ePANACEA

Smart European Energy Performance Assessment & Certification

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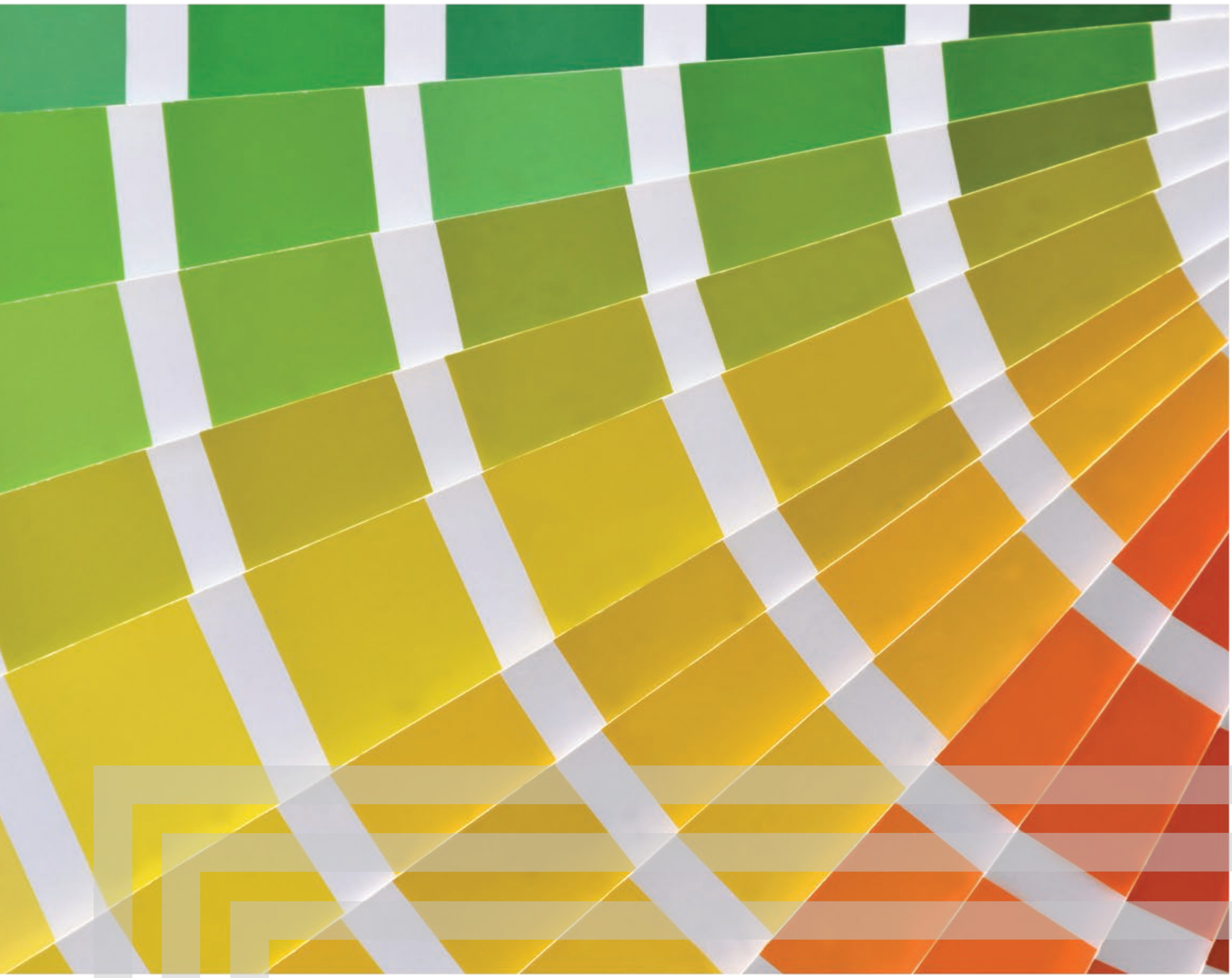

Description of current Energy Performance Certificates (EPCs) related policy framework in implementing countries

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HISTORY OF CHANGES

Version	Month Year	Organisation	Comments
1.0	04.2021	TUW	First draft with open questions to implementing countries
1.2	04.2021	CRES/CENER	Review comments
1.3	05.2021	TUW	Final version including internal review comments
1.4	05.2021	All partners	Final version after review from CENER und CRES
1.5	31.05.2021	CENER	Final revision by CENER

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OVERVIEW OF THE ePANACEA PROJECT

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

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

ePANACEA comprises the creation of a prototype (the Smart Energy Performance Assessment Platform) making use of the most advanced techniques in dynamic and automated simulation modelling, big data analysis and machine learning, inverse modelling or the estimation of potential energy savings and economic viability check.

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

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

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

EXECUTIVE SUMMARY

The EPDB is the most important policy directive at the EU level that defines the directive of the energy performance of buildings in the EU-Member States. The EPBD 2018/844/EU Article 2e introduces the EPCs (Energy Performance Certificate of buildings and units) as an instrument to provide building energy performance information. Over the past years, EPCs have developed increasingly and still play an important role in the political context of decarbonisation of the building stock.

This report presents an overview of the current policy framework of EPCs, and how some aspects of the EPBD have been implemented in the implementing countries Austria (focus Styria), Belgium (focus Flanders), Germany, Greece, Finland and Spain. To develop the present report, ePANACEA project partners were invited to respond to a questionnaire (with about 60 questions) that covered the following topic areas related to the EPCs and buildings related topics: environment, recommendations, end-user perception, technology uptake, energy assessment and rating system. By reviewing the current state, this report prepares the ground for future project activities, which are: the development of possible pathways how the policy framework could evolve in the future and the analysis and estimation of future replication potential of EPC results and the corresponding impact. That will be included in the project report “Pathways of EPC related policy framework”.

Besides the description of the current state, this report also provides insights about possible future perspectives according to current national political discussions and implementing partner’s expertise. Complementary to this report, other reports also provide information about the current state:

- Report on the use of innovative certification schemes and their implementation
- Guidelines on how national EPC schemes and SRI could be linked
- Report on the use of (energy) data within EPC schemes
- Report on the current status of national plans, schemes and initiatives on building renovation passports
- 1st REBs conclusions report

This report is structured as followed: chapter 1 presents a short introduction about the country-specific EPC framework, chapter 2 presents the current state of each topic area and in each country and chapter 3 presents the future perspectives of each area. Finally, chapter 4 presents the main conclusions of both topics.

GLOSSARY

ARA	The Housing Finance and Development Centre of Finland
BACs	Building Automation and Control System
BRP	Building Renovation Passports
BEMs	Building Energy Management System
BMWi	Bundesministeriums für Wirtschaft und Energie (Eng.: Federal Ministry for Economic Affairs and Energy)
CCAA	Autonomous Communities
DHW	Domestic hot water
EEM	Energy Efficiency Measure
EnEV	Energieeinsparverordnung (Engl.: Energy saving regulation)
EPC	Energy Performance Certificate
EPBD	Energy Performance of Buildings Directive
EU	European Union
EV	Electric Vehicle
DIBt	Deutsches Institut für Bautechnik
GEG	Gebäudeenergiegesetz (Engl.: Building Energy Act)
GDPR	General Data Protection Regulation
iSFP	inviduelle Sanierungsfahrpläne (Engl.: individual renovation roadmap)
KfW	Kreditanstalt für Wiederaufbau (Engl.: Reconstruction Loan Corporation)
LTRS	Long-term renovation strategies
MFHs	Multifamily houses
MSs	Members States
nZEB	nearly zero energy building
VEKA	Flemish Energy and Climate Agency
REBs	Regional Exploitation Boards

1. EPC FRAMEWORK – ePANACEA IMPLEMENTING COUNTRIES

This chapter presents a short overview of the EPC policy framework of each national country. It introduces how the EPBD is implemented, which are the roles and responsibilities between national and regional authorities and presents, if applicable, some national singularities in the organization

1.1. Austria

In **Austria**, the EPC is a legally binding certificate for all federal states, presenting the energy-related indicators of a building as well as their calculation procedures. The content is defined by the Austrian Building Code (OIB-RL 6 or OIB Directive 6) and some specifications for the EPC are standardized for the whole country (Nationalrat, 2021). Nevertheless, the federal regions can adapt their EPC scheme, generating differences and singularities between the states. The Austrian regions are Burgenland, Carinthia, Lower Austria, Salzburg, Styria, Tyrol, Upper Austria, Vienna and Vorarlberg. Some regional energy agencies are responsible for handling the regional EPC Database (when available) and may support the public authorities in the analysis of the data. As the 9 federal provinces of Austria are responsible for the building legislations, there is a slightly different EPBD implementation in terms of EPC input data and calculation. In the present document, the focus will be on the region of Styria.

1.2. Belgium

In Belgium, the energy performance of buildings and the energy performance certification is mandated to the regions. The implementing provisions of energy performance certification of buildings are different in the three regions. The information in this document is related to Flanders; one of the regions in Belgium.

In Flanders, EPC for new residential buildings came into force in 2006 (Energy Performance of Buildings Decree of 22/12/2006). EPC for new offices and schools came into force in 2006 and for all new non-residential buildings from January 2017. The EPC of new buildings is linked to the building permit application. EPC for existing residential buildings that are put into the market for sale came into force from November 2008 and for rent from January 2009, together with the EPC for existing public buildings. The EPC for small non-residential buildings started in January 2020. The EPC for common parts of apartments will be required from January 2022 with a delay to January 2024 allowed for part of the stock due to the corona crisis. The EPC for existing large non-residential buildings is in development.

For all of these application domains, some distinct methodologies and tools are managed by VEKA. For instance, the energy performance of existing public buildings is based on measured energy use, while for all other domains it is based on calculated energy use. For residential buildings, the energy performance is determined based on the residential unit, e.g. an apartment in a multifamily house. VEKA also is responsible for the education of EPC practitioners, quality control and evaluation of EPCs and the implementing framework

1.3. Finland

In Finland, EPCs were introduced at the beginning of 2008, based on the Energy Certification of Buildings Act. Legislation to implement the requirements of the EPBD (Directive 2010/31/EU) was adopted at the beginning of 2013 and came into force in June 2013. All requirements apply to private and public buildings (residential, commercial and public). EPCs are needed for all new buildings, along with the building permit application, including public buildings. For existing buildings, an EPC is needed when the building (or a part of a building, e.g., an apartment) is sold or rented. Energy performance certificate extends to the whole building or a significant portion of the building if the building has multiple usage areas. Single apartments are not certified separately. The Ministry of the Environment is responsible for legislation and guidelines regarding EPCs, EPC templates and other instructions concerning the issuance of certificates. The EPC is produced by a qualified expert. The ARA is the administrative authority ensuring the quality of certificates and qualified experts and the appropriate preparation and use of the EPCs. As the responsible authority, it can also make compliance checks of issued EPCs. Energy performance is based on overall primary energy consumption (kWh/m^2.year), taking the energy source (primary energy factor) into account. Primary energy factors for energy sources are fixed in the Governmental Decree.

1.4. Germany

In Germany, the issuance, use and principles of the EPC are regulated in the EnEV (Energieeinsparverordnung; Engl.: Energy Saving Ordinance) which is German law. From May 1, 2021, the issuance of energy certificates is regulated by the GEG (Gebäudeenergiegesetz; Engl.: German Energy Act). Hence, the implementation of the EPC in Germany happens on a national level. The 16 federal countries of Germany are responsible for the quality check of the registered EPCs. The energy certificate is mandatory for new constructions since 2002 and since 2008 homeowners have to present the EPC to new tenants and owners, making the EPC also applicable to existing buildings.

There are slight differences between the EPC issued for residential and non-residential buildings. Besides, the EPC can be distinguished in terms of another aspect: the EPC can be generated based on the calculated energy demand or based on the measured energy consumption. Generally, there is freedom of choice; a demand-based EPC is only required in the following cases:

- Multi-family houses with less than five residential units that do not yet comply with the Wärmeschutzverordnung (Engl.: Thermal Insulation Ordinance) from 1977;
- New buildings - there is no data about the energy consumption of the last 3 years available;
- After the facade has been subsequently insulated or if more than 10 per cent of the surface of an external building element has been renewed (energy consumption data of the last 3 years must be available).

1.5. Greece

In Greece, the Ministry of Environment and Energy (YPEN) is responsible for the implementation of the EPBD. The adoption of the Directive 2010/31/EU was approved by the Greek Parliament in February 2013 under Law 4122/2013 “Energy Efficiency of Buildings - Harmonization with Directive 2010/31 / EU of the European Parliament and the Council and other provisions”. From 9 July 2015, Law 4122, among others, reduces the limit of floor area to attain an EPC in public buildings to 250 m^2 (in force since 9 July 2015) and sets control mechanisms for quality control of the issued EPCs and inspection reports.

The EPC is a legal document that must be issued in each new rental or sale transaction. In addition from the beginning of 2021, the EPC should be issued before any rental or sale transaction and the energy class must be displayed in all commercial advertisements. The content of the EPC is defined in the technical guidelines (T.O.T.E.E.20701-4/2017) and it is the same for all building uses.

1.6. Spain

In Spain the certification is regulated through RD 235/2013, and the implementation is carried out at the national level. However, the registration, control and inspection of the certificates correspond to each of the Autonomous Communities and autonomous cities in Spain.

The obligation to certify new buildings dates from 2007 and for existing buildings since 2013. This obligation falls whenever there is a sale or rental of a property, or in the case of Administration buildings.

The methodology is based on the calculation of the annual energy and emissions of the building, through an hourly calculation. The main differences between residential and non-residential buildings consist in the analysis of the lighting and ventilation systems for non-residential buildings, as well as in the choice of the conditions of use of that non-residential building, which in the case of residential buildings are set by regulations for energy evaluation.

2. CURRENT STATE

This chapter of the current state describes briefly per country EPCs and buildings related topics: recommendations, end-user perception, technology uptake, energy assessment and rating system. By reading the document, it should become more transparent, which are the country-specific differences and singularities.

2.1. EPC environment

Under the topic EPC environment following areas have been considered: EPC issuing activities, EPC databases, quality control of EPCs (in the database and/or issuing program), the validity of the EPC, costs of the EPC (including aspects related to the on-site visits and ownership rate (to understand the potential of different EPC issuing proposes – real estate transaction (sell, buy and rent transactions) and deep renovation).

