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Analysis of the EPC template in Annex V to the EPBD recast proposal

Focus on newly proposed indicators and identification of synergies between EPCs and other tools

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Contents

Abstract

According to the *Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings (recast)*, by 2025 Energy Performance Certificates (EPCs) across the European Union shall comply with a common template, presented in Annex V to the Proposal.

This report presents a review study regarding the indicators of the EPC templates across Europe in comparison to the proposed ones within Annex V of the EPBD recast. To this end, the authors developed a methodology based on a qualitative and quantitative approach. The study provides a comprehensive overview, presented in tabular and graphical forms, where each indicator listed in Annex V is clustered and analyzed for compliance verification. The report also includes a section about the estimation of additional burden/costs that might impact the overall costs for both assessors and building owners, derived from the inclusion of those new indicators into the EPC template.

A second part of the study aims at highlighting synergies between EPCs and other building-related certification tools, namely the Smart Readiness Indicator (SRI), LEVEL(s), Building Renovation Passports (BRP), and Digital Building Logbooks (DBL). Data are often spread over many places and tools and in some cases are re-created several times leading to a lack of transparency and clarity. The study set the basis for a comprehensive overview, implementable over time, presenting in tabular and graphical form the correlation among the energy efficiency-related tools and the potential synergies with the EPC scheme.

Finally, the report highlights how the framing of information can lead an EPC to be more or less effective at encouraging the choice of more energy efficient buildings.

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1 Introduction

Energy Performance Certificate, since its introduction in 2002 by the Energy Performance of Buildings Directive (EPBD), has registered a greatly different level of implementation across EU, varying from country to country and depending to a large extent on the political and legal context, the available technical capacities to support the implementation, as well as the characteristics of the construction sector and buildings market in general.

Their current state differs significantly in building energy standards due to a real difficulty to translate directly from state-to-state as they are inherently customized to local environmental and market conditions. Nevertheless, they remain a key vehicle for advancing energy efficiency: in some Member States (MSs), where the EPC schemes have a long tradition and their implementation is properly done, the positive impact of the EPC on the real estate market has been recorded.

In 2021, the European Commission (EC) proposed, in the context of "Fit for 55" legislative package, the third revision of the EPBD, originally adopted in 2002, replaced in 2010, and revised in 2018, to improve and focus even more on energy efficiency for reaching the long-term climate and energy goals and to increase the renovation rate of the building sector in Europe. The recast EPBD was finally adopted in 2024.

There is a general consensus in existing literature, official EU communications, and technical reports, that EPCs and their availability in accessible databases can improve the transparency of the performance of the building stock, informing about energy performance, share of renewables, energy costs and the potential room for energy efficiency improvement at the building level. At the district, regional, national, or EU level, they are crucial for identifying the quality and the sample dimension of the worst-performing buildings that need urgent renovation measures.

In 2008, the EC launched the Call for proposal "Next-generation of Energy Performance Assessment and Certification" to stimulate and enable the roll-out of the next-generation of energy performance assessment and certification, with a view to achieving enhanced reliability, cost-effectiveness, and compliance with relevant EU standards and the EPBD.

Considering this, the EPBD proposal includes measures to make Energy Performance Certificates much clearer, more reliable and visible, with easy-to-understand information on energy performance and other key indicators, to benefit building owners, financial investors, and public authorities.

The EPBD revision also provides a clearer definition of what is considered a good-quality EPC, its purpose, and how it should be issued. Control mechanisms and visibility in property advertisements should be further improved. It provides a general picture of the EPC template with an identification of mandatory indicators on energy and GHG emissions, coupled with suggested ones, such as on charging points, indoor air quality, and Global Warming Potential based on the building's life-cycle carbon emissions.

Currently, the main information reported in the EPC can be summarized as follows:

- identification of the building or building unit being certified;
- description of the energy characteristics of the building, thermal envelope, facilities, standard operating conditions and occupation, thermal comfort, lighting, indoor air quality, and other data useful for the energy efficiency rating assessment of the building;
- the energy efficiency rating of the building expressed through an energy label from A (more efficient) to G (less efficient);
- recommendations to help the owner on improving the energy efficient rating of at least one letter grade if the existing rating of the property fall within classes B or C; or two letter grades if the existing rating falls within classes D, E, F or G;

— recommendations' estimated payback period on investment throughout its life cycle to help the owner determine the extent of work and how to proceed (e.g., major renovation, incremental steps);

— recommendations' cost-effectiveness based on several standard criteria (e.g., assessment of energy savings, underlying energy prices, preliminary cost estimate).

This study aims to evaluate the implementation status of EPC schemes across Europe by taking into account the indicators (both mandatory and suggested) of the EPC template in Annex V of the proposed EPBD recast. The aim is to identify good practices in making EPC data reliable, accessible and re-usable by the buildings community (i.e. real estate, buildings owners, tenants, experts, policymakers, etc.), but also to provide a rough estimation on additional burden/costs deriving from their inclusion in the EPC.

A second part of the study aims at highlighting synergies between EPCs and other building-related certification tools. Current construction practices are characterized by a significant amount of technical information generated and gathered over the life cycle of buildings from the design to the renovation phase. Nevertheless, building-related data (such as physical building characteristics, energy performance, comfort quality and renovation actions) continue to be scarce, of unreliable quality, characterized by limited accessibility, and in some cases ambiguous. This lack of clarity and synergies among existing and under-development tools leads to additional costs and inefficiencies, stifles innovation, increases risk and reduces investor confidence.

The digitalisation of data contributes to several EU initiatives and Strategies, such as "A Europe fit for the digital age", the "European Green Deal'' and its Renovation Wave, the new Circular Economy Action Plan, and the dedicated Strategy for a Sustainable Built Environment. However, many building information databases and tools exist across the EU, with high risk of redundancy where some information only benefits few market players and in many cases the information must be re-created several times. Information is spread over many places, and tools for safely storing, digitizing, and updating information are largely missing. Connecting and making synergies among all these data sources and users requires common "languages", interfaces and protocols to enable interoperability, data consistency, and information exchange.

In this respect, the second objective of this report is to investigate the current EPCs schemes and the most relevant initiatives to further stimulate their implementation across Europe showing similarities and potential synergies. The selected and investigated initiatives are four: Smart Readiness Indicator (SRI), Level(s), Building Renovation Passport (BRP), and Digital Building Logbook (DBL). All of them have been supported by the EC to provide a common framework respectively for rating the smart readiness of buildings, rating the sustainability level, outlining a long-term step-by-step renovation roadmap, and creating a unique digital repository of information that supports and follows throughout the whole building life cycle.

The intention of the EC is to support building digitalisation, new functionalities, automation, and monitoring of technical building systems for the improvement of energy efficiency. The integration of the SRI underlines the more and more holistic approach of the building assessment, (e.g., by enlarging the assessment from energy to health and well-being), digitalisation, and the integration of the building in the infrastructure of overall decarbonisation of the economy. The Digital Building Logbook (DBL) tool serves as an archive where all building information can be stored and continuously updated. In this way, a full record of the building history will be electronically available with data regarding construction plans and permits, maintenance and system replacement activities, energy and heat consumption and production, etc. The Building Renovation Passport (BRP) has been conceived as a tool that can stimulate cost-effective renovation in the form of a long-term basis, step-by-step deep renovation roadmap following defined quality criteria, and outline energy renovation measures that will improve the energy performance of the building. Building Renovation Passports and the Digital Building Logbook are tools that can help in achieving energy efficiency in existing buildings and contribute to reaching the EU Renovation Wave goals. The

Level(s) approach, through its Calculation and Assessment Tool, provides a common language for assessing and reporting on the sustainability quality of buildings from design to end of life.

The maturity level of the above-mentioned initiatives and related tools is different. The SRI and Level(s) present a specific assessment method with respectively dedicated tools which are under tuning since their definition with testing activities across the EU. The DBL and the BRP present a common framework and consensus at a general level, while the methodological implementation approach and the respective structure and functionalities are still under analysis and development, having not yet reached a common vision. This led to the proliferation of several national and local initiatives with different approaches and assessment methods and relative indicators, which make the comparative studies more difficult to be performed.

Overall, this study allowed the authors to frame the landscape of EPC indicators currently in use or already implemented by MSs, referring to the newly proposed ones in Annex V of the EPBD recast proposal. The results constitute a comprehensive reference to provide recommendations on several key aspects of the data structure and sources (i.e., policy compliance, data enrichment, dissemination, and main barriers) which should be taken into consideration for the creation of a common EPC scheme at EU level.

Secondly, trusting that the implementation potential and chances for success of the energy efficiency-related actions will increase through synergies within EU and international initiatives, this report summarizes the synergies and correlations between the four selected building-related tools and the EPC template presented in Annex V of the EPBD recast proposal.

Finally, the study looks at EPCs through the behavioural science lens and highlights how the framing of information can lead a certain EPC to be more or less effective at making citizens more likely to choose energy efficient dwellings.

2 Overall methodology of the study

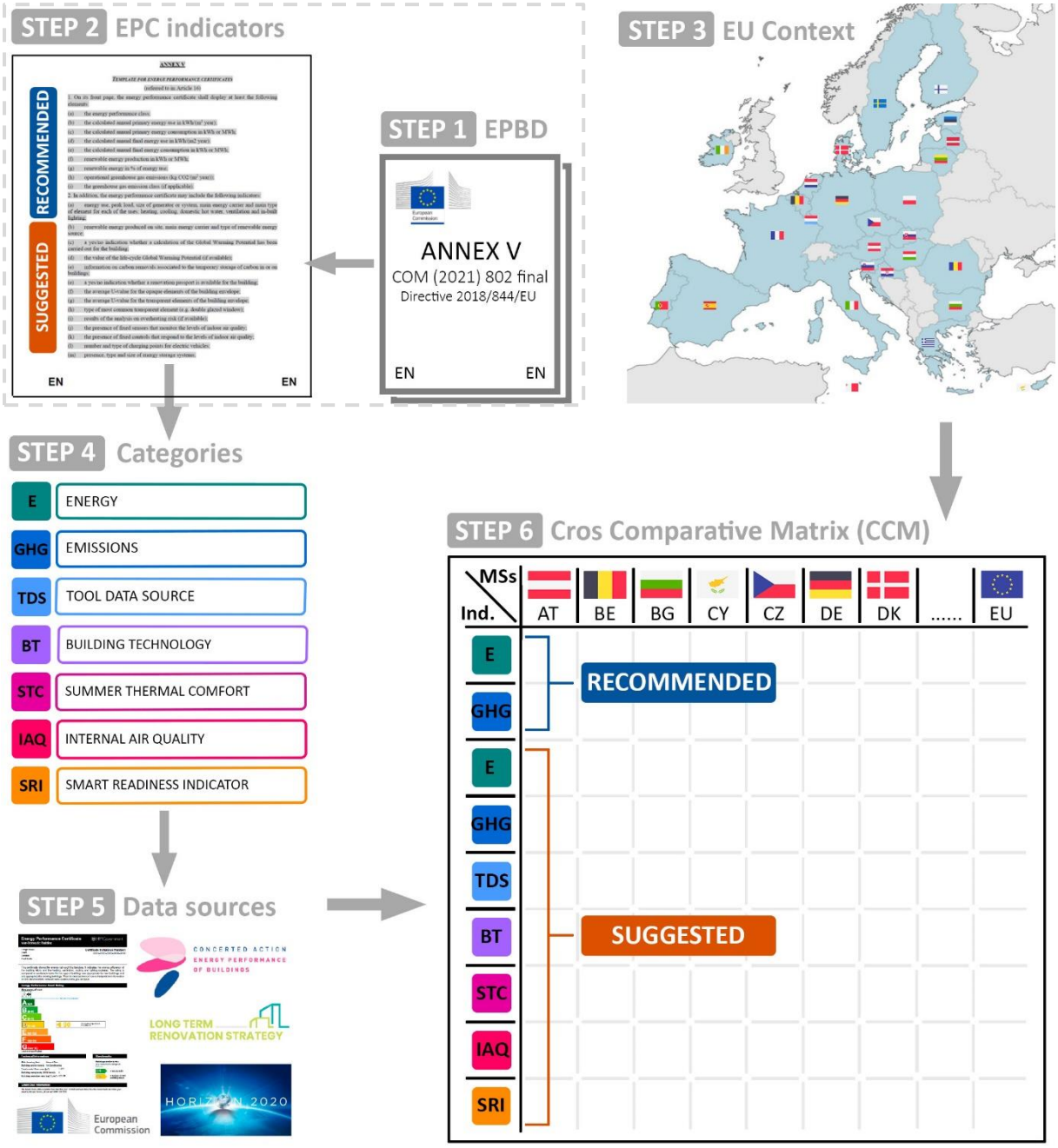
2.1 Methodology for the cross-comparative analysis on the EPC indicators

This section describes the methodology adopted for the analysis of the EPCs indicators included in the proposal for the EPBD recast (COM (2021) 802 final) into the Annex V. The evaluation methodology is based on a cross country comparison between the energy performance indicators to allow the identification of relevant discrepancies due to their implementation in the EPCs schemes (Sesana, et al., 2024).

The evaluation of each single indicator and the European context of application should request a very complex framework of results and interactions, for this reason the authors have decided to develop a Cross Comparative Matrix (CCM) across Europe of the EPC template indicators to conduct a qualitative and quantitative analysis.

The steps followed for the creation of the CCM has been graphically summarized in Figure 1, which also represents the data structure and the data flow foreseen for the population of such tool.

Figure 1. Graphical abstract of the methodology adopted within this work for the analysis of the EPC indicators across EU.



Source: Adapted from Sesana, et al. (2024).

The starting point (step 1 in Figure 1) for the CCM development is the complete list of first-page indicators of the Energy Performance Certificate template provided by Annex V of the EPBD recast (COM (2021) 802 final). The proposal foresees also a first classification of the indicators Table 1), considered as step 2 within the methodology approach, between:

- mandatory (Art 1, Annex V "On its front page, the energy performance certificate shall display");
- suggested (Art 2, Annex V "In addition, the energy performance certificate may include").

Table 1. EPC template indicators according to Annex V of the EPBD recast proposal. Numbers from 1 to 9: indicators that the energy performance certificate shall at least display. Numbers from 10 to 27: indicators that the energy performance certificate may include. Numbers from 28 to 30: indicators supporting the link with other relevant EU policy initiatives.

	No.	Indicator
Mandatory	1	Energy performance class
	2	Calculated annual primary energy use in kWh/m^2year
	3	Calculated annual primary energy consumption in kWh or MWh
	4	Calculated annual final energy use in kWh/m^2year
	5	Calculated annual final energy consumption in kWh or MWh
	6	Renewable energy production in kWh or MWh
	7	Renewable energy in % of energy use
	8	Operational greenhouse gas emissions (kg CO_2/m^2year)
	9	Greenhouse gas emission class (if applicable)
Suggested	10	Energy use, peak load, size of generator or system, main energy carrier, and main type of element for each of the uses: heating, cooling, domestic hot water, ventilation, and in-built lighting
	11	Renewable energy produced on-site, main energy carrier, and type of renewable energy source
	12	Yes/no indication whether a calculation of the Global Warming Potential has been carried out for the building
	13	Value of life-cycle Global Warming Potential (if available)
	14	Information on carbon removals associated with the temporary storage of carbon in or on buildings
	15	Yes/no indication whether a renovation passport is available for the building
	16	Average U-value for the opaque elements of the building envelope
	17	Average U-value for the transparent elements of the building envelope
	18	Type of most common transparent element (e.g., double-glazed window)
	19	Results of the analysis on overheating risk (if available)
	20	Presence of fixed sensors that monitor the levels of indoor air quality
	21	Presence of fixed controls that respond to the levels of indoor air quality
	22	Number and type of charging points for electric vehicles
	23	Presence, type, and size of energy storage systems
	24	Feasibility of adapting the heating system to operate at more efficient temperature settings
	25	Feasibility of adapting the air conditioning system to operate at more efficient temperature settings
	26	Metered energy consumption
	27	Operational fine particulate matter (PM2.5) emissions
	28	Yes/no indication whether a smart readiness assessment has been carried out for the building
	29	Value of the smart readiness assessment (if available)
	30	Yes/no indication whether a Digital Building Logbook is available for the building

Source: Table elaborated by the authors.

Table 2. EPC template indicators clustered into seven categories selected by authors

NO.	CATEGORY		INDICATORS NAME
1	E	1	Energy performance class
2	E	2	Calculated annual primary energy use in kWh/m^{2}year
3	E	3	Calculated annual primary energy consumption in kWh or MWh
4	E	4	Calculated annual final energy use in kWh/m^{2}year
5	E	5	Calculated annual final energy consumption in kWh or MWh
6	E	6	Renewable energy production in kWh or MWh
7	E	7	Renewable energy in % of energy use
8	GHG	1	Operational greenhouse gas emissions (kg CO_2/m^{2}year)
9	GHG	2	Greenhouse gas emission class (if applicable)
10	E	8	Energy use, peak load, size of generator or system, main energy carrier, and main type of element for each of the uses: heating, cooling, domestic hot water, ventilation, and in-built lighting
11	E	9	Renewable energy produced on-site, main energy carrier, and type of renewable energy source
12	GHG	3	Yes/no indication whether a calculation of the Global Warming Potential has been carried out for the building
13	GHG	4	Value of life-cycle Global Warming Potential (if available)
14	GHG	5	Information on carbon removals associated with the temporary storage of carbon in or on buildings
15	TDS	1	Yes/no indication whether a renovation passport is available for the building
16	BT	1	Average U-value for the opaque elements of the building envelope
17	BT	2	Average U-value for the transparent elements of the building envelope
18	BT	3	Type of most common transparent element (e.g., double-glazed window)
19	STC	1	Results of the analysis on overheating risk (if available)
20	IAQ	1	Presence of fixed sensors that monitor the levels of indoor air quality
21	IAQ	2	Presence of fixed controls that respond to the levels of indoor air quality
22	SRI	1	Number and type of charging points for electric vehicles
23	SRI	2	Presence, type, and size of energy storage systems
24	SRI	3	Feasibility of adapting the heating system to operate at more efficient temperature settings
25	SRI	4	Feasibility of adapting the air conditioning system to operate at more efficient temperature settings
26	SRI	5	Metered energy consumption
27	IAQ	3	Operational fine particulate matter (PM2.5) emissions
28	SRI	6	Yes/no indication whether a smart readiness assessment has been carried out for the building
29	SRI	7	Value of the smart readiness assessment (if available)
30	TDS	2	Yes/no indication whether a Digital Building Logbook is available for the building

Source: Sesana, et al. (2024).

