Recommendation report on integration of Next Generation EPC in national/regional certification schemes v1

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DELIVERABLE 6.2

Recommendation report on integration of NG EPC in national/regional certification schemes v1

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Executive Summary

One of the most important requirements and effective features (regarding providing information to the end-user) of the Energy Performance of the Buildings Directive (EPBD) is the Energy Performance Certificate (EPC). The purpose is to increase the demand for buildings with excellent energy efficiency performance and the use of renewable sources, both in new construction and renovation. Therefore, EPCs became mandatory at the point of selling and renting or for a construction permit in the Member States of the European Union.

Several years have passed since the first publication and implementation of the EPBD in Europe. The EPBD has been adapted and amended since its first application and an adapted EPBD is on the way and will be published soon. For sure, there will be many changes regarding the requirements for buildings by 2030, 2040 and 2050 in order to decarbonise the built environment. New features and requirements as well as adaptations are going to be added to the already existing ones. This report concentrates on the implementation of a few aspects of the EPBD and its amendments until 2021. Nevertheless, new changes will remain relevant for the implementation of the project D^2EPC.

The research carried out within the project shows that some of the Member States have adapted the EPC schemes since their first implementation in order to make them user-friendly. There are different methodologies currently used to issue an EPC at the European level. In some countries, the EPC is issued based on calculated energy demand (asset rating) or on real energy consumption (operational rating). Some Member States store the EPCs in a database at national or regional level. The information available in these databases is being used for different purposes – mostly for research and quality control of the EPCs. Some countries have obligatory education and trainings for the experts issuing EPCs. In the light of the new EPBD, the qualification of the EPC issuer gains more importance since the new set of indicators as well as renovation measures for a roadmap are going to be in part of the EPC scheme.

This report not only gives an update on the implementation of some aspects of the EPBD, such as quality control of EPCs or education of the EPC issuer, but also addresses further aspects, such as Smart Readiness Indicators, market acceptance, use of smart meters, connection of the EPC database to other databases and use of digital models, which are part of the project and its outcomes. For this purpose, a questionnaire was developed for the experts in the participating countries to gain an overview on these subjects. The questions address the following issues: i) Smart Readiness Indicators; ii) use of EPCs beyond provision at the point of selling, renting or construction; iii) methods of checking the application of renovation measures; iv) use of digital models, use of EPC databases; v) education of EPC issuers; vi) use of smart meters and finally; vii) market acceptance of EPCs.

Since the engagement of stakeholders – especially for the project exploitation and usability – is crucial, different aspects of the project's outcome for a "digital dynamic EPC" will be discussed and both advantages and opportunities for application will be determined within the workshops and meetings with relevant stakeholders (identified during the first project period). The feedback and the results of these interactions with stakeholders will feed into the work implementation of the project. The aim is to compile a recommendation report for the Next Generation of (dynamic) EPCs according to the latest version of the EPBD at the end of the project.

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List of Acronyms and Abbreviations

Term	Description
API	Application programming interface which is a connection between computers or between computer programs
BEPS	Building Energy Performance Simulations
BIM	Building Information Modelling
BMS	Building Management System
CO2-eq	Carbon Emission Equivalent
dEPC	Dynamic Energy Performance Certificates
EPC	Energy Performance Certificate
EPBD	Energy Performance of Building Directive
GIS	Geographic Information System
HVAC	Heating Ventilation Air-Conditioning
LCA	Life Cycle Assessment
NG EPC	Next Generation Energy Performance Certificate
nZEB	Nearly Zero-Energy Building
R&D	Research and Development
SRI	Smart Readiness Indicator
SWOT	Strengths, Weaknesses, Opportunities, Threats

1 Introduction

Energy performance certificates (EPCs) represent an essential part of the Energy Performance of Buildings Directive (EPBD) introduced in 2002, revised in 2010, and amended in 2018. The EPBD is the legislative and policy instrument tool of the EU to improve the energy performance of buildings across Europe, focusing on both existing and new buildings. EPCs are a mandatory requirement in Member States (MSs) at the point of selling or renting and when constructing a building. EPCs serve as a transparent information instrument for building owners and real estate agents and play an important role in providing information on the energy performance of buildings.

Even though current EPC schemes have contributed to the understanding of the energy performance of buildings in Europe, the experience so far has unveiled a number of constraints and limitations since their implementation. Looking at existing practices, energy performance certificates of new buildings are issued at the early stages of the building construction and do not consider the actual energy used in the building, especially concerning the living style of the occupants. The availability of building energy-related data and recordings of actual energy consumption through smart meters and sensors introduces several possibilities for integrating building management systems and digital twins into the certification process.

Although the EPC calculation process is based on a comprehensive set of standards, it still overlooks some important contributing aspects regarding the actual use of energy as it varies from one user to other such as indoor air quality and availability of daylight. In addition, there is room for improvement in the information provided by the EPC to the building user in a simple, user-friendly form. Even though thermal and acoustic comfort, indoor air quality and daylight are among the primary drivers for buildings renovation, they are not considered in current EPCs.

Generally, in the Member States, recommendations for the energy upgrade of existing buildings are automatically generated through a standard list of general measures such as thermal insulation or replacement of windows and are not presented in a tailor-made way that encourages the renovation of the building.

The aim of the D^2EPC project is to deliver and produce practical knowledge that can be integrated into the national and European energy legislative framework. Particularly, three topics will be analysed and elaborated that will deliver the required framework for improving the existing set of standards used in the calculation process of the buildings energy performance. These include practical ways of linking the findings of the project to national and regional certification schemes, connecting the planned scheme with building passports and renovation roadmaps as well as introducing the polluter pays concept into the new EPC schemes for those users who do not meet their expectations.

The aim of this report in Work Package 6 (Policy-related implication for the enforcement of the next generation EPCs scheme, Task 6.2 Linking NG EPC with integrated national/regional certification schemes & choices) is to examine the integration of NG EPCs in national/regional schemes of the partner countries.

1.1 Scope and objectives of the deliverable

This report will analyse the role and relationship of next generation EPCs (NG EPCs) in the EPBD and examine if there are any restrictions on their implementation in European countries. In the next step, the current implementation of the EPBD regarding the EPCs in the partner countries will be highlighted. For this task, a questionnaire was prepared and sent to the partner countries.

Additionally, the advantages of NG EPCs in the EU and in the project participating countries (e.g. real-time energy consumption instead of theoretical values) on a policy level will be identified (taking into account WP5 and WP1 results). The advantages will be weighed against market acceptance and user-

friendliness, costs and benefits, readiness and training of EPC issuers. To do this, the partners will collect information on the usability of existing EPC schemes and the linkage with national/regional EPC-databases (including structure, interfaces, etc.). Within this task, the stakeholders at national/regional level will be identified and invited to exchange information. These workshops will take place in the second phase of the project when interim results are available. The outcomes of these workshops will feed into the updated version of this report. In these workshops, the function and advantages of NG EPCs will be presented and the stakeholders will be advised on implementation of NG EPCs.