2.1.1. Austria (Styria)

2.1.1.1. EPC issuing activities and databases

The EPC is issued in both formats: PDF and XML (machine-readable). Figure 1 shows that there are three different EPC databases used by six (out of nine) federal states. While Vienna (WUKSEA database) and Vorarlberg (EAWZ database) have their databases in place, the four provinces of Burgenland, Carinthia, Salzburg and Styria are working with the same system ZEUS.

Figure 1: Spatial allocation of different EPC databases used by the federal states of Austria (ArchiPHYSIK, 2020)

Besides the Austrian federal provinces databases, there are other EPC databases in Austria. For example, from the federal real estate company (Bundesimmobiliengesellschaft). Furthermore, there is one federal database managed by the Austrian Federal Statistical Office (Statistik Austria). The EPC database from Statistik Austria stores the values (and output data from the calculation procedures) available in the EPC (according to the requirements of the OIB-RL 6) – for example, energy supply system, type of space heating, hot water supply system, type of energy carrier and type of ventilation. However, none of them can be publicly accessible (Geissler et al., 2016). The EPC database ZEUS[1], operating since 2007, which is currently used in the provinces of Styria, Salzburg, Carinthia and Burgenland includes approx. 200.000 EPCs. From that, the ZEUS-Salzburg has about 80.000 EPCs (according to an exchange from the EPC database manager). The Styrian Energy Agency controls a

[1] Accessible at www.energieausweise.net

statistically significant sample size of the EPCs issued every year. For this sample, the most common EPC building type in 2020 was the SFH (76%), the MFH (16%) and non-residential buildings (8%). The ZEUS Database stores building input data and also the output from the calculations.

2.1.1.2. Quality assurance and control

In Austria, the respective federal state decides on the exact procedure of carrying out quality checks. It is common to delegate this obligation to a local energy agency. In the federal state of Styria, the Directive 2010/31/EU (EPBD) was transposed into federal law in 2014 ("Steiermärkische Baugesetznovelle 2014"). The Styrian Energy Agency controls a statistically significant sample size of the EPCs issued every year. If mistakes or faults are detected, the energy expert is required to recalculate the EPC and resubmit it again at his costs. The competent authority issues the permission to construct or renovate a building only when the controlled EPC has been corrected.

2.1.1.3. Validity and Costs of EPC

The EPC is valid for ten years. The costs for EPCs are not regulated in Austria. This is because the workload required calculating an EPC cannot be generally assumed. The calculation highly depends on various factors (e.g. type and complexity of the building, existence and level of detail of plans and building-related documents, requirements for on-site inspection). Since there are general regional price differences as well as there is a variety of institutions offering the service of calculating EPCs (e.g. architects, engineers), the price is a result of market conditions (high-quality EPCs - all prices incl. VAT 20%):

- Single Family House: approx. 450€
    - Usually, it's something like 3 €/m² gross heated area plus a basic fee (approx. 200-250€)
    - Timing: 2-3 hours (plus on-site visit, if possible/necessary)
- Larger residential buildings (1.000 m² gross heated area):
    - 1 €/m² gross heated area plus a basic fee (approx. 200-250€)
    - Timing: 3-8 hours (plus on-site visit, if possible/necessary)
- Non-residential buildings (5.000 m² gross heated area):
    - 0,5 €/m² gross heated area plus a basic fee (approx. 400-500€)
    - Timing: 8-16 hours (plus on-site visit, if possible)

The complexity of the building's HVAC system and availability of data are considered the main factors to determine the EPC cost. In the case of having an on-site visit, the work hours and travel expenses influence the cost. There are significant differences in the costs to the building use (hospital, school, residential).

2.1.1.4. Ownership rate

The ownership rate of residential dwellings is Austria 48,5%. The ownership rate is the share of primary residence households that live in house or apartment ownership. The rental rate is the share of all types of rental housing in all main residential dwellings. According to the Central Population Register (ZMR), at least one person is registered as a principal residence, making it the usual place of abode of at least one person. The home ownership rate is an average of all nine federal states. There are some considerable differences between the individual federal states. While the home ownership rate in Burgenland is 69,1%, it is just 18,8% in Vienna. This is certainly also because the purchase prices for condominiums and houses are highest in Vienna and lowest in Burgenland in an Austrian comparison (Wöhrmann, 2020).

2.1.2. Belgium (Flanders)

2.1.2.1. EPC issuing activities and databases

In Flanders Region, in Belgium, EPCs are mandatory for existing residential and small residential building units for real estate transaction (sale or rent), common areas in MFHs, existing public buildings with floor area exceeding 250m², and for new and renovated buildings and deep energetically renovated buildings is mandatory and linked to the building or environmental permit. EPCs for existing large non-residential buildings is not yet mandatory; the method is in development, but it is announced in the long-term strategy approved published by the Flemish ((Flemish Region, 2017) government in 2020 that EPCs will become mandatory (starting from 2025). EPC is not mandatory for industrial or agricultural buildings. Historical data on the number of EPCs issued per year is available from VEKA[2]. According to the statists, EPCs of single-family houses are commonly issued. The published statistics show the number of EPCs issued in 2017: 38117 EPCs of newly constructed or renovated buildings (in 2020 was 42030), 89045 EPC of existing buildings and 165 EPCs of existing public buildings. In general, EPC issuing activities are slightly increasing in the last years, except by public building EPC issuing activities evolution. These yearly numbers of EPCs for public buildings show a strong variation but in general a decreasing trend according to the statistics (VEKA, 2017).

The Flemish Energy Agency manages the Flemish Database, currently, there are databases for residential buildings and public buildings. It is announced that a data platform for non-residential buildings will be developed (during the current governmental legislative period 2019-2024). The EPC for existing public buildings can be publicly downloaded (CSV file format). The EPC database for residential buildings interoperates with the "Woningpas" in Dutch (which is the individual building passport). The building owner can choose if the data should (or not) be shared.

2.1.2.2. Quality assurance and control

There are several compliance data checks inherently in the EPC software. Based on these and some limited sampled controls and some targeted controls, quality and compliance are checked. Citizens can also notify complaints on non-compliance, which may also lead to targeted controls. Various fines exist for the different parties involved in the process (such as the EPC assessor and the owner of the building, or the notary) and the respective requirements. The nature and the magnitude of the penalty depend on the nature and the frequency of the incompliance. These differ from a financial fine of 250 euro to 5000 euro or (temporary) loss of the assessor's accreditation. EPC is also used to provide subsidies (subsidy based on EPC label and loan without interest).

Flemish energy agency also controls the mandatory frequent additional training of EPC assessors.

There are various non-compliance penalties. In case the EPC is not available at sale or rent, there is a minimum fine of 500€. The notary must notify in case of unavailability of EPC at a sale. If the notary fails to do so, he/she also risks a financial penalty.

2.1.2.3. Validity and Costs of EPC

EPC is valid for 10 years. EPC only needs to be issued or renewed in case one is required according to the EPBD legislation and there is no valid EPC available (that has not yet expired). Price is regulated by the free-market principle, there are no other

[2] https://www.energiesparen.be/sites/default/files/atoms/files/uitgebreidcijferrapport_2019.pdf

https://opendata.vlaanderen.be/dataset/energieprestatiecertificaten-voor-publieke-gebouwen

https://apps.energiesparen.be/energiekaart/vlaanderen regulations. The average time for EPC auditing and issuing is 3 h 25 minutes. However, it may reduce according to the number of EPCs issued per year by the energy auditor (or assessor). Below, some prices indicated from the literature:

- Single Family House: around 220€ per building unit all-inclusive.
    - For semi-detached houses: average 194€ excl. VAT without on-site measurement or 213€ excl. VAT with on-site measurement.
- Multi-family houses: per apartment unit the price average 158€ - 170€ respectively. These costs include on-site visit, processing of information, insertion in software and communication with the client.
- Residential buildings (new or deeply renovated): the price is 950€ excl. VAT and 650€ excl. VAT for a small renovation[3].
- Non-residential buildings: the cost of EPC for new or renovated building strongly depends on its characteristics (mainly the size).
- Existing public buildings: the cost of EPC strongly depends on the characteristics (mainly the size) of the building. No data have been found, but this cost will be lower compared to the cost of EPC for other non-residential buildings (because of less extensive procedure).
- Existing small non-residential buildings: no data has been found for the cost of EPC, mainly because this only came into practice in January 2020. It is estimated that it will be similar or slightly higher compared to that of an existing residential building with a similar size, as the procedure is similar with slightly more detail on a limited number of aspects.
- No data has been found for the cost of EPC of common parts of multifamily houses (but this only came into practice recently (January 2020).

The EPC price difference may differs significantly because of a very different methodology according to the building typology, e.g. public buildings (measured energy use data and questionnaire, few on-site measurements) versus existing single-family houses without valid technical information at hand (extensive on-site inspection procedure).

2.1.2.4. Ownership rate

The values expressed are based on the literature (Heylen and Vanderstraeten, 2018). For residential building units, 72% is the owner of the building unit he/she resides in (the number relates to the household level). 19% are tenants in the private rental market, 7% tenants of social housing and 2% are residing for free. These numbers are fairly stable over the previous years (2013-2018), only the share of free residents diminishes significantly over the considered period (from 2,5 to 1,7%).

The length of the rental period in the contract is 31% for 3 years or less, 40% for 9 years or longer and for 29% for no duration in the contract (data of 2018). However, this does not represent the duration people usually live in the building.

2.1.3. Finland

2.1.3.1. EPC issuing activities and databases

EPCs in Finland are required for all new and public buildings and for the sale or rental of existing buildings (requirements for older single-family homes come into force on 1 June 2017). Certified experts issue the EPCs. Any software can be used as long as it complies with the requirements. After the information required for the EPC is collected and calculated, the expert logs into

[3] Souce: Wat kost een EPB-verslaggever? - Bouwpartners - Livios

the EPC registry and uploads the input to the database. The EPC is a digitally signed pdf that the expert can download from the database and deliver to the customer. Some building types are excluded by default (as stated in the Land Use and Building Act and the Energy Performance of Building Act). ARA is the responsible administrator of the national EPC database. Since the legislation changed in June 2013, about 62672 EPCs have been sent to the ARA, of which 34034 have been produced in 2015. In addition, in 2016 over 22000 EPCs were produced via the national database. At the beginning of 2017, there were 39740 EPCs in the EPC database (Haakana et al., 2016). The current rate is about 30000 EPCs in a year. All the EPCs since the introduction of the EPC database (1.5.2015) have been registered there. There are some statistics available on the site and public search show the number of issued EPCs excluding the smallest residential buildings.

Currently, there is an ongoing project to renew the registry and will improve the machine-readability of the data and also the tools available, especially for EPC quality management. Although the EPC data is now machine-readable, there is a need to improve the formats (e.g. free text strings instead of enumerations) to become more precise and increase its usability. The database does not interoperate with others, and issues related to legal, privacy-related and technical challenges would have to be overcome. Finally, the first two pages of the EPC (public summary) are publicly accessible in all EPCs except the ones for buildings with only one or two apartments[4].

2.1.3.2. Quality assurance and control

EPC input data has some validity checks in the EPC registry (for all EPCs). Of course, there might be some also in the software, but as any software can be used, those validity checks are not controlled by authorities. In addition to automatic validity checks, the authority responsible for the quality control (ARA) organises manual reviews for the EPCs. The EPCs can be randomly or manually selected. If the EPC is not compliant, the expert will be requested to revise the EPC. It is also possible to replace the expert with another (the original expert would pay), deny the right to issue EPCs or impose a penalty payment if the malpractice continues.

2.1.3.3. Validity and Costs of EPC

EPC based on current regulation is valid for 10 years. The update is not required if a renovation is performed. Market benefits should be promoted to increase the update of EPCs, for example, to guarantee access to some energy grants. There is no automatic updating and the building owner must pay for the update. There is no price regulation and a site visit is mandatory in case of an existing building. Naturally, the price depends on building type and complexity. Motiva, a state-owned company that is responsible for EPC communication in Finland, estimates (Motiva, 2020):

- existing one-family-house, from 300 to 400€
- new one-family-house, from 150 to 200€
- existing apartment building, 670€ on average
- new apartment building, 850€ on average

Most of the costs are based on expert work. Registry fees are minor. Maybe an EPC that complies with the minimum requirements is not very different in different building types. More complex systems and larger building of course add some work, but the difference is not that big. Dynamic simulation is required for buildings with a cooling system, which rules out the simplest tools and adds some costs. A building owner that is willing to invest in proper energy management will probably order

[4] Available in Finnish and Swedish at: https://energiatodistusrekisteri.fi/

Privacy notification at: https://www.ara.fi/download/noname/%7B6B2DE649-7801-4D8A-91D4-49BE9D8FA9AE%7D/140510

It is based on law: https://www.finlex.fi/fi/laki/alkup/2015/20150147 the EPC with some other services. Then the price for the careful modelling and dynamic simulation will not serve just for the EPC, but also for other purposes. When the value for the building owner is much higher, also the price can be much higher.

2.1.3.4. Ownership rate

In Finland, 10% of buildings are public buildings. There are 1,5 million buildings in total (excluding seasonal holiday homes and outbuildings). Most of the buildings are one-family-houses; about 1,2 million. There are 140.000 other residential buildings and 230.000 non-residential buildings (Rämö, 2019). 63 % of Finns live in an owner-occupied house or apartment. However, owning a flat in an apartment building means that you own a share of the housing cooperative, which makes the decisions to renovate the common parts of the building. A single flat owner cannot e.g. change the windows without a common decision with other flats owners (Tiihonen, 2019).

2.1.4. Germany

2.1.4.1. EPC issuing activities and databases

EPCs are mandatory for new constructions, main renovations, in the handover process of a dwelling/building during purchase/rental. Also, there is a notice obligation of the EPC in public buildings which are frequently visited. The non-compliance penalties if the EPC is not issued consist of 15.000€ fine for the building owners if an EPC is not issued for new construction. The same penalty applies to sellers/landlords who do not present the existing EPC as required when selling, re-renting a dwelling/building. In Germany, the EPC customer can choose between energy demand or energy consumption assessment EPC except for the following cases:

- New constructions require the demand-based EPC
- For small buildings (until four residential units), that do not comply with the Wärmeschutzverordnung (Engl. Thermal Protection Ordinance) 1977, demand-based EPC is mandatory.
- For residential buildings with fewer residential units, the consumption-based EPC is only permitted, if the building application was made after November 1st, 1977.

