TIMEPAC

Towards Innovative Methods
for Energy Performance Assessment and Certification of Buildings

Deliverable 1.1

Context analysis of EPC generation

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Executive Summary

This deliverable summarizes the results of Task 1.1 “EPC generation” included in Work Package 1 (WP1) of the TIMEPAC project. The objective of WP1 is to carry out a comparative study of the elements involved in the development of future scenarios to work with enhanced Energy Performance Certification (EPC), in each of the four identified stages of the EPC data flow: generation, storage, analysis and exploitation. As a result of this study, possible improvements, vulnerabilities, threats, and risks related to an upgrade of already-existing certification schemes are identified

Within WP1, the purpose of Task 1.1 is to objectively analyse the EPC generation procedures in six TIMEPAC countries (Austria, Croatia, Cyprus, Italy, Slovenia and Spain). The scope of the deliverable required a detailed analysis of national frameworks, regulations and the EPC generation tools in all six participating countries in relation to the requirements envisioned in the recast of the Energy Performance of Buildings Directive (EPBD), published in December 2021. The research work focused primarily on identifying good practices as well as potential barriers that need to be overcome in order to implement enhanced EPC schemes.

The participants in this study were energy experts in the partner institutions and other institutions dealing with EPC generation. The outcomes of this deliverable provide a clear, cross-country comparison and can be useful for national and regional certification bodies dealing with the rules and regulations of the EPC generation process. Experts from all six Member States clearly indicated that existing models are not able to properly take into account key aspects that need to be considered in a building’s EPC, as envisioned in the EPBD recast. To capture information about the understanding of the EPC generation process from the end-user’s perspective and to better understand the end-user’s needs and expectations, a survey was conducted in all six participating countries. The analysis of the responses revealed that there are many aspects that need to be improved, concerning the quality and value of the energy certificate, in particular for the renovation of buildings. The integration of operational data is crucial for improving the quality, reliability and usability of the EPC. Experiences from the EPC of non-residential buildings in Slovenia clearly show that a dynamic rating based on the consumption data could help to improve the effectiveness of EPC.

During the development of this task, contacts were established with expert groups that are working on improving EPCs, including the Concerted Actions (CAs) Energy Efficiency Directive, the CAs Energy Performance of Buildings Directive, the CAs Renewable Energy Sources, the E^nR Club (network of energy agencies) and the European Energy Managers (EUREM). These contacts will help disseminate and communicate the activities of the TIMEPAC project.

1 Introduction

1.1 Purpose and target group

In the framework of the European climate-neutrality and sustainability goals, buildings are no longer considered static and isolated objects. Instead, they are seen as an integral part of a comprehensive and dynamic built environment that also includes the energy and transport infrastructures. Therefore, buildings are dynamic entities in the smart grid through on-site renewable generation, controlled with smart metering and which are intrinsic components offering demand-side flexibility connected with electro-mobility. The value of the energy performance certification (EPC) as a tool that supports the building-renovation process has been acknowledged in the final versions of all National Energy and Climate Plans[1] (European Commission, 2022). In this context EPC has been recognized as an effective assessment methodology to systematically analyse and improve the energy performance of buildings. However, it was also recognised that existing, static EPCs must be transformed into dynamic and holistic EPCs that will consider not only the building, but also the multiple building subsystems (construction systems and materials, technical building systems, automation and control systems) and their interaction with the environment (carbon footprint, renewable energy production) through its lifetime (building passports, energy audits, as-built design reports and user behaviour).

This deliverable is the result of Task 1.1 “EPC generation” of the TIMEPAC project. It is focused on analysing the EPC generation procedures in six TIMEPAC countries: Austria, Croatia, Cyprus, Italy, Slovenia and Spain. The work required a detailed analysis of national frameworks, regulations and the EPC generation tools in all six participating countries in relation to the requirements of the Energy Performance of Buildings Directive (EPBD) concerning EPCs. This work focused on identifying good practices as well as potential barriers that should be overcome before the implementation of enhanced EPC schemes.

The target groups are the energy experts in partner institutions and others dealing with EPC generation. The outcomes of this deliverable provide a cross-country comparison and can be useful for national and regional certification bodies dealing with the rules and regulations of the EPC generation process.

1.2 Deliverable structure

In addition to the introductory chapter, this document has four additional chapters where the research work addressing the following topics is presented:

- Research methodology.
- Context of EPC generation in addressed EU Member States.
- EPC generation in the context of the end-user’s requirements in the addressed EU Member States.
- External context of the energy performance assessment of buildings.

The chapter dealing with the context of EPC generation follows the same structure for each addressed Member State and contains the following subchapters:

- Data-acquisition methods and the availability of data.
- Performance assessment and calculation software.
- Energy performance indicators.

[1] The final versions of National Energy and Climate Plans are available at: https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

- Validation process for EPC data and quality assurance.

Also, the chapter dealing with EPC generation regarding the end-user's requirements follows the same structure for each addressed Member State and contains the following subchapters:

- Understanding EPC data and the generation process.
- Understanding the proposed energy-efficiency measures.
- Usefulness of the EPC.

The cross-country comparison, the main gaps and the recommendations for TIMEPAC are outlined in relevant subchapters with the information about how they will be used in the project's next steps for the development and implementation of the transversal deployment scenarios. The Conclusion provides a summary of the key findings of the context analysis of the EPC generation process. The references are given in a separate chapter. Annex 1 of this deliverable contains the master version of the questionnaire that was designed by the JSI to assess EPC generation in the context of the end-user's requirements.

1.3 Contribution of partners

The research work carried out in the framework of Task 1.1 was coordinated by the Jožef Stefan Institute (JSI). On the national level, the responsible partners (SERA, EIHP, CEA, CUT, EDILCLIMA, POLITO, MzI, GOLEA, ICAEN and FUNITEC) analysed and compared approaches, models and certification tools used for the EPC generation. For the analysis of the EPC generation by end-users, partners were responsible for translating the questionnaire into their national languages, for selecting the way in which the survey will be conducted, for distributing it through their professional networks and for analysing the responses and feedback from the target audiences.

1.4 Relations to other project activities

This analysis of the EPC generation carried out in Task 1.1 is related to the other tasks of WP1 in the following ways:

- EPC storage (Task 1.2). The quality of the stored EPC data has a huge influence on energy planning and consequently the extensive renovation of the buildings on local, regional and national levels. The quality-control elements in all six national contexts were evaluated and the potentials for improvements were identified.
- EPC analysis (Task 1.3). The integration of operational data is crucial to improving the quality, reliability and usability of EPC, and it was examined as part of the analysis of the EPC generation process.
- EPC exploitation (Task 1.4). Future EPC exploitation must support the extensive renovation of the EU building stock, including the exploitation of renewable energy sources (RES) in buildings, raising awareness among building owners and occupants, verifying the actual savings, e-mobility and renewable energy communities. The main gaps in the current EPC generation process in the framework of future EPC exploitation were identified.

The main findings in this deliverable will serve as a reference for the future activities of the TIMEPAC project, especially those that are dealing with EPC generation in the transversal deployment scenarios (TDS2, TDS3 and TDS4), demonstration scenarios (DS1, DS2, DS3 and DS4) and the development of training materials (TS1, TS2, TS3, TS4, TS5 and TS6). The findings from this deliverable will also be used as a baseline for the new, enhanced certification schemes proposed in WP5.

2 Research methodology

This section introduces the methodology used in the analysis of the EPC generation process in the six TIMEPAC countries, in particular the methods and techniques that were used to identify, select, process and analyse information about the EPC generation process. This methodology section answers two main questions: How was the data collected or generated? How was it analysed? Furthermore, it critically evaluates the study's overall validity and reliability.

2.1 Purpose

The purpose of analysing the EPC generation process is to identify good practices, limitations, deficiencies and obstacles in the current EPC generation process that should be overcome prior to the implementation of enhanced EPC schemes.

2.2 Methods and tools

The framework for the analysis of the context of EPC generation in the addressed TIMEPAC countries was created by the JSI. In each country, the partners analysed the data-acquisition methods and the availability of data, the performance assessment and the availability of the calculation software, used energy-performance indicators and the main shortcomings of the validation process of EPC data and quality assurance.

To assess the EPC generation process, a survey was created with four general and fifteen technical questions, with most of them having answers on a Likert scale, with grades from 1 to 5, where 1 means "Completely unaware / Not agree / Completely not understandable", 2 "Mostly unaware / Mostly not agree / Mostly not understandable", 3 "Neutral", 4 "Partly aware / Partly agree / Partly understandable", 5 "Completely aware / Completely agree / Completely understandable" (see Annex 1).

2.3 Participants

Partners were responsible for translating the questionnaire into their national languages, for selecting the method for conducting the survey, for distributing it through their professional networks and for analysing the obtained results and feedback from the target audiences. The profile of the people who participated in the study was as follows: experts in the energy efficiency of buildings, professionals from facility management and financing institutions and energy managers, among others.

2.4 Limitations

The main shortcoming of the study is that the EPC generation process was analysed in only six countries participating in the TIMEPAC project. However, there is comprehensive information available about all the Member States from other sources such as the public area of the Concerted Action EPBD website (https://epbd-ca.eu/ca-outcomes), so that this study can be seen as an in-depth investigation prior to subsequent TIMEPAC activities. In addition, during this task appropriate contacts were established with expert groups like CA EED (MzI, JSI), CA EPBD (MzI, SERA, POLITO), CA RES (MzI, JSI), the European Energy Network – E^nR (EIHP) and European Energy Managers (EUREM) at the JSI. These groups will be instrumental in disseminating and communicating the project's activities and will provide valuable inputs for the adaptation of the TIMEPAC approach and the creation of guidelines for EPC enhancement at the EU level through the TIMEPAC Academy.

3 Context of EPC generation in the addressed EU Member States

3.1 Austria

3.1.1 Qualification of certifiers

Regarding the qualification of the certifiers, the federal trade law (GewO, 1994) applies. This, among other factors, defines the conditions for access to trades. The Chamber of Commerce and the Chamber of Architects and Engineers are responsible for defining professional admission rules to obtain the license for a certain profession, for offering the required courses, for holding examinations for the professions, and for issuing the license.

With regard to the EPC, the responsible ministry has issued decrees on which professional groups are authorised by trade law and their professional accreditation to calculate the EPCs, for example, Architect, Civil engineer, Consulting engineer, Master builder, Electrical engineering, Gas and sanitary engineering, Heating technology, Refrigeration and air-conditioning technology, Ventilation technology, Master woodworker, and others.[2] There is no differentiation regarding residential buildings, non-residential buildings, or other criteria, and there are no additional qualification requirements. Especially at the beginning of the EPBD implementation, there were serious quality issues and authorities were busy with the re-calculations and re-submissions of EPCs.

The provinces are free to define additional qualification requirements because the EPC is part of the documents to be submitted to obtain a building permit and/or the housing subsidy for a new construction or renovation. This is also reflected in Guideline 6 of the Austrian Institute of Construction Engineering (OIB – Österreichisches Institut für Bautechnik) (for detailed explanation see the chapter below) stating that EPCs must be issued by qualified and professionally accredited people, and thus emphasizing both the professional accreditation and the qualification. In practice, the association called ARGE-EBA[3] (Arbeitsgemeinschaft Energieberatung – Working Group for Energy Advice) consisting of the nine provinces and their energy agencies is very important because it offers standardised and acknowledged courses (basic level and advanced level) in collaboration with the regional vocational training institutions of the Austrian Chamber of Commerce called Wifi (Wirtschaftsförderungsinstitut – Business Development Institute). These courses are also recommended for all experts authorised to issue EPCs by professional accreditation.

The qualification of energy auditors according to the Energy Efficiency Directive 2012/27/EU is regulated by a different federal law (Energy Efficiency Law, 2014). There is a differentiation between the energy auditors for buildings, transport and industry. Energy auditors for buildings must comply with the following requirements: a defined basic education, relevant continuing education in the area of energy, practical experience, and reference projects. A certain number of points is allocated to each element, and a minimum number of points must be achieved to be included as an energy auditor in the public register.

3.1.2 Data-acquisition methods and availability of data

Regulation at the federal and provincial levels: The Energy Performance Certificate (EPC) is regulated at the federal level (EPC Presentation Law, 2012). Accordingly, owners and tenants need to have a certificate for buying or renting a building or a building unit, and the certificates need to be included in real-estate advertisements. All technical aspects and the display of the EPC in public

[2] https://www.wko.at/service/wirtschaftsrecht-gewerberecht/Die_Befugnis_zur_Erstellung_von_Energieausweisen.html

[3] https://arge-eba.net/

buildings are regulated at the level of the federal provinces as part of the provincial building regulations.

Harmonisation of provincial building regulations: There are nine Austrian provinces, and they are all members of the Austrian Institute of Construction Engineering (OIB – Österreichisches Institut für Bautechnik). The OIB was established in 1993 based on an agreement concluded by the Austrian provinces "in accordance with Article 15a Federal Constitutional Law concerning cooperation in the construction sector". This Institute has a mandate to harmonize the provincial building regulations by developing and issuing the so-called OIB Guidelines, which then serve as a blueprint for the provincial building regulations. The provinces can either adopt the OIB Guidelines as they are, without any changes, or adapt them to the needs of the respective province. In recent years, only a few adaptations were made. Energy aspects are reflected in OIB Guideline 6 (OIB Guideline 6, 2019), which represents the transposition of the technical elements of the Directive 2010/21/EU on the Energy Performance of Buildings (EPBD).

Availability of EPCs: There are a few exemptions from the obligation to have an EPC, i.e., those referred to by the EPBD.

EPCs are required for new buildings and major renovations as part of the building-permit procedure. Regarding major renovations, this requirement was not effective in practice. Often, renovations were planned in such a way that the condition of major renovation was avoided. Thus, this requirement did not substantially contribute to increasing the numbers of EPCs to achieve better coverage of the building stock.

While the availability and quality of EPCs is good for new buildings because the EPC is part of the building-permit procedure regulated by the provinces, the situation regarding EPCs to be issued in the course of selling or renting a building or a building unit (regulated by federal law) still needs to be improved. The obligation to hand over the EPC is hard to enforce. Although the law provides for a penalty in the case of non-compliance, a civil complaint is required for the penalty to become effective. In practice, such charges are rarely filed. There are no other effective mechanisms in Austria, such as the need to present the information to a notary for the purchase contract or to the bank for a loan.

In the residential sector, the social housing subsidy scheme plays an important role because the conditions are defined in such a way that the majority of Austrians are entitled to receive this financial support. In addition to income-related criteria, there are energy-related criteria that must be met, as well, and an EPC is the proof of meeting these energy-related criteria for new constructions and renovations. Therefore, this part of the building stock is well covered with EPCs. However, there is no EPC for a large proportion of single-family houses because they are owner-occupied and not rented out or sold, or because renovations are carried out without subsidies. The inspection of heating and cooling systems is regulated by the regional laws on Fire Police, Air Pollution Control and the Inspection of heating and air conditioning systems. Unfortunately, there is no connection with issuing an EPC. In practice, the focus of these laws is fire safety and air-pollution control. Due to the strict subsidy requirements, some people would rather do without a subsidy than comply with the strict requirements.

EPC Method: For new buildings and existing buildings there is A calculated EPC. There is no measured EPC in Austria, but it is worth noting that energy consumption and production data can be collected in addition to the EPC as part of the requirements of the social subsidy scheme.

OIB Guideline 6 and THE supplementary documents provide an EPC template for residential buildings, non-residential buildings and others, information about the minimum requirements for energy performance and the method used the calculation.

Regarding the calculation method, there are basically two options:

- The detailed method (standard method) based on building-specific data (mainly for new buildings) or using default data, and options in between.
- The simplified method based on default values (only for existing buildings).

Regarding calculation methods, there is a reference to the following Austrian Standards:

- ÖNORM B 8110-5 on Basic data: Climate model and user profiles.
- ÖNORM B 8110-6-1 on Useful energy: Heating and cooling demand.
- ÖNORM H 5057-1 on Useful energy: Ventilation and air-conditioning energy demand.
- ÖNORM H 5050-1 on Final energy: Total energy-efficiency factor and final energy requirements based on reference equipment and primary energy demand and carbon dioxide emissions.
- ÖNORM H 5056-1 on Final energy: Heating-energy demand and humidification-energy demand.
- ÖNORM H 5058-1 on Final energy: Cooling-energy demand.
- ÖNORM H 5059-1 on Final energy: Lighting-energy demand.

Data acquisition and calculation: Regarding data acquisition and calculation, the provinces provide guidance, such as the Guideline on issuing the EPC[4] in the province of Styria and other information relevant for the EPC and building-energy performance published at the portal called "*I do it for our future*" (Ich tu's für unsere Zukunft[5]).

The nature and quality of the available documentation regarding the data needed for the EPC calculation is an important factor and also influences the cost of the EPC. It is necessary to determine in advance whether a detailed calculation of the input values (e.g., U-values) will be carried out or whether standard values of the simplified recording procedure will be used. An inspection of the building, an additional measurement, subsequent detailed refurbishment consultations, the preparation of a refurbishment concept or calculations of sound insulation and the preparation of advice to reduce overheating in the summer are not part of the EPC calculation and must be agreed and invoiced additionally.

According to OIB Guideline 6, the simplified EPC calculation procedure is only allowed for existing buildings, whereby simplifications can be made in the recording of the building's geometry, the physics of the building and the technical building systems.

In addition to information about the location of the building, the type of uses, the type of construction, and the description of the technical building systems (including information about the efficiencies, energy sources and pipes), the following data are needed for an EPC calculation:

- Approval plan or as-built plans (floor plans, sections, views, and site plan).
- Building physics (component structures).
- Detailed plans of technical building systems (e.g., line diagram and heating plan).
- Test reports (especially in the case of deviations from the default values).

[4] Energieausweise erstellen: Anleitungen - Hinweise – Empfehlungen der Fachabteilung Energie und Wohnbau, September 2018 https://www.ea-stmk.at/documents/20181/25550/Energieausweise+erstellen+2018/699406ca-1b23-4867-8a39-97aeb1c06709 and updated version July 2020 https://www.ea-stmk.at/documents/20181/25550/Energieausweis+erstellen+2020/029253a5-aa02-4c48-8346-d21d49c8c67e

[5] Electronic platform with information for download: https://www.ich-tus.steiermark.at/cms/beitrag/11872587/99839330

If plans are not available, it is recommended to compile the data by means of the following methods:

- Measurement of the building.
- Photogrammetric analysis.

In addition, if an on-site visit is agreed, documentation in the form of pictures is recommended: pictures of the building to determine deviations from the approval plan, building conversions or extensions, facade view, shading by other buildings or terrain, technical condition of the building (e.g., windows and doors); pictures of the boiler room showing a readable type plate of the boiler and/or burner, district heating heat-exchange station, heat pump, storage tank, insulation of the storage tank and the fittings, insulation of the pipes and connection parts; pictures of the building services systems: ventilation system, air conditioning, photovoltaic system, solar thermal system; pictures from inside the building, if possible: heat-delivery system with control, decentralised hot-water tank, lighting.

For the calculation of the energy demand, it might be necessary to divide the building into different zones. The respective calculation zones result from different uses for residential and non-residential buildings. Each of the uses is represented by a standardised use profile according to ÖNORM B 8110-5.

3.1.3 Performance assessment and calculation software

There is no unique official calculation software, but commercial software is available based on OIB Guideline 6 (2019) and the respective Austrian standards. Software programmes must comply with defined validation examples to be approved. These reflect the legal situation in the provinces regarding building regulations and the social housing subsidy scheme in order to be applied. They support the standard calculation method and the simplified calculation method that is only allowed for existing buildings.

In practice, calculation programmes must also have an interface with the regional EPC database. It is specified in most provincial regulations that software programmes must offer the interface for uploading the EPC into the EPC database.

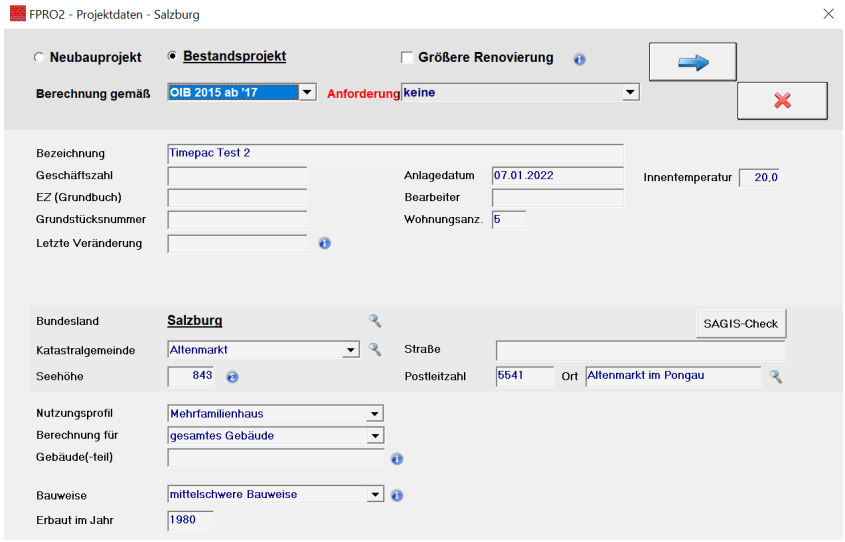
There are several validated and approved commercial software programmes available with an interface to upload information to the regional databases:

- ArchiPHYSIK, A-NULL Development GmbH (www.archiphysik.at).
- AX3000, EDV-Software-Service GmbH & CO KG (www.ax3000.at).
- GEQ, Zehentmayer Software GmbH (www.geq.at).
- Gebäudeprofi, ETU GmbH (www.etu.at).
- Ecotech Gebäuderechner, BuildDesk Österreich GmbH (www.ecotech.cc).

The user is free to choose from among the software programmes available on the market, because they all comply with the requirements described above. In addition, they offer different features, such as BIM compatibility (ArchiPHYSIK and AX3000), good representation of renewable-energy systems (GEQ), and good representation of material aspects (Ecotech). The calculation programmes support the users to varying degrees by means of selection options (drop-down lists), libraries and default values, which can be replaced by specific information, if available. So, the choice of software depends mainly on the user’s preferences and the type of calculation.

There is an informal working group consisting of representatives of the calculation software companies, the provincial EPC database operators, and the programmers of the regional EPC databases. Further development of the software and the databases is done in a coordinated way based on identified areas of improvement.

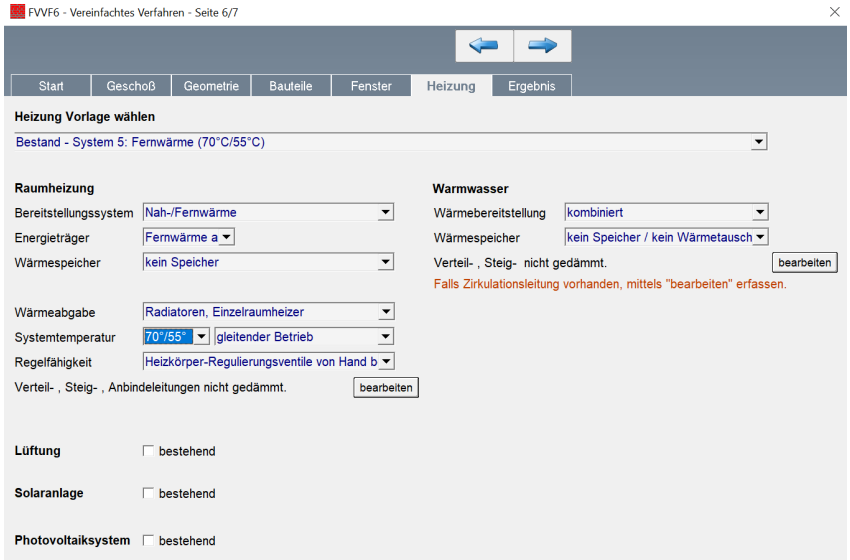
Figure 1 shows screenshots of the EPC calculation programme GEQ.



Input of basic project data, with pre-selected options that can be changed.

The selection of user profile and construction type has implication for the pre-filled data.

Indoor temperature is also filled in and can be changed. While 20°C was used in the past, nowadays 22°C is used.



Simplified calculation procedure for existing buildings.