Step 2 in Task 6.2 is to discuss the outcomes of the project with national/regional stakeholders. The results of this work will be shown in the deliverable D6.6, which will include the advantages of the dynamic and digital EPC in comparison to established EPC systems, their integration in national/regional strategies, and recommendations.

1.2 Structure of the deliverable

This report (D6.2) is the first part of the report on recommendations for the integration of NG EPCs in national/regional certification schemes. It contains information on the status of the implementation of EPCs in partner countries and its development according to the deficiencies identified since the first implementation of the EPBD. It summarises the findings of the research during the first phase of the project and provides an overview of the usability of the different EPCs.

1.3 Relation to Other Tasks and Deliverables

The basis for Task 6.2 and this report are the outcomes of several work packages (WP). The stakeholders who are going to be involved in this WP were identified within WP1 (T1.2 Next-generation EPC's user and stakeholder requirements & market needs) as well as WP7 (Project communication, dissemination and exploitation). The stakeholders, especially at the level of decision-making, will contribute to improving future policies. These target groups at national/regional level can boost the exploitation of projects' results and the realisation of their long-term impact. This leads to overcoming barriers and promoting/applying NG EPCs in the market. Furthermore, this task considers the results of WP1 (Foundations for next-generation dynamic EPCs (dEPCs): Identifying challenges, needs and opportunities) and WP5 (Demonstration and impact assessment), especially the comparative assessment of current EPC schemes and the evaluation of the impact achieved by the D^2EPC framework in pilot buildings as well as consolidation of the lessons learned from real-life demonstrations.

2 Energy Performance Certificate

For the preparation of this report, the Energy Performance of Buildings Directive (EPBD) and its implementation status in the partner countries were the starting point. The Directive and its recast and amendment are:

- Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings
- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)
- Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency

The amended Directive (EU) 2018/844 requires that the transparency of the EPC should be improved and that Member States *'should adopt adequate measures to ensure, for example, that the performance of installed, replaced or upgraded technical building systems, such as for space heating, air-conditioning or water heating, is documented in view of building certification and compliance checking'* [3].

It also stipulates that *'[t]he installation of self-regulating devices in existing buildings for the separate regulation of the temperature in each room or, where justified, in a designated heated zone of the building unit should be considered where economically feasible…'* [3]

The Directive encourages digital solutions for the built environment in order to provide building users and owners with more accurate information about their consumption behaviour and to enable them to set steps towards higher energy efficiency. The use of a Smart Readiness Indicator to measure the capacity of buildings and of information and communication technologies and electronic systems is highly recommended.

Furthermore, the amended EPBD recommends raising the quality of EPCs, possibly by using databases to control the EPCs, to have an overview of the performance of buildings and to provide statistics at regional or national levels.

The European Commission further recommends using current independent control systems for energy performance certificates to check compliance and ensure that certificates are of good quality. Since having reliable data is vital to have an overview of the performance of buildings and energy savings generated by measures initiated by the Directive, high quality information of EPC databases could be used to verify compliance and produce statistics on regional or national building stocks.

In December 2021, the European Commission released a proposal for the recast of the EPBD for consultation[1]. The consultation will end at the end of February 2022. Therefore, possible adaptations regarding the EPCs will be considered in the second version of this report by the end of the project.

2.1 Definition

For a better understanding of the aim of the project, different EPC calculation methods and issuing procedures need to be explained:

[1] https://ec.europa.eu/energy/sites/default/files/proposal-recast-energy-performance-buildings-directive.pdf

EPC

According to the EPBD, the *'energy performance certificate of a building'* is:

'a certificate recognised by a Member State or by a legal person designated by it, which indicates the energy performance of a building or building unit, calculated according to a methodology adopted in accordance with Article 3' [1].

According to Article 3, '*Member States shall apply a methodology for calculating the energy performance of buildings in accordance with the common general framework set out in Annex I'* [1].

The EPC can be determined using a methodology based solely on calculated energy demand (**asset rating**) or on real energy consumption (**operational rating**).

The rating is based on the energy efficiency value, which results from the calculated annual consumption of delivered energy, weighted according to the coefficients determined for different types of energy. For asset rating, a set of defined default values (e.g., indoor temperature …) is used. Operational rating, on the other hand, is derived from metered data of actual energy consumption and, therefore, reflects user behaviour and potential malfunctioning of equipment. This EPC can be issued based on 2–3 years of operation of the building. In the European countries, this methodology is used for limited types of buildings (e.g., non-residential buildings).

Dynamic EPC

The dynamic EPC allows for the regular monitoring of the actual performance of building by users based on real-time data, e.g., monthly or every six months.

The new dynamic EPC scheme in accordance with the requirements identified under the D^2EPC project is related to the regular measurements of a building's performance, as well as the further linkage of EPCs to the building renovation passports and digital logbooks. We use the term operational EPC to refer to the methodological approach employed to gather data of an as-operated building. This means collecting actual energy consumption, examining it and based on the outcomes, suggesting mitigation actions to combat uncontrolled energy use.

D^2EPC

The NG EPC studied in D^2EPC goes further. It sets its foundations on the smart-readiness level of buildings and the corresponding data collection infrastructure and management systems. It is fed by operational data and adopts the 'digital twin' concept to advance building information modelling, calculate a novel set of energy, environmental, financial and human comfort/ wellbeing indicators, and through them determine the EPC classification of the building. The calculation is based on real-time energy consumption and considers intelligent financial schemes associated with output-based assessment. A complete user profile in the scheme will comprise a set of comfort/wellbeing and behavioural indicators, along with the respective algorithms. Adding Life Cycle Assessment (LCA) indicators enables the evaluation of the environmental impact of any system throughout its life cycle by considering the required input and associated output resources of that system. The establishment of simplified indicators will enhance the building certificate's user-friendliness. A set of financial indicators based on the well-established concept of whole life cycle costs will enable the interpretation of individual elements of the buildings energy performance into normalised monetary values.

Asset rating versus operational rating of EPCs in the Member States

During the research previously carried out within the project, 14 MSs use asset rating as energy performance methodology, 2 make use of operational rating, and 13 MSs, including the United Kingdom (UK), use a combination of calculated and measured rating. For new buildings, asset rating is the EPC methodology most widely used because measurements of previous energy consumption are not available to perform operational rating calculations.

2.2 The role of the energy performance certificate in the EPBD

According to Directive 2002/91/EC, Directive 2010/31/EU and Directive (EU) 2018/844, the energy performance of a building should be calculated based on a methodology (which may differ in various regions) including the thermal performance of the building elements (windows, exterior walls, floor and ceiling) and its heating/cooling installations. A qualified expert who guarantees the independent objective evaluation of the building should issue the EPC.

The EPC as a document should provide information on the performance of the building in terms of energy use for the user or owner of the building. It should also make recommendations for cost-effective measures in case of major renovations. These measures should be technically feasible and provide an estimate of the range of payback periods or cost benefits over its economic life cycle. The EPC should be provided at the point of selling or renting or for construction permission. The Directive requires the certificate to be valid for a maximum of 10 years.