The number of EPCs issued per year is not published. There was no publication found after extensive desktop research.

There is a national register for EPCs at the DIBt (Rogsch, 2013) that stores the following EPC data, in a machine-readable format: name and address of the issuing person, state and postcode of the location of the building, an indication of whether it is a new building or an existing building, date of issue of the EPC or the inspection report and the type of EPC (demand or consumption EPC) and the type of building (residential or non-residential building). Although EPCs must be registered by the DIBt, a database with the values of all EPCs does not exist and, for example, energy efficiency indicators are not stored in the database. There are no known linkages between the DIBt database and other registers. Also, the EPC data is not publicly available.

2.1.4.2. Quality assurance and control

The EPC input data is not automatically checked in the EPC calculation software (a plausibility check can be carried out in several EnEV softwares). The EnEV registration office is located in the DIBt for all federal states. EPCs are provided with a registration number with which they are registered at the DIBt. All EPCs that are registered with the DIBt are checked for validity in stage 1 (electronic control). A significant number of EPCs are required by the federal states to be checked in control levels 2 and 3[5]. The state authorities then request the EPC issuer to submit further documents for an examination. Significant

[5] Control level 2: Checking the input building data and checking the results specified in the energy certificate, including the modernization recommendations made

differences in enforcement practice between the federal states become apparent: according to the federal states, apart from Bremen, Hamburg and Thuringia, no responsibilities at all have been established. But even in the case of established control points, enforcement is small. In Bremen, only 84 samples have been taken from new buildings since September 2011. There is not even data available on enforcement in the other federal states. Violations of certain regulations of the EnEV can be punished with fines of up to 15.000€. The practice of persecution has so far been extremely cautious in all federal states. Except for Bremen, no state was able to provide specific information graphs due to a lack of appropriate data (Deutsche Umwelthilfe, 2015).

2.1.4.3. Validity and Costs of EPC

The EPC in Germany is valid for 10 years. The EPC only needs to be renewed before this period expires, if the heated area of a building is expanded by more than 50 % or the new area is larger than 50 m^2. However, the EPC must first be reissued if the renovated building is re-rented/sold. By re-issuing the EPC, EPC costs may incur.

Prices for EPCs in Germany are not regulated. They are gradually emerging on the market and differ from region to region. The prices listed below do not include on-site visits, as they are not mandatory in Germany and have to be paid additionally:

- Consumption-based EPC: available from 50 – 100 €
- Demand-based EPC: 200 - 300 € for a simplified procedure without on-site visits
- With on-site visit: costs of around 500 – 1000€ can be incurred

2.1.4.4. Ownership rate

The building ownership rate is in Germany: 46,5% in 2018 (DEStatis, 2018). 55% of all private tenancies last longer than 5 years, more than 40% even last longer than 10 years. The average term of rent is 8 years.

2.1.5. Greece

2.1.5.1. EPC issuing activities and databases

EPCs in Greece are mandatory for real estate (sale and rent), new construction, deep renovation, public buildings over 250 m^2 and national funding programs. According to the annual distribution of EPCs issued in the period 2011-2019, the average is 220.198 EPCs per year (Figure 2). Sales and mainly rentals have the largest percentage of EPCs (82%), while the 87% of the total issued concerns residential buildings. The 79% of residential buildings concerns individual apartments in multifamily buildings [6].

Control level 3: Complete review of the input building data, full review of the results specified in the EPC including the recommendations made and, if this is possible in particular with the consent of the owner of the building, inspection of the building to check the correspondence the specifications given in the energy certificate with the building for which the energy certificate was created.

[6] Source: building energy audits-statistics 2011-2019, Ministry of Environment and Energy, June 2020

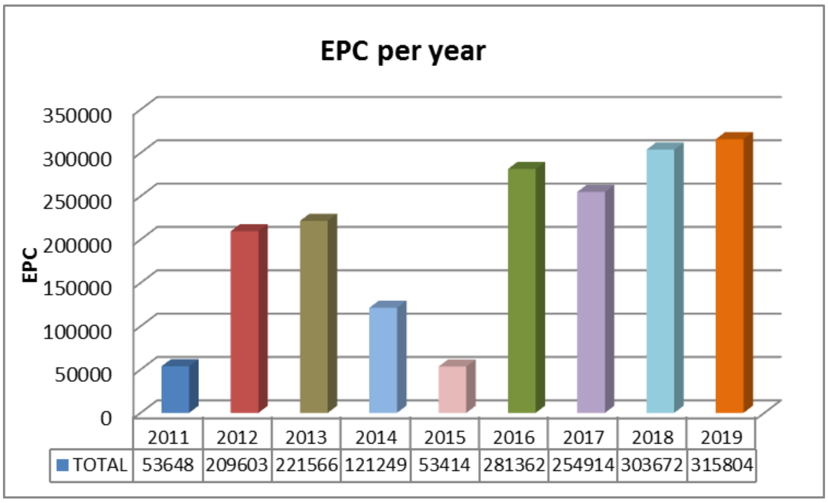

Figure 2: Development of EPC issuing activities in Greece (2011-2019)

The EPC database in Greece is national, owned by the Ministry of Environment and Energy and operated by CRES. The EPC data is stored as machine-readable XML files. All data that appear on the printed EPC, is also stored on the database, along with administrative data (e.g. owner names, land registry numbers, etc.). The other input and output data is stored in a standardised XML file (but are not logged to the database). Although the EPC data is not publicly available, the EPC database interoperated with the following other registries, providing data (to the other registry), and/or receiving (from the registry), as listed below:

- From Land Registry: Users (Building Inspectors) using the Land Registry's GIS system to specify the exact location of the buildings.
- To Land Registry: Storing for each EPC the corresponding Land Registry ID (entire building only – no online connection to Land Registry to check the data at present).
- To Tax Authority:
    - Validating fee data. (For each EPC issuance a fee must be paid. It can be paid via e-banking and the relevant code is stored in the EPC DB)
    - Linking each rent/lease contract to an EPC
- To Technical Chamber of Greece:
- To the platform of the national incentive programme 'EXOIKONOMO-AUTONOMO':
    - An EPC should be issued before and after the renovation. The information system managing the programme connects a web service of CRES to validate the EPCs and retrieve information regarding the achieved savings.

2.1.5.2. Quality assurance and control

Firstly, EPC input data can be automatically checked by the EPC calculation software. Possible checks are: checking empty fields checking some values or fault data (example of rule is: if the primary energy for heating is equal or lower than 0, then it is a faulty EPC). After being issued and have logged the EPC database, 5% of the total EPCs issued is randomly selected and verified. If necessary, also random on-site checks can happen. Finally, all EPCs issued for subsidy programmes are on-desk checked. If the EPC is not complaint, then penalties are provided, as defined in the relevant law. The penalties are divided into two categories:

1. Penalties for low-quality EPCs imposed on energy auditors:
    - Administrative:
        - 1st warning, if repeated faults are identified
        - Temporary license suspension (1-3 years) or permanent, depending on the gravity/impact of mistakes

- Monetary: 500-20.000€, depending on the gravity/impact of mistakes

2. Penalties for non-compliance imposed on building owners:
   - Monetary: 1000 – 10.000€ (recently lowered to 200 – 10.000€)

2.1.5.3. Validity and Costs of EPC

The EPC is valid for 10 years, with exception of major renovation before the end of the decade. In this case, a new EPC must be issued after the renovation. According to law 4093/2012, the minimum cost of EPCs issuance was abolished and nowadays the costs are regulated by the market. According to the national funding programme for residential buildings (EXOIKONOMO-AUTONOMO) the cost for EPCs issued is eligible and defined by the programme:

- for detached houses or apartments: 75€ +2,5€/m^2, with a max of 400€ incl. VAT
- for multi-family buildings: 75 € +1,7€/m^2 with a max of 1095€, incl. VAT.

In general, the market fees range, depending on the use and complexity of the building (e.g. for an average size household of 60 - 110 m^2, it ranges from 80 to 150 €).

2.1.5.4. Ownership rate

The percentage of ownership status in Greece in the year 2018, according to Eurostat statistics, is 75.4%. The building ownership status is high so the families live in their own houses as long as possible.

2.1.6. Spain

2.1.6.1. EPC issuing activities and databases

EPCs in Spain are mandatory for the sale or rental of real estate, as well as for some public aid programs.

There are penalties for non-compliance:

- Infringement regarding the defence of consumers and users following the provisions of sections k) and n) of Article 49.1 of the Consolidated Text of the General Law for the Defense of Consumers and Users, approved by Royal Legislative Decree 1/2007.
- Infractions and sanctions regarding energy certification included in Royal Legislative Decree 7/2015, of October 30, which approves the revised text of the Land and Urban Rehabilitation Law.
  1. Minor faults, with a fine of 300 to 600€.
  2. Serious faults, with a fine of 601 to 1.000€.
  3. Very serious faults (false data, EPC performed by a non-enabled issuer, etc.), with a fine of 1.001 to 6.000 €.

Ecological Transition Ministry publishes yearly since (??) 2013 statistical information about the EPCs in the registry. It takes into account both new construction and existing construction, and residential and non-residential buildings. 532.497 EPCs were registered in the regional databases in Spain during 2019, 98% EPCs were existing buildings (single dwellings or whole multi-family buildings). And, 92 % of registered EPCs are residential buildings (Gobierno de Espana, 2021).

Energy Certificate obligation is national for the entire territory through RD 235/2013, but the management of the certificate registry, control over them, and inspection falls on the Autonomous Communities (CCAA)[7], which from the beginning of the certification process have managed and published Autonomous Orders and Decrees that regulate these processes and that are in any case framed in the National Royal Decree. There is a database of certificates in each of the regional registries wich

[7] The political and administrative division of Spain is composed of 17 CCAA and 2 autonomous cities (Ceuta and Melilla).

implies 19 registries (17 for each CCAA and 2 Autonomous Cities). Each of them establishes their own level of registration but a process of homogenizing is on-going. Since 2016, it is possible to store and manage the information from the digital report (XML format) and centralization of the most general information once a year. The current database contains information on the number of registered certificates, discriminating by new construction / existing construction, residential building / non-residential building, and in all cases according to their energy rating in terms of both primary energy consumption and CO_2 emissions. Although neither the databases of each Autonomous Community nor the central database is operable between registries now, there is a work in progress that the next evolution will solve this. The information from the different regional registries is accessible in some cases, depending on the CCAA. The centralized information is published once a year in a report by the Ministry of Industry, Trade and Tourism.

2.1.6.2. Quality assurance and control

There are several control mechanisms:

- The EPC softwares themselves, which alerts for some empty fields, anomalous, or incomplete data.

There are several control mechanisms:

- The EPC softwares themselves, which alerts for some empty fields, anomalous, or incomplete data.
- Control in the XML output file: Before registering the certificate, the digital XML data output file must pass a filter (XML Viewer https://visorxml.codigotecnico.org/certificate), this filter acts on data types, and reasonable ranges thereof.
- Documentary control in the regional registry of certificates. The particular certificate is controlled for the administrative part (identification, certifier, owner, etc).

Besides these mechanisms, the CCAA Governments are in charge of the control and inspections and are responsible for checking yearly a percentage of certificates. In recent years the ratio oscillates between 1 and 5% per year, randomly but with specific criteria depending on the rating (in some regions more A and B EPCs are inspected, others F and G). During the control, it is analysed the EPC basic data of the building, and the recommendations included in it, and on-site visit of the building are checked. If the energy efficiency rating resulting from this external control is different from the one initially obtained, the EPC issuer or the home owner is informed and asked to perform the corrections. Penalties are included in RDL 7/2015 of Land and Urban Rehabilitation Law and also those derived from the Consumer Protection Law.

2.1.6.3. Validity and Costs of EPC

The EPC has a maximum validity of 10 years, although the CCAA could establish more strict values, the reality is that all have regulated in this regard. During that time the owner can voluntarily proceed to update it when she/he considers that there are variations in aspects of the building that may modify the energy efficiency certificate, and will have to pay for it. Work is currently being done on modifying the legal document that regulates the certification, which will lower the validity of the certificates for less efficient buildings to 5 years.

The EPC cost is influenced by the size of the building and the complexity of the simulation, since information on the characteristics and orientations of walls, openings, roofs, thermal bridges, as well as cooling and heating systems, DHW and renewable energies must be entered into the softwares. The more complex the building, both in systems and in the envelope, the more expensive the certificate is.

2.1.6.4. Ownership rate

According to data from the 2018 Continuous Household Survey, 76,7% of the main homes in Spain are owned (14,2 million out of a total of 18,5), compared to 17,8% in rent (3,3 million), and 5,5% of other forms of tenure (1,2 million; given free or low price by another home, the company, etc).[8]

2.2. EPC recommendations

Under the topic of EPC recommendations following areas have been considered to: understand the provision of EPC recommendations mainly the tools used, understand how the EPC recommendations are linked to the major renovations and building stock decarbonisation activities and understand how EPC recommendations and financing options are being linked in today's EPC practices.

2.2.1. Austria (Styria)

There are five commercial programs to issue EPCs in Austria (ArchiPHYSIK, AX3000, ECOTECH, ETU Gebäudeprofi, and GEQ). The energy demand calculation is asset-based, which means that end-user profile and user behaviour are not taken into account in the calculation (but are included in the recommendations). The Austrian Building Code (OIB Directive 6) defines that detailed recommendations for renovation actions have to be provided in the Appendix of an EPC and that the recommendations should target national nZEB ("Niedrigstenergiegebäude") standards. An on-site visit is part of the EPC issuing process and takes between 60 to 360 minutes. In Austria, each federal state can define their housing subsidies regulations for renovation. In Styria, for example, there is a difference in the renovation activities per building type:

1) "Wohnhaussanierung" The housing subsidy scheme distinguishes between small, major renovation with an energy efficiency focus and major renovation for more than three housing units. Further subsidies are available for renovation in case of disabled accessibility or vitalisation of the town centre.

2) "Ökoförderungen" This subsidy supports: change of heating system towards more efficiency, change of heating systems to one based on renewable resources, connection to district heating networks, solar thermal systems and EV charging.

3) "Revitalisierung" subsidy for the renovation of buildings with cultural importance.

