



# ePANACEA

Smart European Energy Performance Assessment & Certification



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## **Recommendations for the design of the next generation of Energy Performance Certificate (EPC)**

Guidelines of psychological aspects regarding the EPC usage (display of multi-user perspectives, recommendations for tailored communication measures)

Version 1, June 2023

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## OVERVIEW OF THE ePANACEA PROJECT

After 10 years of track record, the current EPC schemes across the EU face several challenges which have led to a not full accomplishment of their initial objectives: lack of accuracy, a gap between theoretical and real consumption patterns, absence of proper protocols for inclusion of smart and novel technologies, little convergence across Europe, lack of trust in the market and very little user awareness related to energy efficiency.

The objective of the ePANACEA project is to develop a holistic methodology for energy performance assessment and certification of buildings that can overcome the above-mentioned challenges. The vision of ePANACEA is to become a relevant instrument in the European energy transition through the building sector.

ePANACEA 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.

A relevant part of the project is to have a fluent dialogue with European policy makers, certification bodies, end-users and other stakeholders through two types of participatory actions: a feedback loop with policy makers, carried out through the so-called Regional Exploitation Boards (REBs) covering EU-27+UK+Norway on the one hand, and dialogue with end-users, established by means of specific thematic workshops, on the other.

Thanks to these participatory actions, the acceptance of the ePANACEA approach will be tested and validated in order to become aligned with and meet the needs of national public bodies, end-users and other stakeholders.

ePANACEA will demonstrate and validate reliability, accuracy, user-friendliness and cost-effectiveness of its methodology through 15 case studies in 5 European countries.





## EXECUTIVE SUMMARY

The energy performance certificate (EPC) is an information and market tool for climate protection which shall foster the market for energy efficient living space. It allows potential renters and buyers to compare the energy performance of buildings and provides recommendations on how the energy efficiency of the building can be improved. However, there are potentials for improvement in terms of the user-friendliness of the certificate and the consideration of occupant behaviour in the modeling of building energy use. Hence, the end-users of EPCs such as buildings owners, tenants, building occupants and building managers play a crucial role regarding the redesign of EPCs because learning about their needs can contribute to improve the certificate and exploring their everyday energy behaviour allows to make more accurate assumptions in the modelling of building energy.

This report is a synthesis of the findings from the four user-related tasks in the ePANACEA project which are the stakeholder analysis, the user-needs analysis, the acceptance testing (first and final acceptance test) and the exploration of occupants' energy behaviour. Each research step is briefly recapped (objectives, methods and highlights of the results). Furthermore, the report shows how the research steps (except for the final acceptance test) have influenced the development of new EPC summary pages during the project life time (final version in October 2022). The final chapter provides the recommendations on the next generation of EPC (with a focus on the content and presentation of content in the certificate) that stem from the user-related tasks, including the outcomes from the final acceptance test.





## GLOSSARY

<b>EEM</b>	Energy efficiency measure
<b>EPBD</b>	Energy Performance of Buildings Directive
<b>EPC</b>	Energy performance certificate
<b>IEQ</b>	Indoor environmental quality
<b>REB</b>	Regional exploitation board
<b>SRI</b>	Smart readiness indicator
<b>TAM</b>	Technology acceptance model



# 1. INTRODUCTION

The energy performance certificate (EPC) is an information and market tool for climate protection. It shall foster the market for energy efficient living space as it allows potential renters and buyers to compare the energy performance of buildings and provides recommendations on how the energy efficiency of the building can be improved (deutsche Umwelthilfe e.V.). The end-users of energy performance certificates (EPCs) such as buildings owners, tenants, building occupants and building managers play a crucial role regarding the redesign of EPCs because on the one hand their acceptance of EPC influences the use of EPCs and on the other hand their everyday energy behaviour influences the energy performance of buildings. However, there are deficits regarding the user friendliness of EPC (such as unreliable information, standardized document, does not include the information end-users are interested in, namely annual costs) which leads to the facts that the EPC is given little attention during e.g. a house purchase or that it is rarely used for the implementation of EEMs (Hermann, 2011; ePANACEA report, February 2021, *Insights on user perceptions and needs regarding the Energy Performance Certificate (EPC)*<sup>1</sup>). Also, overly simplified assumptions of user behaviour in building energy modelling contributes to the performance gap between theoretical and actual energy consumption of buildings (Guerra-Santin *et al.*, 2018). Therefore, there is the need to investigate user-needs and acceptance of EPC in order to understand how the EPC should be designed such that it is useful to end-users, as well as to increase our knowledge about users' every day energy behaviour in order to make a better estimation of it in the modelling of building energy use.

This report links the findings from the four user-related investigations of the ePANACEA project, namely the stakeholder analysis, the user-needs analysis, the acceptance testing (first and final acceptance test) and the study of occupant behaviour. Except for the latter, the research steps were participatory actions because they involved EPC users through interviews and workshops.

The knowledge fusion of the research steps serves multiple purposes:

- Highlighting the main findings from each research step and reflecting on how they have influenced the development of the new EPC summary pages (cf. chapter 4.6; Annex).
- Determining the most important user-needs regarding EPC, differentiated by user groups. Based on this, the **core aspects** of EPC and additional aspects - elements which can be moved to an annex/additional pages - can be derived.
- Highlighting **important factors that influence EPC acceptance and use**.
- Providing recommendations for the next generation of EPC (i.e. regarding the content and presentation of information in the EPC and the system around EPC (e.g. communication, implementation as a policy tool) in order to increase acceptance and use of EPC).

The report is structured as follows: First, it describes the methodology used for the knowledge fusion of the user-related tasks. Then, it provides a review of the research steps that were conducted during the project, i.e. the objectives and approaches of the participatory actions and the research about occupant behaviour. In the proceeding chapter the report presents the main outcomes of the research steps and reflects on how the individual steps have influenced the development of the new EPC summary pages. In the last chapter, the most important findings of the individual research steps, including those of the final acceptance test, are brought together. This represents the recommendations for the next generation of EPC (i.e. regarding the content and presentation of information in the EPC and the system and communication around EPC) to increase the acceptance and use of EPC. The report ends with an outlook on what aspects should be pursued to further improve the proposed EPC summary pages.

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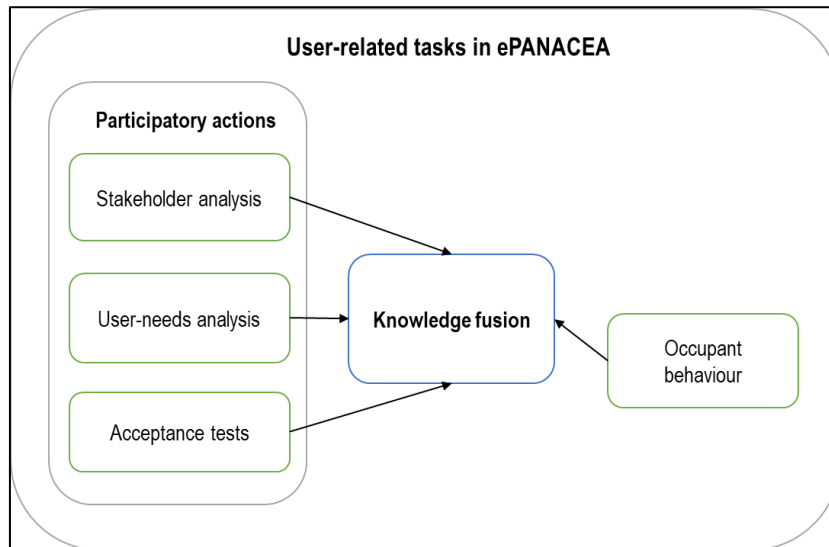
<sup>1</sup> ePANACEA report, February 2021, *Insights on user perceptions and needs regarding the Energy Performance Certificate (EPC)*, DOI: 10.5281/zenodo.4569465



## 2. METHODOLOGY

For the knowledge fusion and to fulfil its multiple purposes, the following approach was chosen:

- The four user-related tasks (cf. Figure 1) are briefly revised, i.e. chapter 3 repeats what was done in the individual steps and what the target group of the participatory actions was. The user-related tasks are the stakeholder analysis, users-needs analysis, acceptance test and exploration of the influence of energy behaviour as shown in Figure 1.



*Figure 1: User-related investigations in ePANACEA*

- In order to reflect on how the research steps have influenced the development of ePANACEA summary pages, the main outcomes from each step are presented in chapter 4. Furthermore, the chapter explains how the research steps have affected the new EPC proposal. Precisely, the main user-needs and results of the acceptance test are presented, as well as the main factors influencing energy use in buildings.
- To provide recommendations for the next generation of EPC (content and presentation of information in the EPC as well as the system and communication around EPC) the main findings from the user-related tasks, are linked and brought into context. This means that repeated critiques, needs and suggestions to improve EPC, which are considered implementable, feed the recommendations. Although some final acceptance results could not be taken into account for the new EPC summary pages, still they were incorporated in the recommendations (cf. chapter 5).





### 3. USER-RELATED ACTIONS IN EPANACEA

Three of the four user-related tasks, the stakeholder analysis, user-needs analysis and acceptance analysis were participatory actions. This means that users were involved in the tasks and user-related data was collected through different activities such as interviews and workshops. The participatory actions with EPC users were part of the ePANACEA project to raise users' awareness about energy efficiency and the EPC and to gather feedback on how the new EPC summary pages should be designed such that they are understandable and useful. The feedback loop between the users' needs and perceptions and the ePANACEA methodology is visualized in Figure 2 and marked in yellow. Also, the regional exploitation board (REB) meetings with policy makers and industry are participatory actions (marked in grey) to create a dialogue with stakeholders of EPC during the project period.