It is possible to generate an EPC based on minimal input data, such as general building information, measurements and the type of heating system.

The calculation is based on default data.

Figure 1. Screenshots of EPC calculation programme GEQ

3.1.4 Energy-performance indicators

Energy-performance indicators and EPC formats are defined by OIB Guideline 6. The latest version dates from 2019 and covers the changes introduced by the amending Directive (EU) 2018/844. According to OIB Guideline 6 (2019), the EPC consists of the first two pages (in the case of other conditioned buildings there are more pages) with a defined format and a technical annex.

There are three core building categories the EPC can be issued for:

- Residential buildings.
- Non-residential buildings (offices, educational institutions, hospitals, care homes, accommodation, restaurants, event venues and multi-purpose buildings, sports facilities, retailers).
- Other conditioned buildings (other than residential and non-residential, for example agricultural buildings).

Figures 2 and 3 show the first two pages of an EPC for residential and non-residential buildings. The technical annex is defined in terms of the content and must include the following information:

- The standards and guidelines used.
- The simplifications used in accordance with the standards.

- The other aids used.
- The determination of the geometric, building-physics and building-services input data.
- Measures and recommendations, except in the case of new buildings and in the case that the requirements for major renovation are already fulfilled.

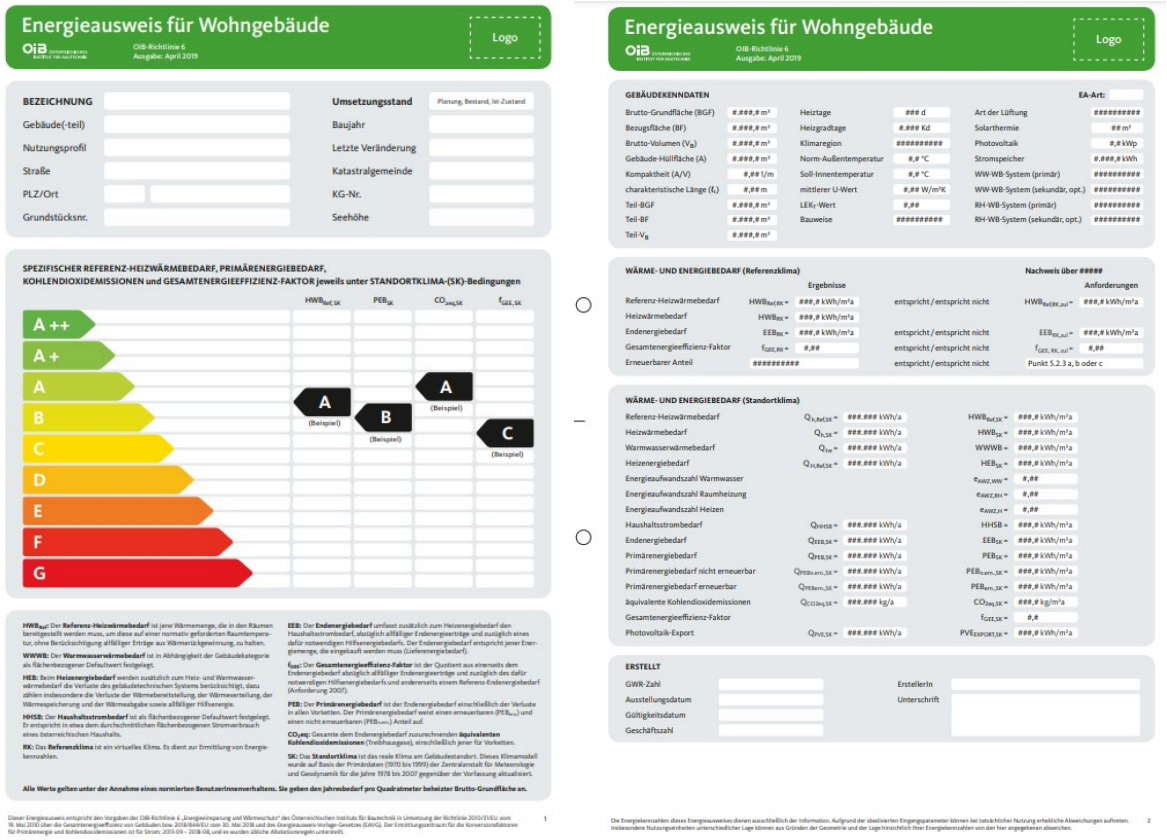


Figure 2. First two pages of EPC for residential buildings

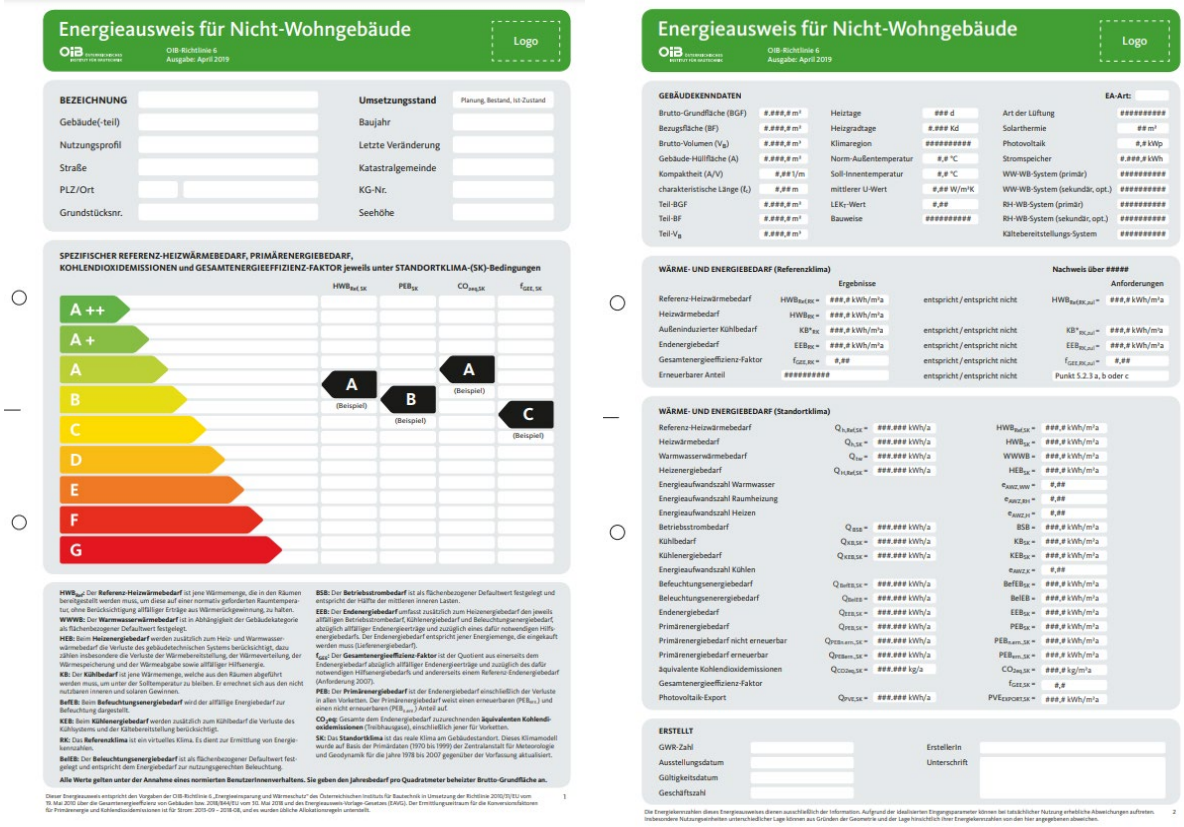


Figure 3. First two pages of EPC for non-residential buildings

Indicators shown on the first page of the EPC (picture on the left-hand side of Figure 3) and their scale from A++ to G are defined by OIB Guideline 6 (2019), as summarized in Table 1: Heating-energy demand (transmission losses building envelope - HWB_{Ref}), Primary-energy demand (PEB), CO_2 equivalents (CO_{2eq}), and the Total energy performance factor (f_{GEE}) representing the final energy. All indicators refer to the climate of the actual location of the building.

The total-energy-performance factor (f_{GEE}) is the quotient of, on the one hand, the final energy demand minus any final energy yields and plus the auxiliary energy demand required for this and, on the other hand, a reference final energy demand.

The indicators for residential and non-residential buildings (as shown on the right-hand side of Figures 2 and 3) are slightly different. The most important differences are the indicators on cooling energy that are required only for non-residential buildings and not for residential buildings. The reason is that building regulations require residential buildings to be planned in such a way that overheating does not occur. However, in times of climate change, this objective might have to be discussed again.

Table 1. Indicators shown on the first page of the EPC and their scale for all residential and non-residential buildings

Class	$HWB_{Ref,SK}$ [kWh/m²a]	PEB_{SK} [kWh/m²a]	$CO_{2eq,SK}$ [kg/m²a]	$f_{GEE,SK}$ [-]
A++	10	60	8	0.55
A+	15	70	10	0.70
A	25	80	15	0.85
B	50	160	30	1.00
C	100	220	40	1.75
D	150	280	50	2.50
E	200	340	60	3.25
F	250	400	70	4.00
G	> 250	> 400	> 70	> 4.00

Regarding HWB_{Ref} and f_{GEE} there is the legal obligation to include both indicators in real-estate advertisements.

In second page of the EPC, there are heating, hot water, cooling, lighting, and conversion-loss indicators (Table 2). These indicators are more comprehensive for non-residential buildings than for residential buildings, where the focus is on heating and domestic hot water. The electricity in residential buildings is covered by an overall indicator called “household electricity demand” that relates to a square-metre-related default value.

Table 2. Detailed EPC indicators for residential and non-residential buildings

Indicators	Residential buildings	Non-residential buildings
Reference heating demand	X	X
Heating demand (indicator for transmission loss of building envelope)	X	X
Hot-water heat demand	X	X
Final energy demand for heating (heating demand plus conversion loss of heating system)	X	X
Energy-performance factor for hot water	X	X
Energy-performance factor space heating	X	X
Energy performance factor for heating	X	X
Household electricity demand	X	
Operating electricity demand		X
Cooling-energy demand (considering internal gains and solar gains, without considering conversion losses of technical building system)		X
Cooling-energy demand (including conversion losses of technical building system)		X
Energy-performance-factor cooling		X
Humidification-energy demand		X
Lighting-energy demand		X
Final energy demand	X	X
Primary energy demand	X	X
Primary energy demand non-renewable	X	X
Primary energy demand renewable	X	X
Equivalent carbon-dioxide emissions	X	X
Total energy-performance factor	X	X
Photovoltaic export	X	X

An official guideline as part of OIB Guideline 6 (2019) is available on how to fill the two pages of the EPC.

3.1.5 Validation process of EPC data and quality assurance

The Austrian provinces use different approaches to implement the independent control system according to EPBD article 18 based on the provincial EPC database:

- ZEUS platform with sub-platforms individually managed the authority of the respective province: Salzburg, Styria, Carinthia, and Burgenland https://www.energieausweise.net/
- EAWZ Energieausweis-Zentrale of the province of Vorarlberg https://www.eawz.at/ (works similar to ZEUS)
- Vienna uses the WUKSEA independent control system https://www.wien.gv.at/amtshelfer/bauen-wohnen/baupolizei/baubewilligung/energieausweis.html

Upper Austria, Lower Austria and Tyrol have been using different approaches until now. Apart from Upper Austria, all other provinces are discussing their incorporation into the ZEUS provincial database.

Checking of the EPC data and quality assurance is organised at the federal and provincial levels:

- Check for valid address and if the building exists: federal level.
- Check of EPC content - check for compliance with minimum requirements: provincial level.
- Check of EPC content - check of input data for calculation: provincial level.

ZEUS and EAWZ offer many more features and capabilities in addition to the basic EPC functionalities.

Check for valid address and if the building exists.

The Energieausweisdatenbank (EADB) was implemented by Statistics Austria after a federal law[6]. The aim of the EADB is the Austria-wide collection of data from EPCs in a uniform database, linked to the relevant data from the address, building and housing register (AGWR), and to make them available for statistical or energy-policy-relevant evaluations. Through the link with the AGWR, the key points necessary for a clear assignment to an object (building or utilisation unit) as well as other relevant data can be made available, while at the same time also ensuring that EPCs are only issued for existing buildings and with legally valid addresses assigned by the municipality. This unique identifier is called the GWR number and is an entry field in the EPC format. However, the EADB has specific and limited functions and is therefore needed in addition to the provincial databases.

EPC experts have access to the EADB either via a provincial database such as ZEUS or, if the province does not have its own provincial database (currently Lower Austria, Upper Austria and Tyrol), via the company service portal (USP). EPCs for buildings located in provinces with provincial databases cannot be registered directly in the federal EADB. The registration must first be carried out in the provincial database. The EPC entered in the provincial database is then transferred from the database to the EADB.

During registration and data entry, the GWR number is generated by the EADB and made available online to the issuers of EPCs for entry in the EPC or, in the case of entry via a provincial database, via this database after entry in the central EADB. EPC data cannot be edited, i.e., changed, once it has been entered into the EADB.

Check of EPC content: check of compliance with minimum requirements.

EPC software has a built-in check to examine ahead of submission whether the EPC meets the legally stipulated minimum requirements (see point a. in Figure 4).

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[6] Bundesgesetz über das Gebäude- und Wohnungsregister (GWR-Gesetz) StF: BGBl. I Nr. 9/2004, in der geltenden Fassung (Building Registry Law 2004, as amended)

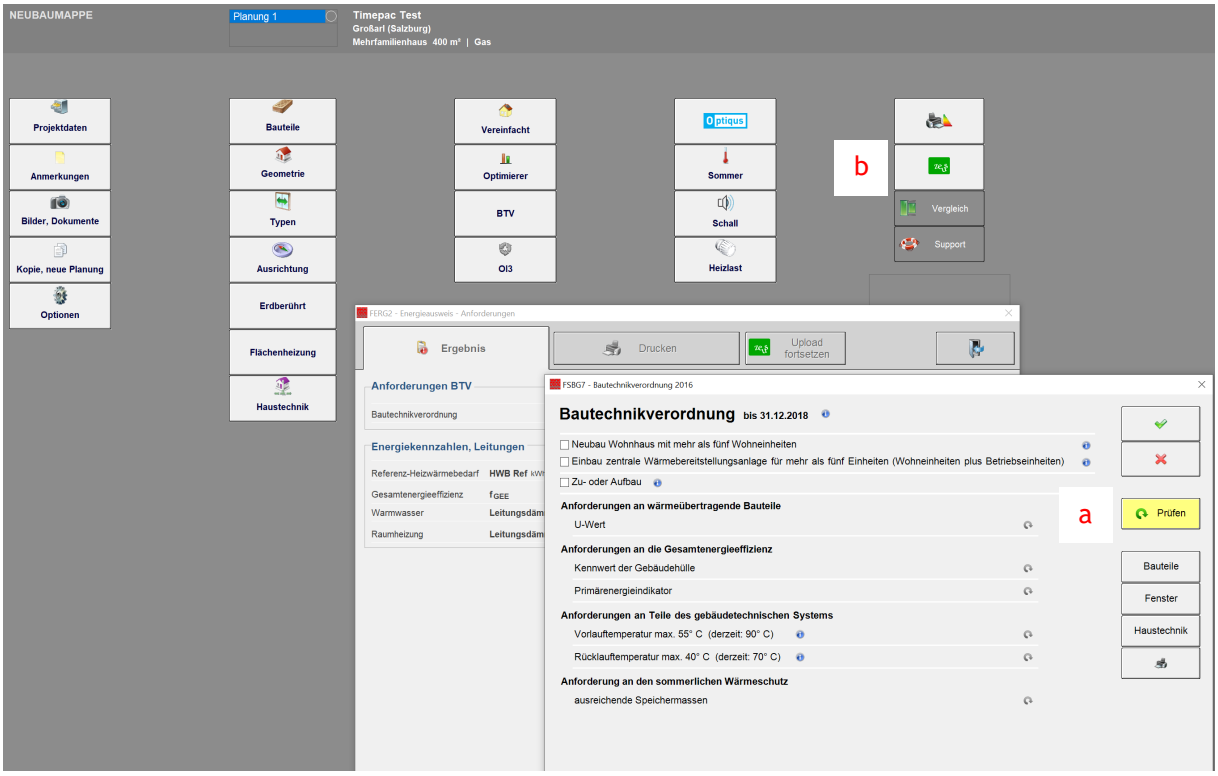


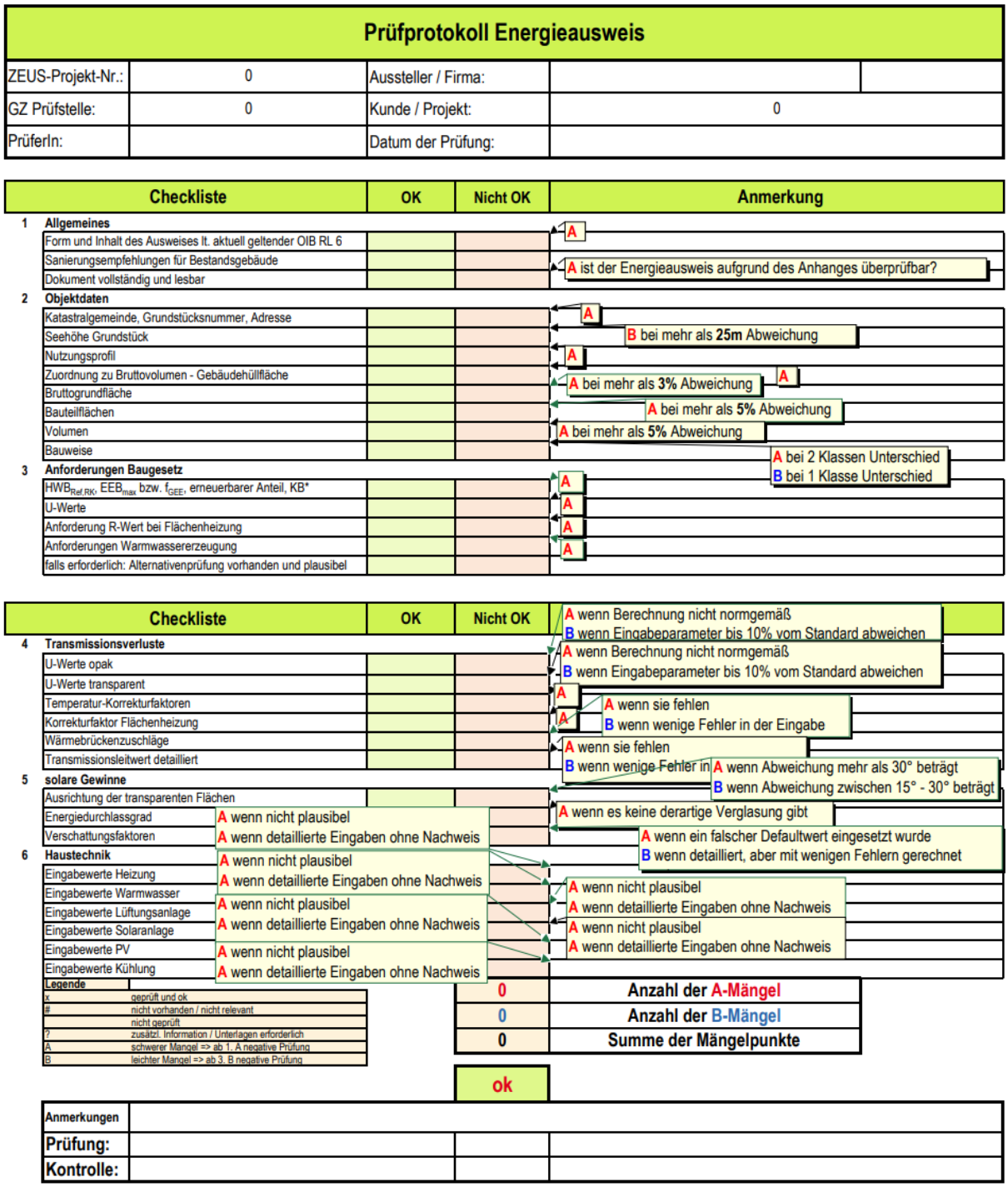
Figure 4. Screenshot of GEQ calculation tool (standard procedure for new buildings, multi-unit residential building). A) built-in check if legal minimum requirements are met. B) button for upload to EPC database with built-in plausibility check.

Check of EPC content: check of input data for calculation.

This process is explained using the example of the province of Styria. According to the Styrian building regulations, EPC experts are obliged to upload their calculations to the ZEUS database. For each upload, certain parameters of the EPC are automatically checked for plausibility. Values that are not plausible (according to the definition that is active in the background of the system) must be corrected or explained before the upload can be completed. This automated check routine has no effect on subsequent manual checks.

The selection of EPCs to be checked manually by the authority is also automated during the upload to the database using a random-sampling system. The control of the selected EPCs involves a test protocol (see Figure 5). The check of input data and the calculation is along section 1 Allgemeines / General information, section 2 Objektdaten / Building data, section 3 Anforderungen Baugesetz / Legal minimum requirements, section 4 Transmissionsverluste / Transmission losses, section 5 Solare Gewinne / Solar gains, section 6 Haustechnik / Technical building systems. Major deficiencies are classified A, while slight deficiencies are classified B. One or more serious deficiencies result in a negative examination. Three or more slight deficiencies result in a negative examination.

The authority also checks the arithmetical correctness of the EPCs. If the inspection of an energy-performance certificate reveals deficiencies, these must be remedied within a reasonable period of time. If the issuer fails to resolve the deficiencies, despite repeated requests, it will be ordered to do so by an official written notice from the provincial government. During the verification process, the energy-performance certificates can only be actively processed by the authority. A project will only be processed after a positive check by the verifying authority for the originally submitted purpose (housing subsidy, building authority) and can only then be processed by the responsible office.



Prüfprotokoll Energieausweis			
ZEUS-Projekt-Nr.:	0	Aussteller / Firma:	
GZ Prüfstelle:	0	Kunde / Projekt:	0
PrüferIn:		Datum der Prüfung:	

	Checkliste	OK	Nicht OK	Anmerkung
1	**Allgemeines**			
	Form und Inhalt des Ausweises lt. aktuell geltender OIB RL 6			A
	Sanierungsempfehlungen für Bestandsgebäude			A ist der Energieausweis aufgrund des Anhanges überprüfbar?
	Dokument vollständig und lesbar			
2	**Objektdaten**			
	Katastralgemeinde, Grundstücksnummer, Adresse			A
	Seehöhe Grundstück			B bei mehr als **25m** Abweichung
	Nutzungsprofil			A
	Zuordnung zu Bruttovolumen - Gebäudehüllfläche			A bei mehr als **3%** Abweichung; A
	Bruttogrundfläche			
	Bauteilflächen			A bei mehr als **5%** Abweichung
	Volumen			A bei mehr als **5%** Abweichung
	Bauweise			A bei 2 Klassen Unterschied B bei 1 Klasse Unterschied
3	**Anforderungen Baugesetz**			
	$HWB_{Ref,RK}$, EEB_{max} bzw. f_{GEE}, erneuerbarer Anteil, KB*			A
	U-Werte			A
	Anforderung R-Wert bei Flächenheizung			A
	Anforderungen Warmwassererzeugung			A
	falls erforderlich: Alternativenprüfung vorhanden und plausibel			

	Checkliste	OK	Nicht OK	Anmerkung
4	**Transmissionsverluste**			
	U-Werte opak			A wenn Berechnung nicht normgemäß B wenn Eingabeparameter bis 10% vom Standard abweichen
	U-Werte transparent			A wenn Berechnung nicht normgemäß B wenn Eingabeparameter bis 10% vom Standard abweichen
	Temperatur-Korrekturfaktoren			A
	Korrekturfaktor Flächenheizung			A; A wenn sie fehlen B wenn wenige Fehler in der Eingabe
	Wärmebrückenzuschläge			A wenn sie fehlen
	Transmissionsleitwert detailliert			B wenn wenige Fehler in
5	**solare Gewinne**			
	Ausrichtung der transparenten Flächen			A wenn Abweichung mehr als 30° beträgt B wenn Abweichung zwischen 15° - 30° beträgt
	Energiedurchlassgrad			A wenn es keine derartige Verglasung gibt
	Verschattungsfaktoren			A wenn ein falscher Defaultwert eingesetzt wurde B wenn detailliert, aber mit wenigen Fehlern gerechnet
6	**Haustechnik**			
	Eingabewerte Heizung			A wenn nicht plausibel A wenn detaillierte Eingaben ohne Nachweis
	Eingabewerte Warmwasser			A wenn nicht plausibel A wenn detaillierte Eingaben ohne Nachweis
	Eingabewerte Lüftungsanlage			A wenn nicht plausibel A wenn detaillierte Eingaben ohne Nachweis
	Eingabewerte Solaranlage			A wenn nicht plausibel A wenn detaillierte Eingaben ohne Nachweis
	Eingabewerte PV			A wenn nicht plausibel A wenn detaillierte Eingaben ohne Nachweis
	Eingabewerte Kühlung			A wenn nicht plausibel A wenn detaillierte Eingaben ohne Nachweis

Legende	
x	geprüft und ok
#	nicht vorhanden / nicht relevant
	nicht geprüft
?	zusätzl. Information / Unterlagen erforderlich
A	schwerer Mangel => ab 1. A negative Prüfung
B	leichter Mangel => ab 3. B negative Prüfung

0	Anzahl der A-Mängel
0	Anzahl der B-Mängel
0	Summe der Mängelpunkte
ok	

Anmerkungen			
Prüfung:			
Kontrolle:			

Figure 5. Screenshot of test protocol that is used for the independent control system by the province of Styria (https://www.ea-stmk.at/qs-energieausweispruefung)

In terms of the quality of the results, determining the EPC reference area is crucial.

