efficiency map [42] and the identification of various barriers to the adoption of EPCs related to the difficulty of accessing aid for renewal and the costs associated with it [43], [44].

However, there are two specific points in which no coincidence between the opinions of the stakeholders and the EPBD recast proposal was found. Specifically, some stakeholders expressed their concern that the EPCs could become a factor that deepens social inequality, causing the exclusion of the most vulnerable population. In this sense, they go beyond the concept of energy poverty widely worked on by different authors [45], [46], [47], [48], but rather mention the dangers of being subjected to a triple exclusion for living in homes with high cost of services due to low energy efficiency, the impossibility of rehabilitation due to the high costs involved and the danger of being affected by taxes and penalties for high consumption in the near future. This transversal view of the danger represented by an implementation of the EPCs that does not consider the social view was not found reflected in any paper in the consulted bibliography.

On the other hand, the EPBD recast proposal introduces a broader perspective related to the problem of EPC data management [49], [50]. Its perspective goes beyond the discussion about what information should be on the label, how to collect it, and how to communicate it. Instead, it postulates questions regarding the security and transparency of data management systems, as well as integration with other databases, which allow States to get the most out of the information collected.

In lack of coincidence in the last-mentioned points, one of the richest findings of the work carried out is identified. In both cases, the central concern revolves around the rights of citizens, one around minimizing the deepening of socio-economic inequalities and the other linked to the protection of privacy.

The EPCs have positioned themselves as a useful tool to combat climate change from the point of view of reducing the energy consumption of buildings. However, it is no longer possible to consider EPCs as a merely technical instrument free of social and economic implications. The creation of a regulatory framework that integrates these aspects from a citizen rights perspective is the next step in the evolution of EPCs.

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