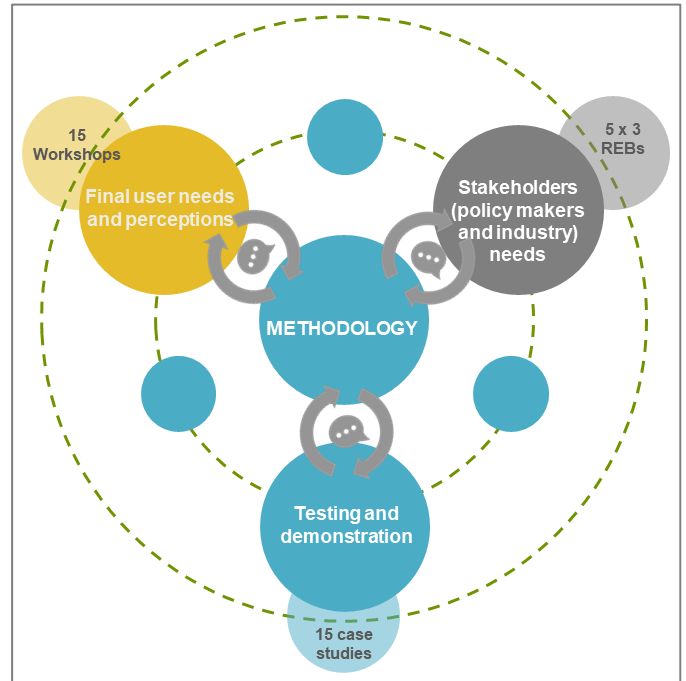


Figure 2: Feedback loops in the ePANACEA project

#### 3.1. Stakeholders along the value chain of EPC

The target groups of the participatory actions with EPC users were end-users of the EPC in the first place as well as other stakeholders along the value chain of EPC in the second place. End-users of EPC are building owners, tenants, occupants and building managers – i.e. all persons that live in, occupy or manage a building (with different socio-demographics). So, this group theoretically does not only include residents but also visitors of public buildings, employees in offices, pupils in schools etc. – widening the scope from residential buildings to public buildings. The group of other stakeholders summarizes the stakeholders along the value chain of EPC (policy making, issuing of EPC, forwarding EPC, advising about energy efficiency, conducting energy efficiency measures (EEMs)) as presented in Figure 3. These other stakeholders can potentially influence the quality of EPC, end-users' understanding and acceptance of EPC and energy efficiency and therefore also can indirectly influence their behaviour in regard to energy efficiency of buildings. They include policy makers, energy advisors, and architects, multipliers of EPC like real estate companies, housing associations and landlords, as well as craftsmen (cf. ePANACEA report, September 2020, *Stakeholder Analysis Report: General and country specific stakeholder maps*<sup>2</sup>). However, policy makers only indirectly influence end-user of EPC through strategies, communication, the design of the EPC and subsidies. They are not directly in contact with the end-users.

<sup>2</sup> ePANACEA report, September 2020, *Stakeholder Analysis Report: General and country specific stakeholder maps*, DOI: 10.5281/Zenodo.4501327

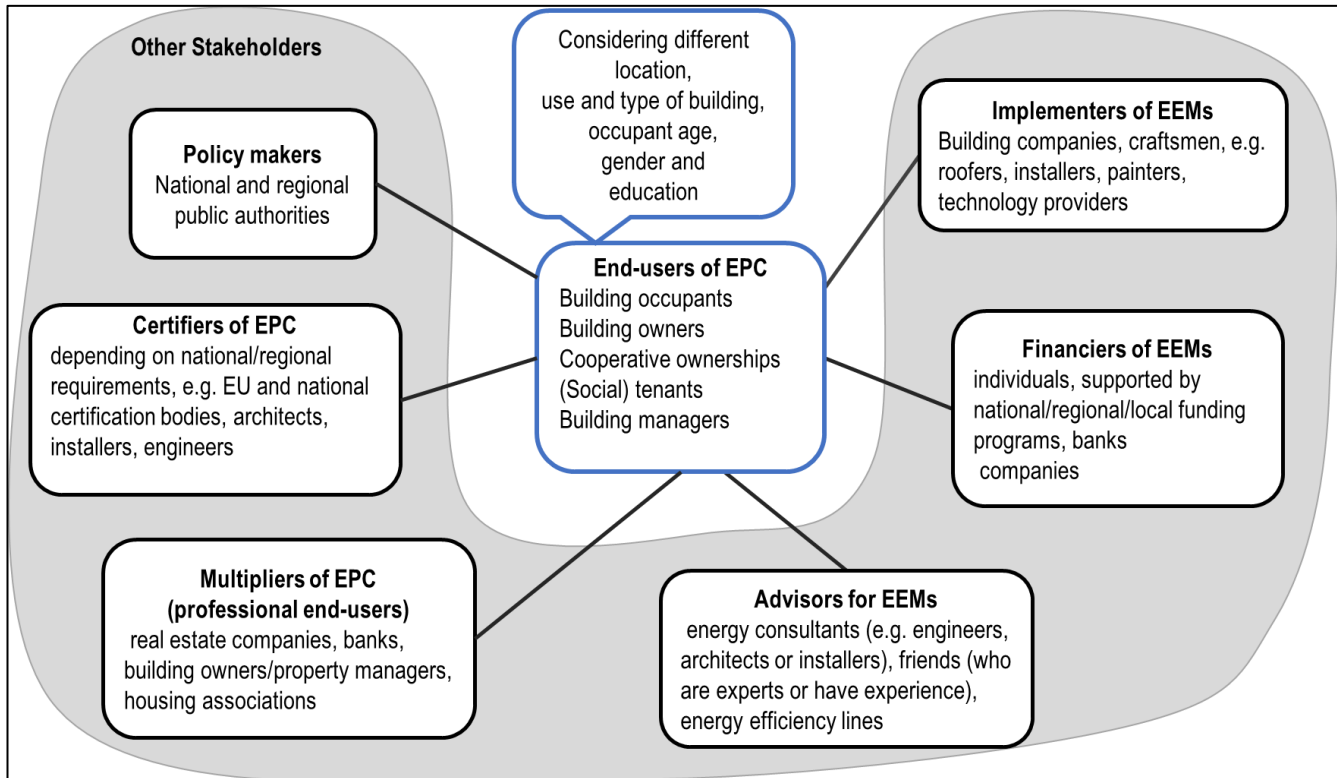


Figure 3: Stakeholders of the ‘value chain’ of EPC

## 3.2. Participatory actions in ePANACEA

The following section briefly describes the procedure during the participatory actions (stakeholder analyses, user-needs analysis and acceptance tests of EPC) and the objectives of it and shows how many participants and what type of stakeholders took part.

### 3.2.1. Stakeholder analysis

For the stakeholder analysis, stakeholder interviews were conducted with end-users and other stakeholders in the five ePANACEA pilot countries (AT, BE, GR, ES, FI) and DE. The purpose was to have a first insight into users’ knowledge, use, perception, interests and needs regarding EPC as preparation for the subsequent workshops, in which user-needs and acceptance were further investigated. In total 63 interviews were conducted on the phone or online in national languages, with the support of ePANACEA national partners, of which 38 were interviews with end-users and 25 with other stakeholders.

### 3.2.2. User-needs analysis

End-users of EPC often do not trust the information in the EPC or do not remember it. This may be e.g. due to the fact that the EPC does not show the financial implications which end-users are interested in (Hermann, 2011; ePANACEA report, February 2021, *Insights on user perceptions and needs regarding the Energy Performance Certificate (EPC)*<sup>1</sup>). An update of the Energy Performance of Buildings Directive (EPBD) aims, among other things, to increase the use of the EPC, its relevance and trust, where a redesign should consider the highlighting of financial implications of EE for end-users (*Ibid.*). In order for the EPC to become more effective, end-users’ (and other stakeholders’) critiques and needs regarding the EPC should be considered during the development of the next generation of EPC.

User critiques, needs and suggestion to improve the respective current EPCs were collected through online workshops in the 5 ePANACEA pilot countries. Also, suggestions to improve features of the EPC were presented to be discussed in the plenary and partly evaluated in an online survey by participants. The proposed suggestions resulted from a previous literature review, the stakeholder interviews and insights from the ePANACEA report, November 2020, *The Report on the Use of Innovative Certification Schemes and its implementation*<sup>3</sup>. Questions in the online survey covered participants’ understanding and perceived usefulness of the presented suggestion.

### 3.2.3. Acceptance tests of the new EPC

The EPC needs to be accepted such that it is used (i.e. is considered during decision making when buying a house/renting an apartment/ considered when thinking about EEMs). We tested the acceptance of proposals for a new EPC in the 1<sup>st</sup> acceptance test and compared the acceptance of the current EPC schemes and the new EPC summary pages in a final acceptance test.

The acceptance and use of EPC do not only depend on the EPC itself but also on subjective and contextual factors. In the context of EPC, we can speak of end-users (and other stakeholders) as acceptance subjects, the EPC (or draft of a new EPC) as acceptance object and the policy framework the EPC is embedded in as the acceptance context.

To identify factors that influence the acceptance of EPC, we used the technology acceptance model (TAM) as a basis. The TAM, with key variables ‘perceived usefulness’, ‘perceived ease of use’, (‘attitude’) and ‘behavioural intention’ is confirmed to successfully explain user behaviours of various information and computer technologies (Liu et al., 2018). The final TAM, as presented in Figure 4, was developed by Venkatesh and Davis (1996).

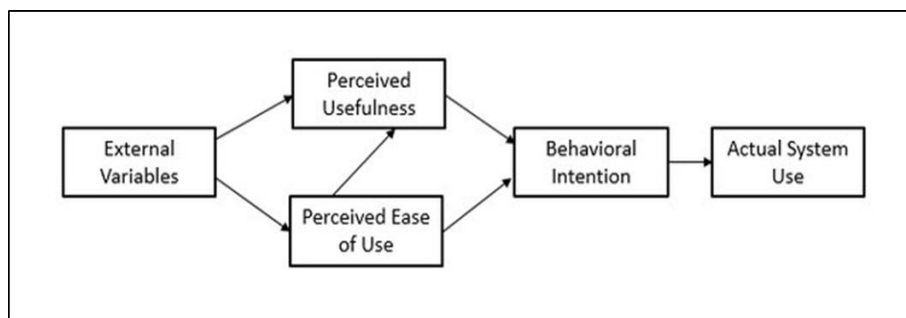


Figure 4: The technology Acceptance Model (TAM) (Venkatesh & Davis, 1996, p.453)

Next to the TAM variables, possible additional factors that influence acceptance of EPC may be ‘knowledge’ (what do users know about energy efficiency and the EPC) and ‘social trust’ (is the authority issuing EPCs trustworthy?) (Liu et al., 2018) and ‘affections’ towards EPC. (Liu et al., 2010; Lee, Thi & Lin, 2017). A model that contains all the factors influencing the acceptance of EPC (based on the TAM and additional factors from literature research) is provided in Figure 5.

#### 3.2.3.1. First acceptance test of EPC

In a 2<sup>nd</sup> round of user workshops, participants’ acceptance and preferences regarding proposals for a new EPC oriented towards end-users was tested. Proposals included e.g. main performance indicators, different illustrations of the energy label, partial performance indicators and additional performance indicators etc. Poll everywhere was used as interactive survey tool during the workshops in order to collect participant’s evaluation of the proposals. The aggregated results were displayed

<sup>3</sup> ePANACEA report, November 2020, *The Report on the Use of Innovative Certification Schemes and its implementation*, DOI: 10.5281/Zenodo.4525223

instantly which served as a basis for an open discussion. This allowed to understand why participants favored certain options or not and to gather more ideas on how to improve the presented proposals.