The EPC reference area is defined as the conditioned gross area (Bruttogrundfläche) [m^2], i.e., the total area inside the building, measured outside the walls. The provisions that apply to the basement affect the reference area. The regulations for determining the conditioned area have the potential to cause errors if they are not clear.

3.2 Croatia

3.2.1 Qualification of certifiers

Pursuant to Article 23 of the Building Act[7] (2019), energy-performance certificates for buildings in Croatia are issued by authorized legal or natural persons. In accordance with Article 27, the license of an independent expert for creating energy-performance certificates can be obtained by a person who fulfils certain conditions defined by the law. The final authorisation of legal entities and experts is decided by the Ministry of Physical Planning, Construction and State Assets.

Based on a public tender, the Ministry of Physical Planning, Construction and State Assets has appointed 13 institutions as training providers for the energy-performance certification of buildings for a period of 5 years. Trainings are conducted several times a year and those institutions are also responsible for the organisation of final exams. The training programme consists of two modules, one following up the other, and a Continuous Development Programme (CPD). Module 1 deals with the authorisation for energy audits and the certification of buildings using a simple technical system, and Module 2 with a complex technical system. Module 1 has a duration of 40 hours and contains themes related to regulations, building physics, heating systems, electric lighting, energy-audits methodology and related computer tools. Module 2 also has a duration of 40 hours. It builds on Module 1, with additional topics such as RES, alternative energy-supply systems, cooling systems, automation systems and public lighting.

An individual who meets the following conditions can obtain a licence and become an independent energy-performance certifier:

- Has reached an appropriate educational level in a technical field (architecture, civil, mechanical and electrical engineering), in accordance with the regulation determining the classification of educational systems.
- Has at least 2–10 years (depending on the type of energy certifier and her/his education level) of relevant work experience since obtaining the required educational level in the professional field of efficient energy use and renewable energy sources in buildings.
- Has successfully completed a training course for independent experts for the creation of energy-performance certificates in accordance with the Building Act.

The energy certification of buildings is carried out by both authorised natural and legal persons. As stated before, authorisation is granted by the Ministry of Physical Planning, Construction and State Assets for:

- Energy audits and the certification of buildings with a simple technical system (natural and legal persons).
- Energy audits of buildings with a complex technical system (natural and legal persons).
- Energy certification of buildings with a complex technical system (legal persons).

The authorisation to audit and certify complex systems also authorises the audit and certification of simpler systems. The energy audits of buildings with a complex technical system (a requirement for EPCs), must be carried out by authorised people:

- For the mechanical part of the building, a person qualified in the field of mechanical engineering.
- For the construction part of the building, a person qualified in the field of architecture or civil engineering.
- For the electrical engineering part of the technical system, a person qualified in the field of electrical engineering.

[7] Building Act (Official Gazette 153/13, 20/17, 39/19, 125/19), https://www.zakon.hr/z/690/Zakon-o-gradnji

The EPC must be signed by the person authorised to issue the certificate and by all the people who participated in the energy audit. The authorisation is granted for a period of 5 years, whereupon it can be extended.

In addition to energy audits for the certification of buildings, the Energy Efficiency Act[8] from 2021 introduced energy audits in large enterprises. The Ministry of Economy and Sustainable Development is responsible for the authorisation of legal entities and experts (authorised natural and legal persons). Based on a public tender, the Ministry has selected institutions as training providers for the energy auditing of large enterprises. Trainings are conducted several times a year and those institutions are also responsible for the organisation of final exams. The training programme consists of themes related to regulations, energy auditing, industrial processes, electric systems, transport, and energy optimization with a duration of 44 hours. An individual who has reached an appropriate educational level in a technical field (architecture, civil, mechanical and electrical engineering), has at least 5 years of relevant work experience and has successfully completed a training course recommended by the Ministry of Economy and Sustainable Development and the Module 2 recommended by the Ministry of Physical Planning, Construction and State Assets, can obtain a licence and become an energy auditor of large enterprises.

The Energy Institute Hrvoje Požar is licensed for the energy auditing and certification of all building types and complexity, public lighting, large enterprises, and for conducting training schemes for the above-mentioned types of energy audits.

3.2.2 Data-acquisition methods and availability of data

The energy-performance certificate of a building must be obtained by the owners of a property (a building or an apartment) in the case of selling, renting or leasing. In the majority of cases, the EPC's validity is checked by notaries during the transaction. Unfortunately, in the case of renting the majority of transactions are often concluded informally, and therefore bypasses any official controls. Building owners who do not sell or rent their properties do not need an EPC. An EPC must also be obtained for all new buildings. For newly constructed and renovated buildings, the EPC generation process is linked to the controls in place to establish whether a building meets the minimum requirements for energy performance. It is very positive that in such cases the qualified expert is usually involved during the design stage or on-site control and has direct access to the building and systems data. The energy certificate is necessary for all buildings owned or used by public-sector entities with a total usable floor area over 250 m^2, and the valid EPC must be placed in a visible location.

The EPC has a pre-defined, four-page structure that contains key energy-related data and calculation results. An EPC can only be produced by applying a defined calculation methodology[9] and it cannot be produced based on actual energy consumption. The methodology is prescribed for residential buildings, non-residential buildings and for all new buildings. The calculation methodology is the same as for the calculation of the building's energy consumption when obtaining a building permit. The energy consumption needs to be calculated based on the predefined baseline-usage inputs, which allows a comparison of similar buildings. The basis for the calculation is the building's documentation, which reflects the actual condition of the building and the installed technical systems. During the EPC-generation process, certified experts receive the data that are necessary to produce the EPC, such as: building dimensions, wall area, composition and materials of the exterior wall, heated floor area, properties and orientation of windows, shading of buildings, properties of heating systems and more. Since the EPC is necessary for all new buildings, experts obtain these data from the project's documentation. In the case of missing some project

[8] Energy Efficiency Law (Official Gazette 127/14, 116/18, 25/20, 32/21, 41/21), https://www.zakon.hr/z/747/Zakon-o-energetskoj-u%C4%8Dinkovitosti

[9] Algorithm for calculation of the energy performance of buildings, May 2017, https://mpgi.gov.hr/pristup-informacijama-16/zakoni-i-ostali-propisi/podrucje-energetske-ucinkovitosti/metodologija-provodjenja-energetskog-pregleda-zgrada-primjenjuje-se-od-1-srpnja-2021/13704

documentation, which is often the case for old buildings, the experts must collect the necessary data on-site with measurements and a visual inspection of the installed materials, technical systems, etc. In the case of existing buildings the data from project's documentation has to be verified on-site and additional information has to be collected (information that is not included in the project's documentation, e.g., electrical appliances. The most important difference between the EPC-generation process in Croatia and the other five addressed countries (Austria, Cyprus, Italy, Slovenia and Spain) is that an EPC cannot be issued without an energy-audit report.

The energy-audit report is a detailed document providing energy-related data and most of the input data needed for the EPC's generation. The energy audit of a new building includes preparatory actions, collection of all the necessary data and information about the building that is necessary for the implementation of the energy-certification procedure and the determination of the energy class of the building, suggestions for using the building and the preparation of an energy-audit report with recommendations for using the building. An energy audit of an existing building includes preparatory actions, the necessary data and information about the building that is necessary for the implementation of the energy-certification procedure and a determination of the energy class of the building, implementation of control measurements if needed, analysis of the consumption and the costs of all forms of energy (and water) for the previous 3 calendar years, measures for improving the energy efficiency of the building with a calculation of the payback period and the preparation of an energy-audit report with recommendations in the order of implementation for economically justified measures that improve the energy efficiency of the building. The only exceptions are independent parts of the building (including apartments) and family houses in which the reason for issuing an EPC is for the sale of the property. In those cases, an analysis of the consumption of energy and a calculation of the payback period for the energy-efficiency measures is not mandatory. The energy audit report must be made according to the requirements described in the Methodology[10] and is a separate document from the EPC, providing in-depth energy-related data and most of the input data needed for the EPC's generation.

For public buildings, an energy-management information system (EMIS) is used in accordance with the Energy Efficiency Law. It is managed by the Real Estate Agency. This online application contains a database of all public buildings. The information contained in the EMIS encompass all the key data about buildings, such as size, location, orientation, envelope U-values, information about technical systems and performance indicators. In addition, the EMIS provides the monthly energy consumption for domestic hot water and costs derived from invoices, mostly taken automatically from suppliers. The database is continuously expanding with new buildings and bills, but most of the buildings have consumption data for the last 6 years. The EMIS has an energy-consumption-analysis module that provides complex analytics with the goal of providing tools for energy-management applications as well as a module that can be used to monitor the savings achieved after implementing the energy-efficiency measures. The EMIS can also be used by private building owners on a voluntary basis. When conducting an energy audit of a building that has been introduced in the EMIS, an energy auditor can use the data in the EMIS database.

The Energy Institute Hrvoje Požar has access to the EMIS database and cooperates with the Real Estate Agency on constant improvements and end-user education.

3.2.3 Performance assessment and calculation software

To support the EPC-generation process, a software tool for calculating the energy performance of a building based on an approved methodology is used. There is public software to support the calculation, but there are also some commercial options. Therefore, experts can choose between available software packages according to the purpose of their assignment, personal preferences, availability and the quality of the software.

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[10] Methodology for conducting energy audits of buildings, June 2021, https://mpgi.gov.hr/pristup-informacijama-16/zakoni-i-ostali-propisi/podrucje-energetske-ucinkovitosti/metodologija-provodjenja-energetskog-pregleda-zgrada-primjenjuje-se-od-1-srpnja-2021/13704

Today, there are three commercially available and one public software packages that can be used to calculate the energy-performance indicators for issuing the EPC. These programmes are all based on A set of EU norms: EN ISO 13790, EN 15316, DIN V 18599, DIN V 18599 and DIN V 18599. The names of these programmes are: Energetski certifikator (public), EnCert, Thorium A+ and KI EXPERT PLUS (Figure 6).

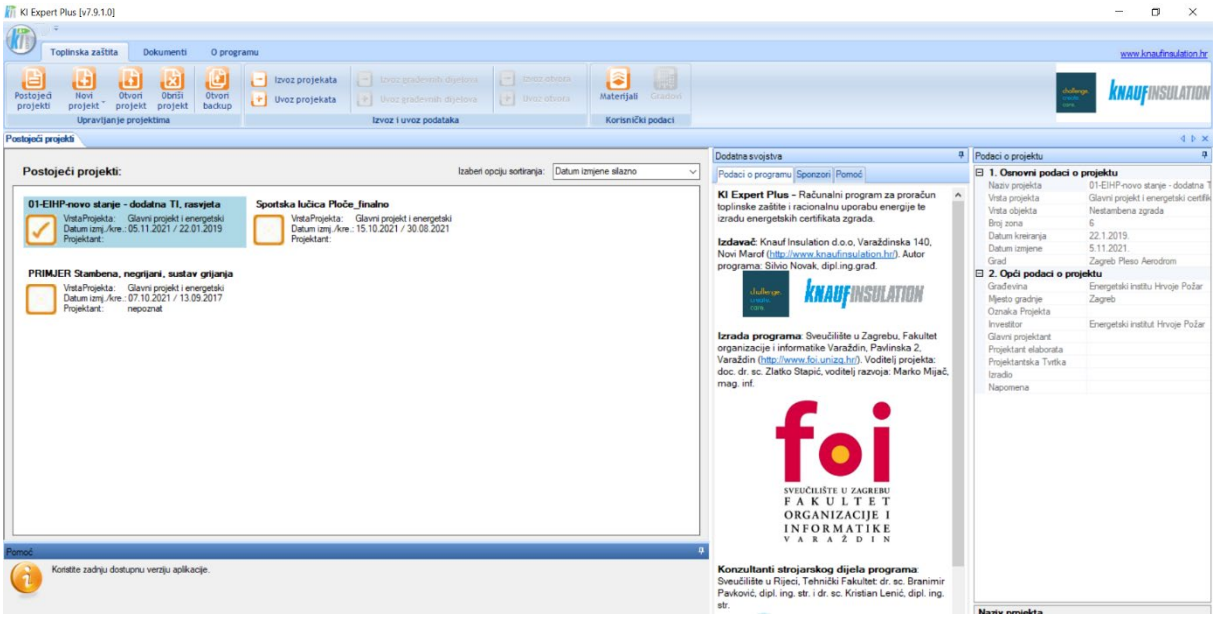


Figure 6. Example of energy-calculation software front-end

3.2.4 Energy-performance indicators

The EPC of a building contains energy indicators and recommendations for measures to increase the energy efficiency (Figure 7). The energy indicators for the energy certificate are:

- Calculated annual energy needs for heating per useful floor area for the reference climatic data $Q_{H,nd}$ [kWh/(m^{2}a)].
- Calculated annual primary energy per useful floor area for the reference climatic data E_{prim} [kWh/(m^{2}a)])[11].

In addition to the key energy indicators, the EPC shows additional information about the calculated energy and environmental consumption:

- Calculated annual CO_2 emissions per useful floor area for the reference climatic data [kg/(m^{2}a)].
- Calculated annual delivered energy per useful floor area for the reference climatic data E_{del} [kWh/(m^{2}a)][12].
- Calculated annual required energy for heating for the reference climatic data $Q_{H,nd}$ [kWh/a].
- Calculated annual demand for cooling for the reference climatic data $Q_{C,nd}$ [kWh/a].

[11] For residential buildings, the heating, the preparation of domestic hot water (DHW) and the mechanical ventilation (if applicable) are considered. For office buildings and retail facilities, the heating, cooling, and lighting are considered. For educational institutions and other non-residential buildings, heating and lighting are considered. For hospitals, hotels and restaurants, and sports halls, heating, cooling, domestic hot-water preparation, and lighting are considered. For all non-residential building types, mechanical ventilation is considered (if applicable).

[12] For residential buildings, the heating, domestic hot-water (DHW) preparation and mechanical ventilation (if applicable) are considered. For office buildings and retail, the heating, cooling and lighting are considered. For educational institutions and other non-residential buildings, the heating and lighting are considered. For hospitals, hotels and restaurants, and sports halls, the heating, cooling, DHW preparation and lighting are considered. For all non-residential building types, mechanical ventilation is considered (if applicable).

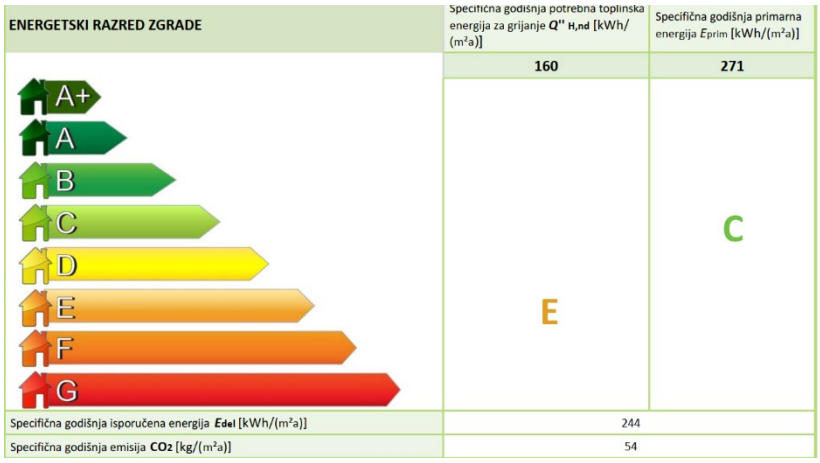


Figure 7. Energy indicators as presented on the EPC

3.2.5 Validation process of EPC data and quality assurance

The data validation and quality controls for EPCs are mandatory. The expert supervision of EPCs and inspection reports are carried out by the Ministry of Physical Planning, Construction and State Assets. According to Article 40 of the Building Act, the Ministry of Physical Planning, Construction and State Assets is obliged to supervise and verify the EPCs. According to Article 16 of the Ordinance on the control of the energy certificate of the building and the report on the regular inspection of the heating system and the cooling or air-conditioning system in the building[13], the Ministry of Physical Planning, Construction and State Assets is obliged to supervise and verify at least a statistically significant share of the EPCs and energy-audit reports issued every year. The annual expert supervision includes a verification of the building data, input data and the results presented on the EPCs, energy-audit reports and energy-efficiency recommendations. The quality control is provided by licenced institutions and companies. The report on quality control can annul any specific EPC, and if there are three invalid EPCs from the same energy-performance certifier the licence to perform energy audits and EPCs is cancelled. The Energy Institute Hrvoje Požar is licensed to conduct quality controls. EPCs can be annulled on the following basis:

- The calculated annual energy needs for heating per useful floor area for the reference climatic data or calculated annual primary energy per useful floor area for the reference climatic data differ by more than 30% from the correct value.
- Any of the two energy-efficiency classes printed on the EPC are different from class obtained in the quality control.
- The energy efficiency measures are not calculated and defined as described in the Methodology (2021).
- The energy-audit report is not written according to the requirements described in the Methodology (2021).

In addition to the above-mentioned controls, the Ministry of Physical Planning, Construction and State Assets carries out an additional set of standardised quality controls during the process of storing the EPC in the national EPC database. In these controls, a number of parameters are checked, mainly any missing information relating to building identification (e.g., address, name, national Land Registry number, etc.) or any missing information relating to the energy-performance indicators.

[13] Ordinance on the control of the energy certificate of the building and the report on the regular inspection of the heating system and the cooling or air-conditioning system in the building (Official Gazette 73/15, 54/20), https://narodne-novine.nn.hr/clanci/sluzbeni/2015_07_73_1391.html

3.3 Cyprus

3.3.1 Qualification of certifiers

The legal framework for the EPC certifiers in Cyprus is set by the Ministry of Energy. There are three categories of energy certifiers: Category A, responsible for all building types; Category B, responsible for industrial and agricultural installations; and Category C, responsible for issuing EPCs for the transportation sector, excluding aircraft and ships.

All EPC certifiers must fulfil the following requirements to be registered as an energy expert:

- They must have a degree on one of the following fields: Architecture, Civil Engineering, Electrical Engineering, Mechanical Engineering, Chemical Engineering and Environmental Engineering.
- They must be registered in the Cyprus Scientific and Technical Chamber.
- They must have 1 year of proven experience in building construction, energy projects or technical systems.
- They must pass the exams for qualified experts issuing energy-efficiency certificates for homes.

3.3.2 Data-acquisition methods and availability of data

The legal framework in Cyprus is based on European legislation. The most important points of the legislation deal with the obligation to issue an energy-efficiency certificate for all new buildings and for existing buildings that are to be sold, rented, or undergoing large-scale renovation. Another important point is the obligation of the owners of all public buildings to issue and advertise the public energy-efficiency certificate.

However, there are a few exceptions regarding the obligation to issue a certificate and they mainly concern conserved buildings, ancient monuments, unheated or not air-conditioned industrial spaces, rural non-residential buildings and small buildings with a surface area of fewer than 50 square metres.

The implementation of the regulations and legislation is controlled and coordinated by various state services, the technical services of municipalities, private bodies and the most important authority, the Cyprus Energy Service, whose mission is to improve energy efficiency and maximize the use of renewable energy sources.

The authenticity of each certificate is verified through a unique registration number, electronically at the link: http://epc.mcit.gov.cy/pea/checkPEA.html.

3.3.3 Performance assessment and calculation software

The energy experts in Cyprus are using the iSBEMcy software (Figure 8) to issue the EPC certificate. iSBEMcy is a free simulation tool based on the "Methodology for Calculating the Energy Efficiency of Buildings". The software is available to the public from the Energy Service of Cyprus through their website.

The EPC certification must include recommendations for improving the energy efficiency on an existing building. All the suggestions are recorded by energy experts using the free software SEAK, which is also available to the public through the website of the Energy Service.

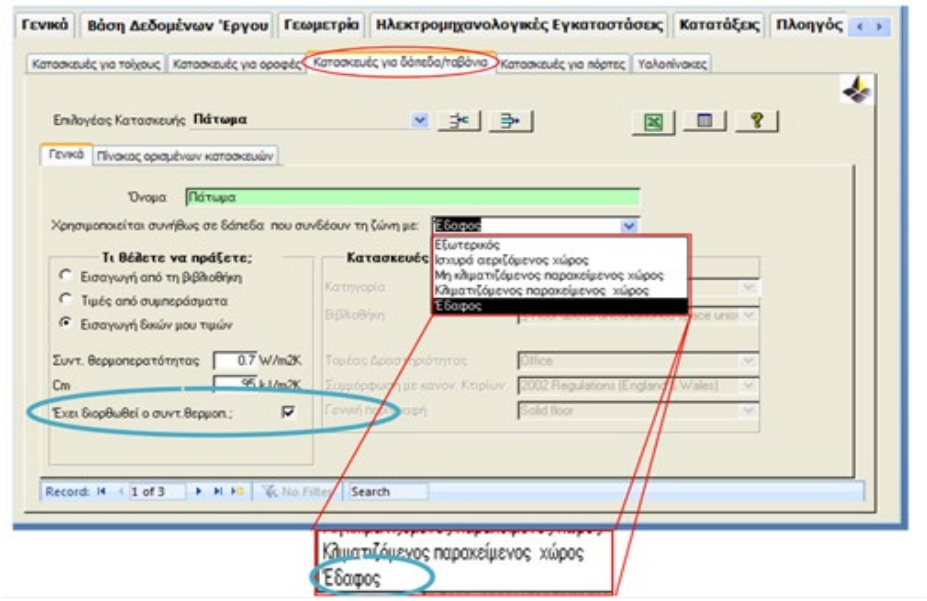


Figure 8. An example of the iSBEMcy software front-end

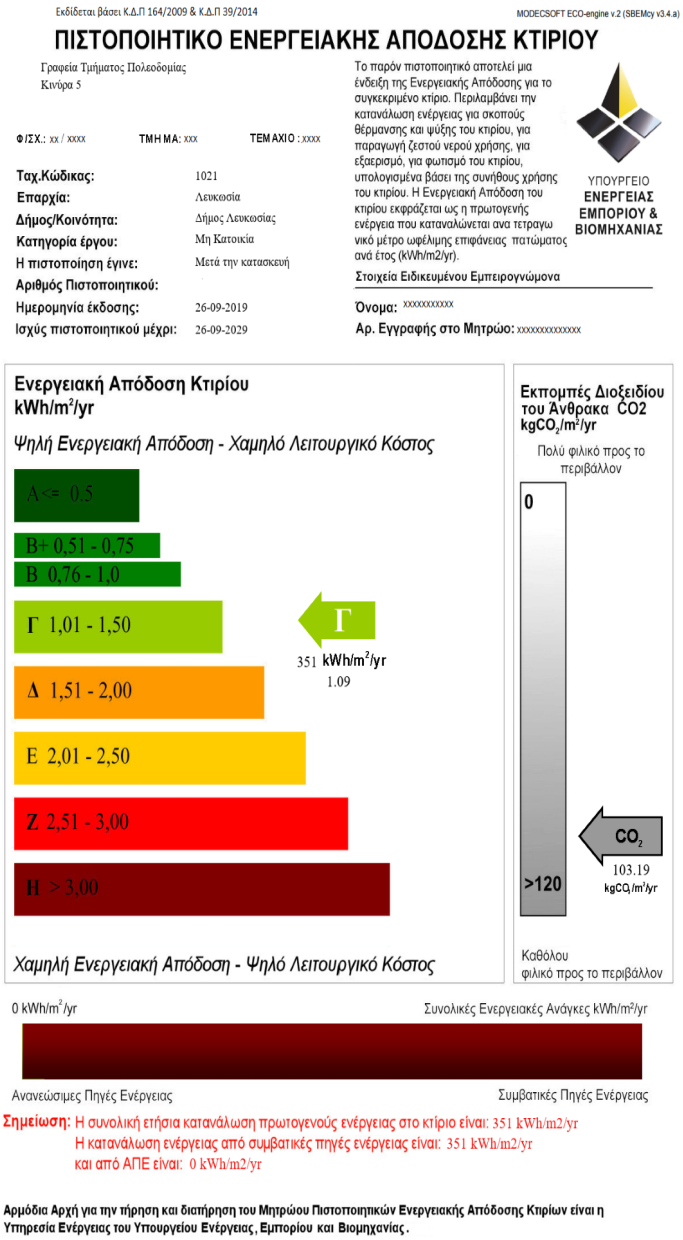
3.3.4 Energy-performance indicators

The EPC certification can related to three types of buildings: residential, commercial and agricultural/transportation. The legal framework for the EPC indicators is defined by the European directives, starting from the directive 2002/91, which defines the calculation methodology used for the energy performance.