Being the European Union the context of the work, step 3 focuses on the analysis of all the 27 EU Member States (MSs), which will constitute the columns of the CCM, coupled with a final column dedicated to Europe as a whole, to also provide an overall continent vision.

The next step regards the definition of the CCM rows which correspond to the whole indicators listed in Annex V, clustered firstly per mandatory and suggested indicators (step 2), and then also per categories to deeply characterize the analysis. Seven are the categories (Table 2) identified by authors (step 4) according to existing literature (Arbulu et al., 2022; Gómez-Gil et al., 2023; Li et al., 2019; Võsa et al., 2021; Zuhaib et al., 2022) and their own expertise: Energy (E); Emissions (GHG); Tool and Data Source (TDS); Building Technology (BT); Summer Thermal Comfort (STC); Indoor Air Quality (IAQ); Smart Readiness Indicator (SRI).

After the organisation of the CCM structure, step 5 foresees the data sources investigation and collection to populate the content itself of the matrix. Different data sources have been considered to collect all the necessary information starting from the regulatory framework (EU legislations, directives, and standards), the concerted action reports, and the national, regional, and local regulations and standards (such as for example the Long-Term Renovation Strategies implemented in each MSs). In addition, H2020 projects' public deliverables and other topic-related reports have been considered valuable sources (such as BPIE reports and other technical reports and scientific publications) to complete the overview and the data collection.

Step 6 consists of the Cross-Correlation Matrix conclusive development, which corresponds to the final activity of the methodology applied by authors to conduct different analyses on the EPC indicators. The modular and clustered structure of the EPC indicators into the CCM and the overview across Europe of the respective collected data permit a multifunctional use of this tool, able to provide multiple data reading features presented in detail in the following paragraphs.

2.1.1 Cross-Correlation Matrix tool: features and characteristics for data analysis

The necessity to analyze EPC indicators referring to different aspects, uses, and contents without spreading all the available information led the authors to develop a matrix. The added value offered by the EPC data collected within a matrix is the possibility to understand, compare and cluster them in order to deeply evaluate their implementation or eventually identified barriers and/or constraints that limit their introduction or calculation into the EPC scheme.

The CCM has been structured and populated to provide both qualitative (see Annex 1 of the present document) and quantitative (see Annex 2 of the present document) analysis results. The choice to pair qualitative and quantitative analysis comes from the necessity to gain richer insights and to allow a final comparison of the indicators through the EU MSs for estimating the Compliance Score (CS) as graphically summarized in Figure 2.

The CS indicator could be evaluated both for each single Member State, in order to quantify how many EPC proposed indicators have been already implemented in the respective national EPC template, but also per indicator to quantify how deep each single EPC indicator is diffused and implemented in the EU comparing the situation of all 27 EU MSs.

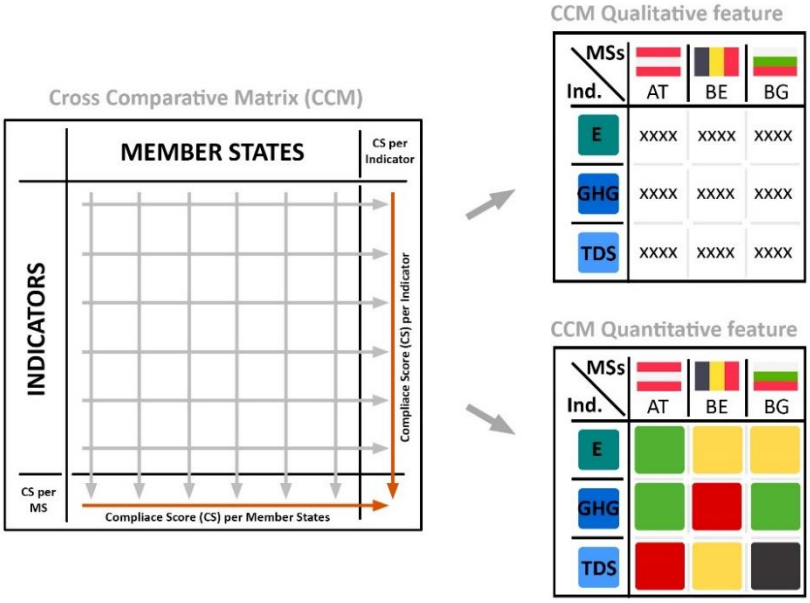
The first CCM reading feature is the qualitative data results which provided properties, characteristics, and details per indicator per Member States according to the data collected from available data sources and existing literature.

The second CCM reading feature is the quantitative one, which provides quantitative values to evaluate the so-called Compliance Score (CS) of each indicator in Europe, comparing the 27 EU Member States, but also the CS of all the indicators proposed by the EPBD revision in each EU MSs.

The quantitative analysis has been represented using a heat-map, a graphical representation of data where values are depicted by color and make it easy to visualize complex data and understand it at a glance. In particular, by aggregating results, the heat-map gives a snapshot understanding to identify trends, optimizing and increasing the comprehension of the current implementation of the

indicators across the different EPC templates in Europe. The legend for the quantitative analysis - based on a 0-2 point-scale rating coupled with colors - has been chosen to enhance the impact and the user-friendly reading level of the matrix.

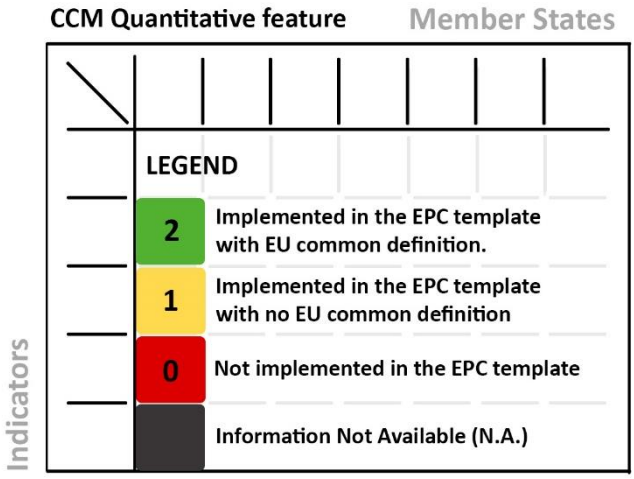
Figure 2. Cross Comparative Matrix structure and qualitative and quantitative reading features



Source: Adapted from Sesana, et al. (2024).

Figure 3 represents the legend of the CCM qualitative data feature, where: black cell stands for information Not Available (N.A.), green and yellow colors represent an indicator already implemented in the EPC template but green color specifies that the indicators has been implemented in the EPC template with a common European definition (i.e. in line with EU regulations or standards); while yellow one corresponds to the case in which the indicator has been implemented with no EU common definition, but with specific definition and/or calculation method defined by its own MS in the function of for example local regulations, climate conditions, or other specific requirements. Finally, the red cell indicates an indicator not yet implemented in the EPC template.

Figure 3. Quantitative legend of the Cross Comparative Matrix, based on the Likert scale rating coupled with colors



Source: Figure elaborated by the authors.

Besides the specific analysis of each indicator in each MS, an overall vision of the EPC indicators implementation is provided by the Compliance Score indicator. Its value in fact indicates both the

state of implementation of the single indicator with respect to the 27 MSs (values in the last column of the CCM), but also the state of progress of implementation into the EPC template for each MS of all the 30 proposed indicators. This simple point-scale rating allows to highlight which indicators have been already implemented and in how many countries (Figure 2).

The value of the CS indicator has been calculated based on a Likert scale rating (from 0 to 2) correspondent to the colors (from red to green) of the CCM quantitative feature Figure 3.

2.1.2 Cross Correlation Matrix tool: methodology and metrics of the Burden Costs analysis

The study foresees also a further investigation regarding the additional burden costs necessary for the implementation of the proposed EPC indicators into the EPC scheme, which might impact the overall costs for both assessors and building owners. Starting from the CCM already structured and populated for the first qualitative and quantitative analysis, authors defined a method of the work to optimize its use to allow even this sectorial evaluation on the additional burden costs due to the implementation of indicators, focusing only on selected countries.

In this context, a dedicated feature of the Cross Comparative Matrix has been derived on Burden Costs (BCs), starting from the selection of some EU countries on which conducting the analysis. The choice derives from the existing connections and networking of the authors to facilitate the data collection and information on the topic, being not well grounded in literature. In fact, the existing literature is mainly composed of deliverables or technical factsheets from EU funding projects (Table 4) referring to the countries of the consortium partners, which mainly correspond also to the selected MSs chosen by the authors. Moreover, dedicated online interviews, between authors and experts involved on those researches, have been conducted in order to enhance the quality and quantity of the available information on the topic. Even if the analysis cover only selected countries, authors and the interviewed experts believe that the main findings of the analysis could be considered valid for the whole MSs reflecting a realistic and similar situation also for the other countries across Europe.

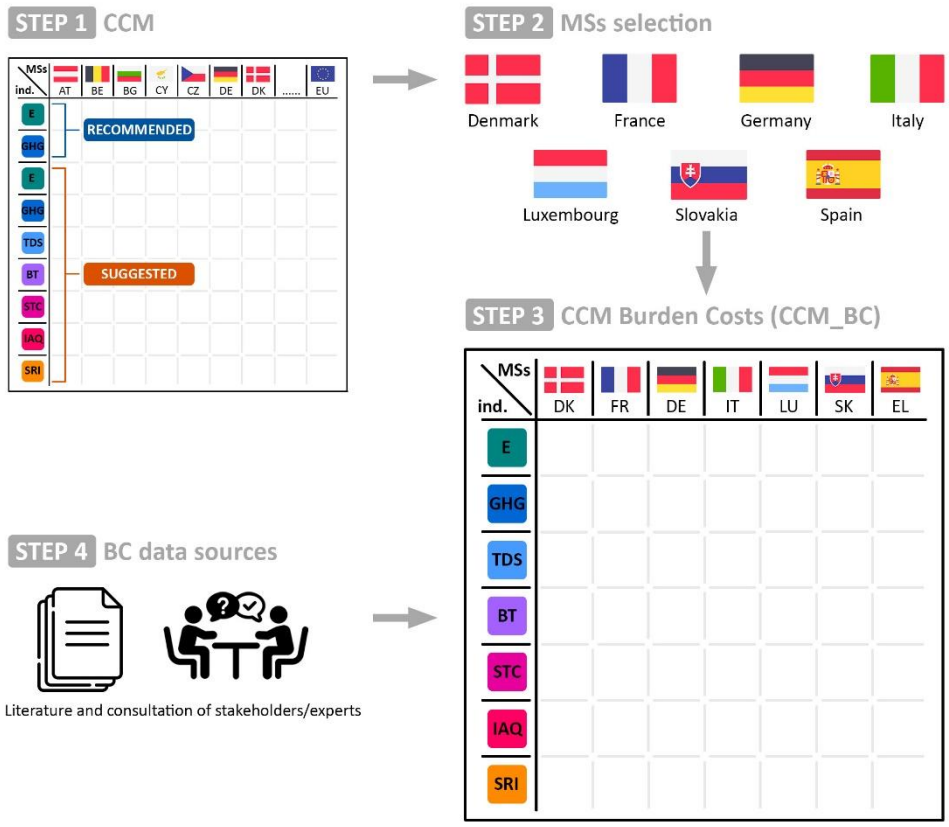
Figure 4 graphically summarized the step-by-step procedure followed even in this case for the CCM on Burden Costs. The starting point is, as anticipated, the CCM general structure (step 1), followed by the selection of the seven EU countries (Denmark, France, Germany, Italy, Luxembourg, Slovakia and Spain – step 2) which led to the final structure of the CCM on Burden Costs (step 3). The review and study of the existing literature on costs for indicators implementation (see documents listed in Table 4) and the consultations performed by authors with stakeholders and experts from each of the selected MSs constitute the step 4.

Even for this matrix a dedicated legend (Table 3) has been defined to facilitate the reading and to limit the margin of error considering inadequate and inaccurate to quantify the price and preferring instead to quantify the additional efforts needed to integrate the indicators into the EPC assessment procedure.

In this context, three are the Burden Cost level identified: negligible, medium and high represented into the CCM BC with an incremental number of symbol "+", respectively with 1, 2 and 3, and in case the indicator has been already implemented in the EPC template, leaving empty the cell.

All the results and contents of the CMM features (qualitative – Annex 1; quantitative – Annex 2 and Burden Costs – Annex 4) are reported in detail within the Annexes of the present report.

Figure 4. Cross Comparative Matrix for Burden Costs analysis: methodology and structure



Source: Adapted from Sesana, et al. (2024).

Table 3. Legend of the Cross Comparative Matrix for Burden Costs

Burden cost level	Motivation	Score
Negligible	The indicator is already in the calculation process, it has only to be displayed on the EPC.	**+**
Medium	The calculation procedure for the specific indicator can be easily implemented.	**++**
High	The indicator is based on real time monitoring that need to be implemented or tool development.	**+++**
-	The indicator is already displayed in the EPC template.	

Source: Table elaborated by the authors.

2.1.3 Data sources for the CCM population and analysis

Due to the lack of a unique European repository for the EPCs, a common harmonized language and structure of the certificates and classes, authors referred to various type of sources ranging from official EU documents, national, regional and local regulations and standards, project deliverables, technical reports and scientific publications, to stakeholders and experts' interviews conducted personally by the authors.

The data collection has been a fundamental step of the methodology to frame a complete overview on the topic and to populate the Cross Comparative Matrix.

For example, the Concerted Actions reports have been the initial data source for the state of the art in each MSs, being a valuable document, which describe the real progress per country on EPCs implementation, including issues of compliance, use of databases, and training of assessors.

Besides that, also the public deliverables and presentations of project research outcomes, funded by the European Commission under the Horizon 2020 Energy efficiency programme during the three-year period from 2018 to 2020, provided further insight into the EPC indicators, exploring current and future ways to implement certification of buildings' energy performance.

The main EU research projects used as data sources are listed in Table 4 in alphabetic order with respective details about period, funding programme, countries involved in the consortium. Additional information about projects' objectives and deliverables or other technical reports (from which data and inputs have been collected) is reported in Annex 5.

Table 4. Summary of the research projects considered as sources for the analysis.

Project name and period	EU funding programme	Consortium partners' countries
crossCert - Cross Assessment of Energy Certificates in Europe (2021-2024).	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; BG; HR; DK; DE; EL; MT; PL; SI; ES; UK.
E-DYCE - Energy flexible DYnamic building Certification (2020-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	DK; DE; EL; IT; CH.
ePANACEA - Smart European Energy Performance AssessmeNT And CErtificAtion (2020-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; BE; FI; DE; EL; ES.
EPC Recast - Energy Performance Certificate Recast (2020-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	BE; FR; DE; IT; LU; SI; ES.
EUB SuperHub - European Building Sustainability performance and energy certification Hub (2021-2024).	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; HR; FR; DE; HU; IE; IT.
iBRoad - Individual Building (Renovation) Roadmaps (2017-2020).	Horizon 2020 - EE-11-2016-17 - Overcoming market barriers and promoting deep renovation of buildings.	AT; BE; BG; DE; EL; PL; PT; RO; SE.
IDEAL EPBD - Improving Dwellings by Enhancing Actions on Labelling for the EPBD (-).	Intelligent Energy Europe Programme.	-
QualDeEPC - High-quality Energy Performance Assessment and Certification in Europe Accelerating Deep Energy Renovation (2019-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	BE; BG; DE; EL; HU; LV; ES; SE.

TIMEPAC - Towards Innovative Methods for Energy Performance Assessment and Certification of Buildings (2021-2024).	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; HR; CY; DE; IT; SI; ES.
X-tendo - eXTENDing the energy performance assessment and certification schemes via a mOdular approach (2019-2022).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; BE; DK; EE; EL; IT; PL; PT; RO; UK.

Source: Table elaborated by the authors.

2.2 **Methodology for the synergy's evaluation of EPC indicators**

The methodology followed in the second part of this study for the synergies evaluation, graphically represented in Figure 5, is based on a step-by-step approach similarly to the procedure defined and used for the cross-comparative analysis on the EPC indicators across EU described in section 2.1.