### 3.2.3.2. Final acceptance test of EPC

A final acceptance test of EPC was conducted in the scope of a 3<sup>rd</sup> round of user workshop. Here the acceptance of the final ePANACEA proposal for new EPC summary pages was tested against the acceptance of the current EPC schemes in the respective ePANACEA pilot countries. For this, the workshop participants were divided into two groups so that one group received and evaluated the new EPC while the other group received and evaluated the current EPC. The t-test was used in order to find out whether the differences in answers between EPC groups were significant. The t-test is a type of statistical analysis that is used to compare the means of two groups and determine if the differences are significant.

The acceptance of EPC versions was tested based on the acceptance factors presented in bold in Figure 5. Factors presented in normal font are contextual factors and rather become relevant once the next generation of EPC was introduced (legal status, the introduction and the communication about a revised policy tool) (Schäfer, Hempel & Keppler, 2013).

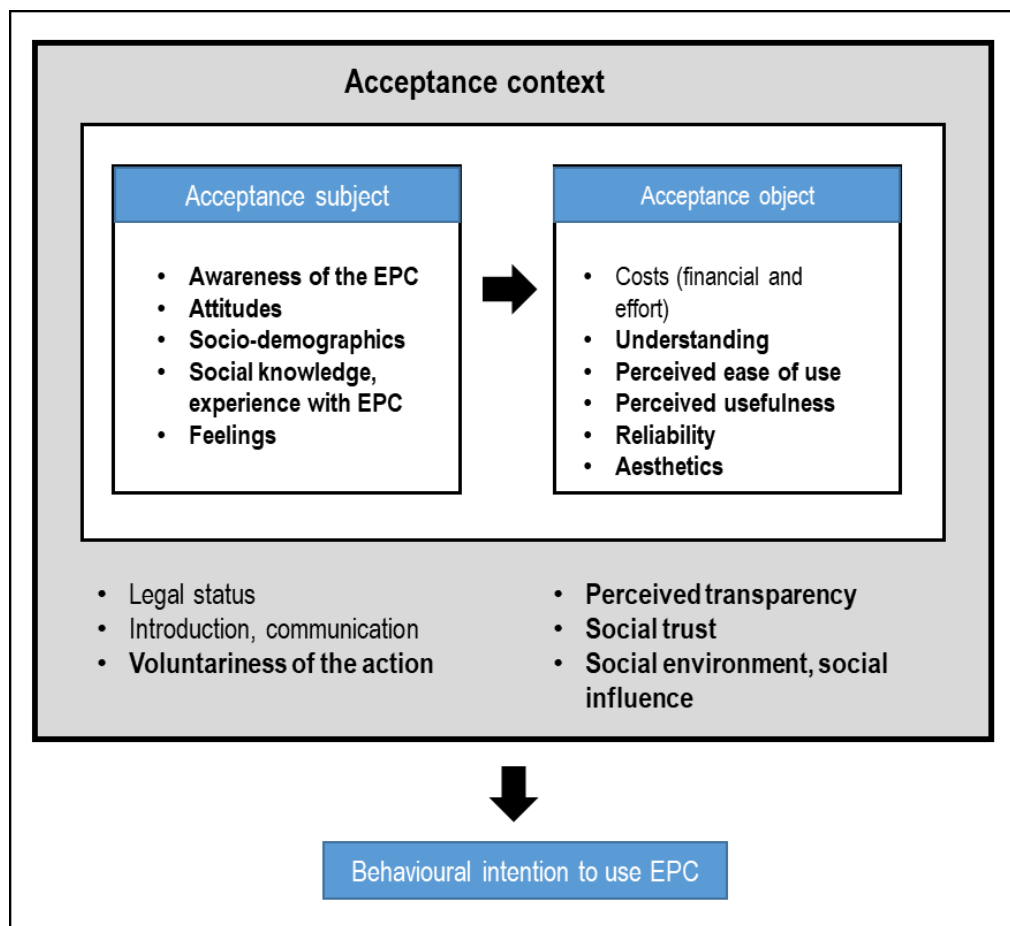


Figure 5: Overview of the acceptance factors which are considered important for EPCs (own illustration)

### 3.2.4. Number and types of participants of participatory actions

The participatory actions started in October 2020 with the stakeholder interviews and ended in December 2022 with the 3<sup>rd</sup> round of user-workshops (cf. Table 1). In total, 63 stakeholder interviews took place and 16 user workshops were held in six EU countries: six in the 1<sup>st</sup> round with 63 participants, five in the 2<sup>nd</sup> round with 102 participants and five in the 3<sup>rd</sup> round with 159 participants. In total 387 participants took part in participatory actions organized for EPC users by the ePANACEA project which

allows to gain a picture about users' perception and acceptance of EPC in all ePANACEA pilot countries. Table 1 presents the dates and numbers of participants for all participatory actions (interviews and 3 rounds of workshops) per ePANACEA pilot country.

*Table 1: Dates and numbers of participants per participatory action in ePANACEA countries*

Participatory action	ePANACEA pilot country	Date	n° participants (n° other stakeholders)	Language
Stakeholder interviews	<b>Belgium (Flemish region)</b>	October 2020	9 (4 other stakeholders)	Flemish
	<b>Spain</b>	October 2020	9 (3 other stakeholders)	Spanish
	<b>Austria</b>	October 2020	11 (5 other stakeholders)	German
	<b>Greece</b>	October 2020	15 (6 other stakeholders)	Greek
	<b>Finland</b>	October 2020	7 (2 other stakeholders)	English
	<b>Germany</b>	October 2020	12 (5 other stakeholders)	German
<b>Total- stakeholder interviews</b>			<b>63 (25 other stakeh.)</b>	
1 <sup>st</sup> user workshops	<b>Belgium (Flemish region)</b>	17.12.2020	6 (2 other stakeholders)	Flemish
	<b>Spain</b>	13.01.2021	16 (8 other stakeholders)	Spanish
	<b>Austrian</b>	14.01.2021	14 (11 other stakeholders)	German
	<b>Greece</b>	13.01.2021	13 (5 other stakeholders)	Greek
	<b>Finland</b>	13.01.2021	6 (3 other stakeholders)	English
	<b>Germany</b>	17.12.2020	8 (5 other stakeholders)	German
<b>Total- 1st round of user workshops</b>			<b>63 (34 other stakeh.)</b>	
2 <sup>nd</sup> user workshops	<b>Belgium (Flemish region)</b>	18.01.2022	21 (13 other stakeholders)	Flemish
	<b>Spain</b>	18.01.2022	27 (13 other stakeholders)	Spanish
	<b>Austria</b>	25.01.2022	26 (13 other stakeholders)	German
	<b>Greece</b>	18.01.2022	18 (3 other stakeholders)	Greek
	<b>Finland</b>	14.01.2022	10 (6 other stakeholders)	English
<b>Total- 2nd round of user workshops</b>			<b>102 (48 other stakeh.)</b>	
3 <sup>rd</sup> user workshops	<b>Belgium (Flemish region)</b>	29.11.2022	30 (14 other stakeholders)	Flemish
	<b>Spain</b>	01.12.2022	38 (16 other stakeholders)	Spanish
	<b>Austria</b>	29.11.2022	35 (16 other stakeholders)	German
	<b>Greece</b>	02.12.2022	39 (17 other stakeholders)	Greek
	<b>Finland</b>	19.12.2022	17 (15 other stakeholders)	English
<b>Total- 3rd round of user workshops</b>			<b>159 (78 other stakeh.)</b>	

Figure 6 shows the type of stakeholders that took part in the 2<sup>nd</sup> round of workshops, representing the stakeholder composition in the participatory actions with users. Looking at the 5 ePANACEA pilot countries, about 40-60% of participants identified themselves as end-users of EPC, whereas 40% - 60% of 2<sup>nd</sup> workshop participants also identified themselves as other stakeholder in relation to EPC (e.g. EPC issuer, architect and other such as researcher in the field of energy efficiency), therefore as expert with more background knowledge in regard to EPC than an end-user. Hence, these participants are in a dual role since they are also end-users of EPC.

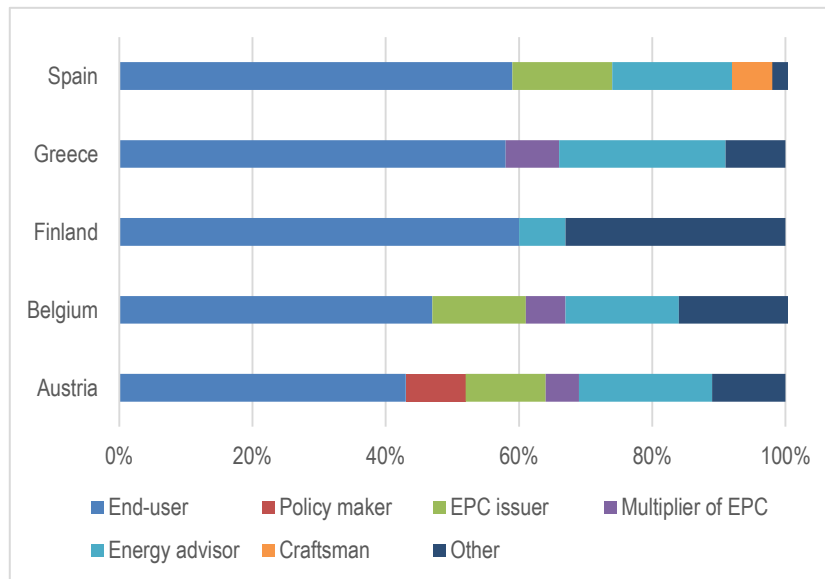


Figure 6: Stakeholder types of 2<sup>nd</sup> workshops participants

### 3.3. Exploration of occupant behaviour

One task in the project was to improve understanding of the everyday energy behavior (including habitual energy behavior) of building occupants, as it affects building energy use in addition to the characteristics of the building envelope, climate, and energy systems. “Building variables explain 39% of the variability in energy consumption; socio-demographic variables explain 24%, heating behaviour 14% and attitude and other behaviours only 5%” (Huebner *et al.*, 2015, p.589). The latter three are related to the user dimension and amount to 43%. Real occupancy patterns result from a large diversity in household characteristics, preferences and lifestyles (Guerra-Santin *et al.*, 2016). Overly simplified assumptions of occupants’ energy behaviour for building energy simulation (BES) is one of multiple sources of the energy performance gap, i.e. the gap between theoretical and actual energy consumption of the building. The pre-bound effect refers to the situation when energy savings are lower than assumed because the energy consumption was overestimated before the renovation (Guerra-Santin *et al.*, 2018). Thus, the pre-bound effect has consequences for the economic viability of energy retrofit programs because cost savings might be smaller than expected. This means that the payback period for low-carbon technologies would be longer in reality than calculated (Guerra-Santin & Silvester, 2017). That is why it is so important for end-users that the energy performance is specified as accurately as possible.