2.2.2. Belgium (Flanders)

In Flanders, the same tool is used to provide recommendations and energy demand calculations. These tools are mandatory for issuing EPCs and depend on the building:

- For existing residential and small non-residential buildings: EPC-software (only accessible for accredited energy assessors and VEKA).
- For new or renovated residential and non-residential buildings: EPB-software 3G (online available, publication managed by VEKA). There are no recommendations except in case there is non-compliance with (part) energy performance requirement; in that case, it is indicated in the software with a link to what aspects need to be adapted.
- For existing public buildings, there is dedicated software, only accessible for accredited energy assessors and VEKA. The recommendations are formulated automatically as a result of the questionnaire that is part of the EPC procedure.

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[8] Source: MITMA from Continuous Household Survey 2018, Spanish Statistical Office (INE)

To issue the EPC, an on-site visit is mandatory, and the duration of the procedure to complete an EPC for existing residential buildings is on average around 3h15' per building unit. For semi-detached houses, it is on average 3h30' if no complete on-site measurement is needed, 4h in the other case. For apartments, it is on average 2h45' and 3h respectively (the numbers have been rounded to the nearest 15'). The duration includes an on-site visit, processing of information, insertion in software and communication to the client. In Flanders, the long-term strategy aims to obtain a nearly decarbonized building stock. This is to be achieved through energy efficiency improvements, implementation of energy from renewable sources and digitalization via smart building technologies. This also includes the implementation of district energy and waste heat from the industry. Interesting also is the mentioning of attention for geographical allocation of buildings and an increase in building density and typology (concerning prognosis in demographical evolution). The following subsidies are currently available to incentivise renovation and stimulate high energy performance levels of existing residential buildings:

- Loan at 0% interest in case of a thorough renovation;
- EPC-label subsidy for dwellings with a low energy performance that will be renovated to a significantly higher energy performance level within 5 years after it is sold. The grant mechanism is based on a recent EPC (≥2019) for the existing state and a new EPC after renovation. The subsidy (maximum 5.000€) can be obtained for SFHs with label E or F that are upgraded to at least label C or apartments with label D, E or F that are renovated to at least label B;
- Unified dwelling renovation subsidy for owners that reside in the dwelling or that rent it via a social rent office. The subsidies can be obtained for structural improvements, energy performance improvement measures for instance of the windows or the technical systems of dwellings of at least 30 years;
- There are subsidies for heat pumps, heat pump boilers, solar thermal systems, PV solar systems and condensing boilers (only for certain social groups). For instance, for installing a heat pump with a minimum energy label in combination with a low-temperature heating emission system and only in case it is not used for active cooling a subsidy can be obtained of up to 8.000€ or a maximum of 40% of the investment cost, but depending on the type of heat pump and the situation (e.g. replacement of electrical heating or not);
- Subsidy amounts for certain social groups are elevated.

2.2.3. Finland

In Finland, there is no national tool for energy demand calculation. Any tool can be used that can handle the required input data and calculation requirements. Dynamic simulation is required for buildings with a cooling system. The experts can freely recommend any measures that suit the building. To issue the EPC the on-site visit mandatory, but no duration is defined. The measures should be cost-effective based on the expert's estimation. The delivered and primary energy savings related to the measure need to be reported. The decree refers to estimates, but of course, it would be natural to calculate the savings using the same software as the actual energy demand calculation. Available incentives and subsidies are:

1. Implemented: Opportunity to apply for an energy subsidy for improving a building beyond the required level for residential buildings (subsidies, Housing Finance and Development Centre of Finland ARA).
2. Implemented: Opportunity to apply for a renovation subsidy in the case of a housing unit/residential building with humidity/microbial damage or indoor air problems, as well as for the planning costs of renovations in such housing units/buildings (subsidies, Housing Finance and Development Centre of Finland ARA).
3. Implemented: Opportunity to apply for a demolition subsidy for the demolition of a vacant building and/or a building in especially poor condition for which an ARA subsidy has been granted. The amount of subsidy was increased to 90% of the demolition costs as of 1 March 2020 (subsidies, Housing Finance and Development Centre of Finland ARA).
4. Implemented: An amendment of the Limited Liability Companies Act (1330/2018) to offer housing companies the opportunity to demolish a building.

2.2.4. Germany

In Germany, the same software used to calculate the energy demand is used to provide recommendations. However, not every software is suitable for energetic building optimization or energy consulting at the same time; renovation proposals (or renovation options) with costs and profitability calculations cannot be calculated with every software. For the generation of recommendations, a report editor or an interface to word processing or spreadsheet programs must be available. Boundary conditions such as the local climate and individual user profiles must also be taken into account. On-site visits are not mandatory in Germany. An on-site visit is expected to take 30-45 minutes. The federal government's energy concept is aiming at a refurbishment rate of 2 per cent per year for residential and non-residential buildings since 2010. However, it is not evident how the long term policy climate targets are being taken into account in the recommendations. Since all recommendations aim at increasing the energy efficiency of the building, the policy climate targets are indirectly referred to. Climate targets have also pursued the reason that, according to the GEG (Gebäudeenergiegesetz; Engl.: Building Energy Act), energy standards must be adhered to when renovating or building new buildings. Also, by the fact that the requirements of the GEG have to be complied with during renovations, goals are strived for. The iSFP (inviduelle Sanierungsfahrpläne; Engl.: individual renovation roadmap) gives owners guidance on the renovation measures that can be used to achieve the lowest energy standard by 2050.

Some incentives and subsidies aim to increase renovation activities: With the "Federal Funding for Energy-Efficient Buildings" (BEG) launched in early 2021, the Federal Government is bundling its previous programs to promote energy efficiency and renewable energies in the building sector. The measures should also benefit climate protection and the economy. Almost six billion euros are available for 2021 to finance new federal subsidies for house and heating modernization through the new federal subsidy for efficient buildings. Moreover, individual measures for energy-efficient building renovation are tax-subsidized, such as the insulation of walls, roofs and storey ceiling, renewal of windows or external doors, renewal of the first installation of a ventilation system, renewal of the heating system, installation of digital systems for energetic operation and consumption optimization and the optimization of existing heating systems. In addition, energetic construction supervision and specialist planning are subsidized by the tax. In tenancy law, effective incentives are set for the deep renovation of the rental apartment stock. The current tenancy law enables the landlord to share the costs of the deep renovation with the tenant. According to Section 559 (1) of the German Civil Code (BGB), the annual rent can be increased by 11 per cent of the cost of the deep renovation. Also, with the Tenancy Law Amendment Act that came into force on May 1, 2013, the tenancy law framework for energy modernization was further improved, e.g. through the tenants' obligation to tolerate energy modernization.

2.2.5. Greece

The software used to provide recommendations is the same as the energy demand calculations (official national software - TEE-KENAK). On-site visits are mandatory and the duration depends on the building size and complexity, for a house (100m^2) the duration is about 60 minutes. End-user profile or user behaviour is not taken into account and the recommendations depend on the building's use (i.e. residential, office, school, etc). In the EPC, apart from the text of the proposed recommendations financial and energy-related data are provided. Specifically for each recommendation the following are provided: emission CO_2 reduction, initial investment cost, potential building energy category, primary energy saving [in kWh/m2, €/kWh and %] and simple payback period.

There is a national funding programme for residential buildings (EXOIKONOMO-AUTONOMO). By 2030 it aims to:

- Improvement of the buildings' energy efficiency by 38% (compared to 2017);
- Reduction of more than 55% of CO_2 emissions (compared to 2005);
- Energy renovation of 60,000 homes/buildings annually by 2030;
- Implementation of € 11 billion investments in the field of energy efficiency;
- Promotion of electric mobility and development of charging/storage infrastructure;
- Increase of RES integration in buildings and infrastructure;
- Tackle energy poverty;

- Strengthen the country's energy security.

2.2.6. Spain

In Spain, there are six official and free EPC tools (LIDER-CALENER (HULC), SG SAVE, CE3, CE3X and CERMA). Some EPC tools propose to the issuer some EEMs aiming at accomplishing the energy efficiency requirements included in the Technical Building Code. Some EPC tools include also the possibility of verifying compliance with these energy requirements. It is mandatory to meet nZEB standard when the renovation includes changes in the energy thermal systems and the renovation of at least 25% of the building thermal envelope. EPC tools do not include any EEM associated with user behaviour, occupancy, or building operation. In Spain, EPC is based on the thermal envelope quality and thermal systems but not on how to use the building. This is the valid criterion to compare the energy performance of buildings. In Spain nearly 30% of residential buildings are unoccupied and in case of considering it, these buildings would obtain a high energy performance rating. EEMs associated with lighting system or ventilation system can only be assessed in non-residential buildings since the EPC procedure does not take into account lighting and ventilation consumptions in residential buildings. Public financing programs for energy retrofitting are engineered to improve the energy rating or reduce the energy demand. All these programs aim to reduce energy demand and the associated CO_2 emissions as well as boosting the renovations sector. EEMs should raise at least one energy rating level. A higher energy rating or the combination of different type of EEMs (e.g. insulation of the building envelope and high thermal system) can obtain a higher grant.

2.3. End-user perception of EPCs

Under the topic EPC end-user perception, the end-users are on the focus. This chapter describes how end-user perceives EPCs, based on existing surveys and interviews performed during this project. Other insights about en-user perception can also be seen in the project report "Criteria set for an adequate EPC" available here [Insights on user perceptions and needs regarding the Energy Performance Certificate (EPC) | Zenodo].

2.3.1. Austria (Styria)

No recent published literature about EPC end-perception could be identified. To obtain closer insights into the end-user perception of EPC, interviews were conducted during the ePANACEA project. It can be summarized that a higher focus on the results of an EPC is set from an owner point of view than from a tenant point of view. Certain scepticism is present among end-users, which could be counteracted by actively promoting the EPC scheme. The EPC is already widely known but is not directly perceived as a useful tool by most customers. As soon as technical building equipment comes into play, the EPC is increasingly used as a planning instrument (e.g. for estimating requirements and dimensioning heat generation units). However, in the last 20 years, the EPC has become more and more complex and therefore more abstract and difficult to understand for the end-user. EPCs can be a valuable document, provided that the calculations have been carried out comprehensively and a meaningful evaluation is possible. It could be helpful if respective building components and building equipment components had to be listed and evaluated for this purpose. Special attention could then be put on comprehensive and easily understandable formatting, where interpretation does not require expert knowledge. Some software programs already provide detailed diagrams of energy losses (transmission heat losses via components, ventilation losses, solar gains, etc.), although this is currently not officially required by the Austrian EPC scheme. Moreover, it was pointed out that building projects should always be accompanied by professional energy consultants, to not only meet legal requirements but also target long-term goals. For end-users, the EPC seems to be relevant only if its technical contents are made understandable. Corresponding consulting services are necessary in such cases since the certificate is quite technical. Therefore, the use of EPCs is estimated most effectively in case of personal contact between building owners and energy consultants, creating space for analysing the EPC in detail.

2.3.2. Belgium (Flanders)

A questionnaire in 3 waves was executed amongst EPC practitioners and real estate agents, including questions on quality aspects for end-users (owner, buyer and tenant). The results are expressed in levels of satisfaction in 5 categories between not at all satisfied and extremely satisfied and one additional left-out category. These are indicated in between brackets in percentage of dissatisfied (PD[9]). Following aspects were assessed: 1) the credibility of EPCs (PD=15%), 2) the usefulness of EPCs (PD=9%), 3) the clarity of EPCs for owners, buyers or tenants (PD=20%), 4) the clarity of the energy label for owners, buyers or tenants(PD=10%), 5) the clarity of the automatically generated recommendations for owners, buyers or tenants (PD=32%), 6) the credibility of cost indications provided with the recommendations (PD=55%), 7) the information given on the cost indications provided with the recommendations (PD=38%), 8) the technical information per aspect (PD=10%), 9) the input information presented in the EPC (PD=11%), 10) the EPC in general (PD=12%), 11) the cost that can be charged for issuing an EPC in relation to the amount of work (PD=60%).

High rates of respondents expressed satisfaction about EPC in general and for all the specific aspects, except for the cost that can be charged with the amount of work. High rates of EPC assessors indicate that according to them the automatically generated recommendations instigate the implementation of energy performance improvement measures. Regarding the methodology, it should be noted that the category (e.g. satisfied) expresses of a positive level (e.g. satisfied) and not a neutral level, leading to a significant bias towards the positive evaluation compared to reality. Furthermore, the end-user (owner, buyer, and tenant) satisfaction is expressed as perceived by the EPC assessors and therefore prone to significant bias, again expected towards the positive evaluation compared to reality. Most general remarks made by EPC assessor's concern general methodology and software issues and cost of EPC. In general, the satisfaction of energy assessors on EPC is high (VEKA, 2019).

2.3.3. Finland

The most recent study about EPC end users' perception was conducted within the frames of IDEAL EPBD project[10] . Although many improvements took place since then, in general, it can be said that single-family house owners are dissatisfied with the cost of the EPC and do not consider it very important (other factors, such as location and layout matter much more). However, awareness about environmental impacts is increasing. Apartment owners in large multifamily houses have little/no interest because EPC is issued for the whole building, not an individual apartment. During interviews and end-user workshop in ePANACEA project, professional property managers indicated potential interest in EPC but consider it too static in its current form.

2.3.4. Germany

Often, EPC end users are not aware that the EPC exists and do not know which information it provides (e.g. end-user expect to receive information about annual heating costs and data about the electricity consumption, which is not the case). End-users who know the EPC perceive it as a standardized and mandatory document. There are several studies on end-users perception

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[9] Average dissatisfaction rates (PD=sum of percentages in categories not at all satisfied and not really satisfied; the dropout percentage was not taken into account in the calculation, but in all cases lower than 3%).