The starting point (step 1) for the synergies' analysis is the review of the tools listed below:

A. Smart Readiness Indicator (SRI)

B. Level(s)

C. Building Renovation Passport (BRP)

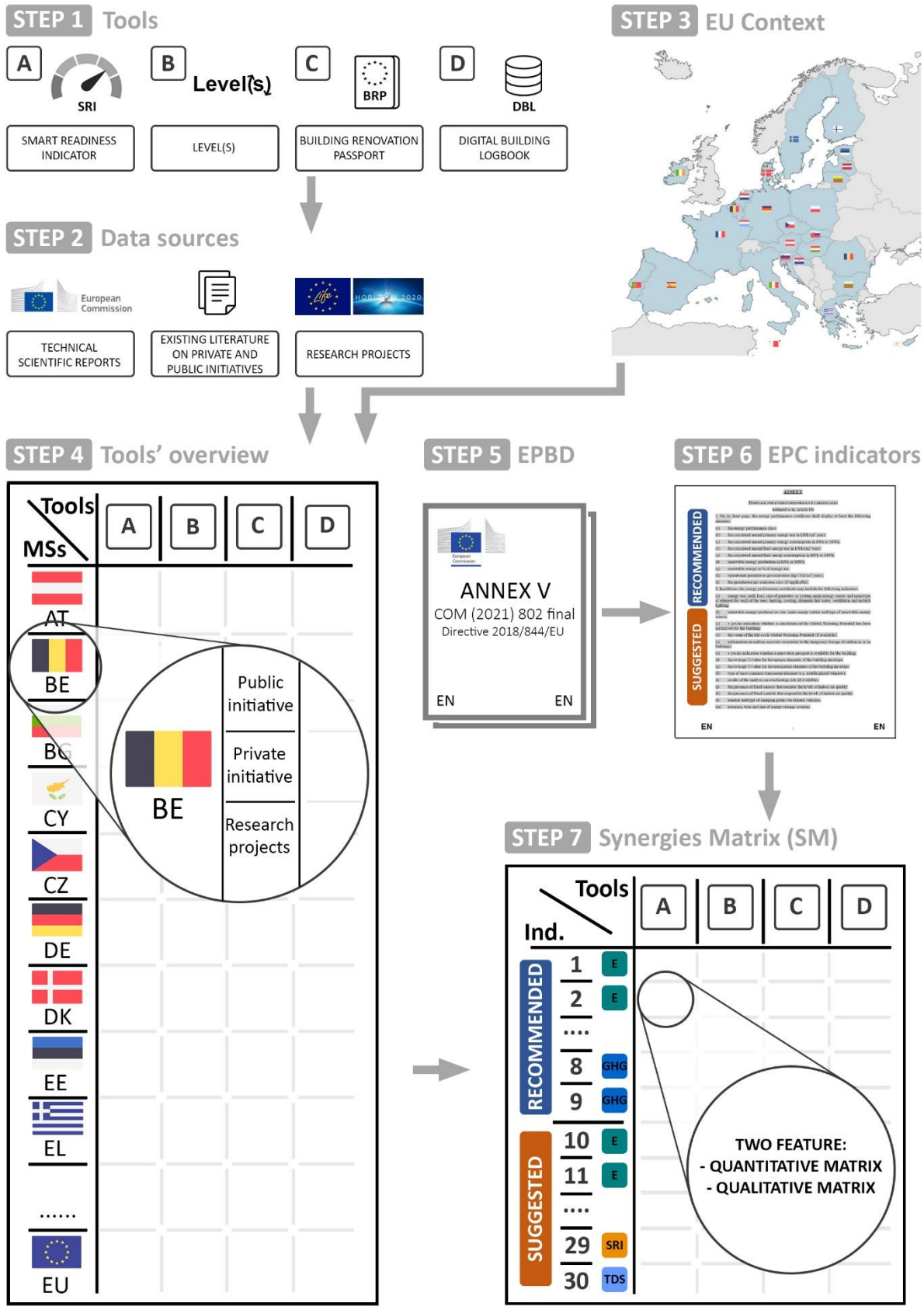
D. Digital Building Logbook (DBL)

Step 2 focuses on the data sources identification and data collection for the selected tools of step 1, available in literature. Being the European Union the context of the work, step 3 focuses on the data collection and clustering per country of all the 27 EU Member States (MSs). Step 4 is basically the summary of all the data collected within step 2 and organized per country (step 3) into the Tools' overview. This action permits to have a first insight on the different tools investigated across Europe regarding the level of knowledge or implementation of such instruments in the respective local practice - under public or private initiatives or research projects - and to draft an overall European vision of their knowledge, diffusion, and comprehension level.

Different data sources have been considered to collect all the necessary information starting from the regulatory framework (EU legislation, directives, and standards), national, regional and local regulations and standards, coupled with technical and official documentation available in literature on the selected tools for the analysis (such as technical/feasibility reports which monitor the state of progress of the instruments or manual and guidelines to facilitate their use). In addition, to complete the data collection, both Life and H2020 research programmes databases have been used as valuable sources for the selection of the most recent and in-line research projects with the topic of the study and their respective public deliverables and other topic-related reports.

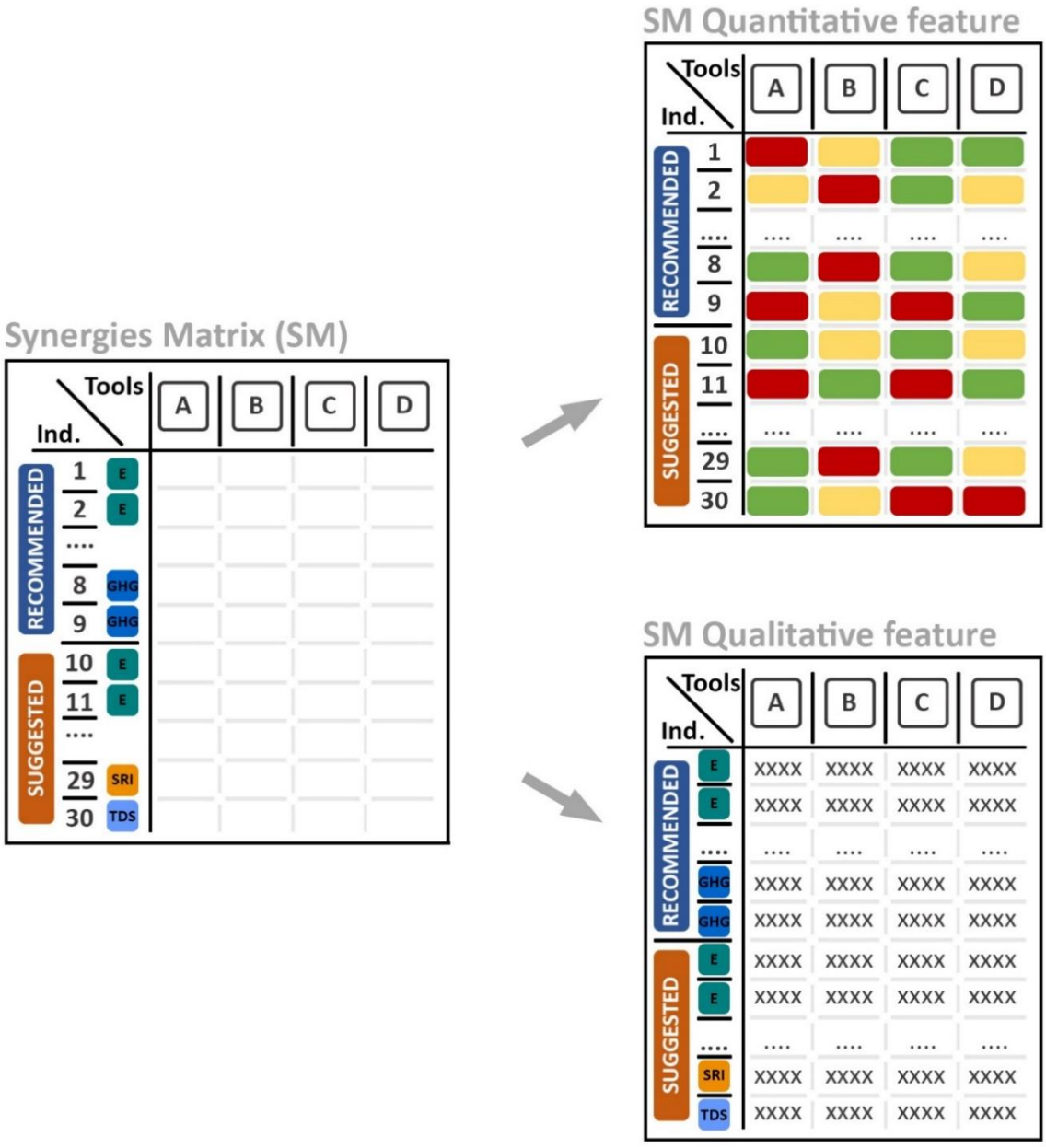
The following steps 5 and 6 recall respectively the EPC templates and the proposed EPC indicators from the EPBD revision into Annex V to combine them with the previous results of step 4.

Figure 5. Graphical abstract of the methodology adopted for the synergies' evaluation between EPC and selected tools.



Source: Figure elaborated by the authors.

Figure 6. Synergy Matrix structure and legends for both the quantitative and the qualitative feature used for the analysis.



Source: Figure elaborated by the authors.

Even for the synergies study, a dedicated matrix has been developed for the analysis of the collected data to evaluate similarities, barriers, and/or limitations regarding those tools around the EU and summarized them into the so-called Synergy Matrix (SM). For this reason, step 7 corresponds to the matrix structure definition based on rows constituted by the EPC indicators (divided into recommended and suggested) and columns by the tools of step 1.

The Synergies Matrix development, which corresponds to the final step of the methodology, presented a modular and clustered structure of the collected data, which permits a multifunctional data reading: both quantitative (Annex 9) and qualitative (Annex 10) features as graphically described in Figure 6. The SM quantitative feature has been represented using a heat-map, where values are depicted by color, making it easy to visualize the status of the EPC indicators implementation at a glance for the four tools. The qualitative feature provided properties, characteristics, and details - referring to each single EPC indicators - per each tool.

2.2.1 Overview on data sources for the methodology implementation

This subsection provides an overview of the current EU initiatives which are promoting the use across Europe of the selected tools: Smart Readiness Indicator (SRI), Level(s), Digital Building Logbook (DBL) and Building Renovation Passport (BRP), for the subsequent comparison with the EPC.

The data collection has been conducted mainly through literature review and interviews with experts and stakeholders. Relevant studies and research projects have been identified through a snowball method, where additional literature was discovered based on a few central studies, as well as stakeholder input (see bibliography for the full list of literature).

The main data sources of the present work are represented by official EU technical reports and scientific research literature published on relevant database and journals. Based on this approach, all the identified initiatives which are promoting the development and diffusion of those three tools, have been clustered according to the following categories: (1) public initiative; (2) private initiative and (3) EU research project.

The more relevant results of the literature review have been summarized respectively in the following tables (Table 5 for public initiatives, Table 6 for private ones and Table 7 for research projects). Each table provides an overview of the single initiative specifying the EU countries involved, the state of progress and the main outputs or tools. More information is provided in Annex 6, including a short description of each initiative.

Table 5. Summary of the public initiatives used as data sources for the analysis.

EU MSs	Name	State of progress	Outcomes/tools
DE	Gëbaudepass	In place - Voluntary	Gëbaudepass consists in a Digital Building Logbook, valid at a regional level.
DE	Hausakte	In place - Voluntary	Hausakte is intended as a Digital Building Logbook, valid at a regional level.
ES	Libro del Edificio	In place - Mandatory	The Libro del Edificio is presented as a series of documents collected into a unique paper as a Building Logbook, valid at a regional level.
PT	Livro de obra	In place - Mandatory	It consists in a series of documents collected into a unique paper that works as a Building Logbook, valid at a national scale.
NL	Opleverdossier	In place - Voluntary	Opleverdossier is a collection of documents that is kept in hard copy as a Building Logbook, valid at a national level.
IT	Fascicolo del fabbricato	In place –voluntary in general, mandatory only if specified in municipality's hygiene regulation	Fascicolo del fabbricato is the collection of a series of documents collected in a unique paper. Its compulsoriness depends on the local level hygiene regulation.
FI	Real estate service manual	In place - Mandatory	Real estate service manual consists in a Digital Building Logbook, valid at a national scale.
BE, Flanders	Woningpas	In place - Mandatory	The Woningpas is intended as a Digital Building Logbook and a Building Renovation Passport, valid at national scale and accessible to owners or third parties after authorisation.
DK	BedreBolig	In place - Voluntary	BedreBolig consists in a series of documents collected into a unique paper that works as a Building Logbook and as a Building Renovation Passport, valid at a national scale, focusing on the levels of energy consumption of buildings.
DE	Sanierungsfahrplan	In place - Voluntary	The Sanierungsfahrplan is considered as a Building

			Renovation Passport valid at a regional level. The renovation roadmap is composed by an overview of all the action planned.
EE	Ehitisregister	In place - Mandatory	Ehitisregister consists in a Digital Building Logbook valid at a national level. It lies on a map of Estonia showing all the building registered.
BE	Dossier d'intervention ultérieure	In place - Mandatory	DIU consists in a series of documents collected into a unique paper that is intended as a Building Logbook, valid at a national level.
EL	Electronic building ID	In place - Mandatory	The Electronic building ID is a collection of documents (building permit, energy efficiency, construction inspection certificate, floor plans, etc.) that is kept in hard copy in the building as a Building Logbook, valid at a national level.
SE	Klimatdeklaration	In place - Voluntary	Klimatdeklaration consists in a Digital Building Logbook valid at a national level.
FR	Carnet d'Information du Logement	In place - Mandatory	Carnet d'Information du Logement is a collection of documents that is kept in hard copy in the building and on digital level as a Building Logbook, valid at a national scale.
NL	CB-23 (Circular Construction 2023)	Under development	CB-23 will be introduced as a Digital Building Logbook and as Building Renovation Passport, valid at a national level.
AT	Austrian national test phase SRI	Under development	Tester of the official European Smart Readiness Indicator scheme.
HR	Croatian national test phase SRI	Under development	Tester of the official European Smart Readiness Indicator scheme.
CZ	Czech national test phase SRI	Under development	Tester of the official European Smart Readiness Indicator scheme.
DK	Danish national test phase SRI	Under development	Tester of the official European Smart Readiness Indicator scheme.
FI	Finnish national test phase SRI	Under development	Tester of the official European Smart Readiness Indicator scheme
FR	French national test phase SRI	Under development	Tester of the official European Smart Readiness Indicator scheme
Various Countries	Test phase of the Level(s) framework	Finished	The pilot test phase of the European framework Level(s) has been conducted by volunteer recruitment and the only data available about this activity specify at national level which country has been a tester without specifying the stakeholder typology of the test/initiative (e.g. public institution or private entity).

Source: Table elaborated by the authors using the references and sources specified into the document.

The data collected showed the predominant inclination towards investment by public bodies towards the implementation of Digital Building Logbook and Building renovation Passport tools. So far, just few EU MSs are actively participating in the testing phase of the Smart Readiness Indicator scheme. The only public initiative regarding the European framework Level(s) is the test that has been conducted in various countries between 2018 and 2020; currently other experiences are ongoing both as private initiatives and research projects, but there are no evidence of data and results to use as references in literature.

Table 6. Summary of the private initiatives used as data sources for the analysis.

Company responsible	Name	State of progress	Outcomes/tools
Eigenheim Manager - DE	Eigenheim Manager	In place - Voluntary	Eigenheim Manager consists in a Digital Building Logbook and as a Building Renovation Passport.
Bundesverband Deutscher Fertigbau e.V. - DE	QDF Hausakte	In place - Mandatory	QDF Hausakte is intended as a Digital Building Logbook and as a Building Renovation Passport. It's mandatory only for prefabricated houses.
Madaster Foundation - NL	Madaster	In place - Voluntary	Madaster consists in a Digital Building Logbook and as a Building Renovation Passport, regarding the materials of a building.
BASTA non-profit company – SE	BASTA Loggbok	In place -Voluntary	Madaster is intended as a Digital Building Logbook and as a Building Renovation Passport, regarding the materials of a building.
Villaagarnas Riksforbund - SE	Min Villa	In place - Voluntary	Min Villa is a collection of documents regarding the maintenance of the building, that is kept as a Digital Building Logbook and as a Building Renovation Passport.
ProduktKollen AB - SE	Produktkollen	In place - Voluntary	Produktkollen consists in a Digital Building Logbook and a Building Renovation Passport.
ImmoPass – BE; LU	ImmoPass	In place - Voluntary	ImmoPass is intended as a Digital Building Logbook.
Finnish Green Building Council - FI	Building Passport	In place - Voluntary	Building Passport consists in a Building Renovation Passport.
Cìclica and Green Building Council España - ES	PAS-E	Under development	PAS-E will be introduced as a Digital Building Logbook and as Building Renovation Passport, valid at a national level.

Source: Table elaborated by the authors using the references and sources specified into the document.

Private initiatives focus on the study and implementation of DBL and BRP tools, some already in use others under development. No private initiatives have been identified concerning Smart Readiness Indicator and Level(s) tools as official testers, due to a still under-development phase both frameworks, but the last online SRI Platform Plenary Stakeholders meeting, organized by EU Commission DG ENER on 23rd November 2022, underlined that contact points had received several requests for information from different independent testers which affirm the increasing interest in the frameworks.

Table 7. Summary of the research projects considered as sources for the analysis.

Project name	Funding programme	Period	Consortium partners' countries
BAMB - Buildings as Material Banks: Integrating Materials Passports with Reversible Building Design to Optimise Circular Industrial Value Chains.	Horizon 2020 - WASTE-1-2014 - Moving towards a circular economy through industrial symbiosis.	2015 – 2019	BE; DE; NL; PT; SE.
Plan Transition Numérique dans le Bâtiment	Plan Transition Numérique dans le Bâtiment	2016 – 2018	FR.
Passeport Efficacitè Energetique – P2E	The Shift Project	2016 – 2021	FR.
ALDREN - ALliance for Deep RENovation in buildings Implementing the European Common Voluntary Certification Scheme, as back-bone along the whole deep	Horizon 2020 - EE-11-2016-2017 - Overcoming market barriers and promoting deep renovation of buildings.	2017 – 2020	BE; DE; ES; FR; IT; SK.

renovation process.			
iBROAD - Individual Building (Renovation) Roadmaps.	Horizon 2020 - EE-11-2016-17 - Overcoming market barriers and promoting deep renovation of buildings.	2017 – 2020	AT; BE; BG; DE; EL; PL; PT; RO; SE.
Ilmastoviisaat Taloyhiöt - controlling energy waste in buildings with IoT sensors	6Aika Programme	2018 – 2020	FI.
BE-REEL! - Belgium Renovates for Energy Efficient Living.	LIFE Programme.	2018 – 2024	BE.
DigiPLACE - Digital Platform for Construction in Europe	Horizon 2020 - DT-ICT-13-2019 - Digital Platforms/Pilots Horizontal Activities.	2019 – 2021	BE; DE; ES; FR; IT; NL; SI.
X-Tendo - eXTENDing the energy performance assessment and certification schemes via a mOdular approach.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2019 – 2022	AT; BE; DK; EE; EL; IT; PL; PT; RO.
U-CERT - Towards a new generation of user-centred EPC.	Horizon 2020 - LC-SC3-EE-5 2018 Next-generation of Energy Performance Assessment and Certification.	2019 – 2022	BE; BG; DK; EE; ES; FR; HU; IT; NL; RO; SE; SI.
BIM4EEB - BIM based fast toolkit for Efficient rEnovation in Buildings.	Horizon 2020 - LC-EEB-02-2018 - Building information modelling adapted to efficient renovation (RIA).	2019 – 2022	BE; CY; DE; ES; FI; IE; IT; PL; SE.
LIFE LEVEL(S) - Life for Lca Lcc Level(s).	LIFE Programme.	2019 – 2022	DE; FI; FR; HR; IE; IT; NL.
Stadt der Zukunft - - Auf dem Weg zum Plus-Energie-Quartier	Open4innovation Programme	2020	AT.
D^2EPC - Next-generation Dynamic Digital EPCs for Enhanced Quality and User Awareness.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	AT; CY; DE; EL; ES; LT; NL.
E-DYCE - Energy flexible DYnamic building Certification.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	DE; DK; EL; IT.
ePANACEA - Smart European Energy Performance AssessmeNt And CErtificAtion.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	AT; BE; DE; EL; ES; FI.
EPC RECAST - Energy Performance Certificate Recast.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	BE; DE; ES; FR; IT; LU; SK.
e-Construction - Study for the application of assessment principles for the carbon footprint of construction works in Estonia.	RITA programme	2021	EE.
crossCert - Cross Assessment of Energy Certificates in Europe.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 - 2024	AT; BG; DE; DK; EL; ES; HR; MT; PL; SI.
EUB SuperHub - European Building Sustainability performance and energy certification Hub.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 – 2024	AT; DE; FR; HR; HU; IE; IT.
iBRoad2EPC - Integrating Building Renovation Passports into Energy Performance Certification schemes for a decarbonised building stock.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 – 2024	AT; BE; BG; DE; EL; ES; PL; PT.