The EPC should provide reference values as benchmarks for energy performance so that the user or consumer can compare and assess the use of energy.

2.3 Implementation of the EPC in the EU & partner countries

2.3.1 Implementation of the EPC in the EU

The EPBD has required Member States to set up certification schemes for buildings since the publication of Directive 2002/91/EC in 2002. Most countries have already had systems in place for many years. At the beginning, there were some issues common for all building types, e.g., the question of costs, and some issues about the quality or the layout of certificates. Nearly all countries have opted for calculated energy consumption for the certification of new buildings. There are regional or national databases in most of the countries to collect EPCs that are used differently, e.g., for research on the performance of buildings, applications to receive subsidies, policy-making, etc.

What raises trust in an EPC is good quality data and information. EPCs are issued on different occasions: construction permit, sale or renting, subsidies, major renovations, etc. with the consequence that there can be different perceptions of the various EPC systems among different stakeholders/types of certificates in a given country.

More than half of European countries use the EPC to assess energy savings of building renovations. The majority of these countries use EPCs produced both before and after the renovation work and link public incentive programmes to improving the EPC [7].

2.3.1.1 Smart Readiness Indicators

In the amendment of the EPBD, it is mentioned that the Smart Readiness Indicator should be used to measure the capacity of buildings regarding information exchange. Additionally, information and communication technologies and electronic systems should be used to adapt the operation of buildings to the needs of occupants and the grid and to improve the energy efficiency and overall performance of buildings. In stakeholder engagement and research carried out in recent years, the scope of this indicator was discussed and documented. Since September 2021, a few member States have been putting this into practice to examine how it can be implemented.

In order to see how far the member countries of the project consortium are in terms of implementing or planning this indicator, a few questions were asked in questionnaires. In this report, a number of these questions are elaborated (see Chapter 2.3.2)

2.3.1.2 Costs and benefits

The EPC is the most visible part of the EPBD. An EPC scheme requires a set of tools and services to cover among others the EPC software, the EPC registry or database with recurring operational costs, the website for qualified experts and the public, helpdesks and the operation of an independent control system as well as associated software tools for data mining or quality control checks.

All Member States are of the opinion that EPCs should be easily affordable whilst providing a maximum of specific information in order to meet various expectations, resulting in a trade-off between cost and content [5]. The majority of Member States declare that the cost for single-family houses is between 100 € and 400 € per EPC. EPCs for multi-unit residential buildings cost more. Several Member States provided information on EPC costs for non-residential buildings, typically in the range of 1–5 €/m^2. There are different reasons for the differences in costs, for example the competence required for the verifier, the hourly rate and the complexity of the methodology used. A country's economic strength does not seem to have a strong influence on the EPC cost [5].

Asset-rated EPCs consume less time and are cheaper than EPCs produced from metered data [10]. However, energy savings are not easily identified because the breakdown of energy use is not recorded. This may influence the methodology selection in Member States where cost could greatly affect the use of EPC.

2.3.1.3 Quality control/Training and education of the EPC issuers

According to EPBD, a statistically significant percentage of all EPCs or inspection reports issued annually must be controlled through a random sample. This random sample is used to provide an understanding of the overall quality of the EPCs or inspections [8]. Even if an effective independent control system can be organised with or without a central EPC database, MSs using such databases recognise them as an essential element of their EPC scheme and as an important factor for high compliance rates. Experience shows that if there are no validation rules in the software, experts make a number of avoidable mistakes that can have a huge influence on the EPC rating.

In order to raise the quality of EPCs, education of EPC issuers is critical. The technical background of experts needs to be well adjusted to the needs of issuing EPCs, and their training needs to be designed to match the precise needs for energy certification. Experts should be trained to select appropriate boundary conditions and choose the right default values. Producing good recommendations for energy-saving measures for existing buildings is another essential task of the expert when preparing an EPC [9].

Best practice example in Europe:

Portugal:

In Portugal, the EPC is issued by a certified trained energy expert and uploaded to a national EPC database. The entries of EPCs are checked on various levels:

Level 1: Automatic input validation for all EPCs

- Platform automatically checks the inputs and identifies inconsistencies or "out of range" values
- EPC issuer can correct the inputs

Level 2: Simple quality checks carried out for 5–6% of EPCs

- Analysis carried out without the involvement of the EPC issuer
- Made solely by cross-referencing the documents uploaded by the issuer

Level 3: Detailed quality checks for about 0.5% of EPCs

- Replicates the work performed by the issuer

- More interaction between the quality assessors and the issuer
- If severe mistakes have been made, fines can be imposed.

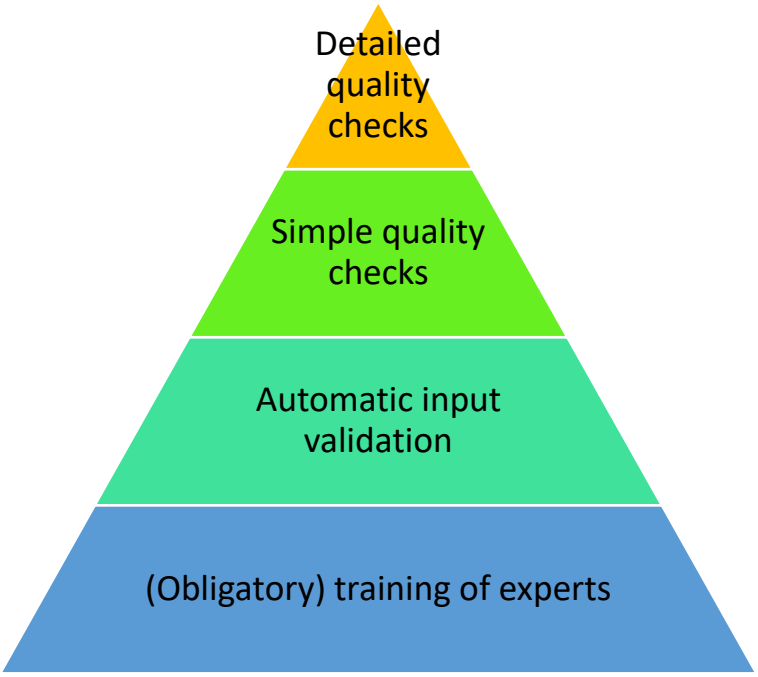

Figure 1: Levels of quality control of the EPC in the Portuguese EPC database (Source: ADENE, 2014) [4]

Errors and other issues identified in this process are registered in the database for recording the quality assurance. The most common mistakes are evaluated and considered in the training of the EPC issuer to avoid these errors in the future

2.3.1.4 Use of EPC databases

Most MSs have a national EPC database and those with regional databases are making efforts to combine them into a central database[2].

EPC databases – if available - are being used differently in Europe. Best practices when using EPC data in the EPC databases show optimal approaches for analysing and presenting data from EPCs for effective and useful implementation of energy-efficient refurbishment.