[10] Afi Adjei, Lorna Hamilton and Mike Roys. (2012), A study of homeowners' energy efficiency improvements and the impact of the Energy Performance Certificate. Deliverable D5.2 of the project "Improving Dwellings by Enhancing Actions on Labelling for the EPBD (IDEAL EPBD)". Available at link. https://www.bregroup.com/projects-reports/project-ideal-epbd/

and acceptance of the EP in Germany available[11]. Also, there are campaigns to increase end users' perception and acceptance of the EPC in Germany (and to initiate energy efficiency measures): for instance, "DieHauswende" - renovation campaign: First nationwide, cross-trade campaign for energy-efficient renovation. Jointly from the public and private sectors: BMWi, companies and industry associations, trades, energy agencies and construction financiers. The campaign targets one and two-family homeowners and has the main objective to bring consumers and experts in contact on-site. Another campaign is „Deutschland macht's effizient" (Engl: Germany does it efficiently"). The Federal Ministry for Economic Affairs and Energy (BMWi) started the information campaign in May 2016 to motivate all citizens, companies and municipalities to take part in the energy transition generation project and to increase energy efficiency. The campaign aims to provide citizens, companies, municipalities, associations and initiatives with comprehensive information, awareness and motivation to use electricity and heat optimally and to avoid unnecessary energy consumption.

2.3.5. Greece

No recent study on EPC end-perception could be identified. In general, there is scepticism about EPCs. The end users can not see any usability in the document yet. As the EPC is now, many end-users still find it a useless document which is considered as an extra building tax/cost and it is taken into account only for funding purposes - since it is mandatory to get eligible renovation measures (covering specific criteria).

2.3.6. Spain

Many public consultations have been carried out but the results are not published. There are no official studies. It is known that certificates still generate a lack of trust in citizens and they found them complex to understand. The lack of quality of some EPCs is a barrier to their implementation. End users workshops and interviews conducted in the framework of the ePANACEA project show scarce interest in EPC. In general, they perceive it as a bureaucratic process since they do not understand EPC indicators.

2.4. Technology uptake

Under the topic of EPC technology uptake, the current state of promising technologies and practices is presented. The tables below show an estimation of the actual share of market penetration of the following technologies in each country. Additional information regarding the incentives and research programs are provided (when available):

(1) Building Automation and Control System (BACS)[12]
(2) EV battery & EV charging infrastructure[13]
(3) Collective self-consumption
(4) Centralised heat pump
(5) Establishment of energy communities

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[11] Steininger, B., I. (2017), *Evaluierung des Energieausweises. Eine empirische Studie zur Wahrnehmung der Energieeffizienz von Wohnimmobilien aus der Verbraucherperspektive*, Working Papers des KVF NRW, Nr. 7 | DOI 10.15501/kvfwp_7

[12] According to EPBD requirements Articles 14 and 15:

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02010L0031-20210101&from=EN

[13] According to EPBD requirements Article 8:

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02010L0031-20210101&from=EN

2.4.1. Building Automation and Control System

Table 1: Current share of BACS in the ePANACEA implementing countries

Share / Country:	0-15%	15-30%	30-50%	more than 50%
Austria	(x)			
Belgium (Flanders)			(x)[14]	
Finland				(x)
Germany[15]				
Greece	(x)			
Spain[16]				

Incentives:

Austria: The smart meter rollout in Austria aims for reaching a minimum share of smart meters of 95% until 2022 (österreichs energie, n.d.). The newest change of the Styrian building law already implements the EPBD requirements Article 14 & 15 for BACS for non-residential buildings[17].

Belgium: The 2018 revision of the EPBD aims to further promote smart building technologies, in particular through the establishment of a Smart Readiness Indicator (SRI) for buildings. The adoption of the SRI scheme on a regional level (e.g. Flanders) would be voluntary. There are various research programs. These do not target specific technologies. There are knowledge organisations and institutions that do focus specifically on building smartness.

Finland: The share depends on how the BACS is defined, but practically all the buildings have BACS functions according to EN15232-1:2017 level C or higher. Practically all the large buildings (office, shopping centres etc.) have level B and some even A. This was studied in a study[18] preparing the implementation of EPBD 2018 BACS requirements.

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[14] Broadly implemented in non-residential buildings

[15] There is no publication about the share of BACS in Germany.

[16] There is no publication about the share of BACS in Spain.

[17] Information under (article 92): https://pallast2.stmk.gv.at/pallast-p/pub/document?ref=225d4b26-f9c0-4793-bd3b-77261be2b96b&dswid=9909#

[18] Kangas, Hanna-Liisa; Turunen, Topi; Karhinen, Santtu; Kotilainen, Anu; Piikkilä, Veijo; Pihlajamaa, Pirkko; Harsia, Pirkko; Vainio, Terttu; Vesanen, Teemu; Mattinen-Yuryev, Maija; Ohrling, Tiina, 2019. Rakennusten energiatehokkuusdirektiivin muutosten kansallisen toimeenpanon vaikutusten selvitys ja arviointi: Automaatiovelvoite, tekniset järjestelmät sekä lämmitys- ja ilmastointijärjestelmien tarkastukset. Helsinki. Suomen Ympäristökeskus SYKE, Tampereen ammattikorkeakoulu TAMK, Teknologian Tutkimuskeskus VTT Oy, Benviroc Oy, Aalto yliopiston kauppakorkeakoulu [in Finnish], available at: www.ym.fi/download/noname/%7B069B79BA-48AE-4D78-B9BB-E995B7F0E06A%7D/146152 (accessed 31.5.2021)

Germany: There are financial incentives from the Federal Office of Economics and Export Control (BAFA) for smart home in new constructions, smart home in existing buildings. The BAFA promotes efficient technologies that supply the building sector with heating or cooling based on renewable energies, including all the smart control technology required for this. Also, the KfW supports BACS: The KfW 159 program promotes measures that reduce barriers, increase living comfort and protect against burglary. This means that, for example, control systems for roller shutters, (video) intercom systems and automated lighting concepts are eligible for funding. NextGenBAT (Next Generation Building Automation Technology), a research project supported by the BMWi (Federal Ministry for Economic Affairs and Energy).

Greece: no information available yet

Spain: There is the PREE[19] aid program in which automation systems are eligible to receive incentives as long as they are linked to energy saving and meet the main requirement (together with the rest of presented the rehabilitation actions), improve the EPC the rehabilitation actions), improve the EPC qualification by at least 1 letter.

2.4.2. Electric vehicle: battery & charging infrastructure

Table 2: Current share of EV battery & charging infrastructure per country in the ePANACEA implementing countries

Share / Country:	0-15%	15-30%	30-50%	more than 50%
Austria		(x)		
Belgium (Flanders)			(x)	
Finland	(x)			
Germany	(x)			
Greece	(x)			
Spain	(x)			

Incentives

Austria: There is a variety of political and financial incentives applied to promote BEVs in Austria. For example, there is a direct subsidy for purchasing BEVs for private persons (5.000 €) as well as for companies (4.000 €). Some of the federal states of Austria provide additional support. Furthermore, there are also other supporting measures such as tax reliefs as well as other non-financial support (BEÖ, 2021).

Belgium: More than half of EV charging stations to total stations, not building or on-site installed charging points. Note that in case such on-site charging points are available for fossil fuel, it is estimated that it is likely that there also is one for EV. In SRI 1st technical study it was assumed that at least 1 in 5 for more than 10 parking spaces contains EV charging infrastructure for

[19] Programa de Rehabilitación Energética de Edificios

https://www.idae.es/ayudas-y-financiacion/para-la-rehabilitacion-de-edificios/programa-pree-rehabilitacion-energetica-de non-residential buildings. The subsidy for electrical vehicles was stopped in 2020. EPBD recast contains requirements on the provision of EV charging infrastructure. The grid providers are mandated to roll out a certain amount of EV charging points in Flanders (Oplaadpunten voor elektrische voertuigen | Vlaanderen.beOplaadpunten voor elektrische voertuigen | Vlaanderen.be). There are various research programs. These do not target specific technologies. There are knowledge organisations and institutions that do focus specifically on EV batteries & charging infrastructure

Finland: Installations already rolling out. Obligatory in new buildings. Available e.g. in shopping centres. Mostly according to EPBD 2018 requirements.

Germany: There is a national development plan for electro-mobility. Payment of the so-called Umweltbous (Engl.: environmental bonus), is an innovation premium. It is only paid by the federal government if the manufacture pays a respective share. To improve the charging infrastructure, the federal government makes 300 million € available: 200 million € for the fast charging infrastructure and 100 million € for the normal charging infrastructure. Next to the support with a purchase, electric cars are also subsidized for tax purposes. They are exempted from road tax for ten years. Company cars only have to be taxed in half and charging at the workplace is no longer subject to tax (example from North-Rhine-Westfalia). The Federal Republic of Germany is the government's electromobility program, which updates the National Electromobility Development Plan. The declared aim is to advance the market preparation and market launch of battery electric vehicles. The Federal Government is being advisedly supported in this project by the National Electromobility Platform (NPE), which was merged into the National Platform "Future of Mobility" (NPM) in the course of 2018, and the Joint Electromobility Office (GGEMO). Besides, there are the "Innovations for electromobility - ELEKTRO POWER II funding program 2016–2018".

Greece: Under the national funding programme for residential buildings (EXOIKONOMO-AUTONOMO), the installation of "smart" electric vehicle recharging points is eligible and the subsidy is 500€ per application.

Spain: Working on implementation

2.4.3. Collective self-consumption

Table 3: Current share of Collective self-consumption per country in the ePANACEA implementing countries

Share / Country:	0-15%	15-30%	30-50%	more than 50%
Austria	(x)			
Belgium (Flanders)	(x)			
Finland	(x)			
Germany[20]				
Greece	(x)			

[20] There are no publications about the share of citizens who are part of collective self-consumption.

Spain	(x)			

Incentives:

Austria: Since the beginning of 2018, facilities for collective self-consumption are legally possible. According to (E-Control, 2020) approx. 291 facilities are operating in 2020. However, approx. 471 are still under construction or in the planning phase. From February to May 2018 the Federal Government of Styria provided subsidies for the installation of PV plants for collective self-consumption and funded 68 plants (1,955 MWp). These facilities were mainly installed on residential buildings (Preiß, 2020).

Belgium: Recent European directives have introduced some new concepts that focus on the active participation of consumers in energy markets, both at the individual level as collectively and in the promotion of the use of self-produced renewable energy and the promotion of energy communities of citizens. These still are to be translated into the regional Flemish legislation. Information retrieved from Energiegemeenschappen | VREG. There are various research programs. These do not target specific technologies. There are knowledge organisations and institutions that do focus specifically on collective self-consumption and energy communities.

Finland: This is limited to electricity and very few cases existing so far. Taxation has stood in the way to profitability and there were only some pilots with special permissions. Now the regulation has been changed and there might be more of these in the future. For heating, the devices would be connected to the central heating system without any problem.

Germany: The European guidelines have not been adopted in German law. The Renewable Energy Sources Act (EEG), which provided feed-in tariffs to promote the generation of renewable energy, probably made a fundamental contribution to the rise of prosumers In Germany. On this basis, many citizens installed PV modules on their roofs or founded energy cooperatives.

Other regulations that favour collective energy consumption may be:

- tenant electricity models which are marketing models for electricity and are generated on-site with a solar system, a CHP or a similar system, delivered to residents without using the general supply network and is consumed in the building. However, the realization of this is connected with a lot of bureaucracy.
- There is the tenant electricity surcharge which is a special promotion under the Renewable Energy Sources Act (EEG) for electricity from solar systems. The tenant electricity surcharge was introduced in July 2017.

No research programme on collective self-consumption, funded by a German ministry could be found.

Greece: no information available yet

Spain: Royal Decree 244/2019, of April 5, regulates the administrative, technical and economic conditions for self-consumption of electricity, recognizes the right to self-consume electricity without tolls or charges and establishes the figure of collective self-consumption.

It allows the association of self-consumers promoting self-consumption in communities of owners, physically close companies or industries.

2.4.4. Centralised heat pump

Table 4: Current share of centralised heat pump per country in the ePANACEA implementing countries

Share / Country:	0-15%	15-30%	30-50%	more than 50%
Austria	(x)			
Belgium (Flanders)	(x)			
Finland		(x)		
Germany	(x)			
Greece	(x)			
Spain	(x)			

Incentives, research programs and other comments:

Austria: In Austria, about 2.385.000 central heating systems have been installed in residential buildings in 2018. The share of heat pumps at that time was about 12.4% (around 295.000). The Austrian official statistics furthermore show a clear upward trend concerning the use of heat pumps (Statistik Austria, 2018).

Belgium: The estimate of the share is based on data of market share of heat pump technologies for heating. There are subsidies for the installation of heat pump technologies for heating (only in case these technologies are not used for space cooling).. The current bottleneck for a broad uptake of heat pump technologies for space heating is the electricity price that is relatively high compared to that of fossil fuels. Also, the primary energy factor for electricity is relatively high and for some time debated on that it should be revised to better reflect local context. There are various research programs. These do not target specific technologies. There are knowledge organisations and institutions that do focus specifically on heat pumps.

Finland: Ground source heat pump has become a popular option as a primary heat source in the building. If it exists, it is a central heating system with water circulation. Exhaust air heat pump is a popular renovation measure for apartment buildings with mechanical exhaust only ventilation and no heat recovery. If it is installed, it will also be a centralised, water-based system, but a secondary heat source. District heating or GSHP are the most common primary sources. Air-to-water heat pumps are installed in smaller buildings. Large heat pumps are used in bigger cities as part of district heating generation.

Germany: 3.4% of 18.9 million residential buildings and 2.2% of 40.6 million dwellings heat with a central heat pump. Hence, the share of the installations of central heat pumps certainly lies within the range of 0-15%. For the installation of a heat pump, one can apply for funding, either in the form of a grant from the Federal Office of Economics and Export Control (BAFA) or in the form of a low-interest loan from the KfW Bank (credit institute for reconstruction). The funds from BAFA and KfW are combined in the "Federal Funding for Efficient Buildings" (BEG). There is no current national research programme on the topic of heat pumps.

Greece: no information available yet.

2.4.5. Establishment of energy communities

Table 5: Current share of established energy communities in the ePANACEA implementing countries

Share / Country:	0-15%	15-30%	30-50%	more than 50%
Austria	(x)			
Belgium (Flanders)	(x)			
Finland	(x)			
Germany	(x)			
Greece	(x)			
Spain	(x)			

Incentives, research programs and other comments:

Austria: the Austrian government presented the law on the expansion of renewable energy in 2020 ("Erneuerbaren-Ausbau-Gesetz – EAG"). The EAG is at the moment available as a draft version and therefore not yet legally effective. The comprehensive (draft) law that sets out, among other things, changes to existing laws and new effective opportunities for collective self-consumption and energy communities. Besides many other aspects providing a basis for a renewable energy future, the EAG aims to implement Renewable Energy Communities ("Erneuerbare-Energie-Gemeinschaften") and Citizen Energy Communities ("Bürgerenergiegemeinschaften") in Austrian law. Therefore, the population will be able to share locally produced energy within the close neighbourhood. It is planned to also enable energy communities not only in the direct neighbourhood but also on different electricity network levels, which is still being discussed with respective Stakeholders since it was claimed that this could lead to technical and operational problems (österreichs energie, 2020).