The main information contained in the certification includes:

- The building's general information, such as the address and the type of structure.
- The energy category of the building (A to H), the category calculated by the software based on specific parameters.
- The primary energy consumption of the building.
- The CO_2 emissions for the building.
- The energy consumption of the building from renewable sources.
- The energy consumption of the building from conventional sources.
- Suggestions for energy improvements.

The energy-performance indicators for the generation of an EPC in Cyprus (Figure 9) are based on the primary energy needs for five uses: lighting, heating, cooling, hot water and air ventilation.



Εκδίδεται βάσει Κ.Δ.Π 164/2009 & Κ.Δ.Π 39/2014

MODECSOFT ECO-engine v.2 (SBEMcy v3.4.a)

ΠΙΣΤΟΠΟΙΗΤΙΚΟ ΕΝΕΡΓΕΙΑΚΗΣ ΑΠΟΔΟΣΗΣ ΚΤΙΡΙΟΥ

Γραφεία Τμήματος Πολεοδομίας
Κινύρα 5

Φ/ΣΧ.: xx / xxxx ΤΜΗΜΑ: xxx ΤΕΜΑΧΙΟ : xxxx

Ταχ.Κώδικας:	1021
Επαρχία:	Λευκωσία
Δήμος/Κοινότητα:	Δήμος Λευκωσίας
Κατηγορία έργου:	Μη Κατοικία
Η πιστοποίηση έγινε:	Μετά την κατασκευή
Αριθμός Πιστοποιητικού:	
Ημερομηνία έκδοσης:	26-09-2019
Ισχύς πιστοποιητικού μέχρι:	26-09-2029

Το παρόν πιστοποιητικό αποτελεί μια ένδειξη της Ενεργειακής Απόδοσης για το συγκεκριμένο κτίριο. Περιλαμβάνει την κατανάλωση ενέργειας για σκοπούς θέρμανσης και ψύξης του κτιρίου, για παραγωγή ζεστού νερού χρήσης, για εξαερισμό, για φωτισμό του κτιρίου, υπολογισμένα βάσει της συνήθους χρήσης του κτιρίου. Η Ενεργειακή Απόδοση του κτιρίου εκφράζεται ως η πρωτογενής ενέργεια που καταναλώνεται ανα τετραγω νικό μέτρο ωφέλιμης επιφάνειας πατώματος ανά έτος (kWh/m2/yr).

ΥΠΟΥΡΓΕΙΟ ΕΝΕΡΓΕΙΑΣ ΕΜΠΟΡΙΟΥ & ΒΙΟΜΗΧΑΝΙΑΣ

Στοιχεία Ειδικευμένου Εμπειρογνώμονα

Όνομα: xxxxxxxxxxx

Αρ. Εγγραφής στο Μητρώο: xxxxxxxxxxxxxx

Ενεργειακή Απόδοση Κτιρίου kWh/m²/yr

Ψηλή Ενεργειακή Απόδοση - Χαμηλό Λειτουργικό Κόστος

A <= 0,5
B+ 0,51 - 0,75
B 0,76 - 1,0
Γ 1,01 - 1,50
Δ 1,51 - 2,00
E 2,01 - 2,50
Z 2,51 - 3,00
H > 3,00

Γ
351 kWh/m²/yr
1.09

Χαμηλή Ενεργειακή Απόδοση - Ψηλό Λειτουργικό Κόστος

Εκπομπές Διοξειδίου του Άνθρακα CO2 kgCO₂/m²/yr

Πολύ φιλικό προς το περιβάλλον

0

>120

CO₂
103.19
kgCO₂/m²/yr

Καθόλου φιλικό προς το περιβάλλον

0 kWh/m²/yr

Συνολικές Ενεργειακές Ανάγκες kWh/m²/yr

Ανανεώσιμες Πηγές Ενέργειας

Συμβατικές Πηγές Ενέργειας

Σημείωση: Η συνολική ετήσια κατανάλωση πρωτογενούς ενέργειας στο κτίριο είναι: 351 kWh/m2/yr
Η κατανάλωση ενέργειας από συμβατικές πηγές ενέργειας είναι: 351 kWh/m2/yr
και από ΑΠΕ είναι: 0 kWh/m2/yr

Αρμόδια Αρχή για την τήρηση και διατήρηση του Μητρώου Πιστοποιητικών Ενεργειακής Απόδοσης Κτιρίων είναι η Υπηρεσία Ενέργειας του Υπουργείου Ενέργειας, Εμπορίου και Βιομηχανίας.

Figure 9. First page of the EPC issued in Cyprus, with the indication of the energy classification for the building

3.3.5 Validation process of EPC data and quality assurance

In Cyprus there is no established methodology or mechanism that validates the data of each and every EPC when it is issued. However. there are levels of checking, prior to and after submission, to assure the quality of the technical and non-technical aspects of the EPC.

For a professional to become an EPC Expert for residential buildings, the legislation states, among other, that they should:

- Be registered as an architect or an engineer in the “Scientific & Technical Chamber of Cyprus” Member’s Register.
- Have at least 1 year of proven experience in the field of buildings, building systems or energy.
- Have successfully passed the relevant exams (>70%).

For a professional to become an EPC Expert for non-residential buildings, in addition to the above, they should have 3 years of experience (instead of 1 year) in the aforementioned fields as well as successfully passing another exam that is specific to non-residential buildings.

The above ensures that the experts have the appropriate knowledge and skills to issue an EPC.

The relevant documentation regarding a specific EPC is submitted electronically via the government portal Ariadni. This portal has in-built checkers and notifications that warn and guide the expert when an input is not right, providing an initial validation for the non-technical information of an EPC.

If a submission comes from a newly registered expert, they must provide a complete dossier with all the relevant documentation regarding the EPC study and the qualifications for them to be accredited as a qualified expert.

Regarding the validation of an EPC, there are two government bodies that can carry out inspections:

- The Energy Service of the Ministry of Energy, Commerce and Industry.
- Local authorities and Building & Construction Authorities.

The former is the main stakeholder for energy issues and has the right to execute arbitrary random sample checks at any time regarding both the expert's qualifications and the validity of the EPC calculations.

The Energy Service employs inspectors who are entitled to conduct inspections based on their own initiative. Through these actions, the agency circulates and notifies, at various times, corrective guidelines when common misconducts, omissions and/or errors are identified.

The local authorities issue the building permits and provide the final building approval through which they can validate the EPC data. This check is limited as it is focused primarily on the geometry of the building, e.g. the perimeter, areas and windows. The same applies to the building and construction authorities.

Each issued EPC has a unique identification number at the top-left corner, which can be checked for validity on a dedicated website (https://epc.meci.gov.cy/pea/checkPEA.html). It should be noted that in the case of a doubt regarding an EPC, both for technical and non-technical matters, the owner of the building (for both residential and non-residential) has the legal right to request a validation directly from the Energy Service, and the latter is obliged by law to conduct a thorough inspection.

Finally, in cases of repeated misconduct and the submission of low-quality EPCs, a professional might be removed from the register of EPC experts, and therefore can no longer issue certificates.

3.4 Italy

3.4.1 Qualification of certifiers

The Decree of the President of the Italian Republic n. 75 of 2013 (DPR 75/2013) defines "the professional requirements and the accreditation criteria for ensuring the qualification and independence of experts and bodies to which to entrust the energy certification of buildings".

According to DPR 75/2013, the individuals qualified for the energy certification of buildings are:

- Qualified technicians, operating both as
    - Employees of public bodies/organizations or public/private service companies (including engineering companies)
    - Freelance or associated professionals
- An energy service company (ESCO).

The qualified technician should have specific qualifications (the appropriate education level in specific sectors, listed in the Decree) and, if not enrolled in the relative orders or professional

chambers, should have a certificate of attendance, with the passing of the final exam, related to specific training courses for the energy certification of buildings.

At the national level, the training courses for the energy certification of buildings and related exams are carried out by universities, research organizations and institutions, orders and professional colleges, authorized by the Ministry of Economic Development, the Ministry of Infrastructures and Transport and the Ministry of the Environment, Land and Sea protection. DPR 75/2013 also defines the minimum content of the training courses.

The qualified technician certifies the independency and impartiality, declaring, for each EPC, the absence of any conflict of interest with:

- Building design and construction process and with the manufacturers of materials and components, in the case of the certification of new buildings.
- Manufacturers of materials and components, in the case of the certification of existing buildings.

3.4.2 Data-acquisition methods and availability of data

According to the Legislative Decree 192/2005, as modified by the Law 90/2013 and by the Decree Law 63/2013, the EPC is compulsory:

- In the case of selling or renting a building. The owner of the building (or of the building unit) must obtain the EPC to inform the buyer or tenant about the energy performance of the property. In the case of selling or renting the property, the EPC must be included in the sale or lease document.
- For new buildings and when "major renovation[14]" occurs.
- For public buildings and for buildings open to the public with a floor area larger than 250 m^2.
- In the case of facility-management contracts in public buildings.

According to the Decree of the Ministry of Economic Development of 26 June 2015 – National guidelines for energy certification of buildings (National guidelines) – the buildings that are excluded from the obligation of an EPC are as follows: isolated buildings with a conditioned floor area of fewer than 50 m^2, industrial buildings, rural or agricultural buildings without conditioning systems, buildings like cellars, garages and parking lots, religious buildings, ruins or buildings under construction.

The EPC is valid for 10 years and is updated if, in the meantime, any renovation takes place that influences the energy class of the building.

The national guidelines define the calculation methodology for the energy performance of buildings to be used at national level that is provided by the UNI/TS 11300 series of technical standards (consistent with the standards developed by CEN - Mandate M/480).

The Decree of the Ministry of Economic Development of 26 June 2015 – Minimum requirements – provides two procedures to calculate the energy performance of buildings:

- The design energy-assessment or asset energy-assessment procedure. It is based on standard climatic data, standard use of the building and on building features based on the design documentation (once the coherence with the building, as constructed, has been verified). The calculation methodology to be used is provided by UNI/TS 11300 and it can be used for every building category, both for new and for existing buildings.

[14] The Decree of the Ministry of Economic Development of 26 June 2015 - *Application of energy performance calculation methodologies and definition of the prescriptions and minimum requirements of buildings* (Minimum requirements) - defines "major renovations" that building renovation involving the building envelope with an incidence of more than 25% of the total thermal envelope area.

- Building survey procedure. It refers to the evaluation of the energy performance of an existing building based on the input data collected through an onsite inspection or, alternatively, obtained by a comparative analysis with other contemporary buildings (using, e.g., databases). For this procedure, both simplified methods according to UNI/TS 11300 or a simplified method provided by ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development) can be used. The former is valid for every existing building, while the latter is only valid for residential buildings with a conditioned floor areas of fewer than 200 m^2.

The qualified technician must carry out at least one building inspection to collect the data necessary for the calculation of the energy performance.

Usually, the data used to carry out the energy performance certification are available through building surveys, cadastral maps, existing reports on the building's construction, and technical datasheets of the building systems.

3.4.3 Performance assessment and calculation software

To generate the EPC, specific software tools must be used. Aside from two Italian regions that have their specific methodologies and public calculation engines, in Italy there is a standard methodology used for the calculation of the energy performance of buildings (UNI/TS 11300 series) implemented in commercial software packages (Figure 10).

To be commercialised and used for the purposes of an energy-performance calculation, the tools should be validated. Pursuant to Article 7 of the Ministerial Decree of 26 June 2015, the Italian Thermo technical Committee (CTI) verifies the commercial software and tools for calculating the energy performance of buildings. This verification guarantees that the energy-performance indicators calculated using a commercial tool have a maximum deviation of 5%, when compared with the indicators calculated through the application of a reference tool prepared by the CTI.

Currently, there are 19 commercialised and validated tools for EPC purposes. All the tools are implemented using the calculation methodology provided by UNI/TS 11300. Among these validated and commercialised tools, there is also a tool provided by ENEA (DOCET), which is downloadable for free[15], in which the simplified methodology for the procedure based on a building survey (described in Section 2.4.2) is implemented.

[15] http://www.docet.itc.cnr.it/registrati.asp

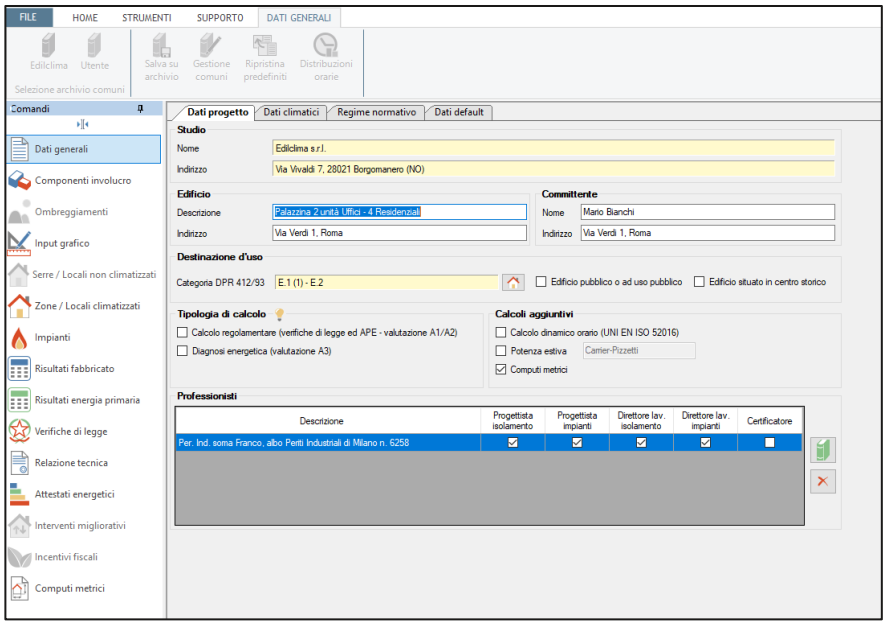


Figure 10. Example of energy-calculation software front-end (Edilclima tool)

3.4.4 Energy-performance indicators

The national guidelines for the energy certification of buildings specify the information that must be included in the EPC (Figure 11). The energy-performance certificate of the building contains energy indicators and recommendations for measures to improve the energy efficiency.

The energy indicators are as follows:

- The energy-performance class (A4, A3, A2, A1, B, C, D, E, F, G) calculated through the overall non-renewable primary energy ($EP_{gl,nren}$) per unit of conditioned floor area of the building [kWh/m^{2}a)], for space heating, space cooling, domestic hot water and, only for non-residential buildings, lighting and the transport of people and/or goods (where the calculation is based on the Italian Technical Standard UNI/TS 11300-6). The energy-performance classification is determined by comparing the $EP_{gl,nren}$ of the real building with the $EP_{gl,nren}$ of a reference building[16].
- The energy performance of the building envelope for the winter season expressed using a qualitative indicator (high, medium, low) derived from the energy needed for space heating ($EP_{H,nd}$) and compared with the energy needed for the space heating of a reference building ($EP_{H,nd,limit}$).
- The energy performance of the building envelope for the summer season expressed using a qualitative indicator (high, medium, low) derived from a comparison of the summer effective solar area per unit of conditioned floor area ($A_{sol,est}/A_{sup\ utile}$) and the periodic thermal transmittance of the opaque building envelope (Y_{IE}) with reference values.
- The annual amount of delivered energy by the energy carrier, calculated for the standard use of the building (units vary according to the energy carrier).
- The annual overall primary energy, both renewable ($EP_{gl,ren}$) and non-renewable ($EP_{gl,nren}$), per unit of conditioned floor area of the building [kWh/m^{2}a)].
- The annual CO_2 emissions per unit of conditioned floor area [kg/(m^{2}a)].
- The annual calculated exported energy per each energy carrier [kWh/a].

[16] A reference building is a building with the same geometry (volume, thermal envelope area, conditioned floor area, etc.), same boundary conditions (climatic data, surroundings etc.), same use category of the real building, and with reference envelope components and technical systems (as defined by the Ministerial Decree of 26 June 2015).

- The average seasonal efficiency for each technical building system (e.g., for space heating η_H, for space cooling η_C etc.).
- The annual primary energy per unit of conditioned floor area of the building [kWh/m^{2}a)] for each building energy service, both renewable and non-renewable.

Each energy indicator is calculated for a standard condition (standard climatic data and occupant behaviour) to provide indicators capable of comparing the energy performance of buildings.

The energy performance is calculated for the building energy services present in the building, except for space heating and, for the residential sector, for the production of domestic hot water. These are always considered present. If they are not present in the real building, virtual technical systems must be considered for EPC purposes, according to the specifications in the above-mentioned national guidelines for the energy certification of buildings.

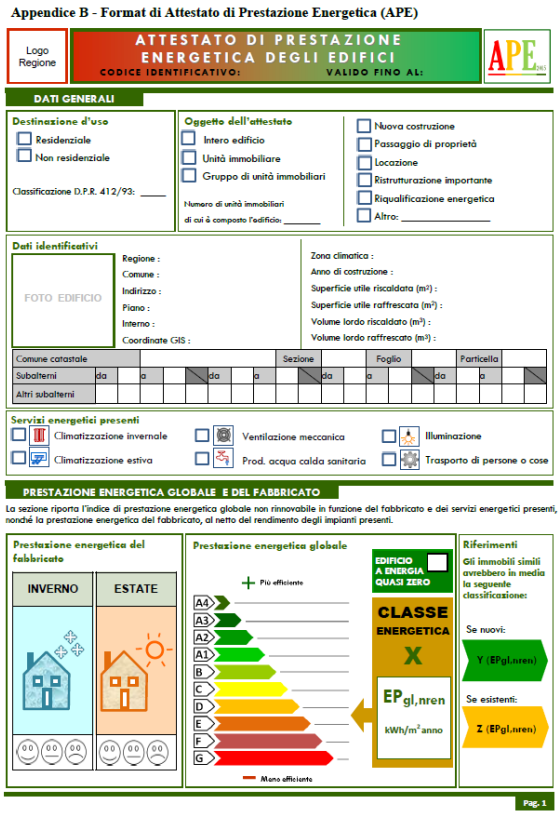


Figure 11. First page of the Italian EPC with the indication of the energy classification of the building

3.4.5 Validation process of EPC data and quality assurance

In Italy it is compulsory to monitor and control the quality of EPCs. Regions and autonomous provinces must check at least 2% of the EPCs stored in their territories each year. These control bodies are required to give priority to the most efficient energy classes, and they must check:

- The documents that are part of the EPC.
- The consistency of the input data with the calculation procedure and the results.
- That there has been at least one on-site inspection during the EPC generation process (the EPCs must contain photographic documentation of the inspection).

Regions and autonomous provinces must transmit electronically to SIAPE (Information System on Energy Performance Certificates, a database at National level managed by ENEA) the information related to the EPCs that have been checked and the number of EPCs that are not valid.

SIAPE is a database of EPCs at the national level that should be interoperable with other regional (or national) cadastres. Each region and autonomous province should transfer the EPC data to SIAPE once a year.

To facilitate the verification process, qualified technicians must upload an XML file related to the EPC in the specific regional portal, whose implementation and maintenance is the responsibility of the regions and autonomous province. There is no specification as to whether an XML file should be in extended or reduced form applicable at the national level. Therefore, in some regions a simplified XML file is requested, while only in a few regions is the extended version is compulsory (Piemonte, Liguria, Friuli Venezia Giulia, Valle D'Aosta, Emilia Romagna). However, in some regions, even if they request XML files from certifiers, they do not collect and share them online due to a lack of money as well as a lack of infrastructure and know how. This causes many problems due to the lack of EPC information in a specific territory.

3.5 Slovenia

3.5.1 Qualification of certifiers

Pursuant to Article 38 of the Act on Energy Efficiency[17], energy-performance certificates for buildings in Slovenia are issued by authorized legal or natural persons. In accordance with Article 40, a license of an independent expert for the generation of energy performance certificates can be obtained by a person who fulfils certain conditions defined by the law. The final authorisation of legal entities and experts is made with a decision of the ministry responsible for energy.

Based on a public tender, the ministry responsible for energy appointed the Building and Civil Engineering Institute ZRMK and the Chamber of Architecture and Spatial Planning of Slovenia as the training providers for the energy-performance certification of buildings for a period of 5 years. Trainings take place several times a year and these two institutions are also responsible for the organisation of the final exams. More detailed information about the content of the training courses is published on the web pages of the authorized training providers.

An individual who meets the following requirements can obtain a licence and become an independent energy-performance certifier:

- They have reached an appropriate educational level in engineering, architecture, spatial planning, construction or physics, in accordance with the regulation determining the classification of educational systems.
- They have at least 2 years of relevant work experience since obtaining their educational qualifications, referred to in the previous indent, in the professional field of efficient energy use and renewable energy sources in buildings.
- They have successfully completed a training course for independent experts for the generation of energy-performance certificates in accordance with Act on Energy Efficiency at least 5 years prior to the application for a license.

3.5.2 Data-acquisition methods and availability of data

The energy-performance certificate of a building must be obtained by the property owners (whole building or building unit) in case of selling or renting their property for a period longer than one year. However, there are some exceptions, and an EPC is not required in cases where a new contract or series of contracts are to be signed with the same tenant for a period exceeding one year after the expiration of the first original contract. In the majority of cases, the EPC's validity is checked primarily by notaries during the sale. Unfortunately, in the case of renting the majority of transactions are often concluded informally, and therefore bypasses any official controls. Building owners who do not sell or rent their properties do not need an EPC.

[17] Act on Energy Efficiency, (Official Journal RS, Nr. 158/20), http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO8136

An EPC must also be obtained for all new buildings. For newly constructed and renovated buildings, the EPC generation process is linked to the controls in place to establish whether a building meets the minimum requirements for energy performance. It is highly recommended that in such cases an expert is involved during the design stage or on-site control and has direct access to the building and the systems data.

The energy certificate is necessary for all buildings owned or used by public-sector entities with a total usable floor area of more than 250 m^2, and a valid EPC must be placed in a visible location. The EPC is also necessary for all buildings that are not owned or used by the public-sector entities but have a total usable floor area of more than 500 m^2 and are often used by the public. In this case the EPC must also be placed in a visible location.