At their best, EPC databases enable [4]:

- Governments and academics to track the progress of policies to promote energy improvements across Europe's buildings;
- Governments and legitimate commercial providers of retrofit services to identify buildings most in need of energy upgrades;
- Building owners and occupiers and housing market actors to see the energy performance of individual properties and entire communities;

[2] The revision of the EPBD in December 2021 includes the national EPC databases have an overview of the buildings: *Member States shall set up national databases for energy performance certificates of buildings, which also allow to gather data related to building renovation passports and smart readiness indicators. Information from the national databases shall be transferred to the Building Stock Observatory, based on a template to be developed by the Commission*. Source: https://ec.europa.eu/energy/sites/default/files/proposal-recast-energy-performance-buildings-directive.pdf

- The Parties concerned to monitor and assess the quality of energy performance certificates.

In the past, best practice categories have been identified as:

- Open data initiatives,
- Statistical analysis,
- Policy monitoring for renovation activities,
- Use of data by municipalities, presentation and use of data by commercial players, and
- Quality control.

2.3.1.5 Market acceptance and user-friendliness

Although EPCs are raising awareness of energy efficiency among consumers, there is still room for improvement.

Regarding market acceptance, it has to be mentioned that many consumers find EPCs too technical and complicated to understand. Some Member States (about half) have undertaken efforts to make EPCs more user-friendly, e.g., the UK, Germany and Portugal. The use of technical language has been reduced to a minimum in the first pages of the EPC and more self-explanatory icons are used, whereas the technical sections, addressing experts and authorities, have been moved to the end of the document. There is still work to be done in order to increase market acceptance of EPCs.

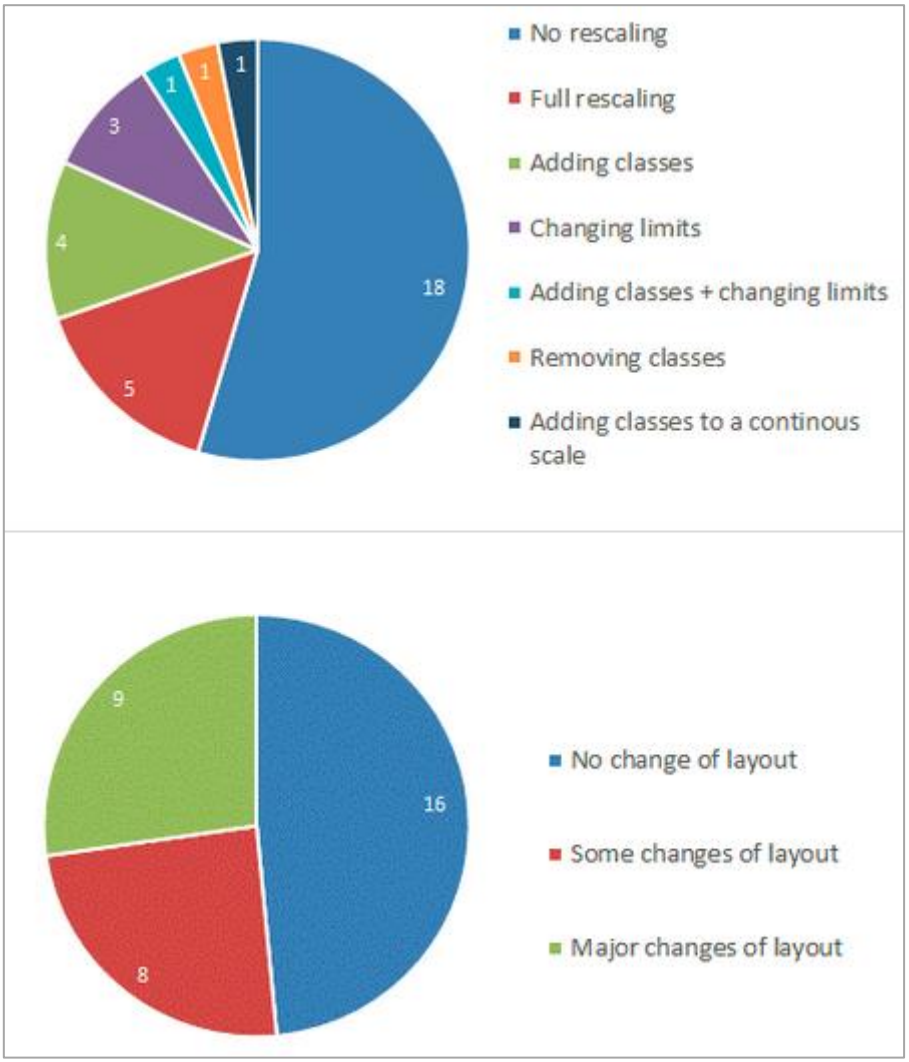

Figure 2: Types of rescaling (top) and layout changes (bottom) made to EPCs between the 2008 and 2014 versions, Source: Heijmans, Loncour[6]

2.3.2 Status of implementation of important aspects of the EPBD in partner countries

2.3.2.1 Smart Readiness Indicator

Implementation of the SRI

Among partner countries, Cyprus is the only country that has already implemented the SRI. In other partner countries, the decision has not yet been made. Since September 2021, a testing phase for implementing the SRI has started in Austria. The aim is to examine how and where the SRI can be displayed.

Incentives to promote intelligence-enabled systems

Paragraph 29 of the EPBD amended in 2018 requires that targeted incentives should be provided to promote intelligence-enabled systems and digital solutions in the built environment. This issue has been addressed differently. The updated EPBD stipulates that targeted incentives should be created to promote smart systems and digital solutions in the built environment. While these requirements have not been implemented in Austria, relatable incentives have been created in the partner countries.

Austria: In Austria, no targeted incentives have been created.

Cyprus*:* In Cyprus, no targeted incentives have been created, but rather evaluation recommendations for cost-effective measures.

The 5% extra building space allowance for buildings that reach Class A und obtain at least 25% of their primary energy consumption from RES was established in 2014. Most of the interest in this incentive comes from developers of large buildings. This incentive can also be used in the construction of new buildings.

The aim is to revise the "I save – I upgrade" scheme in order to remove existing hurdles, but also to design specialised financial products that could operate together or independently of "I save – I upgrade" schemes.

Greece*:* In Greece, no targeted incentives have been created, but smart metering of energy consumption has been incentivised and plans for smart and nearly Zero-Energy Building (nZEB) building investments have been developed.

Germany: The EPBD has led to the adaptation of the Energy Building Act (GEG) in Germany. This has significantly increased the requirements for automation. As a result, the GEG now records the degree of automation of residential buildings and uses it to calculate the energy certificate. This means that anyone who equips residential buildings with smart home functions, for example for heating, ventilation or shading, will receive this positive credit when preparing the energy certificate and thus a "better" energy certificate.

Lithuania*:* Due to the update of the EPBD, public clients are obliged to apply Building Information Modelling (BIM). For other clients, this requirement has only a recommendatory character.

Netherlands*:* In the Netherlands, EPBD III has been fully implemented in building regulations.

Independent control system for the SRI

Member States that decide to implement the Smart Readiness Indicator have to set up an independent control system for SRI certificates.