Regarding occupant behaviour modeling there is a paradigm shift; moving away from considering occupants as passive sources of heat, moisture and emissions, to understanding occupants as active decision-making agents, who are responding to the indoor environmental quality (IEQ) through adaptive actions to meet their comfort needs (Wagner & O’Brien, 2018). However, the new approach faces various challenges that are related to the nature of occupant behaviour, which is stochastic, diverse, complex, and interdisciplinary (Hong *et al.*, 2017). In order to better understand occupant behaviour and how to take it into consideration in building energy modeling, a desktop research was conducted by IZES from May-July 2021. For this, different fields of literature were reviewed such as types of energy behaviour, factors influencing energy behaviour, user profiles for building energy simulation and occupant behaviour modelling. A total of 51 sources are cited in the ePANACEA report, July 2021, *The human factor in energy use in buildings*<sup>4</sup>.

<sup>4</sup> ePANACEA report, July 2021, *The human factor in energy use in buildings*, DOI: 10.5281/zenodo.5377722

## 4. DEVELOPING PROCESS OF NEW EPC SUMMARY PAGES

This section summarizes the main outcomes of the tasks (user-needs and 1<sup>st</sup> acceptance test as well as the research on habitual energy behaviour) and reflects on how all of the research steps (stakeholder analysis, user-needs analysis and 1<sup>st</sup> acceptance test of the new EPC and the study of occupant behaviour) have influenced the development of the new EPC summary page. After that, the new EPC summary pages are presented at the end of this chapter. In the end of this chapter the outcomes of the final acceptance test, which also feed the recommendations, are highlighted.

### 4.1. Highlights from the stakeholder analysis

The stakeholder analysis identified the stakeholders of the value chain of EPC which were approached in the stakeholder interviews and the preceding tasks. The fact that stakeholders of the whole value chain of EPC were considered in the user-needs analysis and acceptance tests of EPC has significantly influenced the development of the new EPC summary because other stakeholders (experts) have different perspectives and can assess what is implementable for an EPC and what not. Exclusively considering end-users' needs would have rather ended in a list of wishes which might not be feasible or fit to the purpose of EPC. REB members also have the expert background and ability to assess the feasibility of suggestions. However, the advantage of directly including experts in end-users' activities was that the two groups could exchange with each other; experts could directly respond to suggestions and ideas from end-users.

The interviews showed that end-users know little about the EPC and perceive it as a mandatory document which they use at most for contractual actions such as deep renovation, selling or renting. Other stakeholders showed a rather positive perception of the EPC as they are aware of its original goal as a policy instrument to contribute to the energy transition in the building sector. However, admittedly the EPC would not have fulfilled its potential yet. Moreover, the consideration of the two main different stakeholder groups (end-users and experts/administration) resulted in developing target-oriented pages (i.e. 2 pages for all and 2 pages for end-users) (cf. chapter 4.6).

### 4.2. Highlights from the user-needs analysis

The analysis of stakeholders' critiques, needs and suggestions for improvement of the current EPCs in the ePANACEA pilot countries (cf. ePANACEA report, February 2021, *Insights on user perceptions and needs regarding the Energy Performance Certificate (EPC)*<sup>1</sup>) served as main input for the development of the new EPC summary pages.

**The low individuality and reliability are a main point of criticism by the end-users.** One of the most evident common needs among end-users from pilot countries + DE (also partially supported by experts) is the **interest in feedback about real energy consumption, connected to the need to receive reliable cost indications for running the building and individual recommendations.** Regarding the latter, the list of mentioned examples is long: realistic investment costs, annual energy savings, information on available subsidies, and links to find appropriate installers, as well as more information about energy-efficient technologies. **Likewise, end-users from all countries except for Finland demanded hints for every-day behaviour to save energy.** However, experts (mainly from Austria) consistently pointed out the original purpose of the EPC – a tool to compare the EE of buildings based on the calculated energy performance based on standard conditions - which excludes to derive information about the real energy consumption. Besides, experts wanted to refrain from adding more information to the EPC which is already complex and difficult to understand for end-users (Austria, Finland and Spain). Also, they worried that the indication of estimated costs would be inaccurate due to changing energy prices.

ePANACEA proposes a way to integrate the “end-user dimension” by providing information based on actual conditions of use as a supplement to end-users. Also, in the new EPC summary pages we indicated that prices are based on the date of

issuance of the EPC and what price per kWh was taken into account so that it becomes comprehensible on what basis the price info was given.

Experts from AT, ES and BE-Flanders suggested **splitting the EPC into two versions**: one user-related version, oriented to end-users, with very visual and simple presentations (e.g. cost savings) and another, more technical version directed to authorities who can use it during decision making regarding the granting of funds. **Besides, it was commonly mentioned to make the EPC more dynamic** – which could be realised by connecting the EPC to databases e.g. on fuel costs, policy targets and conversion factors. This would e.g. allow to provide updated information about heating costs to end-users. By implication, if the option(s) to make the EPC dynamic were implemented, **this would mean that (part of) the EPC would need to become web-based in order to display current, updated information.**

Needs mainly differed among stakeholders due to different knowledge backgrounds and among countries due to differently advanced EPC schemes. Nevertheless, a criteria-set for an adequate EPC was developed based on the collected critiques and needs. Hence, an adequate EPC should be **reliable, comparable** in the national and international context, **individual** (regarding the building user and climate), **understandable** (also for laymen), **tangible** (for end-users because they can refer to real life), **adequate** (for the target group) and **dynamic & digital**. Initially the criteria-set also included “comprehensive” (considering technical and regulative developments), i.e. that e.g. also storages and electric vehicles (EVs) are taken into account etc. However, it was recommended by an expert that this criterion is rather unsuitable or misleading because it can be understood as the opposite of streamlining the EPC which is necessary in order to keep the EPC clear and affordable for end-users. The criterion “digital” should be renamed in “web-based” since “digital” does not mean that something is connected with the internet and can be updated automatically.

Furthermore, addressing the system around EPC, experts from Germany and Austria criticized that requirements to issue an EPC are rather low and broad, so that experts with different backgrounds are allowed to issue EPCs, who are often not competent to do that. Also, experts with different background would fill in the calculation software differently which would lead to different results. Therefore, **requirements to issue an EPC should become more precise and demanding** in order to generate EPCs that are more comparable and of higher quality. Furthermore, experts in Germany criticised **that on-site visits should become mandatory** when issuing an EPC to increase the quality of EPCs. However, this also implies higher costs for EPC. Also, **registration of EPCs should become mandatory** and there should be central institutions where the EPCs are registered. This is not implemented yet in all member states of the EU (e.g. Germany).

Besides, experts draw attention to the potential of other stakeholders **to improve communication about the EPC**. Particularly, assessors, construction companies, selling agencies, property managers and town councils could become active as **intermediate links by translating technical information from the EPC to end-users. Energy advisors play a crucial role by providing service-neutral energy advice to end-users.** Hence, next to the EPC schemes the actors who get in contact with end-users play a crucial role in fostering the awareness and understanding of the EPC as well as the uptake of EEMs.

### 4.3. Highlights from the exploration of occupant behaviour

The exploration of habitual energy behaviour emphasized the relevance of energy behaviour for the energy efficiency and energy performance rating of buildings. Therefore, it also supported the idea to include the user dimension in the ePANACEA methodology and in the new EPC summary pages. The findings from the desktop research about occupant behaviour are presented in the ePANACEA report, July 2021, *The human factor in energy use in buildings*<sup>4</sup>.

Repeating the main insights from this research step, we can summarize that there are different types of energy-related occupant behaviour, such as adaptive and non-adaptive behaviours. Adaptive behaviour is motivated by the occupant's will to improve or maintain the IEQ. Non-adaptive behaviours include, for example, use of electrical appliances and presence/absence in a room. Therefore, non-adaptive behaviour is not primarily motivated by the will to meet (thermal) comfort needs. Presence in

a space is the prerequisite for occupants to interact with building systems or to adapt themselves to the environment (e.g. putting on warmer clothes).

The factors influencing energy-related behaviour can be roughly divided into external and internal factors. To our understanding, occupant-related factors, which we focus on, comprise internal and socio-demographic factors. **A dominant internal factor influencing adaptive energy behaviour represents the individually perceived comfort** (Delzendeh et al., 2017; Hong et al., 2017). Interestingly, psychological variables seem to be negligibly little influential in explaining energy use. **By contrast, socio-demographic factors (income, household size, and household composition) which shape the opportunities and constraints for energy use, appear to be more influential** (Abrahamse and Steg, 2009). Energy use in non-residential buildings (NRBs) compared to residential buildings is influenced by different, additional factors, such as the presence of various agents and the fact that there are actions for which all share responsibility.

In order to improve the consideration of the user dimension in EPCs, user profiles could be taken into account. The information that could be considered in a user profile could be a realistic representation of occupancy, which in turn is determined by socio-demographic variables like household composition (e.g. presence of children/seniors) (de Simone *et al.*, 2018). Other socio-demographic variables, not necessarily influencing occupancy but energy consumption nevertheless, are income and size of the household (Gram-Hanssen & Georg, 2017). Next to the household characteristics and occupancy profile, information about the operation of building components and systems (reflecting comfort preferences) and the use of appliances should be included in the user profile. Using the example of heating behaviour, information on the following parameters could be taken into account: thermostat settings, use of radiators (heating hours) and ventilation while heating.

In the ePANACEA project the building energy model is calibrated amongst others based on the consideration of the actual conditions of use (by taking measured energy consumption into account). In the new EPC summary pages the information on the current and potential energy performance is then displayed based on standard as well as based on actual condition of use. This meets end-users' demands on more individual and tailored information through the reduction of the energy performance gap and visualizes the effect of the user on the energy efficiency of buildings (when comparing the energy performance based on standard conditions to the one based on actual conditions of use). This may increase end-users trust in EPC and contribute to more robust economic estimation of EEMs and more realistic tailored recommendations.

Occupant behaviour thus also holds potential to improve the energy efficiency of a building. Next to recommendations for the deep renovation of buildings the EPC therefore should also contain low-cost recommendations related to occupant behaviour (every-day energy behaviour).

#### 4.4. Highlights from the first acceptance test of EPC

Through the 1<sup>st</sup> acceptance test we received confirmation on the suggested improvements for EPC and collected further information about what needs to be improved. The results from the 1<sup>st</sup> acceptance test of the new EPC summary pages are presented in the ePANACEA report, February 2022, *Assessing user-friendliness of proposals for a new Energy Performance Certificate (EPC)*<sup>5</sup>.