Belgium: Recent European directives have introduced some new concepts that focus on the active participation of consumers in energy markets, both at the individual level as collectively and in the promotion of the use of self-produced renewable energy and the promotion of energy communities of citizens. These still are to be translated into the regional Flemish legislation. Information retrieved from Energiegemeenschappen | VREG. There are various research programs. These do not target specific technologies. There are knowledge organisations and institutions that do focus specifically on collective self-consumption and energy communities

Finland: Very few existing so far. Taxation has stood in the way to profitability and there were only some pilots with special permissions. Now the regulation has been changed and there might be more of these in the future.

Germany: Energy cooperatives have made a significant contribution to the switch to renewable energies in Germany. There are currently around 870 citizens' energy cooperatives in Germany with over 180.000 members. However, the number of new energy cooperatives stagnated. The incentives for the establishment of new energy cooperatives were reduced with the amendment of the Renewable Energy Sources Act (EEG) in 2017. For new projects by energy cooperatives, there is no funding in the form of a fixed feed-in tariff for the energy produced. In future, interested parties will have to submit bids for new projects as part of tenders, with the most favourable bids being awarded the contract. For instance, the project "klimaGEN: From energy to climate protection cooperative" is carried out by the Economics department with a focus on decentralized energy management at the University of Kassel and funded by the Federal Environment Ministry.

Greece: no information available yet

Spain: The development of energy communities is being promoted, already and as contemplated in the National Integrated Energy and Climate Plan (PNIEC), with some specific measures, also reflected in the National Recovery and Resilience Plan. In particular, there are two initially outstanding performances:

- The development of the "Guide for the development of instruments to promote local energy communities" (IDAE, 2019)
- Aid for the investment of thermal and electrical renewables, in which the Local Energy Communities are explicitly considered as beneficiaries.

2.5. Energy assessment

Under the topic EPC energy assessment, the current difficulties and gaps in the energy assessment and calculation procedures are presented. Complementary to this part, the project deliverable [21] reports the technical characteristics of the energy assessment in the different ePANACEA countries.

2.5.1. Austria (Styria)

On behalf of the Federal State, the Energy Agency of Styria is responsible for performing the quality control of EPCs in the Database (details also in chapter 2.1.1.1.) in the Federal State of Styria. From the praxis experience, the following barriers regarding the energy assessment and calculated energy output in the EPC have been observed: mistakes in the input and output data due to lack of knowledge of the assessors, outdated legal requirements (software or/and assessors), illegal assumptions to achieve a better rating, in transparent procedures to determine input data and difficult access to input data.

2.5.2. Belgium (Flanders)

EPC based on calculated energy demand comprises only EPC-related energy uses (as is suggested in the EPBD), while measured energy comprises all. Electrical appliances but also heating or cooling appliances not attached to the building are not included in calculated EPC and even so for wood burning in fireplaces. Measured energy performance needs to be standardised to account for the user behaviour and the external conditions (e.g. climate). EPC based on calculated energy demand often makes use of very conservative default values leading to overestimated energy performance indicators (less performance). Quality in execution during construction, commissioning controls are lacking and there also is no link with maintenance or failing effects mostly are not accounted for. Certain innovative technologies cannot yet be accounted for (or only with insufficient detail) except via the principle of proof of equal value. Primary energy and CO_2 conversion factors should better reflect the local context of the energy system.

2.5.3. Finland

In the context of an energy assessment, there would be needed a lot of harmonisation and data modelling work to be done, preferably on the European level. Ideally, all the data from building components and products, sensor systems, BACS, logbooks and smart meters would be available as Linked data and easily exploited in the tools and methods.

[21] ePANACEA project report: Report on the use of innovative certification schemes and its implementation | Zenodo

2.5.4. Germany

In Germany, there are two versions of EPC (energy demand and energy consumption). However, there are not comparable with each other, and makes the usability of the EPC data more difficult. On-site visits are not mandatory. If they are not carried out, a qualitative assessment of the building is difficult. The methods to calculate the EPC are very complex and experts do not understand everything about it. The calculation method should be simplified for experts so that results become more comparable. For new buildings, the EPC is calculated before construction and is not adapted if plans change and the building is built differently than calculated. Energy demand/consumption is rated according to climate data from Potsdam.

2.5.5. Greece

The methodology for the calculation of the energy performance used up today is based on the EN ISO 13790 (monthly quasi-steady state method) and the relative complementing standards. So the energy consumption which is calculated by the software (EPCs consumption) cannot be compared with real measurements of consumption.

2.5.6. Spain

Following barriers could be observed from the practice: lack of homogeneity of calculations which depend on the accuracy of issuers, the lack of information on the existing buildings (only visual evaluation, etc.).

2.6. EPC rating system

Under the topic EPC rating, the current rating classification is presented. The table below presents the rating system for residential buildings in each country, including rating classes and overall energy performance indicators used in the context of EPCs schemes at Member State level.

The term primary energy use is used in countries that provide calculated energy performance in their EPCs, while annual energy use is the more appropriate term in countries where measured energy consumption data is provided. In Germany, the EPC has a clear rating for energy use (ANNEX), however rating for primary energy use is not transparently documented and could not be used in this report.

Table 6: Rating classification in the ePANACEA implementing countries

	Austria	**Belgium (Flanders)**	**Finland**	**Germany**	**Greece**	**Spain**
Building type	residential buildings	existing residential buildings	apartment building	residential buildings	all residential buildings	all residential buildings
Metrics[22]	PE_{total} PE_{nonren} PE_{nren} (CO_2 equivalent)	PE_{total} (CO_2 emissions)	PE_{nonren}[23]	PE_{total} (CO_2 emissions	PE_{total} PE_{nonren} PE_{nren} (CO_2 emissions)	PE_{nonren} (CO_2 emissions)
Unit	kWh/m²yr ($kgCO_2/m^2year$)	kWh/m²yr ($kgCO_2/m^2year$)	kWh/m²yr ($kgCO_2/m^2year$)	kWh/m²yr ($kgCO_2/m^2year$)	kWh/m²yr ($kgCO_2/m^2year$)	kWh/m²yr ($kgCO_2/m^2year$)
Rating system (based on the main overall energy performance indicator)						
A++	≤ 60					
A+	≤ 70	less than 0			PE ≤0,33RR[24]	
A	≤ 80	Between 0 and 100	Less than 75		0,33RR< PE ≤0,50RR	0,15<C1[25]
B+					0,50RR< PE ≤0,75RR	
B	≤ 160	Between 200 and 100	Between 76 and 100		0,75RR< PE ≤1,00RR	0,15≤C1<0,50

[22] Overall energy performance indicators: PE_{total} (Total primary energy use), PE_{nonren} (Non-renewable primary energy use), PE_{ren} (Renewable primary energy use)

[23] Delivered energy multiplied by national conversion factors. Not exactly non-renewable primary energy but close to that.

[24] RR: reference values (reference building)

[25] C1, C2: EPC indexes that allow the calculation of limits between classes based on a calculation according to reference values for the building stock, taking into account 2 building different building types (i.e. single family house and apartment block) for residential sector and 13 different climatic zones.

C	≤ 220	Between 300 and 200	Between 101 and 130		1,00RR< PE ≤1,41RR	0,50≤C1<1,00
D	≤ 280	Between 400 and 300	Between 131 and 160		1,41RR< PE ≤1,82RR	1,00≤C1<1,75
E	≤ 340	Between 500 and 400	Between 161 and 190		1,82RR< PE ≤2,27RR	1,75≤C1 C2<1,00
F	≤ 400	Higher than 500	Between 191 and 240		2,27RR< PE ≤2,73RR	1,75≤C1 1,00≤C2<1,50
G	> 400		Over 241		2,73RR< PE	1,75≤C1 1,50≤C2

3. FUTURE PERSPECTIVE

This chapter presents the possible future perspectives based on implementing partner's expert insights of each of the following topics: recommendations, end-user perception, technology uptake, energy assessment and rating system. Together with the current state, this chapter prepares the ground for designing future pathways how each area could evolve. The tables present country-specific perspectives.

3.1. EPC environment

In this chapter, we discuss future perspectives of EPC schemes in terms of regulation, financial support, quality control and increase of compliance; to improve the usability of the EPC data, enable comparison of building, assure reliability and increase awareness.

The EPC as a document can be improved by making the information more end-user friendly. This can be done through a user-friendly layout and/or end-user targeted information. For example, improved tailored renovation advice and link with the energy bills. Also, adding additional indicators and information referring to costs and return on investment. Some MSs include appliances and lighting in to calculation. In Finland for example they are included as standard profiles. However, in other countries part of the actual energy consumption is not covered in the EPC, as only building-related energy use is included (e.g. no cooking, plug loads and in some cases lighting, etc.). Additional to this it is also recommended to include additional benefits related to health and work productivity improvements, both at the individual level (end-users) and the societal level (policy members). Furthermore, about the implementation of renewable energy technologies, it would be good to extend the performance indicator set with indicators for a broader environmental impact as for example whole carbon indicator or life cycle assessment.

The second aspect refers to the increase of EPC data collection and use (by setting EPC databases), and interoperating with other national and regional registers (measured energy consumption, geographical information including local (renewable) energy generation etc.). In Flanders, the dwelling passport ("woningpas") is an example for residential buildings, but this could be extended on content and functionalities and for other building categories.

The feasibility of a well-established, trustful and useful EPC scheme relies on important aspects: reliable cost of EPC that still guarantee good quality and affordable at the same time. The free market principle leads in some country to the excessive use of default values to minimise cost, which on the other hand affects the quality. Site visits are important to ensure qualitative EPCs. And with time, penalties for non-compliance legally should become applied more frequently. E.g. the obligation of re-calculation, a step-based penalty system, depending on the frequency of submitting faulty EPCs or an obligation to attend training. A withdrawal of the licence or to go to court should be avoided.

The third aspect is the training of energy experts; the mandatory training, especially for experts with a high number of faults. In Greece, it was in force up to 2016. It was abolished in the Law of 2016 and it is currently voluntary.

***¡Error! No se encuentra el origen de la referencia.**: Expert insights about future trends regarding of EPC environment in the ePANACEA implementing countries*

Trends	Austria (Styria)	Belgium (Flanders)	Finland	Germany	Greece	Spain
EPC price development	The price increase, because of increased efforts for the assessors to calculate the EPC	Price slight increase expected to increase in complexity of the methodologies (more technologies can be taken into account and more detail is added in existing modules).	The average price of EPCs may increase, because rising awareness enables more careful work in inspecting and studying the building. On the other hand the price of carefully made EPCs may decrease, because there will be more demand and competition	The price increase, because the quality should/will increase e.g. because on-site visits become mandatory	Not available data	The trend is to make more precise, reliable and homogeneous certificates and that will require more effort and knowledge on the part of the certifiers (EPC prices above 150 €)
EPC database set/use by public authorities	The acceptance to work with digital data is increasing; more public authorities are linked to the database ZEUS	The dwelling passport will be extended to other building categories. Links with other databases will be extended	EPC database will be used more intensively to support public authorities as there will more data to learn from	EPC database will be used more intensively to support public authorities and would make it possible to derive policies based on it	EPC database will be used more intensively to support public authorities	The database will be more useful. It will be equipped with more information and will contain more registered certificates
Increased penalties for non-compliance[26]	No	No	No	No	No	No

[26] (or other measures to increase compliance)

More quality control routines	The control of a statistically significant sample size of the EPCs issued will be implemented in more provinces	New EPC methods have been introduced recently, so there will be an increase, but this is not a change in routines	More quality control routines to serve, not to punish	This was recently implemented. For now, it is a random quality check (by the DIBT) that could be conducted in a more structured and comprehensive way.	There are no planned additional actions	As all processes are even more digitized, control will be easier and efforts can be increased.

3.2. Recommendations

EPC is an instrument to support the EU's building stock decarbonisation in different ways. On one hand, the EPC makes the energy performance and CO_2 emission of the buildings visual and comparable with other buildings. With appropriate innovative indicators, for example, ones that reflect the renewable energy ratio; also the use of renewable energy systems could be promoted.

The EPC recommendations and renovation advice are an important link between the current building state and the achievement of climate-neutral building standards. As the EPC recommendations should indicate the building's owner, which are the necessary measures. Besides that, the building passports can guide the building owner through this process, provided detailed and specific recommendations. In Germany, EPC recommendations are considered short guidelines to provide a first orientation. The more in-depth energy consultancy takes place with an energy auditor. There is a programme in Germany aiming at providing recommendations after on-site visits, providing recommendations as individual roadmaps or as a one-off measure (cf. iSFP - Individueller Sanierungs-Fahrplan). 80% of the costs for the on-site visit and advice and the individual renovation schedule is funded by the BAFA. When issuing EPCs, it should be checked whether a possible renovation roadmap/iSFP is also developed for the building. As a result, the individual measures prevailing on the market would be provided with more targeted advice.

Some EU members states (MSs) are already exanimating the possibility of clearly linking EPCs and the long-term renovation strategy (LTRS) of the federal government; this is the case for example of Flanders (Belgium). There targeted building performance indicators (global energy performance requirement levels) are been defined in the LTRS. Currently, in Flanders, it is stated that to decarbonise the residential building stock, all dwellings (on average) need to evolve to label A by 2050, for which the required renovation rate would triple.

Moreover, it can be observed a trend of increasing specification and accuracy of recommendations listed in the EPC. For example in Greece, in the past there were mainly overall recommendations, like „outer-walls should be insulated“. Now the tendency is slowly changing towards more detailed recommendations, like „insulating the outer-walls with 16 cm improves the heat demand by 20 kWh/m²“. In Spain, according to the PAREER CRECE analysis (national subsidy programme), the most usual intervention is the addition of thermal insulation on the building envelope (including windows replacement) following by the replacement of the existing boiler by gas condensing boilers.