While in Austria and Cyprus the SRI is integrated into existing control systems like EPC databases, a new control system was set up in Greece. Other partner countries stated that there is still no decision regarding the control system for SRI certificates.

Professionals assessing the SRI

According to the EPBD, under the Smart Readiness Indicator system, the smart readiness of buildings and parts of buildings should be assessed by qualified or accredited professionals. In partner countries, the SRI is assessed by the following professionals:

Austria: Any professional with a technical background, e.g., architects, engineers, are considered qualified professionals.

Cyprus*:* Energy auditors, EPC assessors, qualified experts (EPC), energy managers

Greece*:* Only licensed professionals registered in the national database are allowed to assess the SRI.

Germany: Energy performance certificates are issued by experts who are qualified according to Section 88 of the Building Energy Act – GEG.

Lithuania*:* According to Lithuanian legislation, there is no requirement to assess the smart readiness of buildings.

Netherlands: So far, there has been no decision about the qualification of the SRI assessor.

2.3.2.2 Method of checking and establishing energy savings and the quality of renovation

In order to ensure that financial means related to energy efficiency are used in the best possible way for building renovation, they should be linked to the quality of the renovation work in terms of the energy savings sought or achieved. In Greece, Lithuania and the Netherlands, there are methods of checking and establishing energy savings and the quality of the renovation. In Austria, Cyprus and Germany, there is no method in this regard.

Greece: Quality control takes place through on-site visits and collection/check of new data/inputs.

Lithuania: Air leakage test must be performed for the buildings that are renovated using EU or Lithuanian budget grants.

Spain: Since there are financial aids that covers part of the cost of the renovation, it is mandatory to deliver the EPC of the building before and after the renovation. In addition, the financial aid is directly related with the improvement in energy efficiency, covering more part of the expenses when the improvement is bigger. Furthermore, in certain regions of Spain, a third-party company must verify that the real building and the information of the EPC are aligned, especially in buildings with high performance (energy class A, B or C).

2.3.2.3 Data and digital models

Using BIM in the EPC

The use of digital models such as BIM (Building Information Modelling) in EPCs differs among partner countries. In Austria, Cyprus and Greece, BIM is occasionally used in contrast to Germany, Lithuania and the Netherlands.

Austria: There are additional modules for BIM for the calculation of EPCs.

Cyprus: BIM documentation and literature or digital logbooks are not employed in any way for the issuance of EPCs. Building Management System (BMS) is not mentioned in the legislation in connection with EPCs. BMS can be a source of relevant data (heating efficiency recording) for newly issued EPCs. There is no legal obligation to use Geographic Information System (GIS) as a tool for EPC assessment.

Lithuania: According Lithuanian legislation there is no requirement to use digital models (like BIM) while issuing building EPCs.

Netherlands: Software suppliers for the calculation of energy use and savings use data from digital models; however, these digital models are not used for EPCs.

Spain: Some of the software that are used to deliver an EPC can get the geometrical data of the building from a 3D model. This model only has basic data about the building (distances, heights, etc.), all the remaining information that is needed in the calculation process has to be provided by the EPC assessor.

Likelihood of applying digital models

The likelihood of applying digital models is high in all partner countries.

Table 1: Likelihood of applying digital models in partner countries

Austria	Greece	Germany	Lithuania	Netherlands	Cyprus	Spain
likely	likely	no answer	likely	likely	very likely	not likely

Austria: Digital models such as BIM are increasingly used in the design and construction phase of buildings.

Lithuania: There is a commitment to using BIM technologies for certain types of projects.

Netherlands: This will be strongly influenced by legislation and the overall penetration grade of digitisation in the construction and real estate sector. Government and umbrella organisations, for example housing associations, can act as role models.

Spain: there is no plan to develop new software that can get the information of a building from the digital twin.

2.3.3 Use of the EPC

Regarding the use of the EPC, beside provision at the point of rent or sale or for building permits, the following purposes have been listed:

Table 2: Use of the EPC in partner countries

Austria	For: the approval of major renovations, the application of subsidies, financing renovation activities (e.g., loans)
Greece	For: the building notification of individual energy efficiency-related measures, the approval of major renovations, financing renovation activities (e.g., loans)
Germany	For: the approval of major renovations, the application of subsidies, financing renovation activities (e.g., loans)
Lithuania	For: the approval of major renovations, the application of subsidies
Netherlands	For: the application of subsidies, financing renovation activities (e.g., loans), discount on mortgage
Cyprus	For: the building notification of individual energy efficiency-related measures (e.g., replacement of the heating system, change of windows, etc.), the approval of major renovations
Spain	For: approval of major renovations, application of subsidies, financing the renovation activities (e.g., loans)

These answers were given regarding the provision of renovation recommendations:

Table 3: Provision of renovation recommendation

Austria	Greece	Germany	Lithuania	Netherlands	Cyprus	Spain
Automatically generated	Automatically generated	Tailor-made and automatically generated	Automatically generated	Tailor-made and automatically generated	Automatically generated	Tailor-made and automatically generated

Only in Greece, renovation costs are integrated into EPC recommendations. In Austria, energy advisors use a tool during energy audits that can provide an estimation of costs of energy efficiency measures. In Spain, the predefined improvements generated by the tool can be modified by the EPC assessor. The renovation costs can be added by the EPC assessor.

2.3.3.1 Use of smart meters in partner countries

Austria: At the end of 2020, the roll-out rate of communicative smart meters for Austria as a whole was only around 28%[3]. According to the plans submitted by the network operators (as of the end of March 2021), a roll-out of around 69% will be exceeded by the end of 2022 in order to reach the target of 95% by the end of 2024.

Cyprus: In Cyprus, there is no law in place concerning the use of smart meters.

Greece: Law 4342/2015 foresees the provision of individual metering devices to customers for electricity, natural gas, district heating, district cooling and domestic hot water, whenever an existing meter is replaced or a new connection is made. The Hellenic Electricity Distribution Network Operator (HEDNO S.A) is the responsible body for electricity meters.

Germany: There is no significant implementation of smart meters.

Lithuania: The current accounting situation for individual utilities in Lithuania is diverse in terms of modernity: out of 1.6 million household electricity meters, only 5,800 are smart. 11,000 out of 21,000 heat (input) meters have a remote reading function. 247,000 out of 665,000 hot water meters have a remote reading function, and all gas (582,000) and cold water (989,000) household meters are not smart. The situation also differs concerning suppliers: most electricity and gas meters throughout Lithuania are maintained by one supplier, and separate companies in different cities provide other utilities.

By the end of 2023, residents consuming more than 1,000 kWh of electricity per year and all business customers will be upgraded from old meters to new smart ones (about 1.2 million). Starting from 2024, old meters will be exchanged at the end of their metrological validation for the remaining residents. Upgrading the meter will not entail additional costs for the residents – it is part of the network investments performed by ESO (state-owned energy supplier of electricity and gas).

Netherlands: In 2015, network operators began offering smart meters on a large scale to households and small businesses. By 2020, smart meters are to be offered for around 8.5 million connections.