The main message from this is that **information should be clear, reduced to the necessary and possibly conveyed by means of intuitive illustrations. Besides, the valuation basis should be made transparent.** Also, only valid data should be provided. **The EPC should become web-based, perhaps also provided as an interactive EPC app.** This would facilitate the provision of additional information for interested users.

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<sup>5</sup> ePANACEA report, February 2022, *Assessing user-friendliness of proposals for a new Energy Performance Certificate (EPC)*, DOI: 10.5281/zenodo.6334736



Regarding main performance indicators there is a **strong interest in annual energy costs in all countries**, whereas **primary energy use** is also considered as highly important. The unit kWh/(m<sup>2</sup> year) is the most preferred unit for the indication of primary energy use according to the results. **Overall, indoor air quality and thermal comfort are the most interesting additional indicators.** A detailed building renovation roadmap was selected as the most interesting additional source of information by participants from Spain, Greece and Belgium. In all countries information about the total investments required for measures would present the biggest benefit that could motivate participants to pay more for an EPC. Except for in Austria, where information about energy and costs savings would be of biggest interest. **It is striking that again the information on costs seems to be important (annual energy costs, investment costs, cost savings etc.).** This is in line with the collected user-needs from the user-needs-workshops. However, as has become clear once again, prices for energy and materials are quite volatile and also vary from region to region. This **information should only be made available if it is reasonably accurate, which could at best be done by calculation based on current databases.**



## 4.5. Other feedback loops

When the new EPC pages were created not only user-needs and the results of the acceptance test were taken into account, but also REB members' and project partners' assessments, the goals of ePANACEA and the suggestions by Annex V of the draft for the new EPBD 2021<sup>6</sup>. Here is an alignment of ePANACEA's proposals for an improved EPC with the proposed indicators of the Annex V of the draft for the new EPBD 2021. Matches are marked with a check mark while discrepancies are commented in blue font.

"On its front page, the energy performance certificate shall display at least the following elements:

- (a) the energy performance class;
- (b) the calculated annual primary energy use in kWh/(m<sup>2</sup> year);
- (c) the calculated annual primary energy consumption in kWh or MWh;

During the last user workshop we received the feedback that it is sufficient to provide information in kWh/m<sup>2</sup>year. By knowing the area of the building, information in kWh or MWh can easily be calculated. In this way, space can be saved.

- (d) the calculated annual final energy use in kWh/(m<sup>2</sup> year);
- (e) the calculated annual final energy consumption in kWh or MWh;

Same comment as above.

- (f) renewable energy production in kWh or MWh;

Is indicated indirectly by the information about actual production of renewable energy on-site and nearby.

- (g) renewable energy in % of energy use;
- (h) operational greenhouse gas emissions (kg CO<sub>2</sub>/(m<sup>2</sup> year));
- (i) the greenhouse gas emission class (if applicable)."

## 4.6. New EPC summary pages

The different described user-related tasks (except for the final acceptance test), inputs from the REB meetings, consideration of Annex V of the draft for the new EPPB and feasibility checks with the project consortium resulted in the new EPC summary pages (Version October 2022). Throughout the project different versions of new EPC summary pages were developed, starting with the first version in November 2020. The new EPC summary pages we proposed first of all include the information that EPC users (the market) demand, followed by what the ePANACEA methodology can deliver and what the revision of the EPBD envisages.

The new EPC summary pages (October, 2022) are structured into general EPC summary pages for all stakeholders (administration/experts and end-users), pages 1+2 shown in Figure 7 and pages 3+4 oriented towards end-users, shown in Figure 8. The EPC summary pages are meant to be applicable to all EU member states as they contain room for national specific needs (e.g. national rating systems, country-specific indicators/information like the potential for biomass etc.). Figure 7 and Figure 8 show a template for existing buildings (therefore containing recommendations) and show a case example of a building in Spain. Details of these pages are shown in the annex of this report in order to make the writing more legible.

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<sup>6</sup> European Parliament: [P9\\_TA\(2023\)0068 Energy performance of buildings \(recast\)](#)

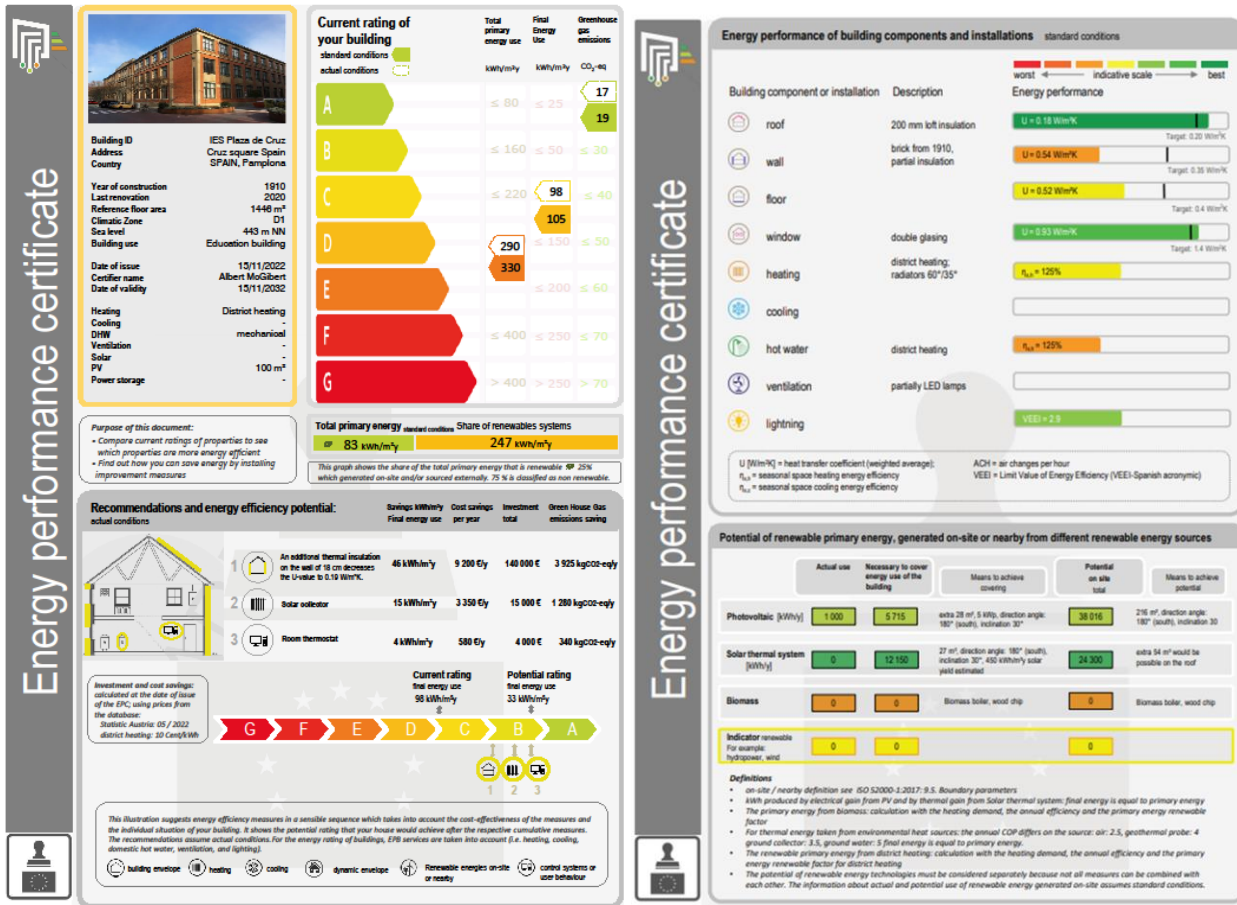


Figure 7: New EPC, summary pages 1 and 2, oriented towards all (administration + experts and end-users)

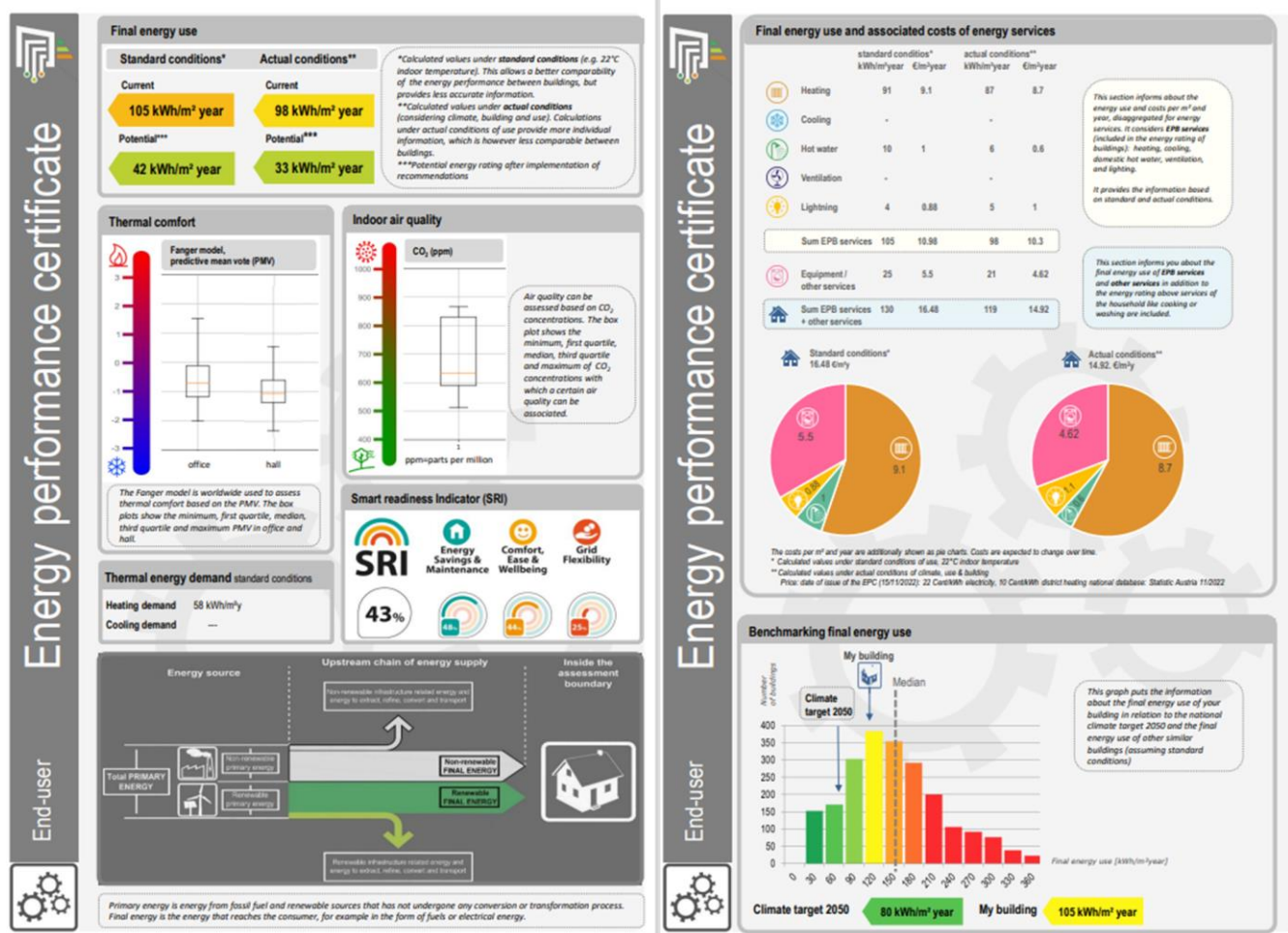


Figure 8: New EPC, summary pages 3 and 4, oriented towards end-users (accessible for all)

## 4.7. Highlights from the final acceptance test of EPC

In the final acceptance test the acceptance of the new EPC summary pages was tested based on e.g. the understanding of information, the perceived ease of use and usefulness, attitude towards the presented EPC and the use intention (cf. the topics in Figure 5). The results of the final acceptance test are presented in the ePANACEA report, May 2023, *User acceptance of new EPC summary pages*<sup>7</sup> and are incorporated into the recommendations in the following chapter. The main outcomes which are relevant for the recommendations are presented in this section.