TIMEPAC - Towards innovative methods for energy performance assessment and certification of buildings.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 – 2024	AT; CY; DE; ES; HR; IT; SI.
PnPE^2 – Portale Nazionale sulla Prestazione Energetica degli Edifici.	PnPE^2 – Portale Nazionale sulla Prestazione Energetica degli Edifici.	2021 – 2025	IT.
SmartLivingEPC - Advanced Energy Performance Assessment towards Smart Living in Building and District Level.	Horizon Europe - HORIZON-CL5-2021-D4-01-01 - Advanced energy performance assessment and certification.	2022 – 2025	AT; BE; CY; DE; EL; ES; IE; IT; NL
CHRONICLE - Building Performance Digitalisation and Dynamic Logbooks for Future Value-Driven Services.	Horizon Europe - HORIZON-CL5-2021-D4-01-01 - Advanced energy performance assessment and certification.	2022 – 2025	DK; EL; ES; IE; IT.
SRI-ENACT - Co-creating Tools and Services for Smart Readiness Indicator Uptake.	LIFE Programme.	2022 – 2025	AT; BE; BG; CZ; EL; ES; HR; RO.
SRI2Market - Paving the way for the adoption of the SRI into national regulation and market.	LIFE Programme.	2022 – 2025	AT; CY; ES; FR; HR; PT.
easySRI - Improving and demonstrating the potential of SRI.	LIFE Programme.	2022 – 2025	AT; CY; EL; IE; IT; NL.
Smart^2 - Smart Tools for Smart Buildings: Enhancing the intelligence of buildings in Europe.	LIFE Programme.	2022 – 2025	BG; DE; CY; EL; IT; RO.

Source: Table elaborated by the authors using the references and sources specified into the document.

Among the various research projects, there is an equal distribution of the tools analyzed, except for Level(s), which is studied by only three of them. Some of the research projects try to combine more than one tool in their studies, especially focusing on Building Renovation Passport and Digital Building Logbook in which some indicators from the frameworks SRI and Level(s) have been integrated in the data structure of the BRP or DBL. From the analysis of those research projects and the current available documentation and results, the ongoing project titled EUB SuperHub is the only which declare in its methodology the intention to use and try to correlate all the four tools under investigation into this work.

2.3 Behavioural insights on how to frame EPC information

In addition to other factors such as the calculation method and quality assurance, the framing of the information can lead a certain EPC to be more or less effective at making citizens more likely to choose energy efficient dwellings. By framing of the information, we mean the EPC:

- content,
- wording,
- and layout.

After analysing the EPC template from a technical point of view, focusing on proposed indicators and synergies with other tools, the study has dealt with the importance of framing the EPC information drawing from behavioural sciences insights.

Policy makers have assumed for decades that individual decisions, including choosing which dwelling or energy appliance to invest in, follow a rational decision-making approach (the so-called rational choice model). However, this model has been confronted with the empirical failure to depict actual individual behaviour.

Individuals have been proved capable of making rational decisions, but they need cognitive resources, and these are limited. Therefore, to overcome these cognitive limitations, they use

shortcuts, the so-called *heuristics*, as tools to make complex decisions (the choice of which dwelling to live or invest in is one of those complex decisions). However, these heuristics may lead to systematic and predictable *errors* (Kahneman, 2003).

The evidence of these errors has offered additional lenses with which to approach policymaking. In particular, these findings have provided a framework to policy makers to take more realistically into account how individuals take decisions and, thus, to better predict policy effects (Baggio et al., 2021), including the effect of an information policy tool, like the EPC. At the same time, it offered new policy tools to influence behaviour, such as the choice of an energy efficient dwelling.

In recent years, one concrete application of behavioural sciences that has received major attention in policymaking is *nudging*. Thaler & Sunstein (2008) identify nudging as a cost-effective intervention to redirect behaviour without forbidding any option or changing economic incentive, drawing from the evidence that the surrounding choice environment influences decisions. Practically, nudges are interventions on the choice architecture that alter people's behaviour in a predictable way.

As the EPC is addressed to house-owners and prospective buyers and renters, who will receive the certificate when deciding to buy or rent a property, they can embed nudges to help individuals more effectively understand the current and potential energy performance of the dwelling (Della Valle & Bertoldi, 2022).

Based on a literature review and desk research, the authors have highlighted some of the main nudges that can be applied to EPCs in order to influence people's behaviour towards more sustainable choices.

3 Overview on selected tools

The goal of this section is to provide a presentation of the four selected tools, before making a deep dive analysis per indicators referring to the listed ones into the EPC template in Annex V of the EPBD recast proposal.

The selected tools are currently the most compelling ones and searched in literature to boost the decarbonisation of the construction sector. An overview of the tools is reported in the following respective subsections: Smart Readiness Indicator (section 3.1), Level(s) (section 3.2), Building Renovation Passport (section 3.3) and Digital Building Logbook (section 3.4), providing a description at a glance in order to highlight the most important aspects for each of them in relation to the EPC and specifying the level of development, influence and diffusion into practice in the EU Member States.

3.1 Smart Readiness Indicator (SRI)

The potential of smart technologies in the building sector was heavily emphasized in the 2018 revision of the European Energy Performance of Buildings Directive (EPBD), through the establishment of a Smart Readiness Indicator (SRI) for buildings. This indicator, as illustrated in Figure 7, allows for rating the smart readiness of buildings, i.e., the capability of buildings (or building units) to adapt their operation to the needs of the occupant, also optimizing energy efficiency and overall performance, and to adapt their operation in reaction to signals from the grid (energy flexibility).

Figure 7. Three key functionalities of smart readiness in buildings.

Source: Final report on the technical support to the development of a smart readiness indicator for buildings, 2020.

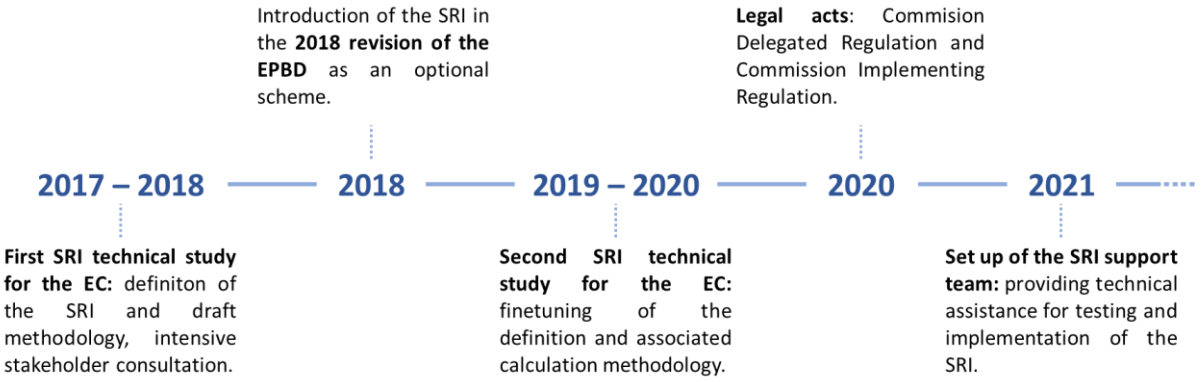
The European Commission services (DG ENERGY) commissioned and supervised two studies to further implementation of the SRI concept, as represented in timeline of Figure 8, involving a broad range of stakeholders from the building sector, with the aim of providing technical support to feed into the discussions on a common methodology and potential implementation pathways of this indicator. The results of the two technical studies, published in 2020, led to the first Smart Readiness Indicator rating. Alongside, the SRI legal acts (SRI delegated act, SRI implementing act) have been published in the Official Journal of the European Union in December 2020 and have entered into force on January 10th, 2021.

The Commission Delegated Regulation (EU) 2020/2155 established the definition of the SRI and a common methodology, by which it should be calculated while the Commission Implementing Regulation (EU) 2020/2156 detailed the technical modalities for effective implementation of the SRI.

As these two Regulations come into force, the testing phases in Member States have officially started. By design the SRI is a voluntary scheme so it is up to the Member States of the European Union to decide how to implement the SRI at national level and as desired only after undergoing a no commitment national testing exercise. According to the Commission Implementing Regulation (EU) 2020/2156, all arrangements of the SRI national test phases must be defined by EU countries. At the end of the national test phases, countries shall assess the outcomes and decide whether they will implement the SRI.

To support the implementation of the SRI across Europe, the Commission has contracted a support team to provide technical assistance to the Commission services and to EU countries in testing and implementing the SRI and in establishing and operating a permanent setup to effectively support the broad roll-out of the SRI in the EU. The support team provides also assistance in finding Private or research stakeholders not involved in official implementation or test phases willing to participate in discussions and to conduct informal SRI-related activities. However, no formal SRI certifications can be issued without prior Member State agreement. At last, the support team helps the European Commission to promote the SRI scheme. The SRI is currently being officially tested in four EU countries: Austria, Czech Republic, Denmark, and France. In each of the four front-runner countries, the national administration is supported by one or several local technical partners and by the SRI Support Team. Croatia and Finland also volunteered for the testing phase of the SRI scheme, in June 2022. These countries rely on different types of assessors for the evaluation of the SRI scheme. Austria, Czech Republic, and Denmark refer to technical partners, while France and Finland contract external assessors. Croatia is still in a preparation phase for the testing.

Figure 8. SRI scheme implementation timeline.



Source: Smart Readiness Indicator (SRI): The SRI platform Plenary meeting #1, 2021.

The method for calculating the SRI is based on the multi-criteria assessment method defined in Commission Delegated Regulation (EU) 2020/2155. The basic structure of the methodology is a flexible and modular multi-criteria assessment method that builds on assessing the smart-ready services present in a building.

Services are enabled by smart-ready technologies but are defined in a technology-neutral way.

The proposed calculation methodology is structured amongst nine technical domains and seven impact criteria, for a total of 54 indicators, as summarized in Figure 9. For each of the services, several functionality levels are defined. A higher functionality level reflects a "smarter" implementation of the service, which generally provides more beneficial impacts to building users or to the grid compared to services implemented at a lower functionality level.

Figure 9. Overview of the scoring matrix, containing the key functionalities, the impact criteria, and the technical domains.

		Overall SRI score (%) + SRI class						
		%		%				%
3 Key functionalities		Optimise energy efficiency and overall in-use performance		Adapt its operation to the needs of the occupant				Adapt to signals from the grid (energy flexibility)
		%	%	%	%	%	%	%
7 Impact criteria		Energy efficiency	Maintenance and fault prediction	Comfort	Convenience	Health, well-being and accessibility	Information to occupants	Energy flexibility and storage
9 Technical domains	Heating	%	%	%	%	%	%	%
	Cooling	%	%	%	%	%	%	%
	Domestic hot water	%	%	%	%	%	%	%
	Ventilation	%	%	%	%	%	%	%
	Lighting	%	%	%	%	%	%	%
	Dynamic building envelope	%	%	%	%	%	%	%
	Electricity	%	%				%	%
	Electric vehicle charging		%		%		%	%
	Monitoring and control	%	%	%	%	%	%	%

Source: Assessment package: practical guide SRI calculation framework v 4.4, 2022.

In the proposed method, the smart readiness score of a building or building unit is expressed as a percentage which represents the ratio between the smart readiness of the building compared to the maximum smart readiness that it could reach. The SRI calculation sheet helps the assessor in carrying out the assessment, calculating the intermediate scores at domain and impact level, and weight those to a final single score.

At least two different SRI assessment types could be envisioned: a light version with a limited set of services and a detailed version. Both methods have a similar structure, but method A uses a reduced set of services, thus requiring less efforts and expertise to carry out the assessment. The simplified Method A was foreseen to be mainly oriented towards small buildings with low complexity, whereas the more detailed Method B is mainly oriented towards buildings with a higher complexity. Both method A and method B have been implemented in the same calculation tool, as well as the weighting factors proposed in the consolidated method of the technical support studies. The calculation tool used to test the level of SRI of a building is a Microsoft Excel file, available upon request to the SRI support team on the official website of the framework, divided in multiple spreadsheets, summarized in the Table 8. In addition to these, there are further worksheets containing general information for the compilation of the Excel file spreadsheets and more specific information on the impact score of individual services in each domain. The proposed SRI methodology provides a flexible and modular framework. The applicability of the SRI methodology is likely to vary depending on specific circumstances (building type, climate, site specific conditions, etc.). Local and site-specific context will mean that some domains and services are either not relevant, not applicable, or not desirable and thus the SRI needs to be flexible enough to accommodate this.

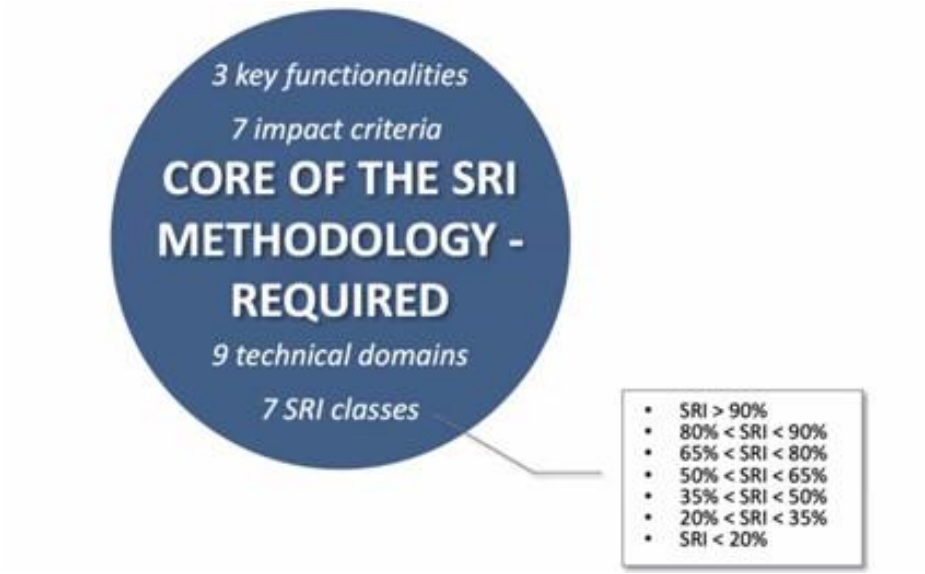
Table 8. Summary of the calculation spreadsheet of the SRI scheme.

Spreadsheet name	Description
Building Information	Building Information spreadsheet contains a list of all inputs required for the correct analysis of the SRI level of the building. These inputs are: • Assessor information. • General building information. • Methodology selection.
Overview of services	Overview of services spreadsheet defines all indicators within the SRI analysis and their functionality levels. Specific columns indicate which services are to be considered for each methodology.
Weightings	Weightings spreadsheet is used to alter the weighting factors manually in the calculation sheet. There are two types of weightings: • Domain weightings: these weighting factors are used to aggregate domain scores to impact scores. • Impact weightings: these weighting factors are used to aggregate the impact scores to a single SRI score.
Calculation	Every line in the sheet represents a service of the smart service catalogue. The assessor should indicate whether a service is applicable to the building. For each service to be assessed, three fields may be completed: • Main functionality level: the functionality level of the service. A description of the different functionality levels is provided in the spreadsheet. The levels range from Level 0 (non-smart indicator) to Level 4 (max level of smartness). • Share of the functionality level: the percentage of net surface area of the building that complies with the main functionality level. • Additional functionality level: the functionality level that applies to the remaining surface area.
Results	Results spreadsheet contains various types of SRI scores: • Total SRI score: the total SRI score, considering domain weightings and impact weightings. • Impact scores: the impact scores for each impact criterion, considering domain weightings. • Domain scores: the domain scores for each domain, considering impact weightings. • Detailed scores: the detailed scores for each domain and each impact criterion, which results in a matrix for nine domains and seven criteria. • Aggregated scores: the aggregated scores for three key functionalities (1-building, 2 – user, 3 – grid).

Source: Practical Guide SRI calculation framework v4.4, 2022.

The core of the SRI methodology can be summarized by the required aspects and one of the most important parameter, which could be considered as benchmarking indicator of the framework, is the SRI class, structured into seven percentage intervals as represented in Figure 10.

Figure 10. Graphical summary of the core SRI methodology required aspects.



Source: SRI Platform Plenary Stakeholders meeting #2 presentation, November 2022.

Currently the decision to launch a test phase or implement the SRI belongs to EU MSs, only where a government decides to do so, formal SRI assessments can be conducted. Private or research stakeholders not involved in official implementation or test phase can participate in discussions and conduct informal SRI-related activities. However, no formal SRI certifications can be issued without prior MS agreement.

Box 1. Preliminary results of the test phases about the conduct assessment

The three test phases highlighted some issues about the use and assessment of the SRI methodology:

- issues with the availability of data, in relation with the size of the service catalogue;
- difficulties with the concepts of non-available and non-applicable services;
- sometimes smartness related to the building owner rather than to the building itself.

3.2 Level(s)

In July 2014, the European Commission released the Communication on Resource Efficiency Opportunities in the Building Sector – COM (2014)445. This Communication describes the need for a common European approach to assess the environmental performance of buildings throughout their lifecycle, considering relevant resources such as energy, materials, and water. This approach led to the implementation of Level(s), a methodological European framework for the assessment and reporting of the sustainable performance of buildings across their whole lifecycle, developed by the European Commission in close co-operation with relevant stakeholders.