Spain: The only type of smart metering that is available in households are the electric smart meters provided by the electrical company. You can check in real time the consumption of your home directly from a webpage.

[3] Source: E-Control; Report on the introduction of smart meters in Austria 2021

2.3.3.2 Use of databases

All partner countries have databases (at national and/or regional level) for storing the EPCs. In Austria, six of nine provinces have regional EPC databases in addition to the national EPC database.

For storing the EPC, the following formats are used in partner countries:

Table 4: Format of storing the EPC in EPC databases

Austria	Greece	Germany	Lithuania	Netherlands	Cyprus	Spain
Microsoft Excel	XML	Proprietory formats of the software companies	Microsoft Excel	EP-Online	There are no open data sources. The assessment is based on relevant estimations.	PDF file

Some of the EPC databases of partner countries are linked to other databases:

Table 5: Linkage of the EPC database to other databases

Austria	Greece	Germany	Lithuania	Netherlands	Cyprus	Spain
yes The EPC database is connected to the construction material database called Baubook and heating products database[4].	no	no	yes The EPC database is connected to the real estate registration database	Yes EP-online is connected to the database of the Netherlands' Cadastre, Land Registry and Mapping Agency	no	no

Use of information stored in an EPC database

The information available on EPC databases are used for:

Austria: For research and policy making, for the proof of the energetical quality in case of obtaining subsidies and for registering the site in the EPC database

Greece: For random EPC inspections and reviews of specific EPCs following complaints

Germany: Information only accessible to database managers and not offered for any purpose other than quality checks

Lithuania: The information in the real estate database is used for selling, renting contracts.

Netherlands: To verify and use the correct address notation as contained in the database of Cadastre.

Spain: To have a general vision about the building´s energy performance.

[4] www.produktdatenbank-get.at

2.3.3.3 Education requirements and qualification of EPC issuers

Education of EPC issuers

Austria: Any professional with a technical background, e.g., architects, engineers, is considered as qualified professional.

Cyprus: EPC assessors are required to pass a qualifying examination under the categories of residential, non-residential buildings, or both. Training is not mandatory (Ministry of Energy, Commerce, and Industry, n.d.).

Greece: Qualified engineers registered as auditors/inspectors in the national register; further examination for higher classes of EPCs

Germany:
a) During the degree, a focus on training in the field of energy-saving construction or, after studying without such a focus, at least two years of professional experience in essential construction or plant engineering areas of structural engineering

b) Successful training in the field of energy-saving construction

c) Public appointment as a sworn expert for a subject in the field of energy-saving construction or in essential construction or plant-related areas of activity in building construction

Lithuania: University degree in civil engineering

Netherlands: Requirements for the education of EPC advisers are laid down in BRL9500-W and BRL9500-U[5] (depending on the education level and EPC exams).

Spain: Some education degrees are considered to give the necessary knowledge to deliver an EPC. These degrees are more likely with a technical background such as engineering and architecture.

Obligatory trainings for EPC issuers

Not all partner countries have obligatory trainings for EPC issuers.

Table 6: Obligatory training for EPC issuers in partner countries

Austria	Greece	Germany	Lithuania	Netherlands	Cyprus	Spain
no	yes	no answer	yes	yes	no	no

Austria: There are EPC calculation trainings on a voluntary basis.

Cyprus: There is no legal obligation for a systematic and regular evaluation/assessment of energy assessors' competencies and skills, only a general provision. Circulars and workshops are organised for each new development. If needed, special recommendations are made.

Greece: Law 4409 (July 2016) includes training requirements of energy auditors.

[5] These BRL's are part of the legislation that has been developed in The Netherlands as Elaboration of the EPBD. They describe the requirements for the certification of companies who offer energy labels for dwellings (W) and utility-buildings. Every energy advisor also needs is own education and to pass an exam, has to follow NTA8800 (method of doing a building survey and energy performance calculation) and has to connect with a company or organization who has a certificate in accordance with BRL9500-W and/or BRL9500-U. Connection means that the energy advisor is employed or otherwise associated (e.g. because the energy advisor is self-employed). NTA8800 (>1000 pages) also describes the formal rules who are elaborated in the BRL9500-W and -U. To make the NTA8800 easy to use, has ISSO made the publications ISSO82.1 and ISSO75.1 who give a more workable (easy to read) description of the method of doing building surveys.

Germany: Depending of the background of studies

Lithuania: There are obligatory trainings that include 47 academic hours for those who want to be attested as EPC issuers.

Netherlands: The refresher course for continuous professional development of the EPC adviser is obligatory.

Spain: There are trainings for each one of the software available, but they are not obligatory.

2.3.3.4 Market acceptance in partner countries

In these partner countries, there have been changes to EPCs in order to be better accepted on the market:

Table 7: EPC changes in partner countries for better acceptance on the market

Austria	Greece	Germany	Lithuania	Netherlands	Cyprus	Spain
no	no	yes	yes	yes	no answer	yes

Lithuania:
Indicators were added:

- $CO_{2\text{-eq}}$
- Primary energy demand
- Energy demand for cooling
- Renewable and nonrenewable energy demand
- Renewable and nonrenewable energy rate

Netherlands:

Indicators were added:

- $CO_{2\text{-eq}}$
- Primary energy demand

However, some indicators that were not described by the partner country have also been removed. Moreover, the display/illustration of information has been changed and easily understandable description of indicators has been provided.

Spain:
The Royal Decree 390/2021, issued in June 2021, sets the obligation of carrying out a visit by the EPC-issuer. In Spain is well-known that many times, the EPC-issuer didn't even visit the building, so the EPC credibility was very low.

2.3.3.5 Lessons learned

Lessons learned and steps taken to tackle the challenges seen since the start of the EPC scheme in partner countries are:

Austria: In the beginning, consumers were not particularly interested in the information contained in energy certificates. It was seen only as a document to be presented when selling, renting, obtaining building permits or subsidies. Since the information is calculated based on default values or predefined assumptions, the energy demand does not match the energy consumption. As a result, consumers use the energy bill as a source of information and the EPC does not yet influence user behaviour. This has led to the calculation method and default values being adjusted to minimise the gap between calculated and actual energy consumption.

Greece: EPCs are obligatory in building transactions and have been fully integrated in the current building market. Energy auditors are qualified professionals and have a high level of knowledge. Implementing EPC recommendations is a great challenge, which is mainly addressed through financial incentives and information campaigns. There are some open issues, e.g., EPCs for domestic buildings do not include the energy consumption of important consumers, such as lighting systems and electrical appliances. Also, statistics regarding building characteristics (e.g., U values, HVAC systems of buildings) could be made more easily available.

Germany: Depends on the position: we as Cleopa would prefer a standardisation of APIs and a shift away from the pure kWh/square meter description. Sustainability indicators should also be implemented and tested.

Lithuania: Some procedures that were previously not specified as mandatory for certification scheme, have now been specified as mandatory for certification (e.g. inspection of the object); the accuracy of some values has been increased (e.g., the indicator of building tightness).