The new EPC summary pages was perceived significantly more useful to receive information about additional indicators such as comfort, IAQ and costs associated with running the building in Austria, Belgium, Greece and Spain. However, this has not led to the new EPC being perceived as more useful overall. Moreover, the results indicate that the new EPC summary pages have gained in usefulness and individuality but lost in clearness and organization compared to current EPCs in the ePANACEA pilot countries. Points which have been repeatedly praised with regard to the new EPC in all pilot countries were the improved appealing visualization and the roadmap in order to show the recommendations. Also, the benchmarking of final energy use

<sup>7</sup> ePANACEA report, May 2023, *User acceptance of new EPC summary pages*, DOI: 10.5281/zenodo.8154301

was perceived as useful. Criticisms that were mentioned in the previous workshops such as low usefulness and individuality of the EPC were not repeated. This is a confirmation that these user-needs are already well implemented in the new EPC summary pages.

However, it was not clear based on what overall main performance indicator the energy label is based. Therefore, it must be better highlighted that the current primary energy use based on standard conditions is the parameter that determines the energy rating/energy label of the building. Also, in general the provision of information based on standard and on actual conditions is not clear enough, as participants still ask for the difference, the purpose of it and what is taken into account for actual conditions as calculation basis.

Other information that was newly introduced in the new EPC (e.g. benchmarking, potential energy rating, and share of renewable energy etc.) was understood correctly by the majority of participants although many participants mentioned to not fully understand the boxplots presenting the IAQ and comfort. Also, it appears that that the division of pages between the target groups (the first two pages oriented towards all and the two last pages oriented towards end-users) was not clear.

Moreover, participants of all pilot countries repeatedly criticized that there is too much information which is presented in small space which leads to confusion and loss of focus on the most important information. Additional information could therefore be provided in a different additional format. On the other hand, additional explanations in the EPC or a manual in order to understand the provided information would be appreciated by the majority of participants in all pilot countries. Both – separating main and additional information and providing additional explanations - could be realized in a digital/online-version of the EPC. Although the new EPC has received criticism and there are several suggestions for improvement asking for further development of the new EPC summary pages, the behavioural intention to use the new EPC - as well as with regard to the current EPC - e.g. for decision making when buying/renting a house or before renovating is high throughout all ePANACEA pilot countries. Also, by looking at the context of rising energy prices for gas, oil and electricity we can assume that the EPC will be taken into account more because people have to/want to reduce costs for energy. However, we cannot assume that this e.g. also results in an increased uptake of EEMs as the costs for building materials and installations increases and craftsmen are lacking.

## 5. RECOMMENDATION FOR THE NEXT GENERATION OF EPC

This section provides the recommendations on how the next generation of EPC should be designed such that it is used more by end-users (i.e. taken into account when looking for a house/apartment; used to learn about the energy performance of the building and how it can be improved). The recommendations stem from the outcomes of the user-related tasks carried out in the ePANACEA project, feedback from REB meetings and project partners as well as the alignment with annex V of the draft of the revision of the EPBD 2021.

For the development of the EPC summary pages we considered the critiques, needs and suggestion for improvement from users, as well as the results of the first acceptance test. However, now with having the input from the final acceptance test, it became clear what the core aspects of EPC should be and what still needs to be improved. Hence, most of the following recommendations are already implemented in the new ePANACEA summary pages, with a few going beyond the new EPC summary pages, also because they address the system and communication around EPC. They can also be regarded as addition to the suggestions included in Annex V of the draft for a new EPBD 2021.

First of all, when talking about changing/improving current EPCs it is important to mention that by origin EPCs are designed to calculate the energy performance of buildings based on standard conditions and that this is what they currently do. Therefore, by improving/changing the EPC we will also change the purpose of EPC which however may be necessary as the provision of information based on standard conditions is not sufficient (due to the energy performance gap and resulting pre-bound effect).

The following bullet points list the recommendations regarding the design of EPC, the system and communication around EPC:

- EPCs vary among member states. **Using an EU-wide template for the EPC** (at least a common summary page) would increase the comparability of energy performance of buildings between countries and would also make users aware that the EPC is a European information tool. We also see the need for national specifics regarding indicators and rating systems in the EPC because of different climates and policies in the member states: e.g. triple glazing might get a very good rating in Belgium, however it is already the default in Finland. Or biomass is a common renewable energy in Austria but not in other member states... Also, naturally the cooling demand in summer is higher in Spain, whereas the heating demand is higher in Finland compared to other EU member states.
- As mentioned above, EPCs are very different among EU member states. We analysed what information the EPCs of the ePANACEA pilot countries are lacking which however would be interesting to users. These are **benchmarking of final energy use, the potential energy efficiency class, the share of renewable energies, partial energy performance indicators for building components/installations and additional performance indicators such as thermal comfort and IEQ.**
- We can confirm that **target group-oriented pages are** suitable in order to meet different stakeholder needs. It needs to be well communicated what pages are oriented towards whom and why. **An easy language** (not using jargons) should be used on the pages that are oriented towards all (end-users, administration and experts) and on the pages oriented towards end-users. Our proposal foresees that the general information about the building, the overall rated main performance indicators, the recommendations and potential energy performance, as well as the share of renewable energies and the partial performance indicators (energy performance of building installations and components) should be on the pages oriented towards all, whereas the additional indicators (thermal comfort, IEQ and smart readiness indicator (SRI)) as well as a visualization to show the difference between primary and final energy and benchmarking of the building's final energy use could be on pages oriented towards end-users. This mostly overlaps with the division of core aspects and additional information.
- From the feedback we have to understand that **streamlining the information and presenting it as easy as possible** is very important, especially for end-users. However, the assessment of the energy performance of a building is complex as a building cannot be considered as a simple product; but rather as a system or environment that interacts with the

occupants and climate. This results in the challenge to present complex information in a way that is understandable to laypeople. A guideline should be: **“as much information as necessary, as least information as possible”**. Too much information carries the risk to overwhelm the users and to cause inhibitions to take a closer look at the EPC. Instead of putting a lot of different information in the EPC it is more important to well explain the information that is contained. This could be realized through additional explanations in the EPC or through a manual. Therefore, it is important to distinguish between core aspects of EPC and information that could be provided in an annex/ additional pages. Based on the research steps we suggest the following information as core aspects:

- **Core aspects of the EPC:** general information about the building, current state (energy, GHG, costs), potential state and recommendations on how to reach it, share of renewable energies, benchmarking in order to put the EP of the building into context.
- **Additional information could be:** partial performance indicators (e.g. potential of renewable energy installations, energy performance of building elements/installation), additional indicators such as the comfort, indoor air quality (IAQ), information based on actual conditions of use
- Regarding the main performance indicators it is important to clearly indicate which main performance indicator determines the legal energy label (the primary energy use of the building)
- Use of colours and icons to make information intuitive
- **The provision of accurate and individual information is very important for end-user because this makes the information about costs and EEMs also more reliable and useful. Therefore, the user-dimension in energy consumption of buildings should become visible in EPC.** Also here, the differences and advantages of both – information based on standard and based on actual conditions – should be explained. As the consideration of actual conditions of use contributes in reducing the performance gap, this should be pursued in the next generation of EPCs. However, information based on standard and actual conditions of use should not be confused. Therefore, information based on actual conditions of use could e.g. presented in addition (in a web-based tool). It must be clear to end-users what the legal energy label is that they can use to compare buildings with each other (the energy label based on the calculated primary energy use of the building based on standard conditions of use).
- Also, related to the inclusion of the user dimension, **end-users indicated in all activities to appreciate recommendations related to user behaviour next to tailored recommendations** based on cost-optimal solutions for deep renovation of buildings. This was not included yet in the new EPC summary pages, due to lack of space. However, they should be added as they present a possibility for end-users to easily make an impact themselves through low-cost measures.
- **Digital EPC:** provide a digital (even interactive) version of the EPC which would display updated information and allow users to see the information that interest them.
- Ecological aspect and circularity in the building sector should be considered in the calculation for the energy rating of a building; however, this was not pursued further in the project as it was not a goal of ePANACEA.
- Include electricity demand in the EPC since in the long term the use of electricity in households will become more important (e.g. looking at EVs, PV-systems and heat pumps; expert from Germany).
- **Recommendations regarding the system and communication around EPC:**
  - **Requirements to issue an EPC should become more precise and demanding** so that not a lot of experts with different background are allowed to issue an EPC, who often are not competent enough to do that. For instance, in Germany there is currently no official certificate of approval to issue EPCs. In this way, EPCs would become of higher quality and more comparable.
  - **On-site visits should be mandatory** when issuing an EPC to increase the quality of EPCs. However, this also implies higher costs for EPC.



- **Registration of EPCs should be mandatory** and there should be central institutions where the EPCs are registered. This is not implemented yet in all member states of the EU.
- **Communication about EPC and EEMs:** In addition to improving, the system around EPC, the generation of EPC and the certificate itself, also the communication about the EPC should be improved by intermediaries (certifiers, assessors, building companies, selling agencies and town councils). This could improve the understanding of technical data from the EPC (if the next generation of EPC is still not understandable for all). Likewise, the energy consultation by energy advisors should be holistic and objective. This could foster the trust in energy advisors and the uptake of EEMs. Here as well the improved communications will imply higher costs.