Before Level(s) could be launched on the market and start constituting a basis for different policy and business initiatives, the beta version of Level(s), containing the defined indicators, was thoroughly tested by building professionals across Europe. The European Commission opened a two-year testing phase for Level(s) in spring 2018. During this period more than 130 building projects in 21 countries were registered to test Level(s). Quantitative results and survey feedback was received from 80 different projects in 16 countries.

The outcome of the testing phase was a report identifying the first official version of 16 core indicators for Level(s), indicated in Table 9. These indicators are spread across six key macro-objectives for the building sector: greenhouse gas and air pollutant emissions; resource efficiency; water use; health and comfort; resilience and adaptation; and cost and value.

Table 9. Summary of the six key macro-objectives included into Level(s) approach.

N.	Macro-objectives	N.	Indicator Name
1	Greenhouse gas emissions along a building's life cycle.	1	Use stage energy performance (kWh/m^2/yr).
		2	Life cycle Global Warming Potential (CO_2 eq/m^2/yr).
2	Resource efficient and circular material life cycles.	3	Bill of quantities, materials and lifespans.
		4	Construction & Demolition waste and materials.
		5	Design for adaptability and renovation.
		6	Design for deconstruction, reuse and recycling.
3	Efficient use of water resources.	7	Use stage water consumption (m3/occupant/yr).
4	Healthy and comfortable spaces.	8	Indoor air quality.
		9	Time outside of thermal comfort range.
		10	Lighting and visual comfort.
		11	Acoustics and protection against noise.
5	Adaption and resilience to climate change.	12	Protection of occupier health and thermal comfort.
		13	Increased risk of extreme weather.
		14	Sustainable drainage.
6	Optimized life cycle cost and value.	15	Life cycle costs (€/m²/yr).
		16	Value creation and risk factors.

Source: Level(s), Putting circularity into practice, 2021.

Level(s) framework provides a clear set of priorities for a building's performance and a standardized basis for setting requirements for new and renovated buildings. This provides a

common language, developed at EU level, for stakeholders throughout Europe's buildings and construction sectors to follow or to incorporate within existing sustainability practices or certification systems. Public authorities at national, regional, and local level can also adopt the Level(s) common language to stay aligned with the European Union and its Member States.

Within the Level(s) framework, each indicator is designed to link the individual building's impact with the priorities for sustainability at the European level. This focuses the Level(s) user on a manageable number of essential concepts and indicators at building level that contribute to achieving EU and Member State environmental policy goals.

Level(s) has been designed to ensure a minimum level of comparability between functionally equivalent buildings. To ensure that meaningful comparisons can be made based on quantitative results, specific instructions and guidance are provided for each indicator.

Box 2. The Calculation and Assessment Tool (CAT) for Level(s)

The Calculation and Assessment Tool (CAT) for Level(s) is an intuitive web-based application that provides an easy way to describe a Project in correspondence to the JRC building Project description and assess it. CAT follow three levels of complexity of the Level(s) framework, with level 1 being a basic assessment and level 3 the most complex and detailed.

Levels of complexity for the assessment:

- Conceptual design: Early-stage qualitative assessments and reporting on the concepts that the chosen indicators will cover.
- Detailed design and construction: Quantitative assessment of the designed performance.
- As-built and in-use: Monitoring and surveying of activity both on the construction site and of the completed building and its first occupants.

Gradually increasing accuracy leads all stakeholders to be engaged with the framework with any degree of professionalism. In any of the levels, the methodology addresses sustainability in core areas like health, comfort, costs, risks, resource use and environmental performance during a building's lifecycle.

Creating a Project is the starting point for using CAT. In this way the building and its basic characteristics are defined, as well as the building elements that will be included in the Assessment. In this first section information regarding typology, location, usage, and characteristics of the building are described.

After setting up a Project, the next phase is the Level(s) Assessment worksheet. Creating an Assessment has two main parts: first configuring the Assessment i.e., choosing the Life Cycle Stage, the indicators, and their Level, and second working with the indicators to provide the input. For every Indicator a series of information are required, depending on the Level of Assessment selected. Once all the information is provided, the indicator 6.2 offers a way to evaluate how all the indicators that are included in the Assessment contribute to the value of the Project. The results of the Assessment are useful to testing different approaches to the design, construction, de-construction, and maintenance of a building.

To further support the users, the European Commission developed a comprehensive set of online training materials regarding Level(s). The eLearning course provides a detailed overview of Level(s) and prepares the users to start using it in their working environment.

3.3 Building Renovation Passport

There is no universally agreed definition of a building renovation passport and its meaning and purpose overlap with other instruments. The Building Renovation Passport (BRP) is generally considered an instrument that can stimulate cost-effective renovation by providing a "long-term, step-by-step deep renovation roadmap for a specific building based on quality criteria, following an energy audit, and outlining relevant measures and renovations that could improve the energy performance" (as defined in Article 19a of EPBD 2018/844/EU).

The BRP has been identified as a valuable tool able to boost the availability of information to a wide range of user but also to improve the data flow along the chain to improve data quality. The lack of information and transparency from the one hand they are the main causes for the increased risks and from the other hand they undermine investor confidence. Therefore, a systematized and optimized capture and processing of information also supports investment decision making and creates opportunities for innovation and uptake of energy efficiency and sustainability measures, processes and designs.

According to the scientific literature, the typical structure of a BRP foresees two main elements: the digital logbook and the renovation roadmap. The first one has been conceived as a digital repository with historical and contemporary information about the property, its construction and operational performance; while the second identifies future retrofits and installations to decarbonize the property, along with links to contractors, other service providers and finance options.

Since 2016, the first BPIE report which defined the tool stated clearly the structure of the BRP and identify the main features and possible connections with other tools. At that time, the first three ongoing experiences were in Germany, Flanders and France with the respective BRP called Individueller sanierungsfahrplan, Woningpas and Passeport efficacité énergétique/ P2E.

Subsequently, various EU research projects funded under the call "EE-11-2016-2017 – Overcoming barriers and promoting deep renovation of buildings" of the H2020 programme continue to study this tool trying to define a common language and envisage synergies and connection with existing databases for the data population of the BRP and in particular on the DBL.

For example, the ALDREN project focuses on BRP for non-residential buildings, while the iBRoad project for residential ones. Those two with also other sister projects considered for the state of the art and listed in Table 4 cooperate during the respective project development and they compare results and outcomes which lead to the following shared statements.

- BRP for residential and non-residential buildings could share the main structure in two main elements: Building Logbook and Renovation Roadmap.
- Building Logbooks will have different and specific parameters and/or indicators according to the building typology; while Renovation Roadmaps must integrate the owner needs for the identification of the renovation strategies and interventions.
- The data flow definition must be clear, user-friendly and linked to existing datasets or other existing tools/instruments such as the EPC to ensure data consistency and quality.
- The previous key points will increase the owner's building knowledge and the confidence on investments for renovation activities.

The Global Alliance for Buildings and Construction in 2021 published a practical guideline on Building Passport based on the results of their analysis conducted on a selection of the current and most worldwide diffuse passport-type projects and initiatives. Table 10 summarizes only the European ones considered by GABC in their research, being the area of interest also of the present study, to complement the initial state-of-the-art presented in section 2.2. The analysis remarks that all the tools tend to have a one-dimensional (sustainability) focus, for example on energy efficiency, renovation or building materials. By contrast, the Building Passport does not focus on one particular aspect of data or information, but contains all building-related information, including data and

information (either in an aggregated or disaggregated format) that is generated by other more specific data capture and management initiatives. For example, data from Energy Performance Certificates, sustainability certification schemes, material and/or renovation and climate passports as well as bills of materials, could be either directly added to the Building Passport as a readable document or digitally tagged to the Building Passport, for example via a unique building identifier.

The Technical study on the possible introduction of optional building renovation passports in Europe commissioned by the European Commission's (EC) Directorate-General for Energy (DG ENER) summarized the comparison conducted on 28 EU BRP which underlined that the most successful BRPs have combined the renovation advice with financial support, legal requirements and/or communication campaigns.

Table 10. Overview of the BRP initiatives in EU analysed by GABC and UN Environment Programme (status February 2021).

Name	EU MS	Status	Scope	Link
Post Interventie Dossier / Dossier d' intervention ultérieure	BE	Operational	• Mandatory • Public • Focus: maintenance record	https://www.vlaanderen.be/postinterventiedossier-pid (only available in Dutch)
Woningpas	BE	Operational	• Voluntary • Public • Focus: wide	https://woningpas.vlaanderen.be (only available in Dutch)
Bedrebolig	DK	Operational	• Voluntary • Public • Focus: energy and renovation	https://sparenergi.dk/forbruger/vaerktoejer/bedrebolig (only available in Danish)
Ilmastoviisaat Taloyhiöt	FI	Under development	• Voluntary • Private • Focus: energy efficiency	https://figbc.fi/en/projects (only available in Finnish)
Homebook	FR	Tested	• Voluntary • Private • Focus: energy efficiency	https://homebooksystem.fr (only available in French)
Le carnet numérique du logement	FR	Tested	• Mandatory • Public • Focus: energy efficiency, systems, hazardous materials	https://www.cohesion-territoires.gouv.fr/quels-sont-les-diagnosticsimmobiliers-fournir-en-cas-de-vente (only available in French)
Passeport Efficacité Énergétique	FR	Tested	• Voluntary • Public • Focus: energy efficiency	https://www.experience-p2e.org (only available in French)
Eigenheim Manager	DE	Operational	• Voluntary • Private • Focus: consumption, cost reduction, maintenance support	https://eigenheim-manager.de/faq (only available in German)
QDF Hausakte	DE	Operational	• Voluntary • Private • Focus: wide	https://www.fertighauswelt.de/hausbau/ratgeber/hausakte.html (only available in German)
Building Renovation Passport	IE	Tested	• Voluntary • Private • Focus: renovation	https://www.igbc.ie/policy-andregulation/renovation-strategies/building-renovation-passports
PAS-E	ES	Under development	• Voluntary • Private • Focus: life quality, sustainability, urban regeneration	http://pas-e.es/#/en
BASTA	SE	Operational	• Voluntary • Private • Focus: materials	https://www.bastaonline.se/?lang=en
Min Villa	SE	Operational	• Voluntary • Private • Focus: maintenance	https://minvilla.villaagarna.se (only available in Swedish)
ProduktKollen	SE	Operational	• Voluntary • Private	https://www.produktkollen.se (only available in Swedish)

			• Focus: environmental certificates, product products safety documentation, manuals	
Klimadeklaration	SE	Under development	• Mandatory • Public • Focus: climate impact of new construction projects	https://www.regeringen.se/4a4044/ contentassets/ 3e13a513131b447f8b 1e41eddcbbf6b5/ klimatdeklarationfor-byggnader-ds-20204.pdf (only available in Swedish)
Madaster	NL	Operational	• Voluntary • Public • Focus: materials	https://www.madaster.com/en
Platform CB'23	NL	Under development	• Focus: circularity	https://platformcb23.nl/english

Source: elaboration of the author from GABC and UN Environment Programme (2021), Practical Guidelines.

Box 3. Key takeaways on BRP

- The BRP should be considered as an interesting opportunity for enlarging the scope of EPCs by illustrating reasons for renovation to increase the conversion rate with triggers that go beyond energy savings, coupled with the possibility to ensure the perceived and actual quality of both EPCs and the BRP.
- Implementation, effectiveness and data quality of the EPC schemes currently varies from country to country. Additional training will be necessary to cater to changing requirements and to improve quality but is not the only measure required. There is a clear link between energy efficiency and property price, demonstrating an improved trust in the EPCs.
- The impact of the BRP will be limited unless it is supported with financial, regulatory and informational instruments. BRPs alone, without any of the enabling conditions and measures outlined in this report, are expected to have a limited impact.
- Not only does the BRP trigger additional investment/savings, but it reduces the wrong implementation of single measures and technical lock-ins, thus saving investment cost and sunk costs.
- The potential for BRPs is very contingent on how the Member States design the BRP and how it is integrated into the wider policy framework.

BRP data collection and assessment:

- Finding the right information is time-consuming and it is difficult to make informed choices about the combination of renovation measures, especially that make sense over the long-term.
- The impact on indoor environmental quality is an important factor which must be included in the calculations.
- Integrating the BRP with a digital logbook and linking it to financial schemes and one-stop-shops are potentially effective solutions.

3.4 Digital Building Logbook

The concept of a Digital Building Logbook (DBL) was first introduced with the European "Renovation Wave" strategy and in literature it is considered as one of two fundamental parts of which the Building Renovation Passport is composed: the DBL and a Renovation Roadmap.

The most common definition for the DBL reports: "*A digital building logbook is a common repository for relevant building data. It facilitates transparency, trust, informed decision making and information sharing within the construction sector, among building owners and occupants, financial institutions, and public authorities".*

Information obtained from construction products is only part of the data expected to be archived in the building logbook and be interoperable with other sources of information. Unfortunately, the

number of different national and regional initiatives is a clear obstacle to align them according to a similar approach.

The EC launched a study on policy recommendations for the development of a European framework for digital building logbooks and the final report concluded that it should follow a standardized approach and be consistent with the applicable regulations.

Building logbooks are referred in other initiative such as the Renovation wave but on the contrary to other instruments such as the energy performance certificates, its harmonisation at European level is a challenge. CEN/TC 350 subcommittee 1 – Circular economy may develop a standardized approach but the key of their work is keep consistency with the existing digitalisation initiatives and with the applicable regulations.

This section provides the main results obtained from the reviews of the existing literature on the most developed European Digital Building Logbook models. The analysis includes iBRoad, ALDREN, X-tendo, and the Study on the Development of a European Union Framework for Buildings' Digital Logbook, from the perspective of seven key aspects:

1. References used as a starting point for the model definition;
2. identification of the relevant stakeholders in the DBL;
3. identified potential user needs;
4. proposed structure of indicators;
5. data sources;
6. potential functionalities;
7. operation and use.

The results show clearly that there is still no consensus about crucial subjects of this tool, such as how to collect and use the indicators and which are mandatory or suggested for the assessment of the DL. This is probably due to the fact that the final functionalities (objective and scope) that the DBL should provide are not fully clear and not commonly agreed.

The DBL analysis showed that it should provide access to building information and contribute to better decision-making for future interventions as well as operation, use and maintenance records. The building owner/user is proposed to have full access to the logbook and provide/input about energy bills and building plans/construction materials info. An important aspect is that every time the building undergoes intervention works the DBL should be updated accordingly. The most important barrier is the lack of motivation to update the DBL contents followed by the absence of synergies and consistency with other tools.

Box 4. Key takeaways on DBL for its development and use across EU

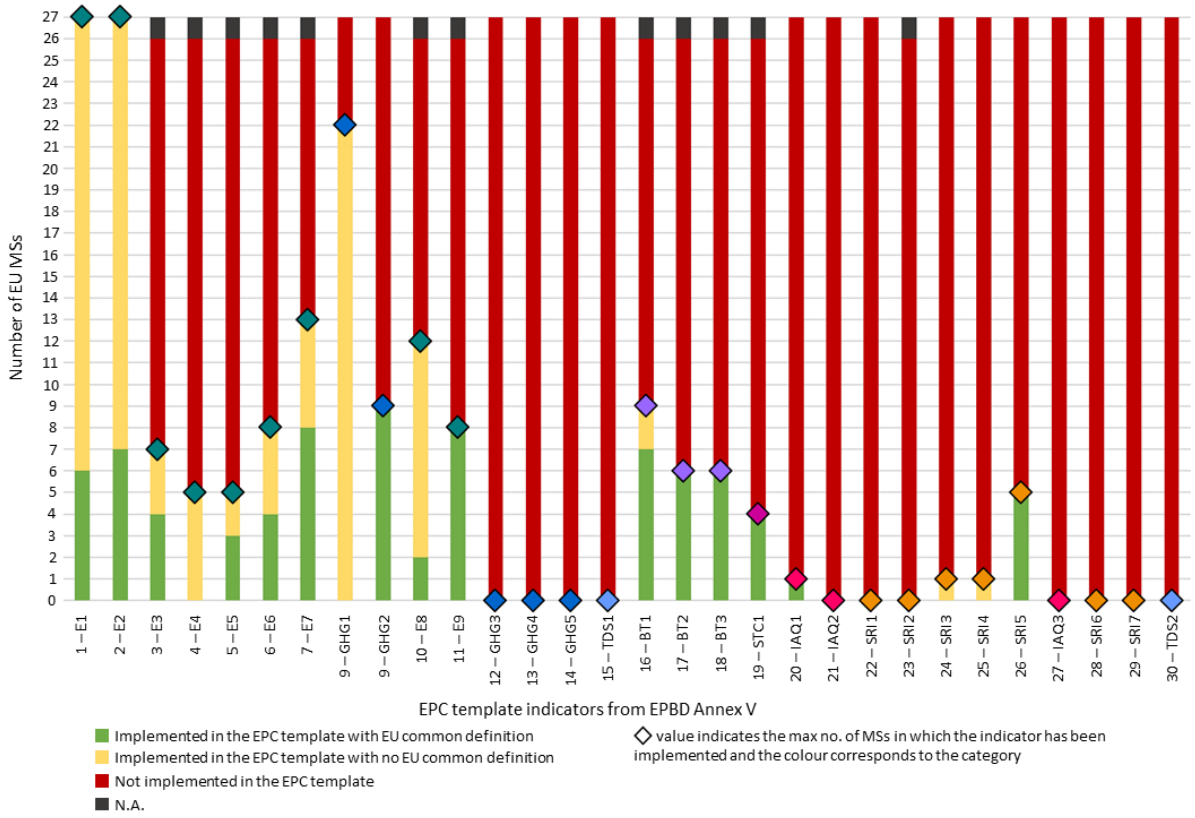
- Implementation by Member States need to keep basic principles of interoperability and the possibility to deliver aggregated European data.
- Sustainability should be one of the key topics to be addressed under a construction-specific approach compatible with the delivery of information by manufacturers (EPD information) but focused on building assessment according to the reference European methodology Level(s).
- Information should be kept by a dedicated body that bears the responsibility of storing, keeping and allowing access to the information when needed.
- Consistency with legislative frameworks needs to be addressed and updated in case of regulatory changes in order to boost decarbonisation and support data exchange with other mandatory certifications.

4 Results and discussion

4.1 Cross-comparative analysis on the EPC indicators

This section reports graphically the main results of the cross-comparative study carried out using the (CCM) presented in section 2.