A calculated energy-performance certificate (cEPC) can be produced and issued for each building. It is prescribed for residential buildings and for all new buildings. The calculation methodology is the same as for the calculation of the building's energy consumption when obtaining a building permit. Energy consumption is calculated based on the assumption that a space heating system will maintain a constant indoor temperature of 20°C (residential buildings). The basis for the calculation is the building's documentation that reflects the actual condition of the building and the installed technical systems. During the EPC-generation process, certified experts acquire data that are necessary for the production of the cEPC such as the building's dimensions, the wall's composition and materials, the heated floor area, the properties and orientations of the windows, shading of the buildings, and properties of the heating systems. Since a cEPC is necessary for all new buildings, acquiring this information is simple, since the experts use data from the project's documentation. In the case of missing project documentation, which is often the case for old residential buildings, the experts must collect the necessary data on-site with measurements and a visual inspection of the installed materials, thicknesses, technical systems, etc.

A measured energy-performance certificate (mEPC) is intended only for existing non-residential buildings, and it is determined on the basis of the actual energy consumption of the building. The basis for the generation of the measured energy certificate is the actual, measured values of the energy consumption in the building or an individual part of the building. Data about the supplied energy and general data about the building are provided by the property owner, for example, in the form of invoices or other reports. When preparing the mEPC, an independent expert inspects the building's technical systems and official measurement points (meters) and checks the reasonableness of the submitted data. However, it must be emphasized that the client is responsible for the correctness and truthfulness of the submitted data about the building, its technical systems and energy use.

3.5.3 Performance assessment and calculation software

To support the EPC-generation process, the methodology implemented in Slovenia requires the use of a dedicated software tool to calculate the energy performance of building. However, there is no public software to support the calculation of the energy indicators, and only commercial software is used. Therefore, the experts must choose between available software packages according to the purpose of their assignment, personal preferences, availability and quality of the software.

There are four commercially available software packages that can be used to calculate the energy-performance indicators for the purpose of issuing an energy-performance certificate: ArchiMAID, Energija 2010, Fibran and URSA 4 (Figure 12). These programmes are all based on rules for the efficient use of energy in buildings (PURES 2010), the technical guidance TSG-1-004:2010, and on the standard SIST EN ISO 13790:2008.

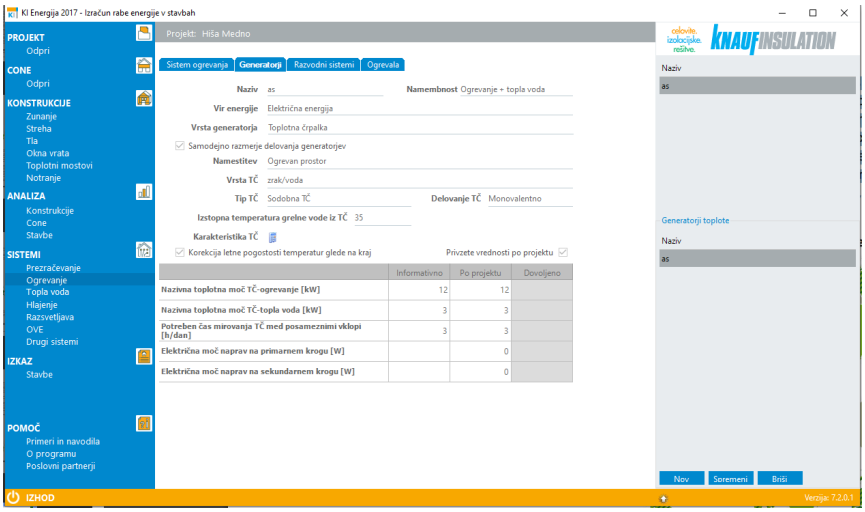


Figure 12. Example of energy-calculation software front-end

3.5.4 Energy-performance indicators

The energy-performance certificate of a building contains energy indicators and recommendations for measures to improve the current energy performance of the building. The indicators can be presented separately for calculated and measured EPCs (Figure 13).

The energy indicators for the calculated energy certificate are:

- Annual energy need for heating required per unit of conditioned building area Q_{NH}/A_c [kWh/(m²a)].
- Annual overall delivered energy for the operation of the building per unit of conditioned area of the building Q_f/A_c ([kWh/(m²a)].
- Annual non-renewable primary energy for the building's operation per unit of conditioned building area Q_p/A_c [kWh/(m²a)].
- Annual CO_2 emissions due to the operation of the building per unit of conditioned building area [kg/(m²a)].

The energy indicators for the measured energy certificate are:

- Annual energy input intended for conversion into heat per unit of conditioned building area [kWh/(m²a)].
- Annual electricity consumption due to the operation of the building per unit of conditioned building area [kWh/(m²a)].
- Annual non-renewable primary energy for the building's operation per unit of conditioned building area Q_p/A_c [kWh/(m²a)].
- Annual CO_2 emissions due to the operation of the building per unit of conditioned area of the building A_c [kg/(m²a)].

Figure 13. Energy indicators as presented on coloured measured scales for calculated (left) and measured (right) EPC

3.5.5 Validation process of EPC data and quality assurance

In Slovenia the data validation and quality controls of EPCs are mandatory. Expert supervision of EPCs and inspection reports are carried out by the ministry responsible for energy. According to Article 46 of the Act on Energy Efficiency, the ministry responsible for energy is obliged to supervise and verify at least a statistically significant share of annually issued EPCs and inspection reports. Annual expert supervision includes the verification of building data, the input data and the results presented on EPCs, the inspection reports and the energy-efficiency recommendations.

In addition to the above-mentioned controls, the ministry responsible for energy carries out additional sets of standardised quality controls at multiple levels. The first-level control is carried out during the process of storing the EPC in the national EPC database. A number of parameters are checked, including:

- Missing information on building identification (e.g., address, coordinates, GIS data, national Land Registry number, etc.).
- Missing/faulty data or values in the following fields: building use, renovation recommendations, unrealistic values of delivered energy, primary energy and CO_2 emission (e.g., negative values, high number).

The second-level control of the quality check is performed on a statistically random sample of EPCs in the database. This quality control is based on a comparison with cadastral plans, cadastral data and aerial photos.

3.6 Spain

3.6.1 Qualification of certifiers

The energy certification of buildings in Spain is regulated at the state level (Royal Decree 390/2021), defining the qualifications of technicians, the scope of application, etc. On the other hand, the management of EPC registers, control and inspection are managed at the regional level.

Royal Decree 390/2021 defines a competent technician as one "who is in possession of any of the qualifying academic and professional qualifications for the drafting of any of the building projects or for the direction of works and the direction of the execution of building works, etc."

In summary, a competent expert must have a degree in architecture, technical architecture, engineering or technical engineering, among other degrees present in the building planning law (Law 38/1999).

Furthermore, the Royal Decree 390/2021 establishes that the figure of competent technical personnel must be reviewed before the 3rd of December 2022, to adapt it to a "model based on the knowledge and professional qualifications necessary for the preparation of the energy-performance certificates."

3.6.2 Data-acquisition methods and availability of data

Currently, it is mandatory to carry out the energy-performance assessment and issue an energy-performance certificate in the following cases:

a) Newly constructed buildings. Municipalities and professional associations verify that the certificate is included in the project.

b) Buildings or parts of existing buildings that are sold or rented to a new tenant. Notaries require the EPC for the sale. In the case of renting, in Catalonia it is required by a department of the regional government.

c) Buildings or parts of buildings owned or occupied by a public administration, with a total useful area greater than 250 m^2. In this case, a follow-up of the application is pending.

As of June 3, 2022, the EPC will also be mandatory in the following cases:

d) Buildings or parts of buildings in which reforms or extensions are carried out:

- substitution, installation or renovation of thermal installations.
- intervention covering more than 25% of the total area of the final thermal envelope of the building, or an extension in which the surface area or the built volume of the unit.
- units of use on which the intervention is intervened is increased by more than 10%, when the total extended useful area exceeds 50 m^2.

In this case the monitoring will be linked to the building permit.

e) Buildings or parts of buildings with a total useful area greater than 500 m^2 with, among others, the following uses: administrative, health, commercial, public residential, educational, cultural, recreational activities, restaurants, transportation of people, sports and places of worship. It will be difficult to establish a control on how this requirement is implemented in practice because it is applicable to existing buildings without having a related administrative procedure.

f) Buildings that must undergo a technical building inspection or equivalent inspection. The technical inspection is delivered to a different public body than the one in charge of collecting EPCs; however, the two documents might be linked in the future.

The property owner is obliged to entrust the EPC to competent technical personnel, who will carry out the assessment of the energy performance of the building or a building part. The requirements are as follows:

- It is mandatory that a competent technician visits the building.
- The competent expert will obtain the information to carry out the necessary assessment of energy performance and issue the certificate of the building. The data should be obtained during a direct observation of the building and the technical building systems, from the cadastre, and other documentation and plans if available. From these sources, the following information should be obtained:

  - Dimensions of the building (useful surface and surfaces of the different enclosures).
  - Construction solutions for enclosures (if this information is not available, energy-certification programs offer predefined default data according to the year of construction of the building).
  - Typology and performance of thermal, renewable and, in tertiary, lighting installations.
  - Hours of operation in tertiary buildings.
- The competent expert will incorporate the acquired information into the building's energy-certification programme and create the energy-performance certificate.
- The certificate is presented at the registry (in the case of Catalonia, it is presented by the technical staff member who signs it). After the registration, the energy label is sent.

In Catalonia the labels of all buildings are public, and can be downloaded online through a search engine (Figure 14) or from a map (Figure 15). In addition, the (non-personal) data of the certificates can be consulted as open data (Figure 16).

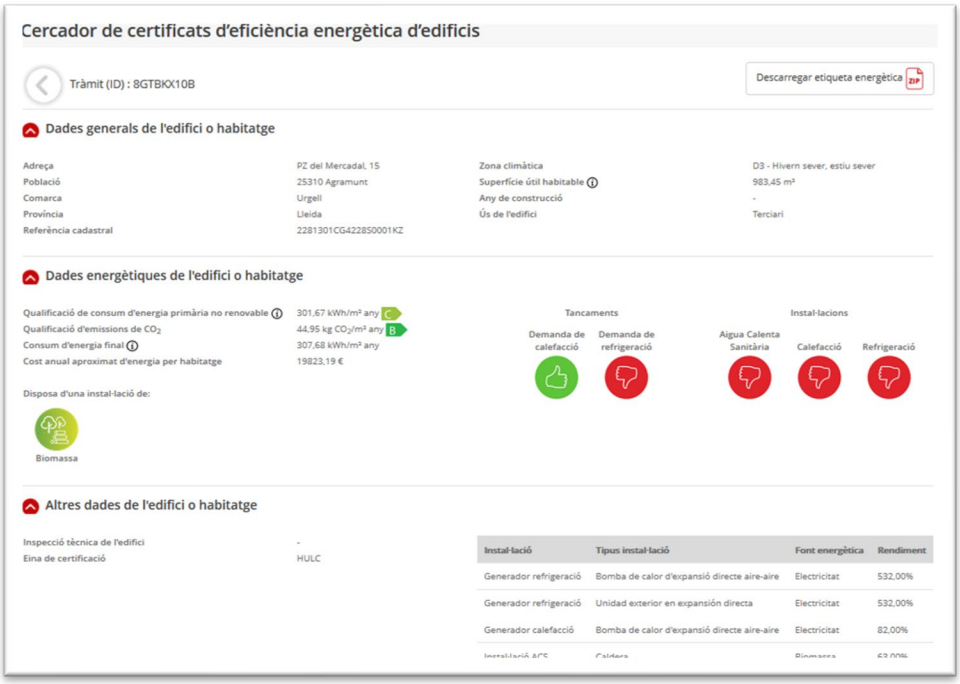


Figure 14. Front-end of energy certificate search engine in Catalonia

Figure 15. Front-end of energy certificate search through map

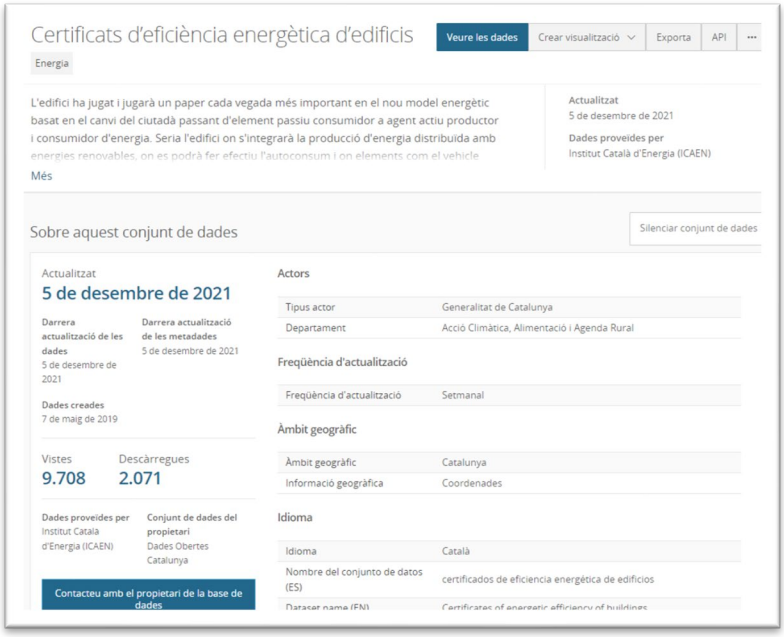


Figure 16. Frontend of EPC register in Catalonia: open data

3.6.3 Performance assessment and calculation software

Different building energy-certification programs are common throughout Spain (Figures 17, 18). These are programs recognized by the Ministry for the Ecological Transition and the Demographic Challenge, they are free and can be downloaded[18].

These programs compare the certified building with a reference building to place it on the certification scale. The results of all the programs must be equivalent. There are simplified methods (they consider the building as a box, defining the surfaces of the different enclosures), and more comprehensive versions (they perform a three-dimensional simulation of the building).

The calculations do not include billing data, as the EPC contains information about a building and not about its users (depending on the behaviour of the end-user, the energy consumption might vary). It should be noted that the aim of these programs is to obtain the EPC, they are not tools to improve the design of the building.

[18] https://energia.gob.es/desarrollo/EficienciaEnergetica/CertificacionEnergetica/DocumentosReconocidos/Paginas/procedimientos-certificacion-proyecto-terminados.aspx

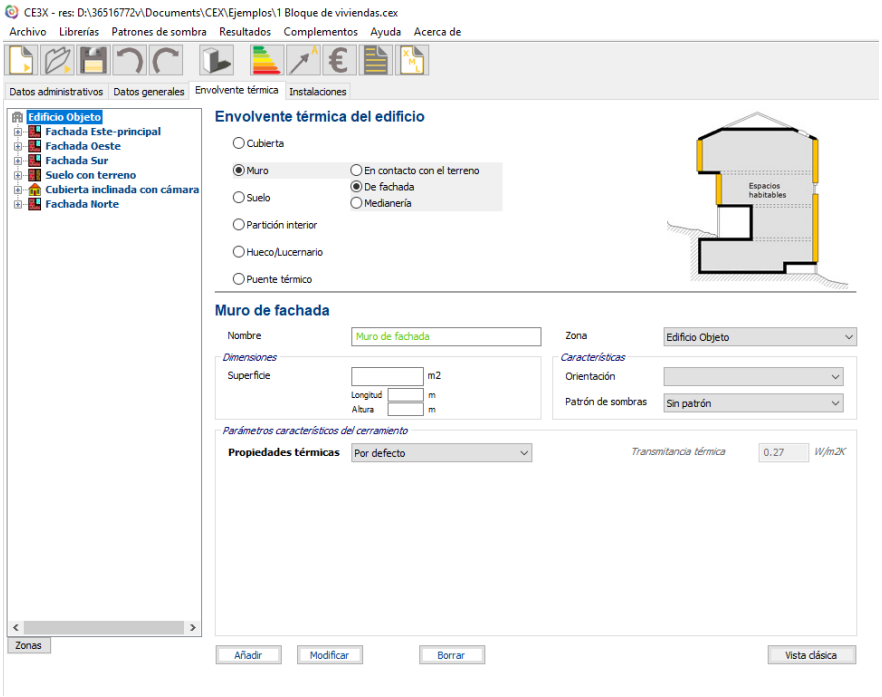


Figure 17. Example of energy-calculation software front-end - simplified CE3X package

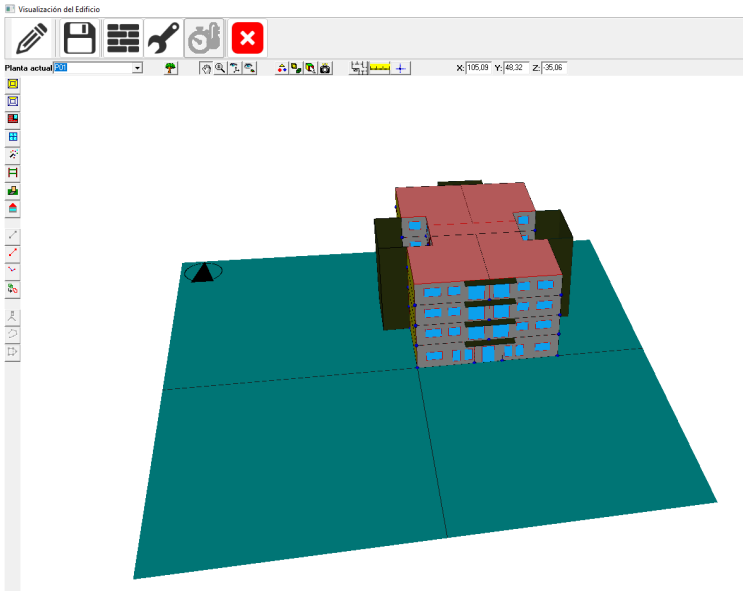


Figure 18. example of energy-calculation software front-end - HULC package

3.6.4 Energy-performance indicators

As indicated in the document "Qualification of the energy efficiency of buildings"[19], in the energy certificates of buildings there are two main indicators:

- Annual CO_2 emissions.
- Annual consumption of non-renewable primary energy.

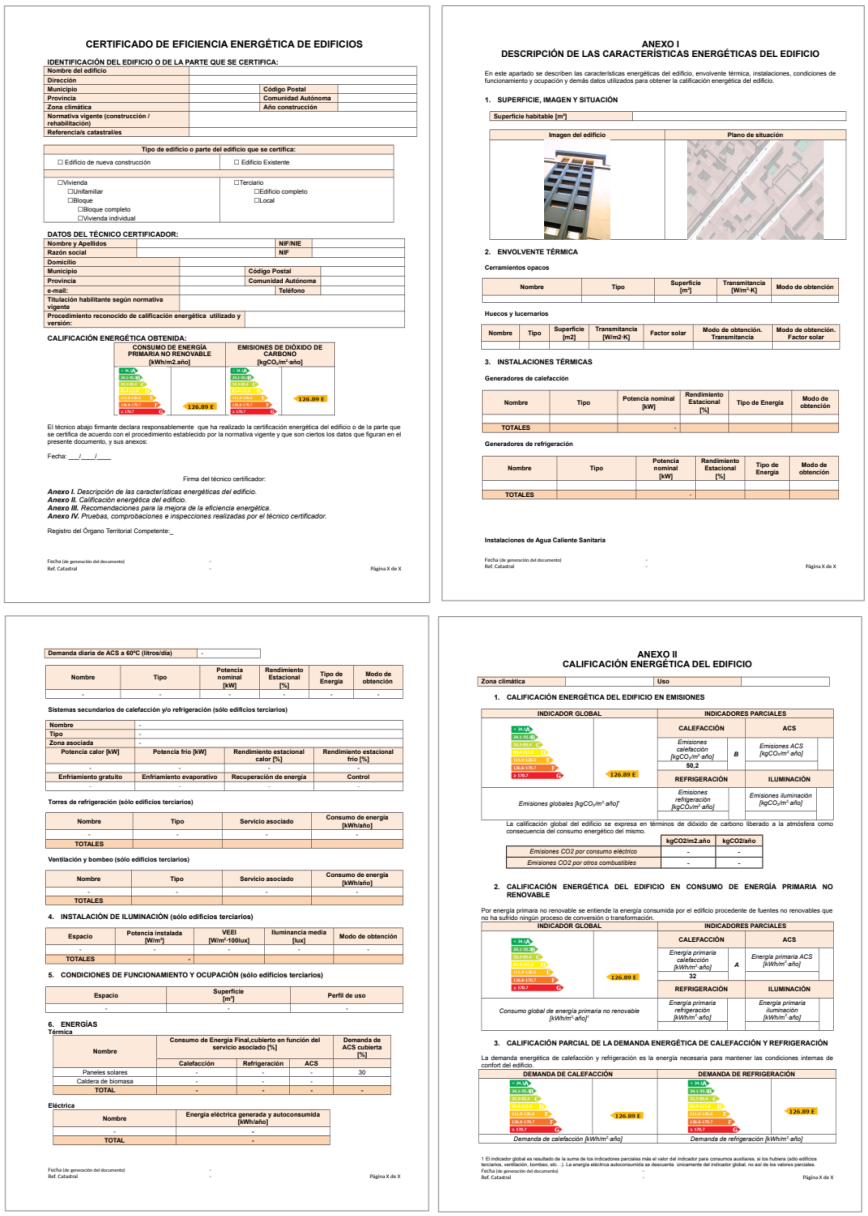
[19] https://energia.gob.es/desarrollo/EficienciaEnergetica/CertificacionEnergetica/DocumentosReconocidos/normativamodelosutilizacion/20151123-Calificacion-eficiencia-energetica-edificios.pdf

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

The complementary energy-efficiency indicators are:

- Annual energy demand for heating.
- Annual energy demand for cooling.
- Annual consumption of non-renewable primary energy disaggregated by services.
- Annual CO_2 emissions disaggregated by services.
- Annual CO_2 emissions are broken down by electricity consumption and by other fuels.

The services considered in the complementary indicators are heating, cooling, production of sanitary hot water and, in buildings other than private residential housing, also lighting. The units used to express these indicators are kWh per m^2 of useful surface of the building, for demand or consumption values, and kg CO_2 per m^2 of useful surface of the building, for emission values. An example of an EPC is shown in Figure 19.


CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS

IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

Nombre del edificio			
Dirección			
Municipio		Código Postal	
Provincia		Comunidad Autónoma	
Zona climática		Año construcción	
Normativa vigente (construcción / rehabilitación)			
Referencia/s catastral/es			

Tipo de edificio o parte del edificio que se certifica:	
☐ Edificio de nueva construcción	☐ Edificio Existente
☐Vivienda ☐Unifamiliar ☐Bloque ☐Bloque completo ☐Vivienda individual	☐Terciario ☐Edificio completo ☐Local

DATOS DEL TÉCNICO CERTIFICADOR:

Nombre y Apellidos		NIF/NIE	
Razón social		NIF	
Domicilio			
Municipio		Código Postal	
Provincia		Comunidad Autónoma	
e-mail:		Teléfono	
Titulación habilitante según normativa vigente			
Procedimiento reconocido de calificación energética utilizado y versión:			

CALIFICACIÓN ENERGÉTICA OBTENIDA:

CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE [kWh/m2.año]	EMISIONES DE DIÓXIDO DE CARBONO [kgCO$_2$/m^2 año]
A, B, C, D, E, F, G 126,89 E	A, B, C, D, E, F, G 126,89 E

El técnico abajo firmante declara responsablemente que ha realizado la certificación energética del edificio o de la parte que se certifica de acuerdo con el procedimiento establecido por la normativa vigente y que son ciertos los datos que figuran en el presente documento, y sus anexos:

Fecha: ___/___/____

Firma del técnico certificador:

Anexo I. Descripción de las características energéticas del edificio.
Anexo II. Calificación energética del edificio.
Anexo III. Recomendaciones para la mejora de la eficiencia energética.
Anexo IV. Pruebas, comprobaciones e inspecciones realizadas por el técnico certificador.

Registro del Órgano Territorial Competente:_

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ANEXO I
DESCRIPCIÓN DE LAS CARACTERÍSTICAS ENERGÉTICAS DEL EDIFICIO

En este apartado se describen las características energéticas del edificio, envolvente térmica, instalaciones, condiciones de funcionamiento y ocupación y demás datos utilizados para obtener la calificación energética del edificio.