Netherlands: Since the implementation of the EPC scheme, the standards have changed very frequently, which made it difficult for certain companies to maintain their software for the calculation processes. When developing the new determination method, attention was paid to simplicity, unambiguity, transparency, and applicability within the requirements of the EPBD guideline.

Spain: EPCs are mandatory when buying or renting a home, in addition, every 10 years is mandatory to recalculate the EPC. The general public don´t see the EPC as a valuable information tool because of the lack of education in the energy field.

Depending on the software that has been used to deliver the EPC, some simplifications or default values may have been taken, as it is not mandatory to check the construction materials that have been used in the building. There are some predefined values depending on the year of construction, but this can cause a deviation from the real performance of the building.

Recently, the legislation has changed in other to have a more realistic image of the buildings in the country, by making mandatory visiting the building. Despite this, there is a lack of information regarding the building construction or systems, that can be solve by implementing the digital twin in EPCs.

3 Involvement of stakeholders in workshops

The project partners have identified a wide range of people and organisations across the EU in order to have a holistic approach to the drawbacks and requirements of the current EPCs. Capturing stakeholder requirements from each stakeholder's perspective is paramount. The range of the stakeholders include:

- Energy experts/consultants for new construction and renovation
- Software producers, tool developers
- Policy makers, state/governmental departments – public bodies
- Facility managers, real estate agents (rental and sales of buildings)
- Standardisation bodies
- Research and Development (R&D) sector, researchers/academia
- Energy service companies (ESCOs)
- Owners/users/tenants
- Building services industry
- Suppliers
- Building material industry
- Energy agencies
- Environmental/social campaigning organisations
- EU Commission

In the questionnaire sent to the identified stakeholders at the beginning of the project, the following challenges were identified regarding the next generation of EPCs:

- Quality of EPC data
- Human-centric certificate
- Software credibility and quality
- Limited information on the actual energy performance of buildings
- Insufficient information for building users and limited user-friendliness
- Assessor's subjectivity during calculation procedures
- EPCs as an active part of a smart city concept

Partners will select the most relevant stakeholders for the level of implementation and invite them to national workshops to introduce the concept of the digital dynamic EPC as envisaged in the D^2EPC project. In these workshops, a brief explanation will be presented in order to show the structure, used data, outputs, and usability of the project's product (see figure below **D^2EPC context diagram**).

In these workshops, stakeholders will discuss the identified gaps and challenges under the objectives of the D^2EPC project. The outcomes of these workshops will be incorporated in the development of the dynamic digital EPC.

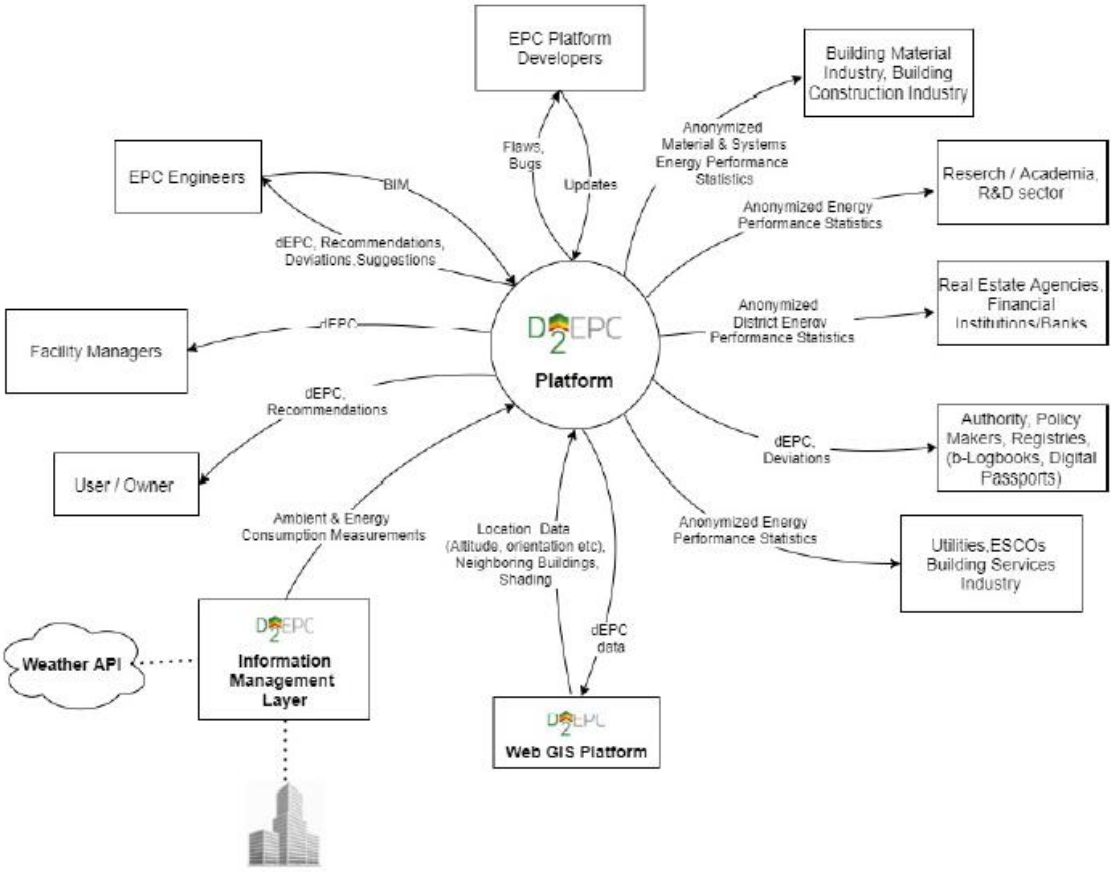

Figure 3: D^2EPC context diagram [11]

Below are the subjects of discussion recommended for the stakeholder workshops, including results of the questionnaires and advantages or strengths of the digital dynamic EPC.

3.1 Recommendations for discussion in the workshops: Results of the questionnaires

These recommendations result from the detailed analysis of users and technical questionnaires as well as from the desk research conducted within the project. The recommendations and guidelines target the following issues:

- Establishment of an operational dynamic EPC issued on a regular basis
- Establishment of EU standards on the classification requirements of buildings
- Establishment of a novel set of indicators covering environmental, financial, human comfort and technical aspects of new and existing buildings
- Issuance of EPCs based on real-time data and advanced BEPS tools integrated into BIM
- Integration of Smart Readiness Indicators in the building's energy performance assessment and certification
- Intelligent operational digital platform for dynamic EPCs issuance and real-time building performance monitoring and improvement
- Education of EPC issuers
- Quality control of EPCs

The energy efficiency rating can easily be converted into a dynamic, electronic format as in D^2EPC. Converting existing data from each source into a compatible format makes it possible to create a

dynamic energy performance certificate that adapts to any changes in the conditions. The energy consumption of a building changes according to current conditions. The types of energy and energy consumption vary, which may also result in changes in the energy efficiency rating. Instead of ordering a new energy performance certificate (which could be costly) each time the property is sold, an up-to-date energy performance certificate is always available in the existing system. This information is available throughout the whole life cycle of the building.