Figure 11. EPC indicators' implementation status in the EU Member States



Source: Sesana, et al. (2024).

As clearly represented in Figure 11, only two out of 20 indicators are fully implemented in all Member States, the so-called: Energy performance class (E1) and calculated primary energy use (E2), both considered as mandatory indicators in Annex V of the EPBD revision list of indicators.

However, the yellow bar specified that less than 30% of the countries implemented those indicators with an EU common definition, so a high number of MSs has implemented them with an independent framework, often related to national, regional, or local standards and regulations.

The other suggested indicators (numbered from 10 to 30 in Table 1) by the EPBD revision have a limited implementation mostly related to Energy (10-E8 Energy use, peak load, size of generator or system, main energy carrier and main type of element for each of the uses; 11-E9 Renewable energy produced on-site, main energy carrier and type of renewable energy source) and Building Technology categories (16-BT1 Average U-value for the opaque elements of the building envelope; 17-BT2 Average U-value for the transparent elements of the building envelope; 18 BT3 Type of most common transparent element (e.g., double glazed window)) and represented by colored dots in the respective indicators' bars.

The indicators from 12 to 15 and from 27 to 30 have not been found in any European EPC template. In particular, the indicators related to the Emissions category (12-GHG3 Yes/no indication whether a calculation of the Global Warming Potential has been carried out for the building; 13-GHG4 Value of life-cycle Global Warming Potential; 14-GHG5 Information on carbon removals

associated to the temporary storage of carbon in or on buildings) focuses on the Global Warming Potential, a newly proposed indicator which requests a dedicated software for whole life cycle emissions evaluation, currently not in use in common practice in relation to EPCs. Therefore, in literature and in common practice referring to most diffuse certification procedures (i.e., BREEAM or LEED), there are different software pre-programmed with calculation routines for the evaluations of emissions referring mainly to the standard EN15978 based on the Life Cycle Assessment (LCA). The other not implemented indicators belong respectively to the following categories:

- Indoor Air Quality (indicator no. 27 - Operational fine particulate matter (PM2.5) emissions);
- Smart Readiness Indicators (indicator no. 28 - Yes/no indication whether a smart readiness assessment has been carried out for the building and indicator no. 29 - Value of the smart readiness assessment (if available));
- Tools and data sharing (indicator no. 30 - Yes/no indication whether a Digital Building Logbook is available for the building).

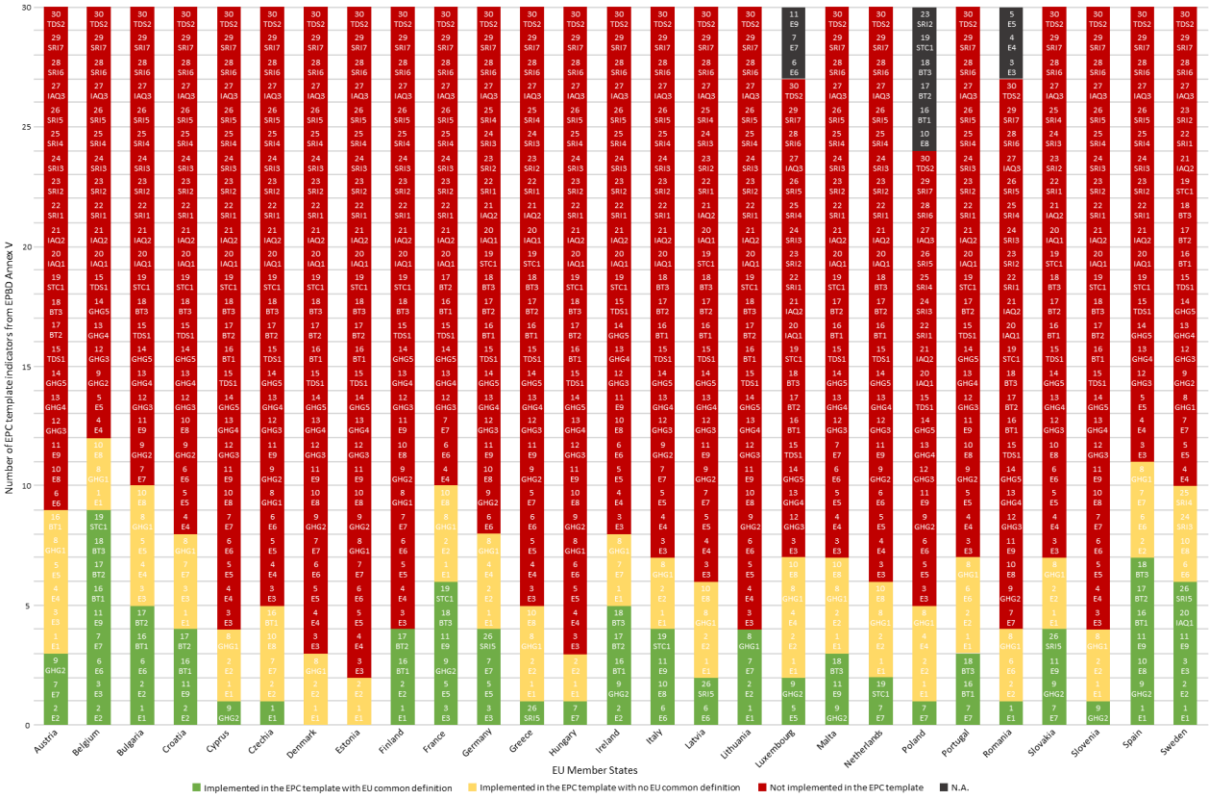
In general, those indicators required a specific methodology and assessment tool for their effective integration into the current EPC schemes.

Figure 12 reports, differently from the previous analysis per indicators of Figure 11, the implementation level per each single Member States of all the indicators proposed by Annex V of EPBD revision.

The results highlighted strong evidence that only two MSs (Belgium and Spain) have implemented more than ten EPC indicators in their current EPC scheme in comparison with the 30 listed in the Annex V of the EPBD revision and in both cases most of the implemented indicators referred to an EU common definition (green bar in Figure 12). The majority, 17 out of 27 MSs (Austria, Bulgaria, Croatia, Czechia, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, Malta, Netherland, Poland, Portugal, Slovakia, Sweden), have implemented a number of EPC indicators belonging to the range from 5 to 10, demonstrating that around two-third of the EU Member States register a percentage of implementation between 16% and 34% of the proposed indicators by the EPBD revision considering both with (green bar) and without (yellow bar) an EU common definition. While 8 out of 27 MSs (Cyprus, Denmark, Estonia, Finland, Hungary, Lithuania, Romania, and Slovenia) are the countries with the lower level of EPC indicators' implementation (less than five indicators out of 30).

It is remarkable to notice that the MSs, which register a medium level of implementation, have implemented mainly indicators with different definitions from the EU common ones.

Figure 12. Overview of the implementation of the EPC indicators proposed by Annex V of EPBD revision across EU



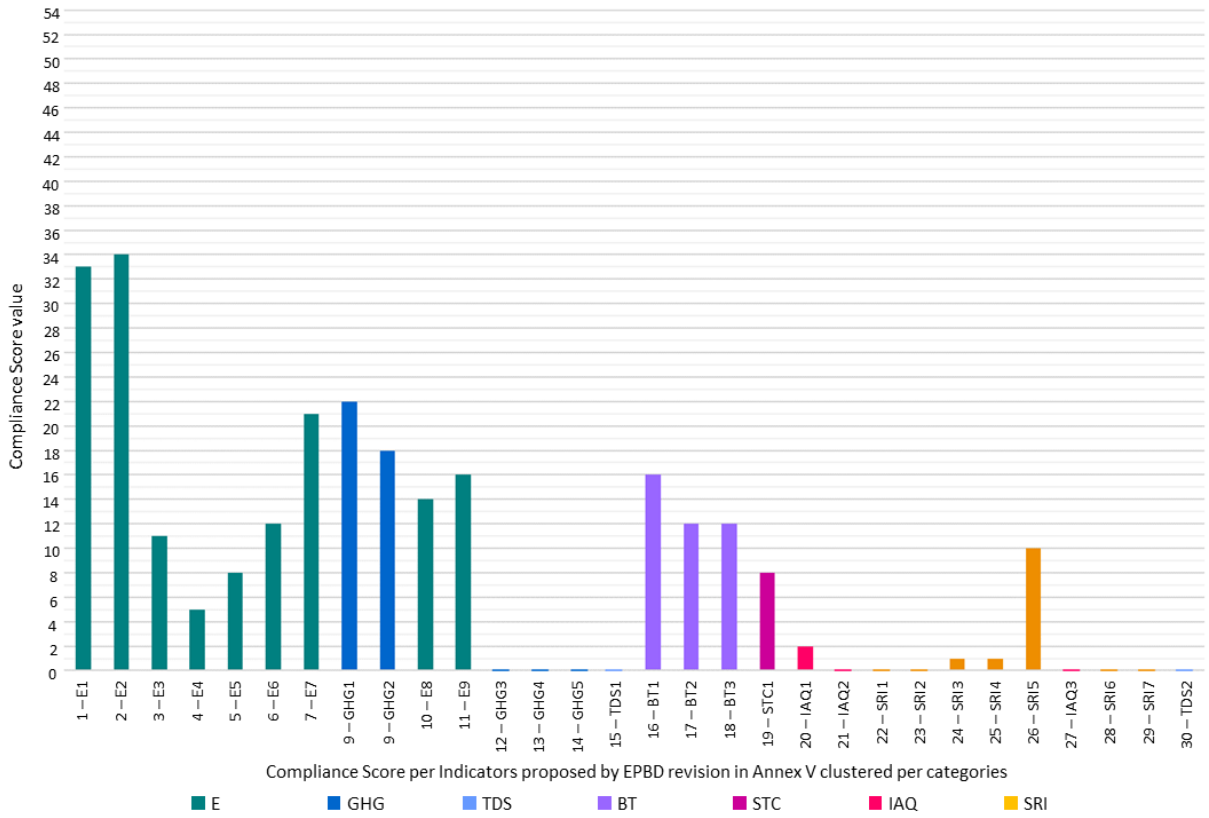
Source: Sesana, et al. (2024). (see Annex 3 for a bigger version of the Figure).

A final overview of the implementation level of the EPC indicators has been graphically represented with the Compliance Score in Figure 13, with an axis range from 0 to 54, corresponding to the range values which the 27 MSs can reach considering the legend defined in Figure 3, which foresees 2 as the possible max score for the implemented indicators.

The graphic highlights at European level a predominance of the Energy category for the indicators' implementation (with a peak for E1 and E2 indicators) followed by Emissions, Building Technology and Summer Thermal Comfort. It has to be remarked that for the Emissions category, only two indicators have been implemented (9-GHG1; 10-GHG2), while the other three indicators proposed by the Annex V and related to the Emissions registered a null implementation (12-GHG3; 13-GHG4; 14-GHG5).

Tools and Data Source category is the only one with all the proposed indicators not implemented (15-TDS1; 30-TDS2), while Indoor Air Quality and Smart Readiness Indicators are the categories with most of the indicator with Compliance Score null, but some of their respective indicators have been implemented (20-IAQ1; 24-SRI3; 25-SRI4; 26-SRI5), underlining that those topics are increasing interest within the EPC scheme.

Figure 13. Compliance Score graphic per Member States, referring to the maximum CS value of 30 corresponding to the implementation level with no EU common definition (yellow label of legend explained in Figure 3).



Source: Sesana, et al. (2024).

Last part of this section of the report focuses on the results of the CCM on Burden Costs using a sample of seven selected countries as specified in the section 2.1.2 (§Cross Correlation Matrix tool: methodology and metrics of the Burden Costs analysis study methodology).

The Burden Cost study has been also supported by the information collected and shared by several EU funded projects within EU research topic "Next-generation of Energy Performance Assessment and Certification".

According to recent H2020 funded projects (refer to Table 4 for further details about them) developing new generation EPCs, in particular, ePANACEA, EPC Recast, EUB SuperHub, QualDeEPC and X-tendo, the current price for issuing an Energy Performance Certificate varies a lot among MS. Only few MS, such as Denmark, Croatia, Hungary and Slovenia, have set the cost for EPCs by law, thus in all the other countries prices are generally set on a market basis with no maximum ceiling.

On average, the EPC price for a single-family house ranges across EU (Figure 14) from €20.0 to €1 000.0, with high differences between countries due to several aspects such as:

- labour cost;
- workload required for calculation;
- number of competing actors on the market;
- cost of EPC software;
- calculation method (i.e., asset rating or operational rating);
- involvement of trained experts;

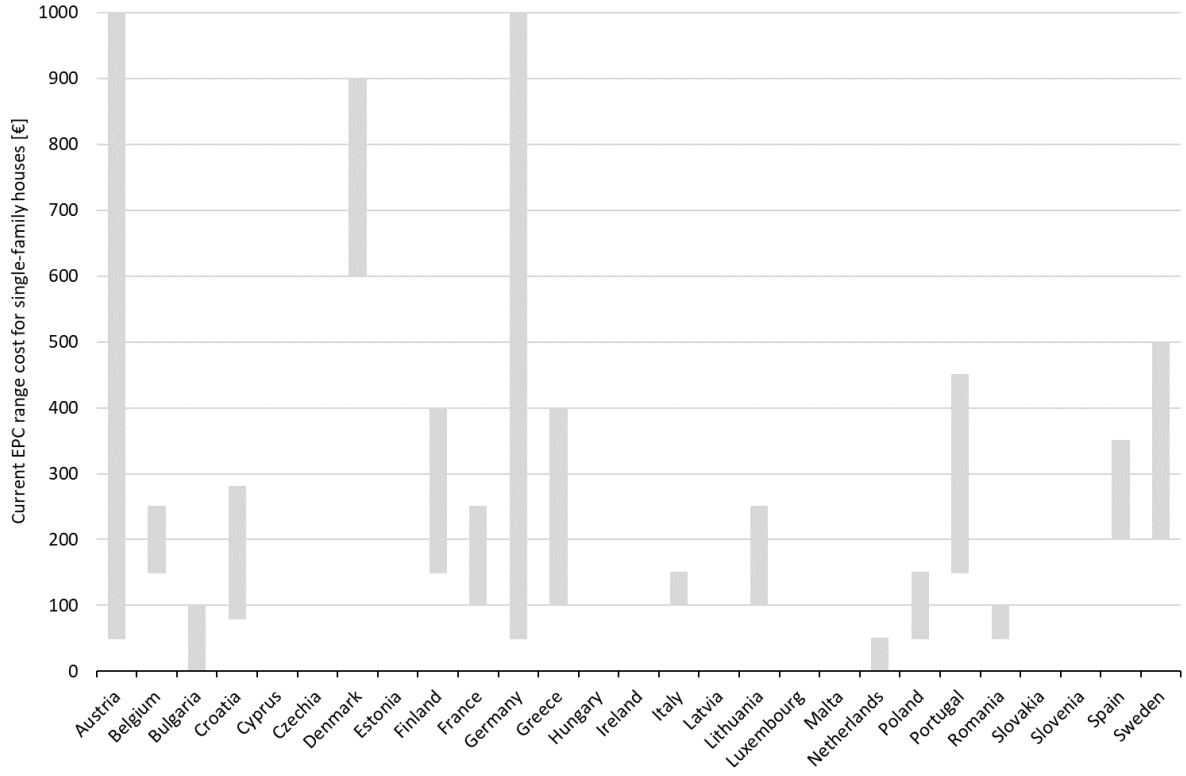
— on-site inspection;

— effort for data acquisition (i.e., demanded-based EPC or consumption-based EPC);

— verification by an independent organisation;

— registration or not in a national EPC database.

Figure 14. Current EPC range cost for single-family houses per EU Member States.



Source: Figure elaborated by the authors.

Regarding the certification procedure, in countries where the EPCs are issued automatically via online tools (e.g. in the Netherlands) the costs are low due to the low level of involvement of trained experts (no needs of specific software and on-site visits). The building characteristics plays a big role in the price definition, in particular the main influencing features are:

— type, size and complexity of the building;

— location of the building;

— use of the building (i.e., residential or non-residential);

— age of the building (i.e., new or in use);

— existence and level of detail of plans and building-related documents;

— characteristics and complexity of the building envelope;

— characteristics and complexity of plant systems and renewable energies;

— need of on-site measurements;

— measured energy use data;

— dynamic simulation due to the presence of plant systems.