Together with the technical conditions, also financial options and incentives have to be available in a considerable amount. In the frame of national incentive (financial or fiscal) programmes for building renovation, EPC issuance is an indispensable part of the process, either for applying to the programme or for completing the process of renovation and final payments. Currently, in

Greece, a major subsidy programme is ongoing – 'EXOIKONOMO-AUTONOMO' – providing loans on low or no-interest rate (according to income), which requires EPC issuance before and after implementation of renovation measures.

Although EPC recommendations play a key role in achieving EU building stock decarbonisation, a successful change depends also on other factors:

- The decarbonisation of the heating in buildings is hampered by the low fossil fuel prices and the regulation of the price of electricity. Flanders (Belgium) already started the revision of the tariff structure;
- Furthermore, the weighting factor for primary energy in the case of electrical energy should be revised. The weighting factor for primary energy should reflect the local context of the energy technologies mix;
- Apart from energy performance of the in-use phase, also broader environmental impacts should be targeted given a decarbonised building stock (such as embodied energy);
- Harmonised indicators, to allow the comparability. In Germany, the fact that there exist energy-demand and energy consumption EPCs, it would make difficult the comparison of publicly accessible databases could be compared.
- Provision of end-user targeted indicators, for example, investment/savings (cost-savings) ratio
- Many policies have focused on existing residential buildings, but they should cover also non-residential buildings as well.
- Additional training/education programs: The quality of EPC input data, especially concerning the correct interpretation of requirements and correct determination of input data, could be improved with additional training for the energy experts.
- Introduce and/or enforce penalties for underperformance. Failure to comply with existing regulation should be strictly regulated and enforced.

3.3. End-user perception

End-user's participation in the decarbonisation process is becoming very important. The answers from the implementing partners have shown that lack of end-users knowledge and understanding about the renovation process, is one of many other barriers to performing a building's renovation. EPCs are relevant to document that can provide building-related information. Therefore, future perspective should include increasing end-users understanding and perception. However, it seems to be a controversial task: EPCs are becoming more complex and with more technical information. But this information has to be simplified and understandable for not experts. There are different ways to achieve this goal.

On one hand, end-users targeted information can be addressed. Also, the accuracy of the indicators has to be improved, to have trustful and reliable results. And, for example, the inclusion of novel energy technologies and related (smartness aspects). The energy performance indicator at the final energy level is another example that could improve the comprehensiveness, by linking or explaining differences with actual energy consumption (non-standard conditions of use and climate) and to enable comparison with billing information. Estimation of annual costs, energy costs savings and multiple benefits are also information on which end-users are interested.

On the other hand, a user-friendly EPC layout could be explored. Inclusive, more explanation about the information provided. For example, the inclusion of visual information such as thermographic images of the respective building, linking the presence of the energy performance with other relevant information and adding an explanation of the indicators to comprehensive information for the end-user: what is primary energy, what does the information on CO_2 emissions [kg CO2/(m².year)] represent. Avoid the display of default values and opting for customized and tailored information. Also, the increase of public communication, campaigns, advertisements and workshop to raise understanding, because in many countries EPC's are still seeing as a mandatory document, without added-values.

Another aspect that could increase end-user perception and trust in EPCs is its public availability; transparency of the controls (for example in the form of up-to-date public statistics on the quality of the EPCs) or the benefits of the associated recommendations. The view of EPCs as a technical document for energy experts should be transformed. Other stakeholders have to recognize an added value on this document as well: policymakers, architects, construction engineers involved in building and building product design, tenant organisations, social housing organisations, real estate companies, private financing companies (e.g. banks), building systems and products suppliers, etc. Apart from these stakeholders, it is important to involve experts in communication, psychology, user-centric design of products, energy visualisation and energy performance assessment and certification methods.

Table 7 below presents trends on how to increase end-user perception above EPCs. In general, we conclude that guidelines for end-users everyday behaviour to use energy more effectively would be helpful to increase their perception and awareness.

Table 7: End-user perception future trends in each country

Country / Trend:	Austria (Styria)	Belgium (Flanders)	Finland	Germany	Greece	Spain
Increase user-behaviour information	Already provided in the EPC	EPBD focus is on the building-related energy performance aspect	Provided in the EPC	Yes, the EPC could e.g be customizable with different user profiles	Yes, could become part of the EPC	Currently taken into account in the revision of the EPC methodology and process
Increase energy consumption information	For some building typologies an "energy accounting tool" is available	EPBD focus is on the building-related energy performance aspect	Energy consumption must be given in the EPC if it is available, but it is for informational purposes, not as an indicator. The measured values had a stronger role in the 1st generation EPC, but it wasn't very successful.	Yes, an add-on to the EPC which visualizes the real energy consumption could help end-users to change their everyday energy behaviour.	Yes, could become part of the EPC	Currently taken into account in the revision of the EPC methodology and process
Increase renovation measures information (e.g. costs, subsidy programmes,	Yes, could make recommendati on more attractive	Currently possible in the "Wonigpas" (for residential buildings)	Tailored recommendati on for the improvements. Standard phrases are not effective.	This would be helpful for end-users; however, this information should be dynamic.	Yes, could become part of the EPC	Currently taken into account in the revision of the EPC methodology and process

materials, techniques, craftsmen and professionals)						
Increase information on how to save energy costs	Yes, could make recommendations more attractive	EPBD focus is on the building-related energy performance aspect	Yes, in connection with the recommendations	Yes, e.g. hints for the everyday behaviour could help end-users to reduce costs.	Yes, could become part of the EPC	Currently taken into account in the revision of the EPC methodology and process

3.4. Technology uptake

Table 8 shows how relevant will the following technologies in the future perspective of each country. Project partners could evaluate each alternative in relevance, less relevant and not relevant. Together with the uptake of these technologies, also regulations, subsidies schemes are requested. The responses were also based on the ePANACEA REB meetings[27], performed with national stakeholders.

(1) Building Automation and Control System (BACS)
(2) EV battery & EV charging infrastructure
(3) Collective self-consumption
(4) Centralised heat pump
(5) Establishment of energy communities

(6) Table 8: Technology uptake future trends in each country

Country / Technology:	Austria (Styria)	Belgium (Flanders)	Finland	Germany	Greece	Spain
Building Automation and Control System BACS	Relevant	Relevant	Relevant	Less relevant	Relevant	Relevant
EV battery & EV charging infrastructure	Relevant	Relevant	Relevant	Relevant	Relevant	Relevant

[27] Project report: 1st REBs conclusion report: Minutes of Meetings of the Northern, Western, Central, Southwestern and Southeastern Regional Exploitation Boards (REBs) | Zenodo, especially the REB Southeastern

Collective self-consumption	Relevant[28]	Relevant	Less relevant	Less relevant	Less relevant	Relevant
Centralised heat pump	Relevant	Relevant	Relevant	Relevant	Not relevant	Not relevant
Establishment of energy communities	Relevant	Relevant	Less relevant	Less relevant	Less relevant	Relevant

3.5. Energy assessment

Until recently, the focus of policy instruments and calculation procedures was on energy efficiency. Most of building energy calculations in EPC schemes are based on the quasi-steady state monthly energy balance method (as the simplified calculation method monthly). Besides in Spain, the majority of EPC methods are in hourly bases. Thermal inertia effects are only accounted for in a very simplified manner. On the EU level, the interest is growing to shift towards the more detailed hourly calculation method (or even more enhanced methods such as calibrated dynamic energy balance simulation).

In some countries, dynamic simulations are compliant to serve as an alternative to simplified or detailed calculations for generating the input data for the final energy demand in EPC calculations. In Finland, dynamic energy calculation is already required for buildings with a cooling system. For small residential buildings, simple monthly methods are more appropriate, as the low price of the EPC would not allow enough effort to perform the dynamic simulation properly. Also in Spain, dynamic simulation is already part of the methodology, with an hour-by-hour calculation. Although it is still possible to officially perform a calculation with an annual balance, practically all the calculation programs enabled in Spain perform the hourly calculation. The accuracy and complexity of the method generate a trade-off EPC cost dilemma. Therefore, other member states argue that the use of dynamic simulations will be too time-consuming and too expensive. Being quantitative of data required by the simplified calculation is also easier to be gathered.

In Flanders, EPC methods are further built on the existing principles of the simplified monthly method, which in general is extended to take into account a wider variety or more detailed aspects of technologies and/or for which the level of detail in the calculation is increased. At the same time, an increase in automation of parts of the information gathering procedures can be seen, such as the extension of the energy performance database with product information. Furthermore, the stepwise introduction of more building categories or the application domain of the existing building categories is being constantly extended and used.

At the same time, we observe an increase in the importance of considering different user profiles to interpret the indicators from the EPC. In this context, new calculation procedures based on measured data have been developed. The indoor temperature, the user profile and plug-in equipment can be very different in the buildings. For example, a calculation study from 2015 in

[28] Especially relevant in single-family-houses

Lerum, Sweden[29], revealed that the energy use in a single-family house can vary on average 25% due to occupants' behaviour. The house with the largest difference has a 113% larger measured energy use than calculated. The most important parameter is the variation in domestic hot water use. This is seldom measured separately. When using measured values, it is required to perform some adjustments on the calculations:

- estimate the share and removing the components that are not included in the EPC (such as EVs, outdoor lighting, appliances etc.);
- weather adjustments with e.g. heating degree days and estimating which part of the measured value is adjusted e.g. for district heating only space and ventilation heating are adjusted, not DHW and for electricity, the floor heating in the bathroom should be adjusted (common in Finland);
- there may not be a separate measurement for every building and the share of each building must be estimated e.g. a district heating measurement is typically for a housing company having a common heat exchanger for a couple of buildings.

In Flanders, likely, the relation between measured energy consumption and EPC will automatically be established shortly by the increasing expansion of linking databases. These procedures are to be set up concerning privacy regulations (GDPR).

Others trends are also observed. In Spain, the analysis and calculation of energy needs and energy use by nationally and internationally recognized calculation engines are becoming more used. Also, the application of the ISO 52000-1 standard to obtain the indicators of total primary energy and non-renewable primary energy (Table 9) shows some possible trends in energy assessment in each country.

Also, if the share of new technologies increase (for example the ones presented in chapter 3.4), new assessment and calculation methods will have to be developed. EPC scheme will have to integrate assessments of the building and its surroundings, as it is the case of energy communities, energy generation, transportation, and efficiency at the neighbourhood and city level. The same for new technologies as energy control and management systems: BACs, BEMs, smartness systems of the building.

It is been observed that not only energy but also other multiple benefits assessment are gaining importance. And, holistic analyses including indoor environment quality assessment are becoming more common. For example, by changing and sealing the windows also the effect on the ventilation is taken into account.

It is important to differentiate the target group – end-users and public authorities. The first needs recommendations on the behaviour, the second needs building to be comparable. Therefore, a future trend might split EPCs into two different versions, according to the group*: "user-certificate" and "building certificate".*

Table 9: Energy assessment expert insights and future perspectives in each country

Country / Trend:	**Austria (Styria)**	**Belgium (Flanders)**	**Finland**	**Germany**	**Greece**	**Spain**
Use of dynamic building simulation	Not discussed currently	Not discussed currently	Already in use	Not discussed currently	Not discussed currently	Already in use

[29] Source: Mainstreaming passive houses: A study of energy efficient residential buildings in Sweden. https://liu.diva-portal.org/smash/get/diva2:1264439/FULLTEXT01.pdf

Use of methods to calibrate building simulation results	Not discussed currently	Not discussed currently	Difficult to define in the regulations	Not discussed currently	Not discussed currently	Not discussed currently
Use of measurement data	Not discussed currently	Not discussed currently	Not discussed currently	Yes, in an additional tool or as an add-on	Yes	Already in use (but not mandatory)
Use of actual building operation data	Not discussed currently	Not discussed currently	Not discussed currently	Yes, in a "user certificate"	Not discussed currently	Already in use (but not mandatory)
Inclusion of energy consumption data	Not discussed currently	Not discussed currently	Already in use	Yes, in a "user certificate"	Already in use (but not mandatory)	Already in use (but not mandatory)

3.6. EPC rating system

Although the EPBD defines the primary energy use (see Annex I, EPBD 2018/844[30]) as appropriate metrics to national and cross-country comparison of buildings, in the practice there are still some barriers. As shown in chapter 2.6, the energy rating is not the same in all countries. The development of the EN-ISO 52000 series has the intention to solve some of the problems related to harmonization – at least by unifying the calculation procedures. However, not all countries are considering adopting the new standards, as is the case for Finland and Germany. In Spain, however, it is planned to modify the methodology to establish the simplified method established by ISO 52016-1 as the minimum level of calculation. The adoption of new methodologies would result that buildings energy performance calculated before and after adaptations would not be comparable anymore. If the current calculation system is well established in the country and works relatively well with other practices, the burdens to change it would be very high. Adopting the harmonised system and rejecting the current one would probably lead to increased costs, conflicts with other practices and schemes and worse results for the energy performance development. The harmonisation should start from the common definitions and understanding different approaches in the member states.

30 EUR-Lex - 32018L0844 - EN - EUR-Lex (europa.eu)

4. MAIN CONCLUSIONS

This report presented the current state and future perspectives of EPC schemes in six EU countries: Austria (focus Styria), Belgium (focus Flanders), Finland, Germany, Greece and Spain. Following topic area related to EPCs and buildings are described: environment (EPC issuing activities and databases, quality assurance and control, validity and costs of EPC, and ownership rate), recommendations, end-user perception, technology uptake, energy assessment and rating system. The main conclusions in each area are:

4.1. Environment

4.1.1. EPC issuing activities and databases

In most countries, the EPC issued are for residential buildings – both existing and new ones. In terms of issuing activities, they have been more or less constant over the last years (in all countries). A possible metrics to assess EPC issuing activities would be the number of issued EPCs per number of buildings.

Requirements for well-established EPC databases are interoperability with other registers, machine-readable EPC format, upload and storage of sufficient and relevant EPC data into the EPC database and public availability of the data. In Flanders, there is a well-established EPC issuing system that is also linked to the EPC database and the "Woningpas" – building renovation passport. The Flanders EPC Database interoperates with other registers, as well as the national EPC database in Greece (for example: with Land Registry and tax Authority). Spain and Austria have regional databases, which are used by regional public authorities to support decision making. In Germany, the national EPC database stores a little building-related information, and there is still potential to further improve it. In Finland, the national database is being renewed and will improve new functionalities, as the machine-readability of the data and also the interoperability with other tools, especially for EPC quality management. In general, EPC databases in the countries are not publicly accessible (besides in Spain and Flanders public buildings in). The requirements related to the GDPR may represent legal obstacles in some MSs for turning EPC data publicly available.