3.2 Recommendations for discussion in the workshops: Comparison of EPC, Dynamic EPC & D^2EPC

A methodology targeting all building types may complicate the energy performance assessment of simple buildings because of the large amounts of input data necessary. By employing a combination of calculated and measured rating, countries are able to define different methodologies depending on building type, stage, construction year, etc., leading to an improved representation of the building stock's energy performance.

In a previous chapter, different types of EPCs were described. All these calculations and provisions have their advantages and deficiencies. In the tables below, the advantages, deficiencies and opportunities that can be used to improve the EPC scheme are listed. These tables will be discussed in the workshops:

Table 8: Comparison of EPC schemes

Advantages/Deficiencies	EPC	Dynamic EPC	D^2EPC
	+/-		

Table 9: SWOT analysis of EPCs

EPC asset rating	
Strengths • X • X • X	Weaknesses • X • X • X
Opportunities • X • X • X	Threats • X • X • X

Dynamic EPC	
Strengths • X • X • X	Weaknesses • X • X • X
Opportunities • X • X • X	Threats • X • X • X
D^2EPC	
Strengths • X • X • X	Weaknesses • X • X • X
Opportunities • X • X • X	Threats • X • X • X

References

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[11]. D^2EPC_D1.4_D^2EPC Framework Architecture and specifications v1, Link

ANNEX A: Questionnaire in Task 1.1

In order to collect data on the integration of information beyond the EPBD requirements regarding EPCs, a questionnaire was sent to European Member States. This was the starting point of the project (in Work Package 1: Foundations for next-generation dynamic EPCs). This set of questions was designed to investigate the challenging matters of EPCs, which are subject of the project. The questions below are the first round of collecting information (see also D1.1: Comparative assessment of current EPC schemes and relevant emerging building performance paradigms v1):

1. What is the period of validity of an EPC currently issued in your region/country?

2. In case of re-assessment of an EPC based on operational data, are there incentives or penalties in relation to the owners' compliance or non-compliance with the certificate assessment/rating?

3. Are BIM documentation and literature or digital logbooks employed in any way for the issuance of EPCs in your region/country?

4. If a Building Management System (BMS) exists, to what extent are data documented by BMS employed in the issuance or re-issuance of operational EPCs?

5. Are Geographic Information System (GIS) data exploited for issuing, validating, monitoring and verifying processes of the EPC calculation?

6. Does the EPC procedure in your region/country include any energy-related financial indicators (e.g., energy €/m²)?

7. Does the EPC procedure in your region/country include any environmental/LCA-related financial indicators (e.g., embodied energy/m²)?

8. Does the EPC procedure in your region/country include any indoor air quality indicators (e.g., CO_2 concentration/m²)?

9. Do EPC auditors have access to joint databases concerning properties of building systems and building elements?

10. Is there a provision for a systematic and regular evaluation/assessment of energy assessors' competencies and skills?

ANNEX A: Questionnaire in Task 1.1

In this questionnaire, the countries are invited to share the status of implementation of EPC schemes and its evolution, lessons learned and steps taken to tackle the challenges seen since the start of the scheme. The aim is to show the advantages of NG EPCs in the European countries (e.g., real-time energy consumption instead of theoretical values) on a policy level. The advantages will be weighed against market acceptance and user-friendliness, costs and benefits, readiness and training of EPC issuers. To do this, information on the usability of existing EPC schemes and the linkage with national/regional EPC databases (including structure interfaces) will be collected.

Questions:

Paragraph 29 of the EPBD amended in 2018 requires that targeted incentives should be provided to promote intelligence-enabled systems and digital solutions in the built environment.

1. To what extent is this requirement met in your country?

Please explain: (free text)

2. In order to ensure that financial means related to energy efficiency are used in the best possible way for building renovation, they should be linked to the quality of the renovation work in terms of the energy savings sought or achieved.
   Is there already a method in your country to check and establish the energy savings/the quality of the renovation?
   - Yes
   - No
   - The method is in progress.

Please explain: (free text)

3. Implementing the Smart Readiness Indicator is optional for partner countries. Will the Smart Readiness Indicator be implemented in your country?
   - Yes
   - No
   - It is already being implemented.
   - There is no decision yet.

4. Under the Smart Readiness Indicator system, the smart readiness of buildings and parts of buildings should be assessed by qualified or accredited professionals with a view to issuing the SRI certificate.
   Who is defined as a “qualified or accredited professional” in your country?

Please explain: (free text)

5. Member States that decide to implement the Smart Readiness Indicator will set up an independent control system for SRI certificates.
   Which control system will be implemented in your country?
   - Newly set up control system
   - Integration of the SRI in existing control systems

6. The Commission Delegated Regulation (EU) of 14.10.2020 supplementing Directive (EU) 2010/31/EU states that to facilitate the calculation of scores for the SRI it should be possible to use digital models of buildings, including building data modelling and digital twins.
   How far is the implementation of using data from digital models like BIM (Building Information Modelling) in EPCs in your country?
   - Not started yet
   - Occasionally applied
   - Applied
   - I don't know.

Please explain: (free text)

7. In your opinion, how likely is the application of digital models in your country in the next 5 years?
   - Not likely
   - Likely
   - Very likely
   - I don't know.

Please explain: (free text)

Use of EPC:

8. What is EPC used for in your country besides provision at the point of selling, renting or for new construction? (multiple choice)
   - For the building notification of individual energy efficiency-related measures (e.g., replacement of heating system, change of windows, etc.)
   - For the approval of major renovations
   - For the application of subsidies
   - For financing renovation activities (e.g., loans)
   - For tax reduction
   - Others (free text)

9. How are the renovation recommendations created?
   - Tailor-made
   - Automatically generated

10. Are renovation costs integrated into EPC recommendations?
    - Yes
    - No

Connection with smart meters or other databases and tools:

11. Are EPCs stored in a database?
    - Yes
    - No
12. In which data format are data stored in the EPC database? (free text)

13. Is the EPC database connected to other databases?
    - Yes
    - No

14. To which other databases is the EPC database connected? (free text)

15. What is the information used for? (free text)

16. How far is smart metering implemented in your country? (free text)

Education of EPC issuers

17. Which education is required to be allowed to issue an EPC? (free text)

18. Are there obligatory trainings for EPC issuers?
    - Yes
    - No

Please explain: (free text)

Market acceptance

19. Has the EPC recently been changed in order to be better accepted on the market?
    - No
    - Yes

20. If yes, what was changed?
    - More indicators were added. Please choose the applicable indicators:
        - CO_2-equivalent
        - Primary energy demand
        - Real energy consumption
        - Smart Readiness Indicator
    - Indicators were removed
    - Display/illustration of information was changed
    - Easy-to-understand descriptions of indicators were provided
    - Other (free text)

21. What are lessons learned and steps taken to tackle the challenges seen since the start of the EPC scheme? Please explain: (free text)