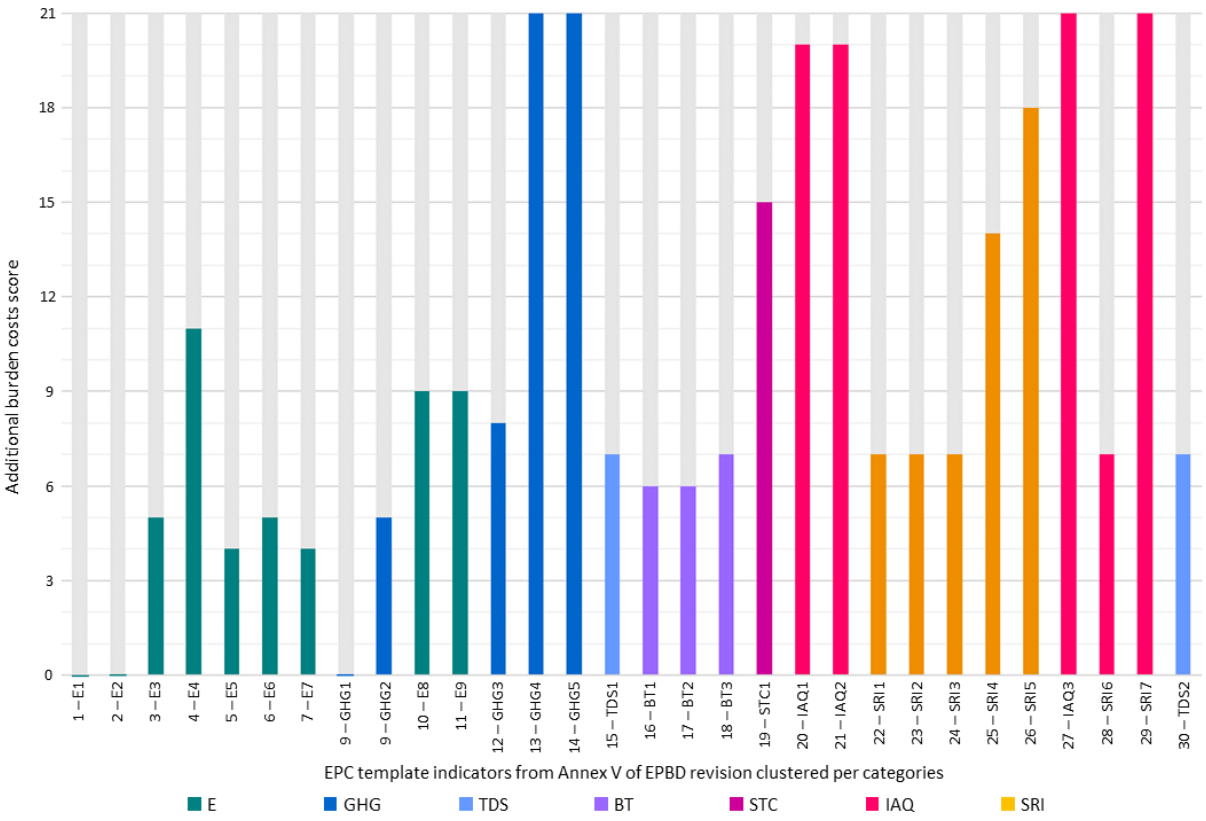
Depending on the factors mentioned above, very low costs for issuing an EPC can call into question the integrity, quality and reliability of the EPC, but on the other hand keeping prices affordable for end-users may increase the public acceptability and uptake of the certification scheme. It is therefore important to guarantee good quality with high affordability of the EPCs to avoid the use of default values to minimize costs. A successful example of high-quality EPC process with low cost is the one developed in the Netherlands for residential buildings. In this process, the owner is firstly given a free temporary EPC with the energy performance of its house/apartment based on cadastral data (e.g., area, construction date, building type, quality of envelope insulation, plant systems and renewable energy characteristics). The owner can then change or add additional documented information on energy measures and select the qualified expert who has to approve the changes on the website. After the expert check and approval, the new EPC is registered in the national database.

From the Dutch experience, it emerges how the availability of data, also with the cooperation of the building owner, is necessary for the certifier to lower the costs of issuing an EPC. On the other hand, if the collection of measured data implies more work for the certifier, for example through a more complex on-site inspection, the burden costs of the EPC is expected to increase.

The increasing complexity and reliability of the calculation methodologies and of the efforts for the assessors are causing a general increase in the EPCs' cost assessment. As for the integration of additional indicators into the EPCs, the price can vary according to the effort needed for their implementation. As reported into the methodology sections, three levels of effort have been identified corresponding to higher cost of implementation: i) negligible, if the indicator is already in the calculation process, it has only to be displayed on the EPC: ii) medium, if the calculation procedure for the specific indicator can be easily implemented, iii) high, if the indicator is based on real time monitoring that need to be implemented or on tool development. In accordance to this approach, Figure 15 shows the additional burden costs score per each indicators' implementation and underlined that only three out of the 30 indicators, do not compute additional burden costs, being already implemented in the EPC template. The categories with a lower score are Energy, Tool and Data Source and Building Technology, while the higher scores are collected by the ones related to newly defined indicators (i.e., Emissions, Summer Thermal Comfort, IAQ and SRI). In particular, nine out of 30 indicators register a burden/cost score higher than 12, indicating that the implementation of new indicators for which there is still not a consensus about definition, methods of calculations and or tools for data collections might require higher cost respect to others (certifier with specific skills and instruments i.e., smart meters; dedicated monitoring campaign).

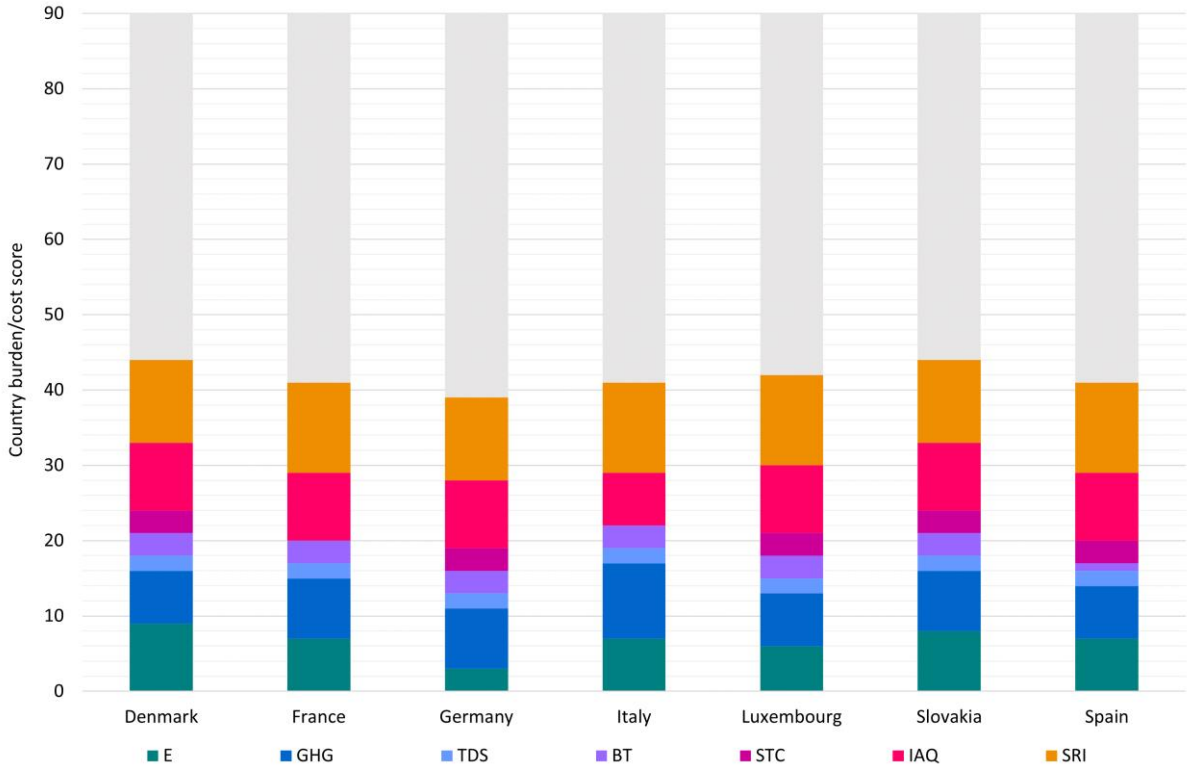
Moreover, Figure 16 shows that the selected Member States present similar burden/cost for the implementation of the EPBD indicators, with scores lower than half of the total. Germany is the country with the minimum score due to the low burden cost related to energy indicators, while the other categories have similar scores for each Member State. Although Italy and France are the only countries without burden/cost for the category STC - summer thermal comfort, already implemented in their current EPC template, they reach a country burden cost score of around 40 due to a low level of implementation of the other categories.

Figure 15. Additional burden costs score for EPC indicators' implementation for the seven selected MSs clustered per categories.



Source: Sesana, et al. (2024).

Figure 16. Burden/cost of implementation score for selected Member States clustered by categories.

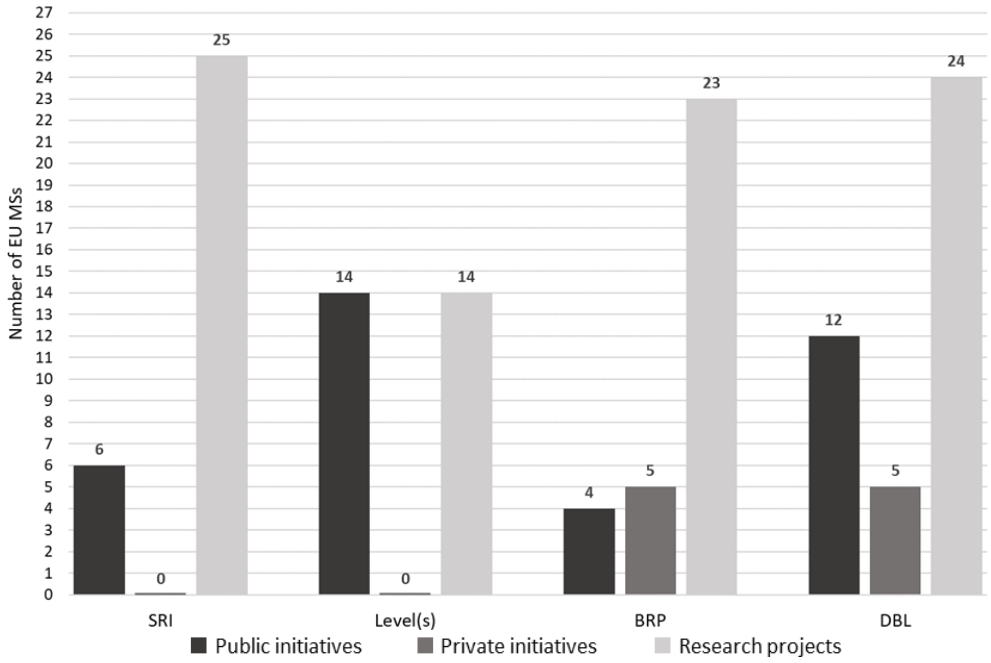


Source: Figure elaborated by the authors.

4.2 Evaluation of synergies between EPC indicators and other tools

This section presents the main results through diagram representations realized using all the data collected to populate the Tools' and Synergy Matrix, taking into consideration all the outcomes of existing literature, ongoing initiatives and research projects, comprehensive of stakeholder meetings, workshop, expert interview and/or quick surveys conducted by authors to collect relevant information about the current status of some non-official ongoing testing or development tools for which no official documentations have been yet published.

Figure 17. Ongoing initiatives of the selected tools across EU.



Source: Figure elaborated by the authors.

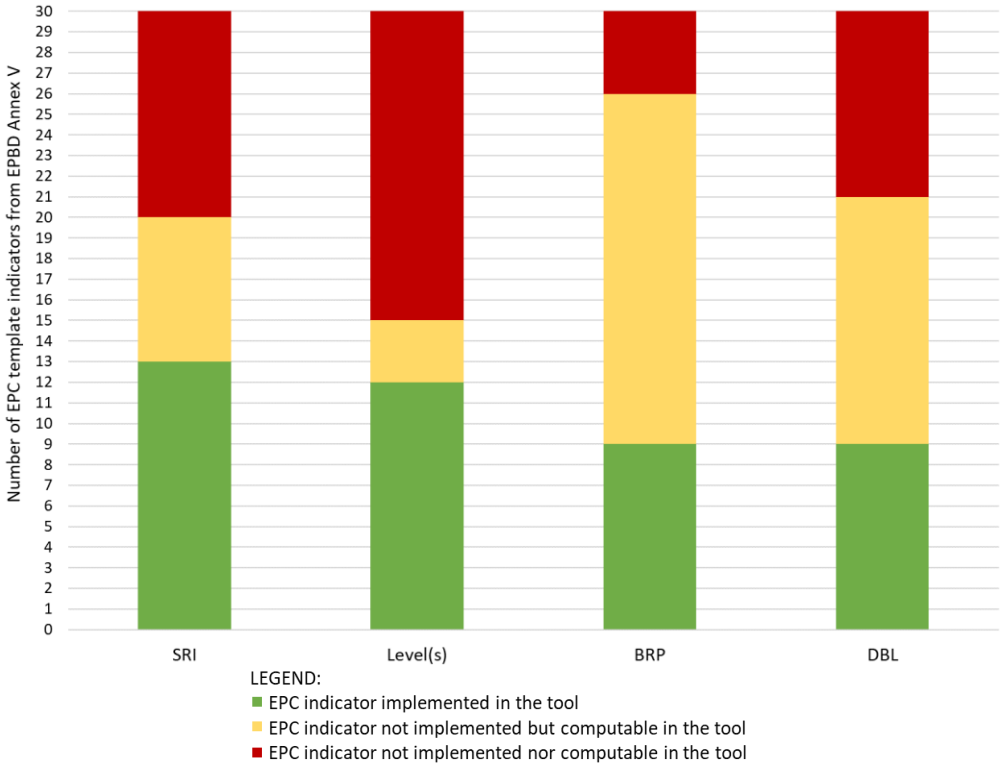
The first results graphically summarized in Figure 17 clearly reveals that the four selected tools reached a very high MSs' interest, being largely tested or under pilot evaluation on average by more than half of the 27 EU MSs. The number of MSs which have tested the tools does not correspond necessarily to the number of initiatives, since for example one of the analyzed experiences could be ongoing in more than one EU MSs. It is the case for example of the Level(s) for which the framework is under evaluation within different initiatives mainly public and recent research projects (just started in 2022) as counted numerically in the quantitative feature of the Tools' Matrix (Annex 7) and detailed in the qualitative feature of the Tools' Matrix (Annex 8).

The most widespread in terms of knowledge and testing phase is the Smart Readiness Indicator with 25 out of 27 MSs, followed by the Digital Logbook and the Building Renovation Passport respectively with 24 and 23 out of 27 MSs. Level(s) officially is the least popular, but it is also seeming to be less connected to the other tools.

The qualitative analysis of the Tools' Matrix in fact reveals for example that many studies have already set as a goal to integrate both SRI and BRP and/or DBL within their research project methodologies, while the initiatives on Level(s) focuses only on this tool itself, concentrating on its assessment, more linked with a Life Cycle Assessment approach. From a cross country point of view, the three countries (LV, CZ and LT) which haven't tested three of the four tools belong also to the group of MSs which has fewer indicators implemented in their EPC scheme (Annex 2. Cross Comparative Matrix: quantitative data feature), underlining their difficulties on those instruments' implementation into their practice.

Subsequently, a deep dive analysis has been conducted on the possible synergies between the specific indicators for the assessment of the above mentioned four selected tools and the ones proposed by the Annex V into the EPC template.

Figure 18. EPC indicators' implementation status in the EU Member States.



Source: Figure elaborated by the authors.

Figure 18 graphically represents the main results of the analysis and it reveals that about 1/3 of the EPC indicators have been already implemented in the four tools, while the not implemented but computable indicators present a non-homogeneous situation among the tools.

Regarding the BRP and the DBL tools, it is important to underlined that - as remarked in the introduction of the document – an EU-wide data structure and respective indicators of the BRP or the DBL is still missing, but different initiatives are ongoing and only for some complete information is public available. For this reason, in order to complete the comparison analysis by populating also the BRP column of the Synergy Matrix both for the quantitative (Annex 9) and the qualitative feature (Annex 10), having a direct experience on the research project ALDREN, the authors decided to refer to the ALDREN BRP methodological framework coupled with the iBRoad passport indicator in order to cover both residential and non-residential buildings, to check the EPC indicators.

Comparing the four tools, SRI registers the highest number, 13 out of 30 EPC indicators implemented already in its assessment method, followed by Level(s) with 12 out of 30, and BRP and DBL with both a value of nine out of 30. On the contrary SRI has ten not yet implemented nor computable EPC indicators out of 30, while BRP and DBL respectively four and nine out of 30. Level(s) has the highest number of EPC indicators not implemented nor computable with 15 out of 30 EPC indicators. This results remarks that Level(s) has its own methodological assessment which is more focused on the Life Cycle Assessment (LCA) with specific indicators.

Correlating these results with also the seven categories introduced by the authors to analyze which are the hot-topics and their indicators, it emerges that comparing the four tools, most of the EPC indicators belong to the Energy category, while the least implemented are the Emissions category indicators.

A more detailed comparison per each tool per indicators categories, have been realized and summarized in Figure 19 to show the level of implementation of each EPC category in the four tools.

At least two Energy indicators have already been integrated in each tool. Most of the Building Technology and Tool Data Source indicators' categories have been implemented in the BRP and DBL tools. On the contrary all the indicators of both the categories haven't been integrated nor computable in SRI and Level(s) tools. Level(s) in particular has implemented or can compute only three categories (energy, emissions and Indoor Air Quality) out of seven defined related to Energy, and no one SRI category has been implemented nor computable.

IAQ and emissions are two categories with more difficulties for their indicators' implementation due to the lack of a general consensus, common definitions and calculation methods. Those barriers led in fact to a slightly different implementation in the tools. In fact, for BRP and DBL the few EPC indicators, not implemented or nor computable, belong to the IAQ and emissions categories. Checking the same proposed indicators by Annex V in the EPC schemes across Europe, those have been already implemented in some countries, but with different and local calculation methodology, being not yet available a common vision on those topics (i.e. for comfort there is not a common rating to refer or for the emission category, GHG potential is a new indicators just introduced and diffuse in literature and regulations).

The EPC indicators which belong to the SRI category - as defined in section 2.1 - have been already implemented and they can be also partially calculated by other indicators both on BRP and DBL, while all seven EPC indicators related to SRI are not implemented in Level(s). On the contrary, checking the list of the first nine recommended EPC indicators, six out of nine have been already implemented in the Level(s) framework and the remaining can be calculated from others existing indicators.

Looking at the first nine rows of the Synergy matrix, corresponding to the EPC indicators recommended by the EPBD revision, we observe that currently, most of the tools (SRI, BRP and DBL) have not yet implemented them, but they can be computable by other indicators (yellow cell in the matrix). Moreover, the indicators which cannot either be calculated (red cell) are mainly related to emissions category. The other suggested indicators (numbered from 10 to 30 in Annex 9) by the EPBD revision present a very not-homogenous implementation among the four tools.