1. SUPERFICIE, IMAGEN Y SITUACIÓN

Superficie habitable [m²]	

Imagen del edificio	Plano de situación

2. ENVOLVENTE TÉRMICA

Cerramientos opacos

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m² K]	Modo de obtención

Huecos y lucernarios

Nombre	Tipo	Superficie [m2]	Transmitancia [W/m2 K]	Factor solar	Modo de obtención. Transmitancia	Modo de obtención. Factor solar

3. INSTALACIONES TÉRMICAS

Generadores de calefacción

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
TOTALES		-			

Generadores de refrigeración

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
TOTALES		-			

Instalaciones de Agua Caliente Sanitaria

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Demanda diaria de ACS a 60ºC (litros/día)	-

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
-	-	-	-	-	-

Sistemas secundarios de calefacción y/o refrigeración (sólo edificios terciarios)

Nombre	-
Tipo	-
Zona asociada	-

Potencia calor [kW]	Potencia frio [kW]	Rendimiento estacional calor [%]	Rendimiento estacional frio [%]
-	-	-	-
Enfriamiento gratuito	Enfriamiento evaporativo	Recuperación de energía	Control
-	-	-	-

Torres de refrigeración (sólo edificios terciarios)

Nombre	Tipo	Servicio asociado	Consumo de energía [kWh/año]
-	-	-	-
TOTALES			-

Ventilación y bombeo (sólo edificios terciarios)

Nombre	Tipo	Servicio asociado	Consumo de energía [kWh/año]
-	-	-	-
TOTALES			-

4. INSTALACIÓN DE ILUMINACIÓN (sólo edificios terciarios)

Espacio	Potencia instalada [W/m²]	VEEI [W/m²-100lux]	Iluminancia media [lux]	Modo de obtención
-	-	-	-	-
TOTALES	-			

5. CONDICIONES DE FUNCIONAMIENTO Y OCUPACIÓN (sólo edificios terciarios)

Espacio	Superficie [m²]	Perfil de uso
-	-	-

6. ENERGÍAS

Térmica

Nombre	Consumo de Energía Final,cubierto en función del servicio asociado [%]			Demanda de ACS cubierta [%]
	Calefacción	Refrigeración	ACS	
Paneles solares	-	-	-	30
Caldera de biomasa	-	-	-	
TOTAL	-	-	-	-

Eléctrica

Nombre	Energía eléctrica generada y autoconsumida [kWh/año]
-	-
TOTAL	-

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ANEXO II
CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

Zona climática		Uso	

1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES

INDICADOR GLOBAL		INDICADORES PARCIALES		
		CALEFACCIÓN		ACS
A, B, C, D, E, F, G 126,89 E		Emisiones calefacción [kgCO$_2$/m^2 año] 50,2	B	Emisiones ACS [kgCO$_2$/m^2 año]
		REFRIGERACIÓN		ILUMINACIÓN
Emisiones globales [kgCO$_2$/m^2 año]*		Emisiones refrigeración [kgCO$_2$/m^2 año]		Emisiones iluminación [kgCO$_2$/m^2 año]

La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

	kgCO2/m2.año	kgCO2/año
Emisiones CO2 por consumo eléctrico	-	-
Emisiones CO2 por otros combustibles	-	-

2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE

Por energía primaria no renovable se entiende la energía consumida por el edificio procedente de fuentes no renovables que no ha sufrido ningún proceso de conversión o transformación.

INDICADOR GLOBAL		INDICADORES PARCIALES		
		CALEFACCIÓN		ACS
A, B, C, D, E, F, G 126,89 E		Energía primaria calefacción [kWh/m^2 año] 32	A	Energía primaria ACS [kWh/m^2 año]
		REFRIGERACIÓN		ILUMINACIÓN
Consumo global de energía primaria no renovable [kWh/m^2 año]*		Energía primaria refrigeración [kWh/m^2 año]		Energía primaria iluminación [kWh/m^2 año]

3. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN

La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

DEMANDA DE CALEFACCIÓN		DEMANDA DE REFRIGERACIÓN	
A, B, C, D, E, F, G 126,89 E		A, B, C, D, E, F, G 126,89 E	
Demanda de calefacción [kWh/m^2 año]		Demanda de refrigeración [kWh/m^2 año]	

* El indicador global es resultado de la suma de los indicadores parciales más el valor del indicador para consumos auxiliares, si los hubiera (sólo edificios terciarios, ventilación, bombeo, etc...). La energía eléctrica autoconsumida se descuenta únicamente del indicador global, no así de los valores parciales.

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Figure 19. Example of EPC - common to all energy-certification tools

3.6.5 Validation process of EPC data and quality assurance

The control and inspection of the EPCs are carried out in the different autonomous communities and in Catalonia. In Catalonia it is managed as follows:

With regard to the control:

- It is carried out in the certificate registry, applying a system of about 90 alarms. They are configurable depending on whether the building is new or already existing, the use of the building, etc.
- When submitting the registration application form to the registry, it connects to the internet to apply these alarms. Two types of messages can appear on the form itself:
    - Notice: it is recommended to review different parameters, although it is allowed to present the form to the registry.
    - Error: the value indicated in the message must be corrected before registering the certificate at the registry.
- Alarms are reviewed in the registry.

Concerning inspection:

- 1% of the certificates issued during the previous year are inspected every year. The sample of buildings includes new constructions, existing buildings, different uses and all possible ratings, with the number of buildings with high ratings being greater.
- An administrative review of the documents is carried out first, followed by a visit to the building.

3.7 Cross-country comparison, main gaps and recommendations for TIMEPAC

The energy-performance certification of buildings is a widely implemented procedure in the six countries considered, especially in those where the energy-performance certificate is required by notaries when selling a property. It is promising that the energy information contained in the EPC is steadily progressing. However, there are many areas for improvement, in particular those related to the quality and value attached to the energy certificate, which largely determine its usefulness as a tool to support building renovation. In this context it is important to remember that he first EPCs in Europe were issued more than 15 years ago, and nearly zero-energy buildings have been introduced only in recent years.

From the theoretical point of view, the improved EPC that the EPBD recast envisions, aims to provide a holistic overview of all the relevant indicators that might help the building's owner or the occupants reduce energy consumption and carbon emissions. Along these lines, the original EPC label has gradually been complemented by a broader set of smart preparedness indicators, for example, those related to the building's ability to produce energy from renewable sources or to building owners' and occupants' awareness of the benefits of building automation and electronic monitoring.

The share of used renewable energy sources is an important indicator that dictates the overall primary energy use. The EPC in some countries still does not show this indicator (e.g., Slovenia), while in other countries like Austria and Italy this information is provided.

Since the improved EPC should cover many different areas, the data needed for the calculation of all the parameters is extensive. The various calculations could be facilitated with the support of a BIM environment and software (see Deliverable 1.4 "Report of existing barriers to exploit EPCs and BIM"). In Slovenia some architects and engineers already use BIM to generate an EPC; however, further work is necessary with regard to the exploitation of data that derive from the BIM process and the interoperability with national EPC databases.

Software is a major issue regarding EPC generation in EU. In general, all the Member States are using the same calculation methodology, but unfortunately, there is no common validated software

for all Member States. This results in multiple national and commercial tools that hinder any comparison of results across countries. When calculating energy indicators, an EPC should state in some way which software and calculation method were used to calculate the indicators. For example, in Austria, this must be stated in the technical annex; however, it is not always handed over, even though it is part of the formal EPC.

In Slovenia and Croatia, different calculation methods (simplified, monthly, hourly) for different types of buildings are expected to be prescribed by law by 2022. Afterwards, this information will be essential to the property owner as well as any possible tenant or buyer. When comparing similar buildings for investment/rent and with an EPC from the period before and after new legal rules applied in 2022, the end user should be aware of what they are comparing.

Also, an analysis of the EPC generation process in Cyprus revealed that the complexity of the process due to the involvement of many, mainly governmental, departments undermine the work of the expert and the owner. While regarding its quality, the certificate loses value since after the issuance there is no reason for a re-examination of the building or a re-evaluation of the certificate (except in cases of financing the building from funds).

Furthermore, the exploitation of national EPC databases in all the addressed countries could be further improved (see Task 1.2 “Comprehensive analysis of data storage in the participating countries”). The data that is captured in XML files during the generation of the calculated EPC is very comprehensive. Unfortunately, public databases show a limited amount of data compared to the XML file, which hinders their capacity to create reliable building-renovation passports.

All countries present key energy-performance indicators, i.e., the energy needed for heating, the primary energy and the share of used renewable energy sources in the total delivered energy. The vast majority though is lacking the up-to date indicators that would make it possible to categorize a building as nearly-zero energy (nZEB). With the exception of Italy and Spain, countries do not specifically address the total and non-renewable primary energy demand, which is key for nZEB. This gap can be addressed in future scenarios to use enhanced EPCs, to be developed in TIMEPAC.

To enhance current EPC generation, TIMEPAC should provide (1) a holistic approach to determine a building’s energy performance, (2) comprehensive training materials, (3) a clearer picture of recommendations for improving the energy efficiency that is evaluated with energy and financial savings, (4) options that are enabled with building’s automation systems and energy-consumption monitoring and (5) other sustainability aspects like carbon footprint or RES potential or the potential to be included in a smart local energy community. Additional efforts should be dedicated to provide recommendations for improving the energy efficiency that is evaluated with energy and financial savings. One of these factors is the lack of advice for immediate energy savings from users on issues such as the proper use of appliances for space heating and cooling

Finally, the results of this study revealed that there are significant differences between countries and regions regarding the minimum requirements for training and the professional experience of the qualified and accredited expert. In many cases the main criterion is to have a degree in architecture, technical architecture, engineering or technical engineering. In most countries, the training (obligatory and/or voluntary) is provided by a variety of institutions, including third-party bodies or private training organisations. This highlights a great opportunity for the TIMEPAC Academy, which can provide tailor-made educational and training materials for professionals and at the same time become a platform for exchanging knowledge and experience on the implementation of advanced certification methods.

4 EPC generation in the context of end-user's requirements in the addressed EU Member States

To assess EPC generation in the context of the end-user's requirements, the Jožef Stefan Institute created a template of the survey that was sent at the end of October 2021 to all the partners of the TIMEPAC project. The main objectives of this survey were:

- To obtain information about the actual understanding of the EPC-generation process from the end-user's perspective.
- To better understand end-user's needs and expectations.

The survey contained 4 general and 15 technical questions, most of them with answers on a Likert scale with grades from 1 to 5, where 1 means "Completely unaware / Not agree / Completely not understandable", 2 "Mostly unaware / Mostly not agree / Mostly not understandable", 3 "Neutral", 4 "Partly aware / Partly agree / Partly understandable", 5 "Completely aware / Completely agree / Completely understandable" (see Annex 1). The partners were responsible for translating the questionnaire into their national languages, for selecting the appropriate tools with which the survey will be conducted, for distributing it through their professional networks and for analysing the results and feedback from target audiences.

4.1 Austria

The Austrian survey was created with the online tool 2ask (www.2ask.com) due to the rules on the protection of personal data that must be respected in Austria. The English questions were not literally translated into German, but in the sense of their meaning, while the structure and design of the English questionnaire were retained. Only question, number 6, was split into two parts, i.e., 6a: single family house and 6b: multiple dwelling unit. We also asked for the professional background of the respondents, to use this information in the interpretation of the results.

The questionnaire could only be completed once per computer or other device and was sent via personal message as link to banks, property managers, students, and the network (approx. 100 recipients). Furthermore, it was sent via newsletters by SERA global GmbH (149 recipients, different from those approached via personal message), ÖGNI (Austrian Green Building Council) (approx. 2000 recipients) and Chamber of Commerce (approx. 850 recipients). It was distributed from 1 to 17 December 2021. By the 1st of January 2022, there were 66 responses; then the questionnaire was closed. The responses were translated according to the English structure of the questionnaire, and comments and suggestions received with the responses were also translated into English.

From the sending dates and the response dates we can see that very few answers (approx.10) came as a result of sending the questionnaire to ÖGNI and the Chamber of Commerce. There are several possible explanations: the EPC is not considered a hot topic, the questionnaire was just one message among others in those newsletters, there is not much motivation to spend time on a questionnaire, even if it was announced to be very short, the busy time before the end of the year, and COVID-19-related challenges. However, the survey was useful because it was not meant to be statistically significant, but to complement SERA's existing knowledge base that comes from a long-term collaboration with the Study Programme Real Estate Management of the University of Applied Sciences FH Wien der WKW, and the long-term professional work in the field of the EPC in Austria and at the EU level.

Figure 20 shows some basic information about the respondents.

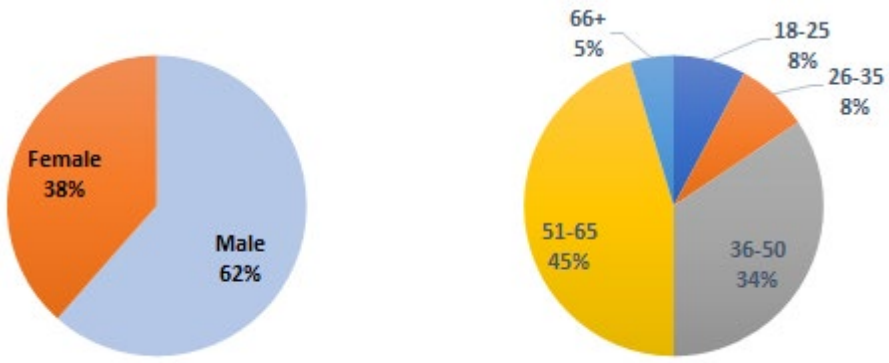

Figure 20. Distribution of the respondents from Austria by gender and age

The analysis of respondents shows a male dominance, which corresponds to the professional situation in the field. The dominance of the eastern region is not surprising, because this reflects SERA's current network and shows us that there is clearly a weakness that needs to be dealt with in the future. The fact that the vast majority of respondents are above 35 years old shows that there is probably a need to address younger people through their preferred social-media tools. The large share of university graduates reflects the professional environment of the network and indicates that the views of the average customers are insufficiently represented.

4.1.1 Understanding EPC data and the generation process

The purpose and the need for the EPC are well understood. The energy agencies in the provinces are aware that the purpose of the EPC is to support the transformation of the building stock to energy efficiency and zero-emission balance, and that this is necessary to achieve the greenhouse-gas emission-reduction targets and to contribute to energy security.

The situation is less clear in terms of understanding when an EPC is legally required. The reason might be the challenge of "major renovation", as the legal definition is not unambiguous and thus creates problems in practice.

There are also some lack of information about who is entitled to issue an EPC. This might be due to the fact that in addition to the information provided by the provincial energy agencies, several privately initiated electronic platforms exist where experts are listed, or the issuing of cheap EPCs (below €100) electronically is being offered.

People are familiar with the information provided by the EPC and what an EPC looks like. Regarding residential EPC prices, the understanding is less clear, although some respondents seem quite aware of the costs of high-quality EPCs based on specific building data (range of €301–700 for single-family houses and more than €1001 for multi-unit dwellings). To encourage the renovation of existing buildings, cheaper EPCs would help. However, this should not be achieved at the expense of data quality, but through subsidies to the building's owner.

4.1.2 Understanding the proposed energy-efficiency measures

The usefulness of the information provided by the EPC for the extensive renovation of buildings clearly depends on the quality of the certificate, the method and the input data used. If the EPC is calculated with a simplified method that is allowed for already-existing buildings, the value of the information might be low due to the lack of building-specific information. EPCs for existing buildings based on the simplified method without a site visit are cheap, but usually only suitable for a rough estimate of the building's energy performance.

There is need for more information about the actual energy consumption of the buildings, because the calculated heat demand can differ significantly from the actual amount of energy consumed.

Therefore, the EPC should also be based on actual consumption data and be updated regularly and with much shorter intervals than 10 years.

Finally, there is room for improvement in the presentation of technical building systems in the EPC.

4.1.3 Usefulness of the EPC

Sometimes the EPC is only understood as the first two pages with the label and the main indicators. At least when the energy-performance certificate is handed over, it happens that the technical annex is only handed over on request. Overall, the potential of the EPC is underestimated, whereby it will depend on the design whether the full potential can be exploited or not.

The indicators included in the first two pages of the EPC are meant for professionals. However, average users interested in renting or buying a building or a building unit will hardly understand the meaning of the table of indicators on the first page and the meaning of the detailed indicators on the second page. As a minimum, the scale on the first page gives an idea of what is good and bad, because people are familiar with the energy-efficiency scale that is also used for other goods. There is a need to make EPCs simpler and easier to understand, noting that this means something different for all the target groups. The indicators which must be published in real-estate advertisements are HWB_{Ref} (transmission losses of the building envelope) and f_{GEE} (total energy-efficiency factor). However, the usefulness of these indicators is very limited for the given purpose.

The value of the property is not defined by the score of the energy performance of the building. However, the energy performance can have an influence under certain conditions. In terms of real-estate valuation methods, actual energy expenses play a role that are not covered by the EPC. Also, expenses for maintenance, repair and technical upgrade play a role, which are not covered by the EPC, either.

The EPC should be made mandatory for the entire building stock. This is essential if good coverage with EPCs is to be achieved. However, the approach needs to be developed together with property managers and building owners to achieve the aim of improving the building stock. In this context, the building-renovation passport could be a solution.

There is a basic willingness to share data about technical building systems and the actual energy consumption of the building with the certified energy-performance evaluator during the energy assessment of a property. However, this depends on the effort needed to provide the data and on how the data will be used.

Depending on its design, the energy certificate can in principle serve consumer protection. In practice, the Austrian consumer-protection organisation has major reservations about the energy certificate as it is designed in Austria, especially for multi-storey buildings with rental flats.

4.2 Croatia

The survey was created with the online tool Google Forms. The English questions were translated into Croatian, and the structure and design of the English questionnaire were retained. The link to the questionnaire was sent by e-mail to our network of contacts with different backgrounds, mainly engineers. Until 20 January 2022 there were 111 responses, and then the questionnaire was closed. Most of the respondents are between 35 and 50 years of age (50%) and 33% between 50 and 65. It is interesting that we did not attract a single respondent younger than 25 years. We explain this by the fact that people who are buying, renting or leasing building are rarely younger than 25, with the exception of students, who in most cases rely on the advice of their parents. Around 55% of the respondents are males, slightly shifting the overall gender balance in Croatia. The vast majority (96%) of responses come from highly educated people (minimum of a bachelor degree) and we are fully aware that this fact influenced the results, since it does not represented the average citizen in Croatia. Also, 70% of respondents have been included in some part of the EPC process in the past, which also influences the results (Figure 21).

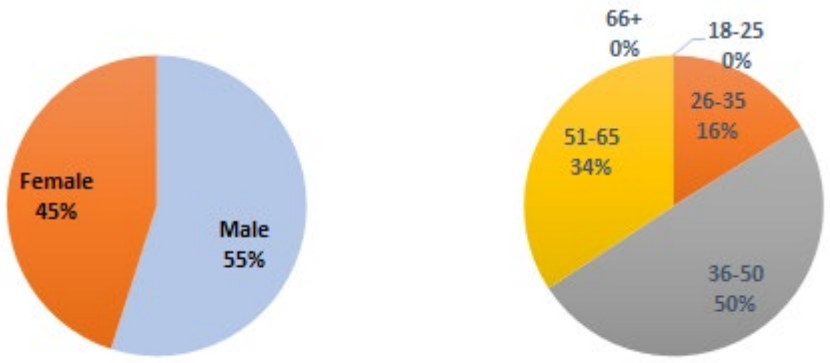

Figure 21. Distribution of the respondents from Croatia by gender and age

4.2.1 Understanding EPC data and the generation process

The purpose and the need for the EPC are both well understood. This is mainly because 70% of the respondents have some link to the certification process, and in part because of increasing awareness at the national level, mainly through various financial schemes for the energy renovation of family houses and multi-apartment buildings.

The situation is less clear in terms of understanding when an EPC is legally required, but the majority of participating stakeholders are aware of the legal requirements. There could be some misunderstandings because of a few grey areas defined in exceptions in the legislation.

It is clear who is entitled to issue an EPC as there is a list of all certified experts that must have authorization from the responsible state ministry.

People are also familiar with the information provided by the EPC and what the EPC looks like. Regarding EPC prices, the understanding is not clear at all. There are a lot of experts that issue EPCs of questionable quality for a very low price. Also, there is maximum price prescribed that in lots of cases cannot be satisfied (because the workload is much higher than the price).

4.2.2 Understanding proposed energy efficiency measures

The usefulness of the information provided by the EPC for the extensive renovation of buildings clearly depends on the quality of the EPC. As there is a clear methodology that must be used for the calculation, the quality only depends on the expert issuing the EPC. In most cases the EPCs and energy audits are of low quality when developed for residential dwellings that are being sold and of higher quality when issued with the goal of reconstruction.

There is a need for more reference to the actual energy consumption of the buildings, because the calculated heat demand can differ from the actual amount of energy consumed. Also, updating data with information about control systems and operating procedures is necessary to understand the building's actual performance.

4.2.3 Usefulness of the EPC

The content the EPC is clearly for professional users. Average users interested in renting or buying a building or a building unit will hardly understand the meaning of most of the indicators and data. Additionally, information about technical systems is not given in a systematic and understandable way. Primary energy, CO_2 emissions and delivered energy are the only indicators that incorporate technical systems. There is a need for more specific information about individual subsystems such as heating, lighting and cooling. As a minimum, the scale on the first page of the EPC gives an idea of what is good and bad, because people are familiar with the energy-efficiency scale that is also used for household appliances. The EPC should become simpler and easier to understand, although this means something different for all the target groups.

The value of the property is not defined by the energy class of the building. However, the energy performance can have an influence under certain conditions. Like other countries, the value of the property is mostly defined by its location.

The results clearly indicate that the EPC should be made mandatory for the entire building stock. This will be essential if good coverage with EPCs is to be achieved. However, to achieve this objective it is necessary to have the collaboration of property managers and building owners. In this context, the building-renovation passport can be a solution.

There is a willingness to share data about technical building systems and the actual energy consumption of the building with the certified energy-performance evaluator during the energy assessment of a property. However, this depends on the effort needed to provide the data and on how the data will be used.

The energy certificate can, in principle, help protect consumers, depending mainly on the quality of the energy-audit report and the recommendations given by the expert.

4.3 Cyprus

The Cypriot survey was created using Microsoft Office Forms, an online tool offered by Microsoft (https://www.microsoft.com/en-us/microsoft-365/online-surveys-polls-quizzes). The language used for the questionnaire was the original English version, as the majority of Cypriots have a good level of understanding of the English language.

The questionnaire could only be completed using a PC (or other similar device) and was sent via personal message as link to banks, property managers, students, and the network (approx. 100 recipients).

Additionally, it was sent to the network of the Cyprus Energy Agency, Cyprus University of Technology and Friends of the Earth. There were just a few answers to the questionnaire and this can be explained by the fact that the EPC is not considered as a trending topic, and the lack of time available to the participants (even if it was mentioned that the survey is short and requires very little time). The fact that the survey did not have the expected level of participation shows the need to educate the public about EPCs.

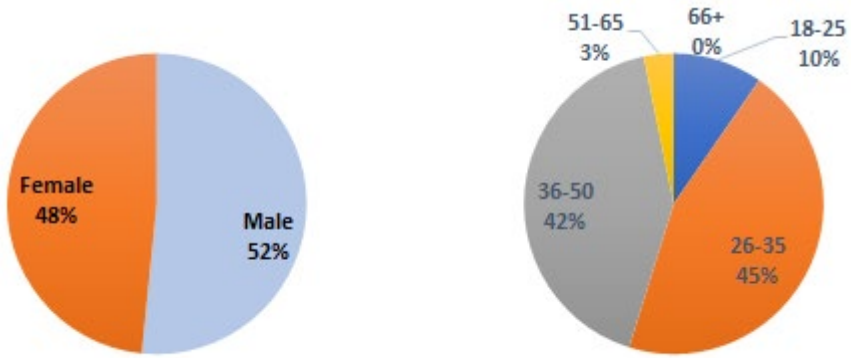

Figure 22. Distribution of the respondents from Cyprus by gender and age

The survey participants were female and male. They shared the same amount of interest in EPCs (Figure 22). The majority of the respondents are between 26 and 50 years old, which shows that EPCs are not well known among younger people and people who are not involved in engineering and the energy network. The fact that most respondents have an academic master's degree as the highest level of education shows that the participants are people related to the energy and mechanical industries.