## 5.1. Outlook

In a continuation of the project's work the insights from the final acceptance test of EPC and the recommendations derived from them could be applied to the suggested new EPC summary pages: for instance, streamlining the content, adding explanations, indicating the legal energy efficiency class, showing well which are the pages oriented towards all (i.e. end-users, administration and experts) and which are the pages oriented towards end-users (cf. recommendations presented above). The biggest deficit of the present new EPC summary pages is that it is not available in form of an app/web-based tool which would be interactive. However, the desire of a web-based, even interactive EPC was continuously communicated by different users throughout the user-related tasks. The advantage of a web-based (and interactive) EPC would be that changing information such as prices for energy carriers could be easily displayed. With an interactive version users could e.g. select what information they want to receive in addition, on what information they want to receive more explanations, isolate energy services to learn about the energy performance of separate energy system installations. Also, the provision of information based on standard and actual conditions could be presented in a less confusing way, if it was web-based and interactive, when user could e.g. switch from "showing information based on standard conditions" to "showing information based on actual conditions of use". Therefore, a web-based and interactive EPC would fulfil multiple needs. With all the improvements to be implemented an increasing price for EPC must be considered. ePANACEA wants to create awareness of the cost issue.



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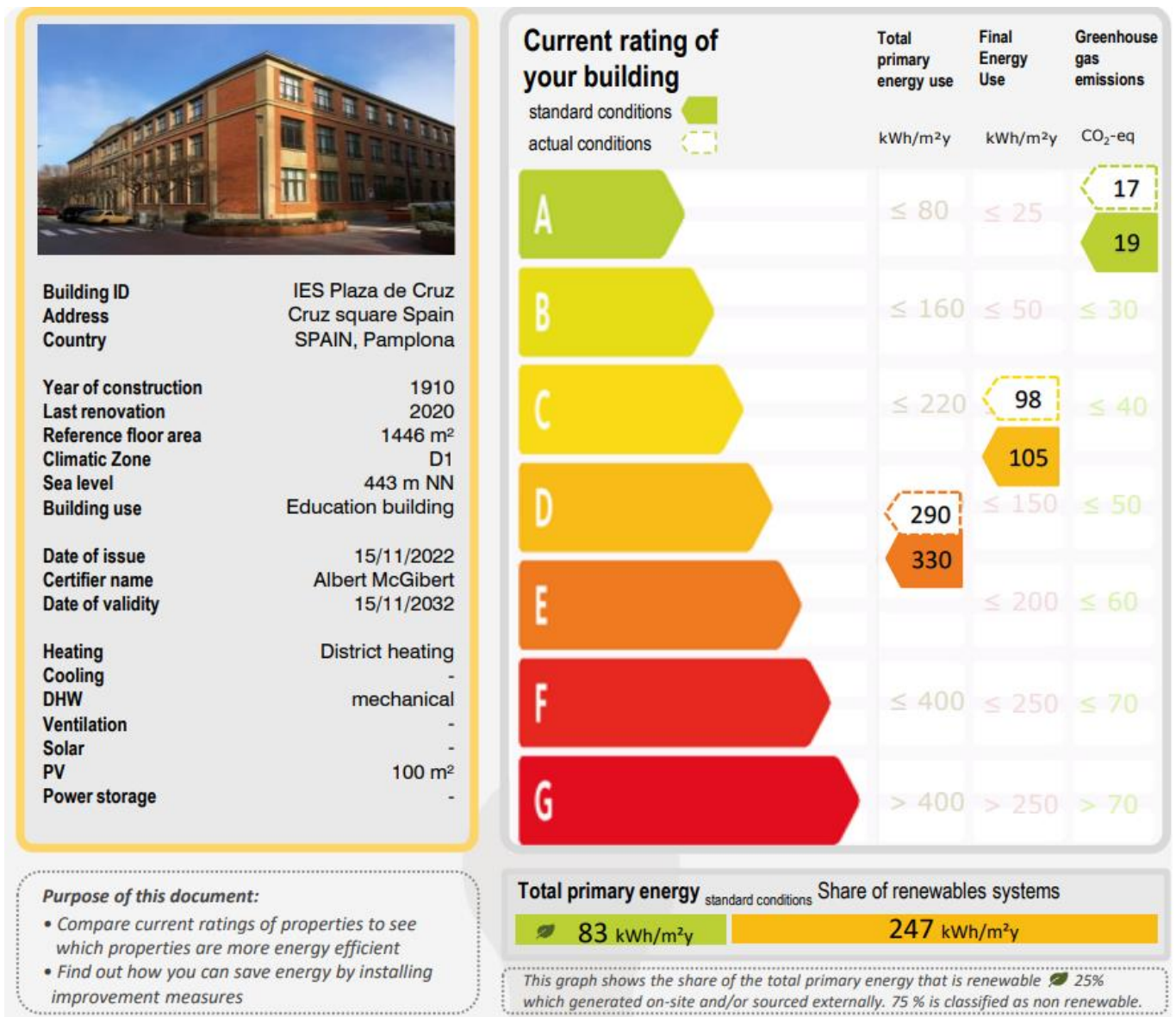
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## 7. ANNEX: DETAILS OF THE NEW EPC SUMMARY PAGES





### Recommendations and energy efficiency potential:

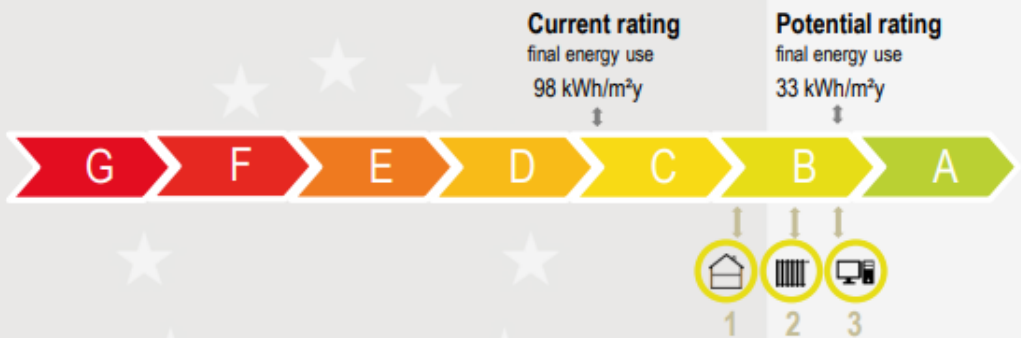
actual conditions

Savings kWh/m<sup>2</sup>y    Cost savings per year    Investment total    Green House Gas emissions saving



Measure	Description	Savings kWh/m <sup>2</sup> y	Cost savings per year	Investment total	Green House Gas emissions saving
1	An additional <b>thermal insulation</b> on the wall of 18 cm decreases the U-value to 0.19 W/m <sup>2</sup> K.	46 kWh/m <sup>2</sup> y	9 200 €/y	140 000 €	3 925 kgCO <sub>2</sub> -eq/y
2	Solar collector	15 kWh/m <sup>2</sup> y	3 350 €/y	15 000 €	1 280 kgCO <sub>2</sub> -eq/y
3	Room thermostat	4 kWh/m <sup>2</sup> y	580 €/y	4 000 €	340 kgCO <sub>2</sub> -eq/y

*Investment and cost savings: calculated at the date of issue of the EPC; using prices from the database: Statistic Austria: 05 / 2022 district heating: 10 Cent/kWh*

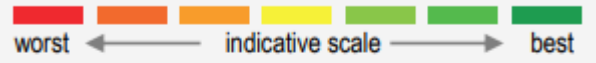


*This illustration suggests energy efficiency measures in a sensible sequence which takes into account the cost-effectiveness of the measures and the individual situation of your building. It shows the potential rating that your house would achieve after the respective cumulative measures. The recommendations assume actual conditions. For the energy rating of buildings, EPB services are taken into account (i.e. heating, cooling, domestic hot water, ventilation, and lighting).*

- building envelope
- heating
- cooling
- dynamic envelope
- Renewable energies on-site or nearby
- control systems or user behaviour



### Energy performance of building components and installations standard conditions



Building component or installation	Description	Energy performance
roof	200 mm loft insulation	U = 0.18 W/m <sup>2</sup> K Target: 0.20 W/m <sup>2</sup> K
wall	brick from 1910, partial insulation	U = 0.54 W/m <sup>2</sup> K Target: 0.35 W/m <sup>2</sup> K
floor		U = 0.52 W/m <sup>2</sup> K Target: 0.4 W/m <sup>2</sup> K
window	double glazing	U = 0.93 W/m <sup>2</sup> K Target: 1.4 W/m <sup>2</sup> K
heating	district heating; radiators 60°/35°	$\eta_{s,h}$ = 125%
cooling		
hot water	district heating	$\eta_{s,h}$ = 125%
ventilation	partially LED lamps	
lightning		VEEI = 2.9

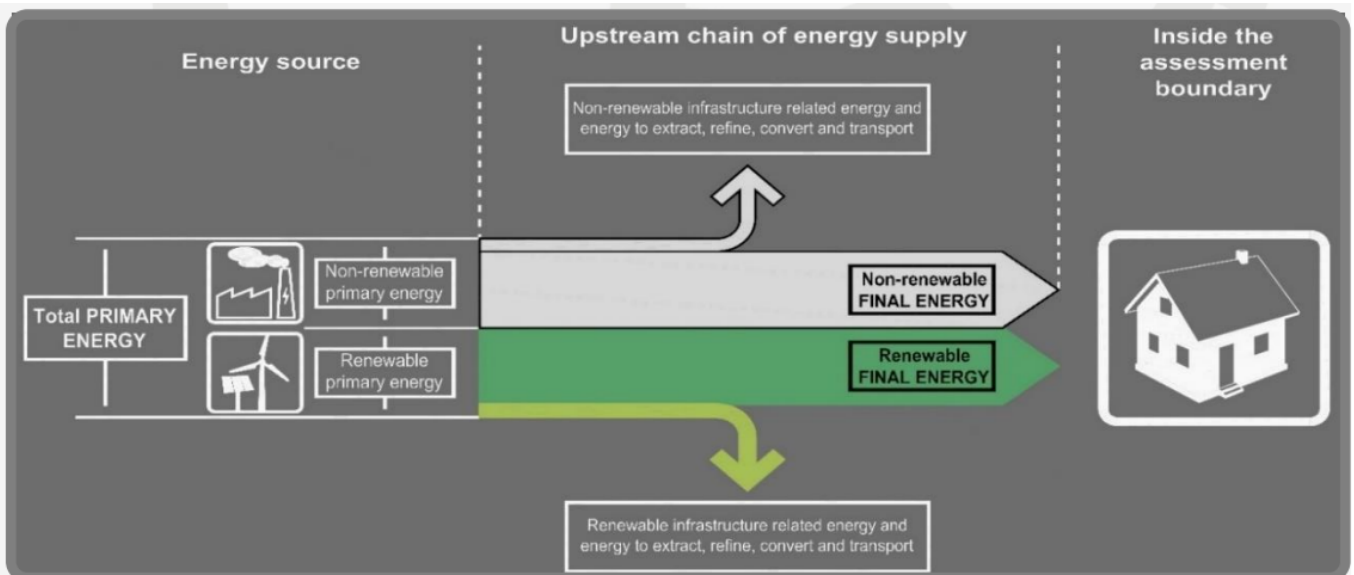
U [W/m<sup>2</sup>K] = heat transfer coefficient (weighted average);  
 $\eta_{s,h}$  = seasonal space heating energy efficiency  
 $\eta_{s,c}$  = seasonal space cooling energy efficiency  
 ACH = air changes per hour  
 VEEI = Limit Value of Energy Efficiency (VEEI-Spanish acronymic)