4.1.2. Quality assurance and control

All countries perform quality control routines. However, the penalties for not complying are not consequently performed. Unfortunately, future perspectives are still not going in a direction to change it. However, this is an important aspect that has also to be linked to the training of experts – to improve the learning process and avoid repetition of mistakes. This is a way to promote a long-term improvement of the quality and reliability of EPCs.

4.1.3. Validity and costs of EPC

The validity of EPC in all countries is 10 years. In Spain, it is under discussion to reduce to 5 years. At least, it should be possible for building owners (especially of single-family houses) to update the document without having to pay the fees again. Or, for example, offering incentives when EPC recommendations are performed. These are instruments to maintain the EPC as a dynamic document, and more constantly updated. Differently from what is happening today in almost all countries – the EPC issued remains outdated for a long period.

4.1.4. Ownership rate

Together with the validity of the EPCs, the ownership rate is an indication of the frequency of updating the EPC. The dynamic update may be easier to implement in real estate transaction EPCs than in owner-occupied dwellings. Because, by changing the tenant (especially in countries with short-time contracts), there is also an opportunity to update the document. The ownership rate is comparatively low in Germany 46,5%, and Austria (48%). While in Finland, 63 % of Finns live in an owner-occupied house or apartment. And living in an apartment represents mostly in a housing cooperative – where decisions on renovating have to be agreed upon between all involved parts. So in Finland, the probability that the EPCs stays outdated for a longer period is higher. Also because building owners may not want to pay for updating the document – without a motivation/or obligation for that. In Spain, this rate is 77%, however different than in Finland, whereas 70% of Spanish live in a MFH. In Spain is possible to issue an EPC for an apartment whereas in Finland for a whole building.

4.2. Recommendations

Currently, EPC recommendations are provided in most countries in a standardized and generic form – for example, based on a list. At the same time, they are the most important link to achieve building stock decarbonisation targets. In all countries, the recommendations are provided with the same software as the one to issue EPCs. Besides the appropriate tool, the provision of accurate recommendations is also dependent on the available building-related information. Besides in Germany, the on-site visit is a mandatory aspect to gather the building data. However, the mandatory on-site visits and complexity of calculations may directly affect the EPC costs. Therefore, there is a trade-off between accurate and specified recommendations and standardised recommendations. In terms of future perspectives, three possible types of recommendations were analysed: climate tailored (recommendations linked to the LTRS with a stronger focus on carbon emission reduction), end-user tailored (considering end-users behaviour) and step-by-step recommendations (or building renovation passport - BRP). The last one has the highest chance to be implemented in all countries. For example in Finland, it appears to be the most appropriate solution for the high number of owner-occupied single-family houses. And in Germany, is it under discussion to combine EPC recommendations and BRP. Climate tailored recommendations were implemented in the EPC schemes in Flanders, while end-user tailored recommendations are provided in Styria (Austria). Another aspect to link EPC recommendations to is the availability of incentives. For example, in Greece and Austria, the EPC is a mandatory document to get access to incentives.

4.3. End-user perception

Studies have recognized that end-users play an important role in performing building renovation. Being the EPC an instrument to provide building-related information to the end-users. However, until now EPCs have had a stronger technical focus and may become even more complex. Therefore, there is a need to provide new end-user targeted indicators and information. Besides in Flanders, no recent studies are aiming to understand end-users perception and awareness about EPCs. In most countries, because EPCs are mandatory, the end-user may “accept” the EPC, but do not interact with or understand it. Therefore, the increase of public communication, campaigns, advertisements and workshop to raise understanding is very important – and especially in Spain, many strategies have been defined in this direction (as defined in the LTRS).

4.4. Technology uptake

The current share of the following five technologies, actual incentives and research programs were presented: 1) Building Automation and Control System (BACS), 2) EV battery & EV charging infrastructure, 3) Collective self-consumption, 4) Centralised heat pump and 5) Establishment of energy communities. Besides a high share of Building Automation and Control System in Finland (more than 50%) and Flanders (30-50%) and EV battery & EV charging infrastructure in Flanders (30%), the actual share of all technologies in all countries is still low; which on the other hand indicates a potential of upcoming incentives, regulations and research activity. For example, in Austria, there is a variety of political and financial incentives applied to promote EVs. Future perspectives show that only EV battery & EV charging infrastructure are relevant in all countries (Table 8). But the link with EPC scheme is not clear yet.

4.5. Energy assessment

The chapter of EPC energy assessment presented the current difficulties and gaps in the energy assessment and calculation procedures in each country. The topics discussed were: quality of the required data (mentioned as an important topic in Styria), energy performance calculation (discussed in Flanders and Germany), and the use of dynamic or static models (discussed in Finland, Spain and Greece). These topics are key for the harmonization of energy performance indicator but at the same time very different in all countries. Between the possible trends use of dynamic building simulation, use of methods to calibrate building simulation results, use of measurement data, use of actual building operation data and inclusion of energy consumption data, there was no common topic that is been now discussed in all countries.

4.6. EPC rating system

Related to the above-mentioned topic, the presented table with the current EPC rating system confirmed the heterogeneity of solutions in the different Member States. The EN-ISO 52003 has the intention to solve some of the problems related to harmonization – however, not all countries are considering changing their systems. The adoption of new methodologies would result that buildings energy performance calculated before and after adaptations would not be comparable anymore. The first step of the harmonisation should start agreeing on common definitions and understanding the difference between approaches in the member states. This seems to be a big challenge to be overcome.

5. REFERENCES

ArchiPHYSIK, 2020. Energieausweis Datenbanken und ihr Hunger nach Daten [WWW Document]. URL https://archiphysik.at/wip-energieausweis-datenbanken-und-ihr-hunger-nach-daten/ (accessed 2.4.21).

BEÖ, 2021. Fördern - Bundesverband Elektromobilität Österreich [WWW Document]. URL https://www.beoe.at/foerdern/ (accessed 2.15.21).

DEStatis, 2018. Eigentümerquote nach Bundesländern [WWW Document]. Statistisches Bundesamt. URL https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Wohnen/Tabellen/eigentuemerquote-nach-bundeslaender.html (accessed 5.3.21).

Deutsche Umwelthilfe, 2015. Regelungs-und Vollzugsdefizite der Energieeinsparverordnung (EnEV)bei der Durchsetzung des Energieausweises als Lenkungsinstrument [WWW Document]. URL https://www.duh.de/uploads/media/Hintergrund_Regelungs_Vollzugsdefizite_270415_02.pdf (accessed 5.14.21).

E-Control, 2020, 2020. Ökostrombericht 2019 [WWW Document]. URL https://www.e-control.at/documents/1785851/1811582/%C3%96kostrombericht_FINAL.pdf/f689b909-2088-77b0-0c9e-eeb260effe7b?t=1569999423109 (accessed 5.21.21).

Flemish Region, 2017. NEEAP 2017 FLANDERS LONG TERM RENOVATION STRATEGIES [WWW Document]. URL https://ec.europa.eu/energy/sites/ener/files/annex_b_neeap_2017_flanders_en.pdf (accessed 12.29.20).

Geissler, S., Vlachos, S., Petran, H., 2016. EPC implementation: status quo analysis.

Gobierno de Espana, 2021. Ministerio para la Transición Ecológica y el Reto Demográfico [WWW Document]. URL https://www.miteco.gob.es/es/ (accessed 5.3.21).

Haakana, M., Laitila, P., Forssel, K.-M., 2016. EPBD implementation in Finland - Statur in Dember 2016 [WWW Document]. URL https://epbd-ca.eu/wp-content/uploads/2018/08/CA-EPBD-IV-Finland-2018.pdf (accessed 5.3.21).

Heylen, K., Vanderstraeten, L., 2018. Living in Flanders in 2018 [WWW Document]. URL https://steunpuntwonen.be/Documenten_2016-2020/Onderzoek_Werkpakketten/WP_1_Nieuwe_woonsurvey_en_woningschouwing/WP1-2_RAPPORT (accessed 5.3.21).

Motiva, 2020. Mitä energiatodistus maksaa? [WWW Document]. Motiva. URL https://www.motiva.fi/ratkaisut/energiatodistusneuvonta/mika_on_energiatodistus/mita_energiatodistus_maksaa (accessed 5.3.21).

Nationalrat, 2021. RIS - Energieausweis-Vorlage-Gesetz 2012 - Bundesrecht konsolidiert, Fassung vom 14.05.2021 [WWW Document]. URL https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20007799 (accessed 5.14.21).

österreichs energie, 2020. Analyse - Erneuerbaren-Ausbau-Gesetz.

österreichs energie, n.d. Smart Meter Roll-Out österreichweit [WWW Document]. URL https://oesterreichsenergie.at/die-welt-des-stroms/stromnetze/smart-meter/roll-out.html (accessed 2.15.21).

Rämö, A., 2019. Tilastokeskus - Rakennuskanta 2019 [WWW Document]. URL https://www.stat.fi/til/rakke/2019/rakke_2019_2020-05-27_kat_002_fi.html (accessed 5.3.21).

Rogsch, A., 2013. 3.

Statistik Austria, 2018. Heizungen 2003 bis 2018 nach Bundesländern, verwendetem Energieträger und Art der Heizung.

Tiihonen, A., 2019. Tilastokeskus - Asunnot ja asuinolot [WWW Document]. URL https://www.stat.fi/til/asas/2018/01/asas_2018_01_2019-10-10_tie_002_fi.html (accessed 5.3.21).

VEKA, 2017. Public statistics of EPCs [WWW Document]. URL https://www.energiesparen.be/sites/default/files/atoms/files/Statistieken_EPC_publiek.pdf (accessed 5.3.21).

VEKA, 2019. Evaluation of the renewed EPC survey among energy experts [WWW Document]. Evaluatie van het vernieuwde EPC -bevraging bij energiedeskundigen. URL https://www.energiesparen.be/sites/default/files/atoms/files/Rapport%20enqu%C3%AAte%20energiedeskundigen%202019%20golf%201.pdf (accessed 5.3.21).

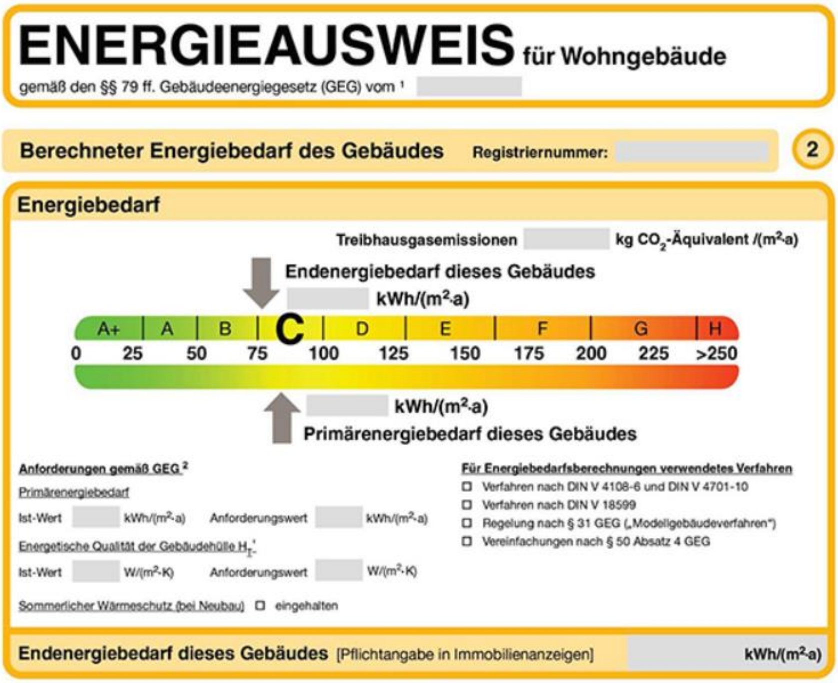
Wöhrmann, U., 2020. Österreich - Miet- und Eigentumsquote Hauptwohnsitzwohnungen 2019 [WWW Document]. Statista. URL https://de.statista.com/statistik/daten/studie/512031/umfrage/miet-und-eigentumsquote-von-hauptwohnsitzwohnungen-in-oesterreich/ (accessed 5.14.21).

5.1. Figures

5.2. Table

ANNEX

Germany's EPC rating system for residential buildings



Source: https://www.bundesanzeiger.de/pub/publication/2SIU5op5G3yYIYriRYt?0

Energieeffizienzklassen in Energieausweisen für Wohngebäude ab Mai 2014

Energie-effizienzklasse	Endenergiebedarf oder Endenergieverbrauch*	Ungefähre jährliche Energiekosten pro Quadratmeter Wohnfläche**
A+	unter 30 kWh/(m²a)	etwa 2 Euro
A	30 bis unter 50 kWh/(m²a)	4 Euro
B	50 bis unter 75 kWh/(m²a)	6 Euro
C	75 bis unter 100 kWh/(m²a)	8 Euro
D	100 bis unter 130 kWh/(m²a)	11 Euro
E	130 bis unter 160 kWh/(m²a)	14 Euro
F	160 bis unter 200 kWh/(m²a)	18 Euro
G	200 bis unter 250 kWh/(m²a)	22 Euro
H	über 250 kWh/(m²a)	25 Euro und mehr

Anmerkungen: * Ist bei einem vor dem 1. Mai 2014 ausgestellten Energieausweis der Warmwasserverbrauch nicht enthalten, muss der auf dem Ausweis genannte Energieverbrauchskennwert um eine Pauschale von 20,0 kWh/(m²a) erhöht werden. ** Die berechneten Energiekosten sind Durchschnittswerte, die je nach Lage der Wohnung und individuellem Verbrauch stark abweichen können. Angenommene Kosten: 6 ct je Kilowattstunde Brennstoff, wie etwa beim Erdgas. **Quelle: Verbraucherzentrale NRW**

Source: https://www.verbraucherzentrale.de/wissen/energie/energetische-sanierung/energieausweis-was-sagt-dieser-steckbrief-fuer-wohngebaeude-aus-24074