4.3.1 Understanding EPC data and the generation process

The **purpose and the need for the EPC** are both clearly understood to the audience of the questionnaire. However, a large percentage are not aware of the **indicators related to EPCs** and do not have an opinion on the **visual identify of the EPC**, which implied that they have never seen one. This is confirmed by question 7, as more than half of the people that took part in the survey have not been involved in the process of issuing an EPC. The above clearly highlights the fact that the users do not understand the legal obligation to have an EPC, which is in place since 2009.

Respondents do not seem to be clear about who is entitled to issue an EPC. Since 2010 it is mandatory in Cyprus to issue an EPC for new and extensively renovated buildings. People who did not build a house in the last decade are less likely to be informed about the regulations for the energy efficiency of buildings. Therefore, a large percentage of the participants are not aware about when it is obligatory to have an EPC. In addition to this, there are free online tools for calculating the energy efficiency of a building, which helps to have an idea of how efficient a building is. It is possible that some people might think that this is a legal certificate.

4.3.2 Understanding proposed energy-efficiency measures

People understand that the EPC provides reliable information about the energy performance of a building, which is required for an extensive renovation. The information provided by the EPC varies, as there are two versions. There is the detailed certificate, for professional use, and a simplified version with less technical information, for the end user. For new and renovated buildings, the current EPCs are sufficient. However, for a better understanding of the energy efficiency of energy systems in technical buildings, further improvements are needed, such as the addition of more key performance indicators.

Also, people tend to prefer the use of colours and shapes on an EPC, but there is also a need for explanations. While the audience of the survey was mostly people from academia with high level of understanding, there is still a difficulty with understanding complicated numbers, for example "The carbon emissions of the building are 123,30 kg CO_2/m^2 per year". There could be an equivalent number with an action that people relate to more, for example "This number is equivalent to 2 trips from Germany to the UK by plane."

In the recommendations section of the EPC, there is a short note at the end, stating that for additional practical recommendations and steps that should be followed to achieve the desired energy performance, an expert should be contacted. This section is very important for the end-users and it would be better given by default to everyone.

4.3.3 Usefulness of the EPC

For a majority of respondents, the information provided by an EPC is useful for an extensive renovation of a building. Additionally, they agree with the statement that it contains all the necessary key performance indicators for a proper understanding on the energy efficiency of a building. Even though they understand the usefulness and importance of the EPC, they do not have an opinion on the visual appearance of the EPC. While the average user can get an idea of the efficiency of a building in which they are interested, they do not understand the actual meaning only from the visual representations.

Regarding the value of the property, most of the participants partly agreed that it is not influenced by the score of the energy performance of the building, even though it is known that the energy performance can dramatically affect the cost of a property in terms of repairs, upgrades and maintenance.

An EPC is considered as a useful tool to protect buyers and tenants. Even though it was not popular in Cyprus, the energy efficiency of a building is now becoming a priority for consumers. This might happen because consumers now understand that energy efficiency can dramatically affect their expenses and our environment. It is important to note that in Cyprus it is mandatory by law to show the EPC, not only to future tenants and buyers, but also in advertisements for the property. This

gives consumers the chance to compare similar buildings before they take a decision. Additionally, the suggestion section that comes with the EPC gives them an idea of what can be done in the event that they would like to achieve better energy efficiency.

4.4 Italy

The Italian version of the survey was created starting from the questionnaire provided by the Jožef Stefan Institute and then translated into Italian by Polito.

The link to the survey was sent to Edilclima, Polito and Regione Piemonte contacts that distributed the link to the questionnaire through their social channels and through emails to personal contacts. The communication through social media was published from 1 to 10 December 2021.

Furthermore, Edilclima published a brief article using the company intranet to share the survey with Edilclima employees and consultants. In the period from January to February, Polito again sent the questionnaire using email to direct contacts.

The main contacts of the Italian partners are people working in the fields of energy performance of buildings (Edilclima staff, Edilclima and Regione Piemonte main contacts); academic staff (PhD, professors, researchers) that, even if specialized in other sectors, knows the basics of the EPC procedure; and practitioners working in the field of building and civil design.

If we look at the respondents to the questionnaire (57), there is a male dominance (39 male and 18 female), that is characteristic of this sector, with the majority aged 36-50 (Figure 23).

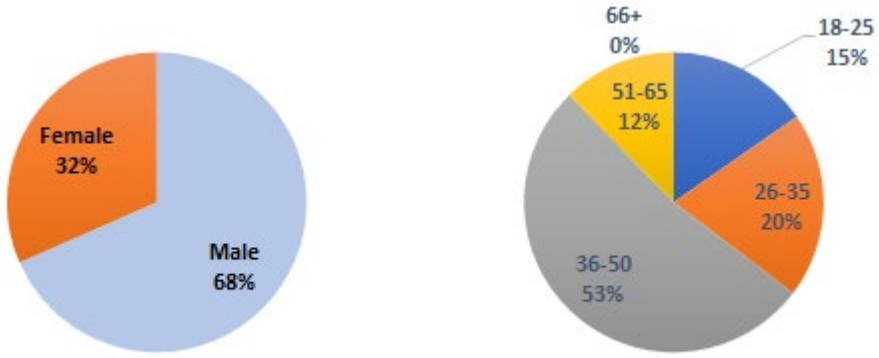

Figure 23. Distribution of the respondents from Italy by gender and age

With regard to the level of education, half of the respondents (51%) are graduates (second-level university degree), 14% have a first-level university degree, while the rest have specialized vocational training (10%), a PhD (10%) or other.

The majority of respondents (67%) have participated in the process of generating an EPC.

4.4.1 Understanding EPC data and the generation process

The purpose and the need of the EPC is clear, and this is reflected in the fact that the main contacts of Edilclima, Polito and Regione Piemonte are working in the field of the energy performance of buildings (almost 80% of the respondents give answers from 4 to 5).

It is also clear that they understand who is entitled to issue an EPC and when an EPC is legally required (more than 70% of the respondents give answers from 4 to 5).

The majority also has a great deal of knowledge about the information provided by the EPC and what the EPC looks like (almost 80% of the respondents give answers from 4 to 5).

Regarding residential EPC prices, on the other hand, the answers are spread from 1 to 5.

Regarding this point, there is a widespread problem, also documented by the answers to the questionnaire, which is directly connected to the collapse in the prices of the certificates. In Italy, the price of an EPC has decreased over the last decade, indicating poor quality due to a lack of inspections, the use of rough calculations and low-quality input data.

4.4.2 Understanding the proposed energy-efficiency measures

Regarding the usefulness of the information provided by the EPC for the extensive renovation of buildings, the majority of the respondents do not seem to be very convinced that the EPC contains useful information.

The recommendations provided in the EPC are affected by the quality of the certificate itself and, if the quality is low (which happens very often in the Italian context), also the recommendations are not very useful to the owners of the building.

Moreover, the recommendations for a building's renovation are calculated through standard or asset procedures. That means, as described in Section 3.4.2, with the standard use of the building and without there being any relation to the real consumption of the buildings.

More reliable information could be obtained using an energy diagnosis and auditing procedure in accordance with EN 16247-2. In this case the procedure would require a greater effort by the qualified technician. But on the other hand, it would result in higher costs for generating the EPC, which can conflict with the principle according to which it must be affordable for the end user.

Regarding the indicators included in the EPC format, half of the respondents are not completely convinced that they are able to describe the overall energy performance of the building. For example, the Italian EPC format does not contain any indicators related to the real energy consumption.

Moreover, the possible use of renewable energy sources is not mentioned. First, the energy classification of the building's energy performance is based on the total amount of non-renewable energy and there is no other indicator considering the renewable part. Second, the calculation methodology does not support the presence of some technologies for RES production or storage (e.g., an electrical battery) and this can penalise some buildings, especially new constructions or refurbished buildings where PV systems coupled with electrical storage are increasingly widespread.

4.4.3 Usefulness of the EPC

The visual identity of the EPC format is clear on the first page of the certificate, when the classification scale and the quality of the building envelope in the winter and summer periods (see description in Section 3.4.3) is presented. Regarding the indicators of the quality of the building envelope (deliberately qualitative and not quantitative), for example, there is an intention to make it understandable to non-experts.

On the other hand, other indicators are not very easy to understand for non-professional users. For example, in the second page there are specific indicators related to the delivered energy calculated for each energy carrier that are expressed as "estimated energy consumption". Obviously, this leads to an incorrect interpretation of these indicators.

Based on the experience of Edilclima (which is familiar with supporting qualified technicians), even experts have doubts about some energy indicators. Of course, this problem is not only related to the quality of the indicators but also to a lack of knowledge of the experts that need to be constantly updated through specific channels.

Regarding the value of the property, the respondents think that this might also be influenced by its energy performance (answers are spread from 3 (26%) to 4 (almost 40%) and 5 (23%)), even though the EPC indicators do not give an overall picture of the building's value. For example, the classification does not consider the possible presence of a BACS (Building Automation and Control System).

Regarding the possibility that an EPC is mandatory for the entire building stock, 32% answered 5, 26% answered 4, and 23% answered 3.

Of course, the more buildings that are certified, the more information is available for the building stock, which can also be used for decision-support planning for building refurbishment.

Regarding the willingness to share data on the technical systems of the building and the actual energy consumption of the building with the certified energy-performance assessor, the answers are evenly spread between 1 and 5.

Certainly, the addition of information relating to the real consumption of the building would add value to the EPC, but it would be necessary to ensure that the data collection and elaboration procedure is as automated and properly regulated so that the extra efforts required for data collection and the additional work by the certifier will not significantly increase the costs of EPC generation.

4.5 Slovenia

Since the Jožef Stefan Institute was in charge for the creation of the questionnaire, the Slovenian version of the survey was created in parallel with the English version. The survey was created with the online tool Google Forms. In addition to the Jožef Stefan Institute, GOLEA and the Ministry of Infrastructure participated in the dissemination of the questionnaire, which was sent by e-mail to different target audiences, from energy and building managers to municipalities and individual building users. The majority of respondents (60%) indicated that they have participated in the process of EPC generation (Figure 24).

The survey was open from 3 December 2021 to 10 January 2022. During that period, 70 responses were received. Only one respondent was not familiar with the EPC. The majority of the respondents are between 35 and 50 years of age (45.7%) and 34.3% between 50 and 65. Only one respondent was in the category of people that are younger than 25 years. Around 81.4% of the respondents are male and 18.6% are female. It is interesting that all the responses (100%) came from highly educated persons (bachelor degree at minimum, 10% of respondents hold PhD), which is also expected since the invitation was sent to preselected target groups. It must be noted that this does not represent the average education level of citizens in Slovenia. The invitation was sent to preselected target audiences to establish direct contact with potential future training audiences and to better understand their needs and expectations. Comments from all respondents will be further evaluated during the design of transversal deployment scenarios and the creation of training materials.

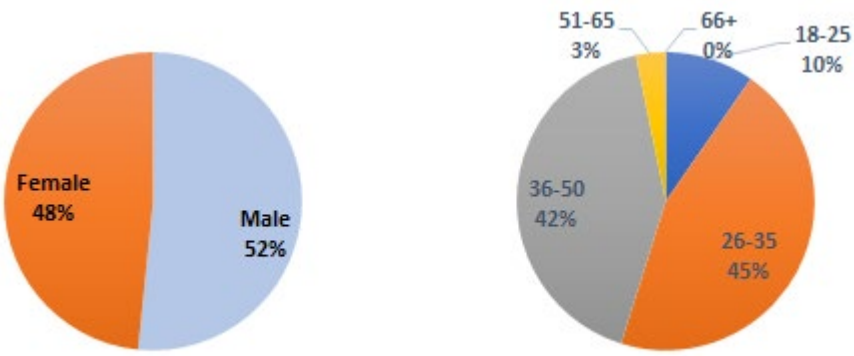

Figure 24. Distribution of the respondents from Slovenia by gender and age

4.5.1 Understanding EPC data and the generation process

Slovenian respondents confirmed that they are very familiar with the purpose and the need for the EPC. More than 90% of respondents gave answers from 4 to 5. This is consistent with the selected target groups that are working in the field of energy efficiency and evaluating the energy performance of buildings (almost 80% of the respondents gave answers from 4 to 5).

Similarly, there is a good level of understanding about who is entitled to issue the EPC, and when an EPC is legally required (more than the 80% of the respondents gave answers from 4 to 5).

Respondents are familiar and have an in-depth knowledge about the information provided by the EPC and how the EPC looks (more than 90% of the respondents give answers from 4 to 5).

However, regarding the price of EPCs, the answers are spread from 1 to 5, where almost 40% gave answers from 1 to 3. In their comments, the respondents clearly outlined that the current level of prices for the generation of an EPC for a building is not sustainable, and it does not provide an appropriate framework for achieving the necessary quality. Unfortunately, there a lot of experts in the market that issue EPCs of questionable quality for an unreasonably low price. This also indicates that there are problems with inefficient inspections and low quality of the input data. It is a positive feature that there are state subsidies for carrying out energy audits in SMEs and buildings, but unfortunately there is relatively low interest for these activities on the demand side (SME and building owners).

4.5.2 Understanding proposed energy-efficiency measures

Regarding the usefulness of the information provided by the EPC for the extensive renovation of buildings, more than 45% of respondents gave answers from 1 to 3 and clearly indicated that they are not convinced that the EPC contains useful information for a major renovation of buildings. In their comments, respondents stated that energy-efficiency recommendations presented on the EPC were too general and without any real usefulness. In the case of the energy renovation of existing buildings, a logical step forward to overcome this obstacle is to connect the generation of EPCs with the energy auditing of buildings and to make the energy-audit report part of the documentation necessary for the application for state subsidies. This will also help building users and owners to get better results for the energy rehabilitation of their properties. It also has the potential to get more energy service companies involved, since their offers for the energy-performance contracting of residential buildings is very limited. Even though recommendations from energy audits will be based on the actual energy consumption, it is important to be aware that they will have to be closely monitored and inspected to provide reliable results. Also, automation of a building's technical systems opens an additional door for the automatic update of the EPC with information from control and management systems, which should be the first step towards a dynamic EPC.

More than 63% of respondents indicated that the EPC does not contain the necessary key performance indicators for a proper understanding of the energy efficiency of technical building's energy systems. For example, the Slovenian EPC does not contain indicators related to renewable energy consumption or at least the potential for the exploitation of renewable energy.

4.5.3 Usefulness of the EPC

The responses of the Slovenian respondents indicated that there is also potential for improving the visual identity of the EPC. More than 43% of the respondents indicated that the visual identity of the energy-performance certificate is not so easy to understand (answers 1 to 3). From the real-life and professional perspectives, it can be said that the average Slovenian citizen interested in renting or buying a property will find it hard to understand the meaning of most of the indicators and data. The increased penetration of e-mobility is putting additional pressure to include elements of smart readiness in the existing EPC. Also, there is a need for more reliable information about the technical systems and the actual energy consumption beyond thermal systems. The EPC should also include more reliable information about control and management systems. This clearly indicates the need for targeted training and educational activities.

Regarding the value of the property, more than 73% of respondents think that energy performance does not have a significant influence (answers are spread from 1 (8.7%) to 2 (37.7%) and 3 (26.1%)). In Slovenia, as in other countries, the value of the property is mostly determined by its location. We must admit that besides the pure rating of the energy performance of a building, all other information presented on Slovenian EPC does not contribute to add value to the property. The EPC does not contain information about advanced systems like PV systems or automatization and control systems or available charging points for electric vehicles that could influence the value of the property.

More than 65% of Slovenian respondents agree on making the EPC mandatory for the entire building stock. In this context it must be added that the majority of respondents think that an energy-performance certificate is useful for protecting buyers or tenants.

The majority of respondents (more than 80%) consider it positive to share data on the technical systems of the building and the actual energy consumption of the building with the certified energy-performance assessor during an energy assessment of a building. However, personal data protection rules must be respected.

4.6 Spain

The Catalan and Spanish versions of the survey were created by the ICAEN and Research Group ARC, Engineering and Architecture La Salle Barcelona Campus. The link to the questionnaire was mainly distributed via newsletters to qualified experts that are responsible for signing EPCs (around 3000 people).

The results of the survey about the knowledge and usefulness of the EPC was determined in Spain from December 2021 until January 2022 (Figure 25). During this period, 156 people participated in the survey. The responses were translated according to the English structure of the questionnaire, and comments and suggestions received with the responses were translated into English.

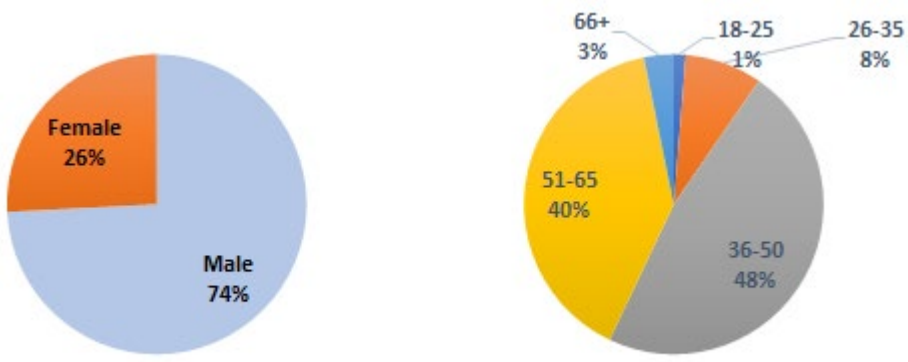

Figure 25. Distribution of the respondents from Spain by gender and age

The analysis reveals a male dominance, which corresponds with the professional situation in the field. The fact that the vast majority of respondents are above 35 years old is probably because young people do not sign the EPC and they are not in the ICAEN database. The high share of university graduates reflects that in order to sign the EPC, it is necessary to be an architect or an engineer.

4.6.1 Understanding EPC data and the generation process

Because the majority of respondents from Spain were people who are signing EPCs, it is obvious that they are familiar with the purpose, the need and have the understanding when an EPC is legally

required. However, it is important to mention that there has been a communication campaign by the ICAEN (social media, short advertising on TV).

Also, the respondents confirmed that they are familiar with the information provided by the EPC and what the EPC looks like.

Regarding residential EPC prices, people know the average price. However, these prices are not regulated in Spain, so they can vary. The last regulation (RD 390/2021) establishes that a visit to the building is compulsory. The previous regulation did not specify this, so there were bad examples of reducing the price for the EPC by avoiding a site visit.

Based on the comments of the survey, the process for energy certifying buildings is seen as a mandatory procedure prior to selling a building or part of a building. For example, the registry receives urgent calls to obtain the energy label to be able to sell or rent at very short. This should not happen because it is mandatory to include the label in all advertising (Royal Decree 390/2021). In addition, there are no inquiries about the interpretation of the certificate itself in the registry. The EPC is technical, with data on transmissions, performance and other technical details that presumably not everyone knows and understands.

For this reason, the Catalonia register sends, together with the energy label, the so-called energy-expenditure report, to facilitate understanding of the data by visually comparing the consumption of the building with the average of those of a similar type (according to climate zone and use) and translating the consumption into euros.

The building energy label (a format common to all of Spain), and the energy-expenditure report that accompanies the label in Catalonia, are presented in Figure 26.

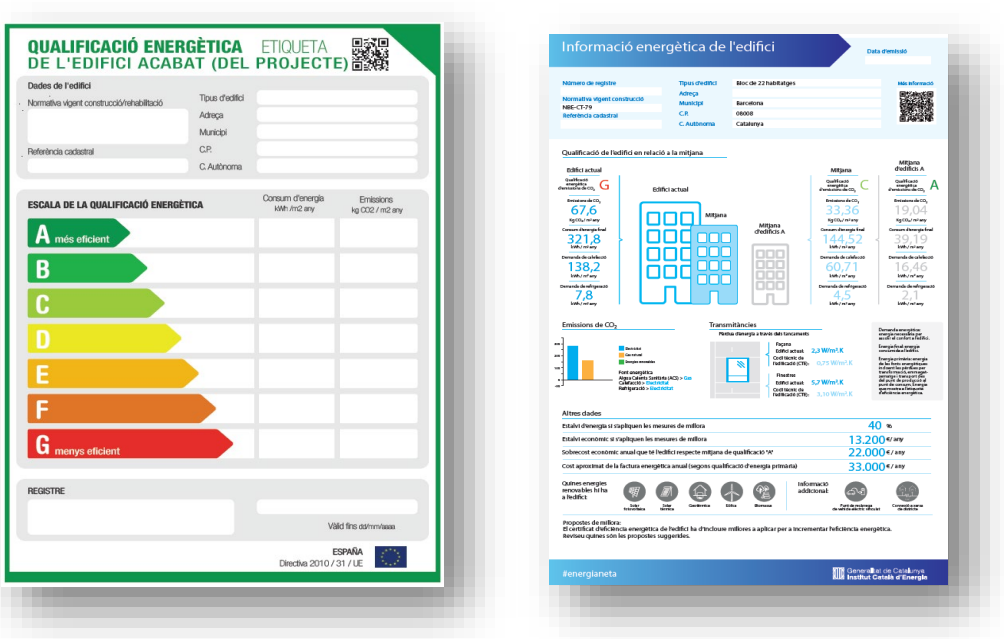

Figure 26. Building energy label (format common to all of Spain - left), and the energy-expenditure report that accompanies the label in Catalonia (right)

4.6.2 Understanding proposed energy-efficiency measures

Like in other countries the usefulness of the information provided by the EPC for the extensive renovation of buildings clearly depends on the quality of the EPC in terms of the method and the input data used.

Some EPC software calculates energy savings and identifies the potential for an improvement of the current energy label. However, all this information is energy related, which is difficult to

understand for the final users. The survey results indicate that it would be useful to develop some models with the main renovation measures.

Also, there is room for improvement in the presentation of technical building systems in the EPC. The most commonly used software for the energy certification of existing buildings is the simplified CE3X tool, which issues a document with improvement measures, calculating the savings and the improvement of the energy rating. A competent expert can include a separate document explaining the proposed measures. In general, this document, if it exists, is usually concise, with little information. The Royal Decree 390/2021 specifies that recommendations for possible interventions to improve the optimal or profitable levels of energy efficiency of a building or a part of it, can address, among others, improvements to the envelope, facilities, automation and control systems, and the most appropriate timetable for carrying out the proposed measures. The recommendations included in the energy efficiency certificate should be technically feasible and should include an estimate of the investment recovery periods, as well as estimates for improvements in comfort, health and well-being conditions. It should also contain targeted information on the cost-effectiveness of the recommendations made in the certificate.

Likewise, this new regulation indicates that the energy certificate must include another document.

4.6.3 Usefulness of the EPC

The visual identity of the first page of the EPC is clear for professional users because the explanation of the displayed indicators is included. However, average users interested in renting or buying a building or building unit will find it hard to understand the meaning of the table of indicators and the meaning of the detailed indicators (transmittance, performance of the installations, etc.). At least, the scale on the first page gives an idea of what is good and what is bad, because people are familiar with the energy-efficiency scale. The EPC could be clearer, perhaps including more text and images, not only numbers.

The value of the property is not defined by the score of the energy performance of the building. The value of the property depends mainly by the location of the building (centre or surroundings of a city). Perhaps, energy performance will be better appreciated when the building renovations become commonplace, and people can compare renovated and old buildings.

The respondents that participated in the survey were divided regarding the potential and real influence of the EPC on protecting buyers and tenants. The energy certificate of a building is usually seen as an unnecessary procedure because at the moment energy efficiency is not an important element in deciding whether to buy or rent one building or another. However, it is positive that there are some policy instruments already in place with the potential to positively change this perception:

- The renovation grants of Next Generation require energy savings.
- The increase in the price of fuels encourages savings and investments in energy efficiency and the exploitation of renewable energy.
- A greater sensitivity towards environmental impacts means that more and more investments are being made in the energy rehabilitation of buildings and the exploitation of renewable energy.