### Potential of renewable primary energy, generated on-site or nearby from different renewable energy sources

	Actual use	Necessary to cover energy use of the building	Means to achieve covering	Potential on site total	Means to achieve potential
<b>Photovoltaic</b> [kWh/y]	1 000	5 715	extra 28 m <sup>2</sup> , 5 kWp, direction angle: 180° (south), inclination 30°	38 016	216 m <sup>2</sup> , direction angle: 180° (south), inclination 30
<b>Solar thermal system</b> [kWh/y]	0	12 150	27 m <sup>2</sup> , direction angle: 180° (south), inclination 30°, 450 kWh/m <sup>2</sup> solar yield estimated	24 300	extra 54 m <sup>2</sup> would be possible on the roof
<b>Biomass</b>	0	0	Biomass boiler, wood chip	0	Biomass boiler, wood chip
<b>Indicator</b> renewable For example: hydropower, wind	0	0		0	

**Definitions**

- on-site / nearby definition see ISO 52000-1:2017: 9.5. Boundary parameters
- kWh produced by electrical gain from PV and by thermal gain from Solar thermal system: final energy is equal to primary energy
- The primary energy from biomass: calculation with the heating demand, the annual efficiency and the primary energy renewable factor
- For thermal energy taken from environmental heat sources: the annual COP differs on the source: air: 2.5, geothermal probe: 4 ground collector: 3.5, ground water: 5 final energy is equal to primary energy.
- The renewable primary energy from district heating: calculation with the heating demand, the annual efficiency and the primary energy renewable factor for district heating
- The potential of renewable energy technologies must be considered separately because not all measures can be combined with each other. The information about actual and potential use of renewable energy generated on-site assumes standard conditions.



Primary energy is energy from fossil fuel and renewable sources that has not undergone any conversion or transformation process. Final energy is the energy that reaches the consumer, for example in the form of fuels or electrical energy.



### Final energy use

#### Standard conditions\*

Current

105 kWh/m<sup>2</sup> year

Potential\*\*\*

42 kWh/m<sup>2</sup> year

#### Actual conditions\*\*

Current

98 kWh/m<sup>2</sup> year

Potential\*\*\*

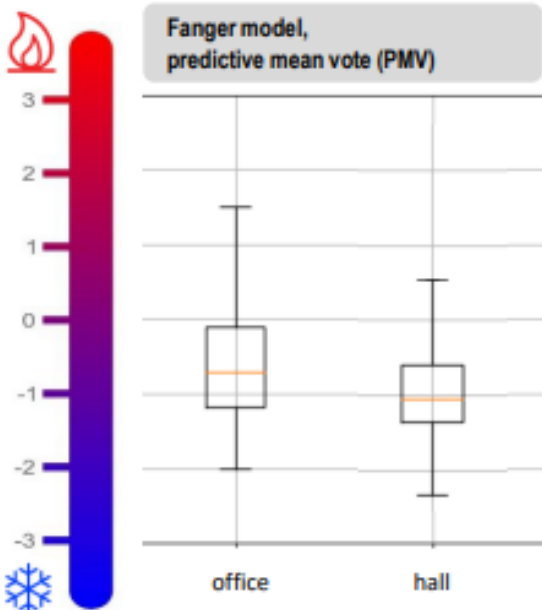
33 kWh/m<sup>2</sup> year

\*Calculated values under **standard conditions** (e.g. 22°C indoor temperature). This allows a better comparability of the energy performance between buildings, but provides less accurate information.

\*\*Calculated values under **actual conditions** (considering climate, building and use). Calculations under actual conditions of use provide more individual information, which is however less comparable between buildings.

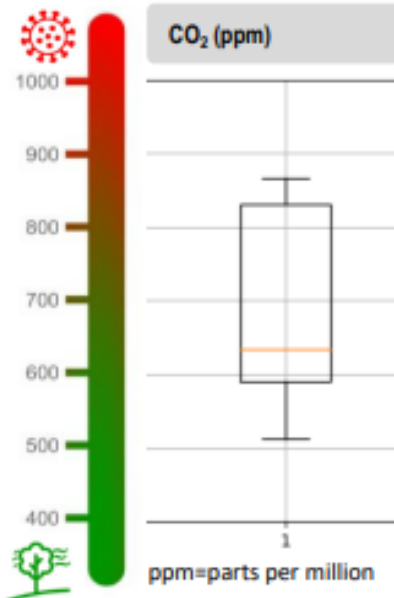
\*\*\*Potential energy rating after implementation of recommendations

### Thermal comfort



The Fanger model is worldwide used to assess thermal comfort based on the PMV. The box plots show the minimum, first quartile, median, third quartile and maximum PMV in office and hall.

### Indoor air quality



Air quality can be assessed based on CO<sub>2</sub> concentrations. The box plot shows the minimum, first quartile, median, third quartile and maximum of CO<sub>2</sub> concentrations with which a certain air quality can be associated.

### Thermal energy demand standard conditions

Heating demand 58 kWh/m<sup>2</sup>y

Cooling demand ---

### Smart readiness Indicator (SRI)



43%



### Final energy use and associated costs of energy services

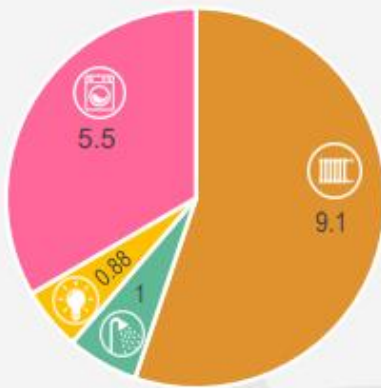
	standard conditions*		actual conditions**	
	kWh/m <sup>2</sup> year	€/m <sup>2</sup> year	kWh/m <sup>2</sup> year	€/m <sup>2</sup> year
Heating	91	9.1	87	8.7
Cooling	-	-	-	-
Hot water	10	1	6	0.6
Ventilation	-	-	-	-
Lightning	4	0.88	5	1
<b>Sum EPB services</b>	<b>105</b>	<b>10.98</b>	<b>98</b>	<b>10.3</b>
Equipment / other services	25	5.5	21	4.62
<b>Sum EPB services + other services</b>	<b>130</b>	<b>16.48</b>	<b>119</b>	<b>14.92</b>

This section informs about the energy use and costs per m<sup>2</sup> and year, disaggregated for energy services. It considers **EPB services** (included in the energy rating of buildings): heating, cooling, domestic hot water, ventilation, and lighting.

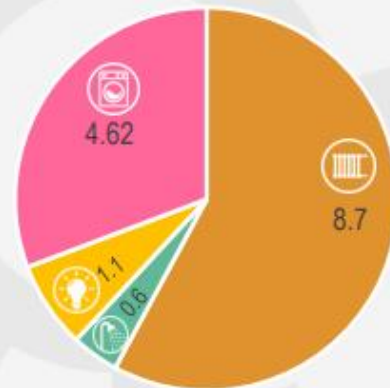
It provides the information based on standard and actual conditions.

This section informs you about the final energy use of **EPB services** and **other services** in addition to the energy rating above services of the household like cooking or washing are included.

Standard conditions\*  
16.48 €/m<sup>2</sup>y



Actual conditions\*\*  
14.92. €/m<sup>2</sup>y



The costs per m<sup>2</sup> and year are additionally shown as pie charts. Costs are expected to change over time.

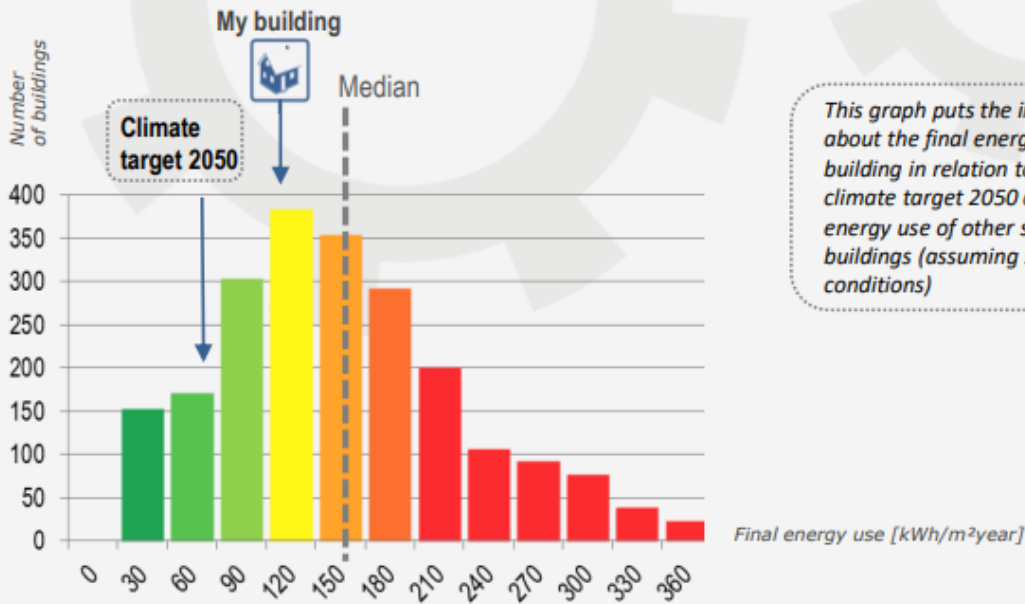
\* Calculated values under standard conditions of use, 22°C indoor temperature

\*\* Calculated values under actual conditions of climate, use & building

Price: date of issue of the EPC (15/11/2022): 22 Cent/kWh electricity, 10 Cent/kWh district heating national database: Statistic Austria 11/2022



### Benchmarking final energy use



*This graph puts the information about the final energy use of your building in relation to the national climate target 2050 and the final energy use of other similar buildings (assuming standard conditions)*

Climate target 2050

80 kWh/m<sup>2</sup> year

My building

105 kWh/m<sup>2</sup> year