The results of the survey clearly indicated that a future update of the EPC-generation process must include a significant improvement of the training process in order to empower competent technical personnel to produce reliable EPCs. Also, additional improvements must be made to the overall understandability of the EPC data, since the EPC is based on numerical data (transmittances, yields, etc.) that are complex and not very understandable for people not used to them. These improvements should be accompanied by an information campaigns for users. Also, respondents clearly indicated that more attention should be paid to the construction of buildings and preventing the EPC being considered as just being an important paper prior to the introduction of a new tax. Unfortunately, some bad practices, mainly dealing with the unreasonably low prices of the EPC, which have the direct consequence of very low quality of the generated EPC, have been reported.

4.7 Cross-country comparison, main gaps and recommendations for TIMEPAC

This subchapter provides a summary of the critical issues and the recommendations for the future work of the TIMEPAC project. They have been identified during the evaluation surveys carried out in the six EU Member States.

In the majority of cases, building users see the EPC as an unnecessary procedure and they do not appreciate that it can be a useful tool for them when deciding to buy or rent a property. It is clear that to make the EPC an effective instrument for analysing and improving the energy performance of buildings, the quality of the EPC should be enhanced. In fact, one of the major problems in all six countries is the bad reputation and the poor quality of the EPC, thus affecting both the reliability of the energy calculations and the suggestions for extensive renovation. For example, in Slovenia more than 63% of respondents indicated that the EPC does not contain necessary key performance indicators for a proper understanding of the energy efficiency of technical building systems and at the end have a positive influence on the actual energy renovation of a building or verification of the energy savings. Some respondents stated that the EPC is too cheap to provide reliable results. The quality of the EPC-generation process can be improved by reducing the errors made by experts (better control and training of experts) and by improving the accuracy of the energy-assessment models that are currently used for the energy-performance assessment. Experts from all six countries clearly indicated that existing models are not able to properly consider several important aspects that need to be considered during the EPC-generation process (for example, flexibility potential, renewable energy production, availability of storage technologies, presence of energy control and management systems, potential for interactions with other buildings and integration into larger energy systems and renewable-energy communities). To overcome these issues, TIMEPAC should provide advanced training materials and technical procedures for how to upgrade existing static models.

Regarding the indicators in the EPC, it is evident that there is significant room for improvement since existing indicators are not able to describe the overall energy performance of the building in a realistic way. To be more effective and comprehensive, they should be integrated with some indicators describing the real energy consumption (and production). With regard to data availability, it must be noted that smart-metering technologies are advancing very quickly and it is clear that having data will not be a problem. However, we need to be aware that this data must be handled with great care to comply with data-protection regulations. To resolve these issues, TIMEPAC should provide technical procedures for how to include new indicators in the EPC and properly explain their usefulness to end-users.

BIM-based tools could become very useful for collecting and updating the overall information related to buildings (e.g., lifecycle of the building and building components) but some interoperability problems remain. To resolve this issue, TIMEPAC should provide technical guidance to solve the interoperability problems between Building Information Modelling (BIM) tools and Building Energy Models (BEM) tools.

Regarding the EPC format, it is evident that there are some parts that are very understandable, while others are less intuitive. To overcome this, on one hand TIMEPAC could propose new intuitive indicators, while on the other hand training and information activities specific to target users can be organized to fill some knowledge gaps, thus encouraging citizens to become more aware of the actual potentials and benefits of energy renovation. Also, better informed and energy-aware citizens will be more demanding with regard to the quality of energy certificates for buildings.

Furthermore, there is no homogeneous EPC format at the European level since each Member State has a different format. The classification scale also differs among countries, as well as the criteria for assigning a building to a specific class.

Finally, the EPC-generation process should consider consumption beyond thermal systems, as well as real consumption. The survey results revealed that end-users are not strictly against the idea of

sharing data about technical building systems and the actual energy consumption of the building with the certified energy-performance evaluator during the energy assessment of a property.

The energy embedded in the materials should also be considered to be able to analyse the performance throughout the entire lifecycle of the building. At the same time, it must be possible to relate it to the other environmental impacts of the buildings, defined, for example, in the European framework Level(s). People who use the building must also have information about water consumption, materials, waste generation, etc., in order to sustainably reduce their environmental footprint.

The competences of the various governing bodies make it difficult to centralise all the information. The information from energy certificates, technical building inspections, building passports, and environmental impacts measured in accordance with the Level(s) regulatory framework should be connected and exchanged using the appropriate protocol.

5 External context of the energy-performance assessment of buildings

The key objective of the energy-performance assessment of buildings is to provide the necessary background on energy consumption, to support the extensive energy renovation of buildings and to enable informed and cost-effective decisions to be made. This chapter provides a brief explanation of the techniques, approaches and requirements to the energy-performance assessment of buildings. This work can serve as a reference for future TIMEPAC project activities, especially those related to transversal deployment scenarios for using the improved EPCs, to the demonstration scenarios for applying the new certification methods and to the provision of training materials for certifiers to apply them in their practice.

5.1 Energy auditing in buildings

Energy auditing is covered by different European and international standards like EN 16247 or ISO 50002. Regardless of the applied standard or national regulation, an energy audit, if conducted properly and in a comprehensive manner, is a powerful tool for evaluating environmental performance and energy management. The purpose of European and international standards, national laws and regulations related to energy, is to provide a common ground for all stakeholders and to help them to minimize energy use, to sustainably improve energy performance and indirectly reduce the negative effects on the environment. The ultimate aim of an energy audit is also clear. It must provide answers concerning the opportunities to reduce energy consumption and related costs, and at the same time to improve the overall environmental footprint.

The energy auditing of buildings is covered in EN 16247-2:2014 and it has the following elements:

- Preliminary contact.
- Start-up meeting.
- Data collection.
- Field work.
- Analysis.
- Report.
- Final meeting.

According to EN 16247-2:2014, energy auditing includes a comprehensive interaction with the assessed building or process and data collection at various levels. According to the latest proposal of the Energy Efficiency Directive (EED recast, 2021), energy auditing is a periodic activity, and it should be carried out in an independent manner by qualified and/or accredited experts according to qualification criteria or implemented and supervised by independent authorities under national legislation. The EED recast also requires that the audit recommendations should be signed by the management of the company. Regarding the energy audit of buildings, it introduces the obligation to monitor the energy performance of data centres, with the aim to subsequently establish a set of "data-centre sustainability indicators". It also reinforces the provisions of availability on qualification, accreditation and certification schemes for different energy-services providers, energy auditors, energy managers and installers. Finally, it is important to mention that according to the latest proposal of the Energy Performance of Buildings Directive (EPBD recast, 2021) Member States must plan financial measures for energy-performance improvements in the renovation of buildings to the targeted or achieved energy savings, as determined by one or more of the following criteria:

a) The energy performance of the equipment or material used for the renovation; and in which cases, the equipment or material used for the renovation is to be installed by an installer with the relevant level of certification or qualification and will comply with the minimum energy-performance requirements for building elements.

b) Standard values for the calculation of energy savings in buildings.
c) The expected improvement achieved through the renovation, by comparing energy-performance certificates issued before and after renovation.
d) The results of an energy audit.
e) The results of another relevant, transparent and proportionate method that shows the improvement in the energy performance.

According to the EN 16247-2:2014, during the energy audit the auditors must conduct an analysis that will deliver at least:

a) For each building service a comparison of the actual against the appropriate level of service (such as indoor environmental criteria, etc).
b) An evaluation of the actual performance of the technical systems against a suitable reference.
c) An evaluation of the performance of the building envelope.
d) An evaluation of the energy performance of the whole building, considering the potential interaction between technical systems and the building envelope.

An energy audit is important because it identifies the corrective actions and investments that need to be implemented to improve the existing energy performance of any technical system or building as whole. The results of the energy audit are recommendations for energy-performance improvements that tie together various aspects of the energy performance:

- People and their motivational and training needs.
- Housekeeping, operation and maintenance-procedure improvements.
- Technical building systems' efficiency improvements.
- Efficiency of energy supply, distribution and consumption.

According to EN 16247-2:2014, the emphasis must be on the performance of the building as whole, and not only on single aspects of the efficiency of a particular technical system. When considering the improvements, the energy auditor will also evaluate the potential impact that energy-saving interventions will have on the ratings of the energy-performance certificates. Another important area that is considered by an energy audit is the minimization of waste through its reuse, recovery or recycling.

Unfortunately, in practice an energy audit is often reduced to a quick check of the efficiency of the main technical systems or even single devices, such as boilers or chillers, thus ignoring the performance of the building as whole. It is obvious that a simplified form of audit can yield only partial results and cannot provide reliable information for a comprehensive and extensive energy renovation of a building. In the case that the energy audit is conducted before the generation of the EPC, its main findings and results should be critically reviewed and, if appropriate, included in the EPC and presented to the owners or tenants. Moreover, using the energy audit as tool for the generation of EPCs will improve the overall quality and reliability of the certificate and the proposed energy-efficiency measures, but will also increase the costs of the EPC.

These issues will be addressed in the TIMEPAC Transversal Deployment Scenario 3 "Creating Building Renovation Passports from data repositories" and Transversal Deployment Scenario 4 "Integration of Smart-Readiness Indicators and sustainability indicators in EPC". In these scenarios the audit reports for all the selected buildings will be critically reviewed to assess their applicability and whether they should be included in the building-renovation passports or be used for the calculation of smart-readiness and sustainability indicators in new and enhanced EPCs.

5.2 Inspections of technical systems in buildings

Inspections of technical building systems are covered by national laws and regulations as well as by different international standards. They are carried out for functional, safety or security reasons. In the context of an improvement of the energy performance of buildings, it is clear that it is necessary to follow an integrated approach, considering measures both on the building envelope and on the technical building systems. According to the latest proposal of the EPBD recast, the energy performance of a building must be determined on the basis of calculated or actual metered energy use and must reflect typical energy use for space heating and cooling, domestic hot water, ventilation, built-in lighting and other technical building systems. Also, it is very positive that the regulation explicitly recognises that energy-performance requirements for technical building systems should apply to whole systems, as installed in buildings, and not to stand-alone components. In fact, this is not a new requirement, but compliance with it has been weak so far and it is now mandatory.

Checking technical systems regarding their energy performance is crucial in all type of buildings. In the context of EPC generation, the certified expert will benefit from the results of inspections of technical building systems. In many cases, especially for complex buildings with many different systems having self-regulating devices, existing inspection guidelines, standards and regulations also target the energy performance of the building as a whole. Certified experts with access to data provided by building automation and control systems (BACS) can identify significant energy savings and potential for an improvement of the indoor environment. According to the latest EPBD recast, BACS systems must be capable of:

- Continuously monitoring, logging, analysing and allowing adjustments in energy use.
- Benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy-efficiency improvements.
- Enabling communication with connected technical building systems and other appliances inside the building, and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers.

Furthermore, the EPBD recast foresees that until 31 December 2024, in all cases where it is technically and economically feasible, non-residential buildings with an effective rated output for heating systems or systems for combined space heating and ventilation of over 290 kW should be equipped with building automation and control systems. This can significantly improve the energy performance of technical systems in buildings, since the data-collection processes will be much easier and modern techniques of monitoring and targeting can be applied.

In short, insights and recommendations from the inspection of technical systems in buildings need to be critically reviewed during the process of EPC generation and presented to the owners or tenants. In TIMEPAC Transversal Deployment Scenario 3 "Creating Building-Renovation Passports from data repositories", available inspection reports for all the selected buildings will be critically reviewed in order to assess their applicability and to what extent their findings should be included in building-renovation passports.

5.3 Re-commissioning

Retro-commissioning or re-commissioning (Re-Co) is the expression used to describe an energy-system operation-optimisation service in existing buildings (California Commissioning Collaborative, 2006). The decision to recommission can be triggered by a change in building use, ownership, a high energy consumption or to resolve some operational problems (Bjørnskov et al., 2022). It focuses on improving the overall performance of a building by investigating and improving how systems operate together. It consists of a rapid energy audit of the buildings, focused on a check and re-set of the energy system's operating parameters, the training and motivation of the building's users and operators and establishing a proper energy-management system in buildings for progress evaluation

and validation. It is a common and well-known practice in the United States of America and Canada. Unfortunately, in Europe Re-Co activities are not standardised and there are no regulations or guidelines on how to carry them out.

Experiences from the EU-funded project IEE/10/328 (Re-Co): "Re-Commissioning – Raising Energy Performance in Existing Non-Residential Buildings (Hospitals, Universities, Office Buildings)" revealed that the optimisation of the operation of energy systems in existing buildings has a huge potential to decrease energy consumption (Plesser et al., 2014). The developed Re-Co methodology was applied to a series of pilot projects, targeting at total savings of 10% of final energy. The project was carried out by 10 partners from 8 European countries, Germany, Austria, Czech Republic, Slovenia, Croatia, Norway, Finland and Belgium. A detailed analysis of all the pilot projects that were conducted showed that it was realistic to expect a 10 to 15 % decrease in energy consumption in complex buildings with the payback period for the executed measures being 1 year or less. The detected high energy consumption was partly due to inefficient operation, inappropriate settings of the control devices and the delayed detection of faulty systems and components in the buildings, which resulted in both increased operational costs and CO_2 emissions. These savings were revealed through the systematic recommissioning of building energy systems, monitoring and targeting and comparing the existing with the expected performance. Based on the operational experience from the Slovenian pilots in the Re-Co project, it was concluded that key barriers to the efficient optimization of energy systems' operation in existing buildings are the lack of knowledge of the building operators and service providers and the absence of a systematic approach (approved methodology, services and proper incentives). It was proved during several projects of public building retrofit (financed by cohesion funds) that after the implementation, several critical mistakes were identified (wrong or incomplete installation of equipment parts, especially of new, modern electronic parts), several energy systems (especially HVAC systems) were not operating properly or were even switched off as they disrupted the building's users. From the service providers' point of view, it was concluded that the Re-Co approach and services have the potential to become an attractive business for engineering service providers. Key factors are teamwork with the maintenance personnel, a good selection of buildings and a focus on effective measures. Even though they might give rise to some additional costs, Re-Co services can be carried out successfully and be a cost-effective part of the EPC-generation process because they will generate additional benefits for the owners and building users.

In Transversal Deployment Scenario 2 "Enhancing EPC schemas through operational data integration" and Transversal Deployment Scenario 4 "Integration of Smart-Readiness Indicators and sustainability indicators in EPC", field surveys of all the selected buildings will be carried out to assess the applicability of the Re-Co services during the EPC-generation process. Additional training and motivation of the building operators and users for the proper use and management of installed equipment will be included in the TIMEPAC Academy. To enable the exchange of knowledge and experiences related to the re-commissioning of existing buildings, cooperation with partners in the LIFE IP Care4Climate project will be established.

5.4 International assessment and certification schemes

Nowadays, there are many national and international assessment and certification schemes for assessing building energy performance and to promote energy efficiency in buildings, together with better indoor comfort for the building's occupants. The most important and widespread are the following:

- BREEAM, United Kingdom, https://www.breeam.com.
- ASHRAE's Building EQ Portal, United States of America, https://www.ashrae.org/technical-resources/building-eq.
- Deutsche Gesellschaft für Nachhaltiges Bauen – DGNB (German Sustainable Building Council), Germany, https://www.dgnb-system.de/en/buildings.

- ENERGY STAR – U.S. Government-backed symbol for energy efficiency, United States of America, https://www.energystar.gov/buildings?s=mega.
- HQE - France's reference certification scheme, France, https://www.behqe.com/.
- Leadership in Energy and Environmental Design - LEED, United States of America, https://www.usgbc.org/leed.
- LiderA – voluntary sustainability assessment system for the support and development of sustainable solutions that assigns, in case of proven environmental performance, Portugal, https://en.lidera4all.com/.
- Passive House, Germany, https://passivehouse.com.

Due to the worldwide alert caused by the COVID-19 pandemic, it is important to mention the international assessment and certification scheme that was designed by the World Organization for Safety and Health in Indoor Environment (WOSHIE), an organisation that promotes health protection to people in indoor environments.

During the work on the development and implementation of the Transversal Deployment Scenario 4 "Integration of Smart Readiness Indicators and sustainability indicators in EPC", all the above-mentioned international assessment and certification schemes will be evaluated and suitable indicators with the potential to be included in the enhanced EPC generation process will be critically reviewed. These indicators will be assessed by the key EPC stakeholders (EPC developers, building owners, building managers and national certification bodies) and compared with those selected from Level(s) framework. It is expected that the list of the most significant indicators that could potentially give added value to existing EPCs will be created.

5.5 Main gaps and recommendations for TIMEPAC

The context in which the assessment of the energy performance of buildings will be carried out in the future has increased in complexity. There are many different tools, approaches, assessments and certification schemes that need to be interrelated with the ultimate goal of improving building energy performance. We must be aware that the successful realization of performance improvements is the result of consecutive decisions about improvements to the operational effectiveness and of actions based on an active search for knowledge and understanding, rather than the result of an isolated and instantaneous event, i.e., issuing a certificate. In that context, an enhanced EPC must include a new set of energy and environmental performance indicators that will empower owners, occupants and technical staff to assess and improve the operating efficiency by identifying operational opportunities that will create improvements of one or more important elements of the building.

As for the TIMEPAC project, the main challenge is how to incorporate the positive elements of all the identified tools and approaches without making the EPC-generation process too complex and costly for the final users. During the definition and implementation of the Transversal Deployment Scenarios these elements must be closely monitored and documented. A trade-off between extra costs and the obtained benefits must be objectively evaluated. An enhanced EPC-generation process must result in more reliable EPCs and they must ultimately provide a framework for the extensive energy renovation of buildings. In this regard, one of the biggest challenges of the TIMEPAC project is to include energy-consumption data and targeted specific energy-saving measures identified by other tools and approaches (for example, from an energy audit or technical inspection reports) into the enhanced EPC.

6 Conclusion

The work carried out in Task 1.1 of TIMEPAC and presented in this report included the analysis of the deficiencies of current EPC-generation processes across six participating countries. The partners analysed and compared certification approaches, models and tools used for the EPC generation at the national level. Experts from all six Member States indicated that existing models are not able to properly take into account many important aspects that need to be considered during the EPC-generation process for today's modern buildings. To capture relevant information about the actual understanding of the EPC-generation process from the end-user's perspective and to better understand their needs and expectations, a survey was conducted in all six participating countries. The analysis of the responses revealed that there are many aspects to improve, related to the value and quality of the certificate, and how it should be related to a more specific view of the building-renovation process. Experiences from the energy-performance certification of non-residential buildings in Slovenia are a clear indication that a dynamic rating based on actual consumption data could be a step forward. The integration of operational data is crucial for improving the quality, reliability and usability of EPC. In this context, it is vitally important to take an additional step and capture the energy consumption of all the technical systems in buildings. Using the available information about the actual energy consumption of the entire building will reduce the performance gap and will provide relevant information for the end-user. It is also necessary to address all the current challenges related to the extensive renovation of the EU building stock, the exploitation of RES, raising awareness among building owners and occupants, verification of actual savings, e-mobility, renewable energy communities, etc. However, we need to be aware that the proposed changes will require additional efforts from certified experts, which means that a dynamic and comprehensive EPC will probably be more expensive, but in the end it will also provide additional benefits to the end users interested in the extensive renovation of their buildings. These experts will need specific training the take advantage of the possibilities that enhanced EPCs might offer.

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Annexes

Annex A – Master version of the survey for assessing EPC generation in the context of end-user's requirements

Email text:

Dear Madam/Sir

Jožef Stefan Institute – Energy Efficiency Centre is reaching you as part of the EU funded H2020 project TIMEPAC - Towards innovative methods for energy performance assessment and certification of buildings (grant agreement ID: 101033819). The project consortium involves partners from seven member states with a wide spectrum of competencies: Fundació Privada Universitat i Tecnologia (Spain), Jožef Stefan Institute – Energy Efficiency Centre (Slovenia), Politecnico di Torino (Italy), Institut Català d'Energia (Spain), CYPE Soft S.L. (Spain), Ministry of infrastructure (Slovenia), GOLEA - Goriska Local Energy Agency (Slovenia), European Science Communication Institute, GmbH (Germany), Edilclima, S.r.l. (Italy), Regione Piemonte (Italy), SERA global GmbH - Institute for Sustainable Energy and Resources Availability (Austria), Energy Institute Hrvoje Požar (Croatia) and Cyprus Federation of Employers & Industrialists (Cyprus).

The main objective of the TIMEPAC project is to develop and test innovative methods for energy performance assessment and certification of buildings. TIMEPAC will also contribute to improving existing energy certification processes, moving from single, static certification to more holistic and dynamic approaches, which consider:

- *the data generated in the overall energy performance certification process;*
- *buildings as part of a built environment; and*
- *buildings as dynamic entities.*

For this reason, it would be great and very useful for our project if you can spend a few minutes of your time and provide us with your view on energy certification of buildings. We think that a survey would be an opportunity for the partnership to understand better end-users' needs which will guide us in our future work.

CLICK HERE TO START THE SURVEY

* = mandatory questions

First part – general questions for understanding background of the participant

1) **Where are you from?** (open) *
2) **Age** (18-25; 26-35, 36-50, 51-65, 66+) *
3) **Gender** Female, Male, other
4) **Which is your educational level?** (Academic bachelor degree, Academic master degree, Advanced bachelor programme, Advanced master programs, Doctoral degree, Higher vocational education, Professional bachelor degree, Professional qualifications, other)*

Second part – Understanding EPC

Questions:

1) **Do you know what is the purpose of the energy performance certificate of the building?**

   (from 1 to 5) 1 Completely unaware, 2 Mostly unaware, 3 Neutral 4 Partly aware, 5 Completely aware

2) **Do you know why do we need the energy performance certificate of the building?**

   (from 1 to 5) 1 Completely unaware, 2 Mostly unaware, 3 Neutral 4 Partly aware, 5 Completely aware

3) **Do you know in which situation is obligatory to have the energy performance certificate of the building?**

   (from 1 to 5) 1 Completely unaware, 2 Mostly unaware, 3 Neutral 4 Partly aware, 5 Completely aware

4) **Do you know who is issuing the energy performance certificate of the building?**

   (from 1 to 5) 1 Completely unaware, 2 Mostly unaware, 3 Neutral 4 Partly aware, 5 Completely aware

5) **Do you know which information contains the energy performance certificate of the building and how it looks like?**

   (from 1 to 5) 1 Completely unaware, 2 Mostly unaware, 3 Neutral 4 Partly aware, 5 Completely aware

6) **Do you know what is the average price of energy performance certificate of a typical building in your country?**

   (from 1 to 5) 1 Completely unaware, 2 Mostly unaware, 3 Neutral 4 Partly aware, 5 Completely aware

7) **Do you think that energy performance certificate contains useful information that are necessary for deep renovation of building (list of energy efficiency measures)?**

   (from 1 to 5) 1 Not agree, 2 Mostly not agree, 3 Neutral 4 Partly agree, 5 Completely agree

8) **Do you think that energy performance certificate contains all necessary key performance indicators for a proper understanding of energy efficiency of technical building energy systems?**

   (from 1 to 5) 1 Not agree, 2 Mostly not agree, 3 Neutral 4 Partly agree, 5 Completely agree

9) **Do you think that the visual identity of energy performance certificate is understandable to the final users?**

   (from 1 to 5) 1 Completely not understandable, 2 Mostly not understandable, 3 Neutral 4 Partly understandable, 5 Completely understandable

10) **Do you think that the value of the property is defined by the score of the energy performance of the building?**

    (from 1 to 5) 1 Not agree, 2 Mostly not agree, 3 Neutral 4 Partly agree, 5 Completely agree

11) **Do you think that the energy performance certificate should be defined for the entire building stock?**

    (from 1 to 5) 1 Not agree, 2 Mostly not agree, 3 Neutral 4 Partly agree, 5 Completely agree

12) **Do you have any problems with sharing data about technical building systems and your actual energy consumption with the certified energy performance evaluator during the energy assessment of your property?**

    (from 1 to 5) 1 Not agree, 2 Mostly not agree, 3 Neutral 4 Partly agree, 5 Completely agree

13) **Do you think that the energy performance certificate is useful for the protecting buyers or tenants?**

    (from 1 to 5) 1 Not agree, 2 Mostly not agree, 3 Neutral 4 Partly agree, 5 Completely agree

14) **Have you ever participated in the process of generation of energy performance certificate of building?**

    Yes/No

15) **Suggestions and comments**

    Box 500 characters