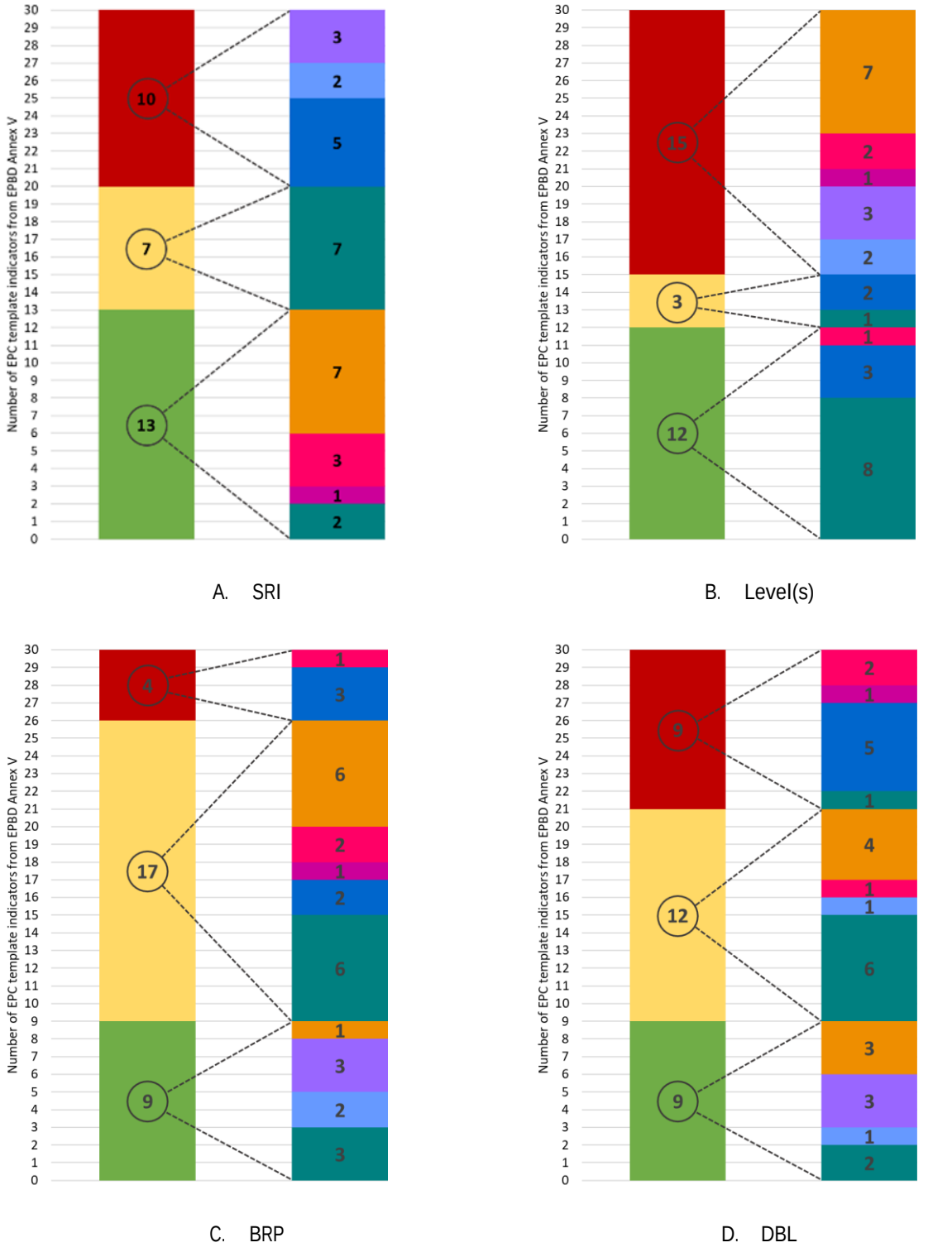
The indicators related to the emission category register the worst situation being not implemented in three out of four tools. While the indicators related to the Building Technology category have been highly implemented in the BRP and DBL, which is in line with the general scope of those tools to increase the knowledge of the building

Similarly to the results presented in 4.1, even this analysis showed the increased importance gained by the comfort topic, but at the same time, underlined the difficulties on having a common and agreed reference methodology and, above all, an indicator to communicate the comfort level. The Summer Thermal Comfort (STC) category - identified in the work only by one indicator by the authors and named as "Results of the analysis on overheating risk", turns out to be already implemented in the SRI assessment method and it could be computable in the BRP ALDREN experience, but even if the topic is relevant no correspondent indicators have been individuated in Level(s) and DBL. ALDREN BRP presented a specific module on comfort and developed a new dedicated rating, the so called TAIL, which should be further investigated and tested to enhance its feasibility.

Similar to the comfort topic is the current situation also of the Indoor Air Quality (IAQ) indicators of the EPC. The main barrier is again linked to the feasibility to verify the presence of smart meters, which is logically connected to the SRI methodological framework, while in Level(s) those IAQ indicators are absent.

In BRP and DBL the IAQ indicators are not implemented as indicated in the EPC template proposal, but they can be derived from other data.

Figure 19. EPC indicators categories' implementation status in the EU Member States.



Source: Figure elaborated by the authors.

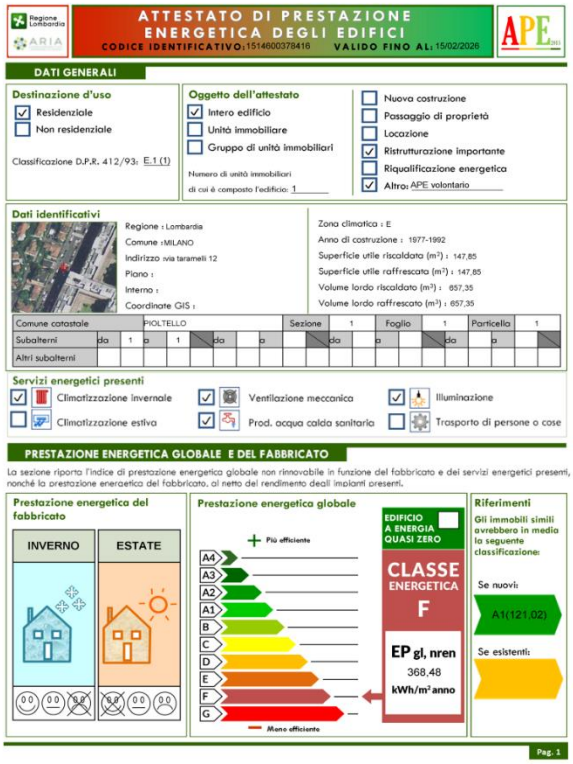
4.3 The application of nudges to increase EPC effectiveness

4.3.1 Nudges on the decision structure

EPC designers and energy efficiency market actors can act as choice architects by influencing the decision structure, such as by changing the effort required to look for information of alternative dwellings. One of the most prominent interventions of this kind is the pre-selection of the desirable option, by making it more immediately available to individuals (Madrian, 2014). As an example, individuals could be automatically subscribed - with the possibility to opt out - to dwelling energy efficiency informational campaigns or to the online database of EPCs (Taranu & Verbeeck, 2018).

Given that understanding the energy consequences of a renting/buying decision requires effort, EPC designers can also reduce the perceived effort associated with that choice and with the processing of information (Della Valle & Bertoldi, 2021). For example, EPC designers can change the factors that affect perceived effort in assessing the energy information, using intuitive graphics or images. The certificates from France and Lombardy region (Italy), shown in Figure 20, offer an example of this kind, in that they embed technical terms and concepts that have been 'translated' into self- explanatory content or images (Taranu & Verbeeck, 2018).

Figure 20. EPC in Lombardy (Italy)



Source: https://www.cened.it/

4.3.2 Second-degree nudges: motivational levers

Behavioural economic studies highlight that individuals display not only cognitive deviations but also motivational deviations from the assumptions of the rational choice model. In particular, individuals are heterogeneous not only in their preferences, but also in their degrees of self-interest and motivations (Sacco & Zarri, 2003).

This heterogeneity in motivations and degrees of self-interest help explain additional factors that influence citizens' decision to choose (or not) efficient dwellings. Some citizens might be willing to choose an efficient dwelling even in the absence of external incentives, because they are intrinsically motivated to protect the environment, or because they think this is the right thing to do relative to a personal or social norm (what they or their relevant peers think it is the appropriate thing to do) (Della Valle & Bertoldi, 2022).

In this context, second-degree nudges (which use biases towards a predictable outcome) can be applied to awake existing motivations and make EPC more effective. More particularly, embedding in the EPC information on energy consumption, energy efficiency, GHG emissions, and monetary savings can contribute to crowd-in existing motivations to undertake the recommended energy efficiency measures (Taranu & Verbeeck, 2018).

As an example, an EPC that makes the monetary savings salient might crowd-out the intrinsic motivation of those individuals who would have already chosen an efficient dwelling due to their environmental concerns. For example, this might happen when people cannot convince themselves or others any longer that they are choosing the efficient dwelling because they are persons who actively contribute to the environment, but they might do so also to save money. Conversely, combining the information on monetary savings with a message informing that choosing that energy efficient dwelling is also "**socially" or "morally" appropriate**, might enable to re-establish and support the positive self-image of a person as "a good person" and potentially offset motivation crowding-out (Alt et al., 2022). An example of this normative message is provided in the Dutch label: 'Fifty percent of existing homes in the Netherlands are now labelled C or better' (Taranu & Verbeeck, 2018). This would make individuals, who care about social conformity, put a higher effort to conform to the descriptive norm provided (thus they would more likely choose C class or beyond).

Similarly, combining the information on monetary savings with an emission-related information might make salient to those individuals who are intrinsically motivated to actively contributing to protecting the environment that choosing the low-emitting dwelling would enable them to contribute to environment protection and, thus, increase the likelihood that the sustainable dwelling will be chosen (Asensio & Delmas, 2015).

4.3.3 Third degree nudges

Behavioural economic studies have provided evidence that individuals evaluate decision outcomes in terms of gains and losses relative to a reference point, usually the status quo, and assess losses as being larger than equal-sized gains (loss aversion) (Kahneman & Tversky, 1979).

The implication is that before deciding to select a certain option (such as a certain dwelling), individuals judge the value of that option based on i) the transaction value and the ratio of the product's perceived benefits to the perceived sacrifice, and ii) the perceived gains or losses relative to reference points (Simonson & Drolet, 2004). Exemplary reference points that have been proven to affect choices are arbitrary anchors, norms, social comparisons, goals, and reference prices (Kahneman, 1992).

In the EPC, third degree nudges (that induce a bias) can provide reference points for a better evaluation of the dwelling. As an example, in the Flanders, the EPC provides a reference point in a grey-shaded area of the scale in reference to the new construction standard ('nieuwbouw') (Taranu & Verbeeck, 2018).

Another implication of reference-dependent preferences is that if individuals perceive that there is a potential for a loss (they see that the energy efficient dwelling has a higher price but perceive its monetary savings as uncertain), they might disregard that option and prefer the known (usually more inefficient) option (Della Valle & Bertoldi, 2021).

In the EPC, third degree nudges can thus be applied to make energy efficiency consequences more tangible, such as by making across classes easier to compare energy savings (Spain) (see Figure 21), monetary savings (the UK), CO_2 reduction (France) or the cost per tonne of CO_2 saved (Denmark) (Taranu & Verbeeck, 2018).

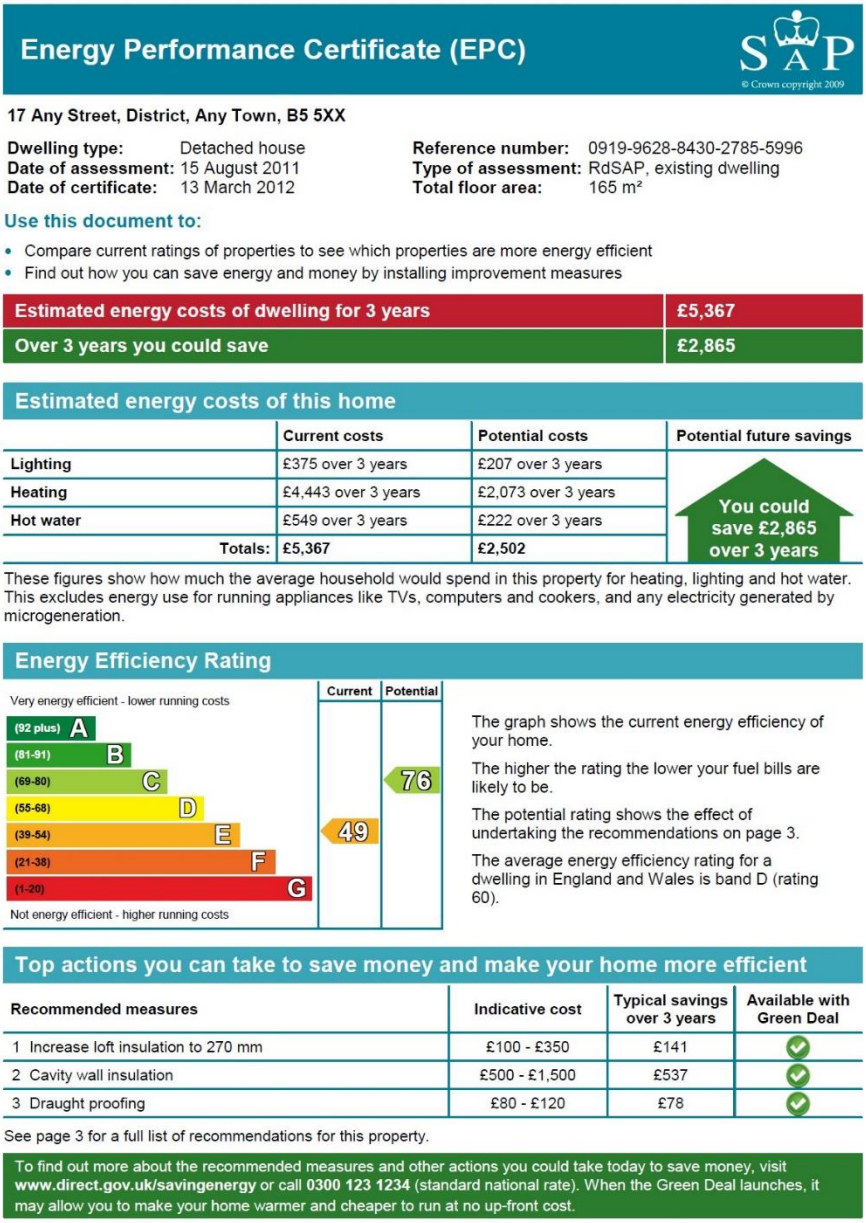
Figure 21. EPC in Spain

Source: https://energia.gob.es/

Empirical studies also report about the "class valuation effect", according to which consumers would evaluate an option with a higher energy efficiency class *per se*, i.e. irrespective of the underlying energy use differences, leading individuals to value more the class and less the detailed information on energy consumption (Andor et al., 2019)

At the same, if designed carefully, EPC enriched with these types of information can also enable to reduce the effect of other behavioural anomalies, such as hyperbolic discounting (individuals tend to prefer consumption options that provide immediate benefits while disliking those that provide larger benefits in the future (O'Donoghue & Rabin, 1999)). As an example, to take into account hyperbolic discounting, the UK certificate (Figure 22), updated the certificate to show shorter time span of the monetary savings associated with the recommended measures over a number of years (from previously five to three years) (Taranu & Verbeeck, 2018).

Figure 22. EPC in the UK



Energy Performance Certificate (EPC)

SAP © Crown copyright 2009

17 Any Street, District, Any Town, B5 5XX

Dwelling type:	Detached house	**Reference number:**	0919-9628-8430-2785-5996
Date of assessment:	15 August 2011	**Type of assessment:**	RdSAP, existing dwelling
Date of certificate:	13 March 2012	**Total floor area:**	165 m²

Use this document to:

- Compare current ratings of properties to see which properties are more energy efficient
- Find out how you can save energy and money by installing improvement measures

Estimated energy costs of dwelling for 3 years	**£5,367**
Over 3 years you could save	**£2,865**

Estimated energy costs of this home

	Current costs	Potential costs	Potential future savings
Lighting	£375 over 3 years	£207 over 3 years	You could save £2,865 over 3 years
Heating	£4,443 over 3 years	£2,073 over 3 years	
Hot water	£549 over 3 years	£222 over 3 years	
Totals:	**£5,367**	**£2,502**	

These figures show how much the average household would spend in this property for heating, lighting and hot water. This excludes energy use for running appliances like TVs, computers and cookers, and any electricity generated by microgeneration.

Energy Efficiency Rating

	Current	Potential
Very energy efficient - lower running costs		
(92 plus) A		
(81-91) B		
(69-80) C		76
(55-68) D		
(39-54) E	49	
(21-38) F		
(1-20) G		
Not energy efficient - higher running costs		

The graph shows the current energy efficiency of your home.

The higher the rating the lower your fuel bills are likely to be.

The potential rating shows the effect of undertaking the recommendations on page 3.

The average energy efficiency rating for a dwelling in England and Wales is band D (rating 60).

Top actions you can take to save money and make your home more efficient

Recommended measures	Indicative cost	Typical savings over 3 years	Available with Green Deal
1 Increase loft insulation to 270 mm	£100 - £350	£141	✓
2 Cavity wall insulation	£500 - £1,500	£537	✓
3 Draught proofing	£80 - £120	£78	✓

See page 3 for a full list of recommendations for this property.

To find out more about the recommended measures and other actions you could take today to save money, visit **www.direct.gov.uk/savingenergy** or call **0300 123 1234** (standard national rate). When the Green Deal launches, it may allow you to make your home warmer and cheaper to run at no up-front cost.

Source: https://www.gov.uk/housing-local-and-community/energy-efficiency-in-buildings

Overall, exploiting different framings that vary the content, the layout and the wording of the EPC has the potential to promote individual choices of energy efficiency dwellings. However, for EPCs to be truly effective, they need to be used carefully (d'Adda et al., 2022) and following an evidence-based approach, such as through the use of experiments on the target population (Troussard & van Bavel, 2018).

5 Conclusions

The present report provides an extensive analysis on the implementation of the proposed indicators by Annex V of EPBD revision in the EPCs schemes across Europe. Subsequently, it highlights synergies between EPCs and other tools related to buildings' energy performance. Finally, it deals with the framing of EPC information from the behavioural science perspective.

The study reveals significant differences between the EPC schemes as well as a non-homogeneous level of compliance for the indicators within the EPC schemes.

The evaluation methodology has been based on a cross-country comparison between the implemented indicators and allowed the identification of different approaches used in the MSs. The level of implementation of the EPC indicators varies from country to country across Europe and depends mainly on the local regulatory and policy contexts, the available technical capacities of assessors to support the indicators' implementation, as well as the knowledge and expertise on new topics and framework such as Levels and SRI.

The results are clearly pointing out that 16 out of 30 indicators analyzed registered a high integration into the EPC template of MSs and nine of those corresponds to the first nine indicators listed in Annex V of the EPBD recast proposal.

Moreover, the outcomes underlined that currently most of the EU Member States has not yet implemented all the mandatory indicators according to the EPBD revision (indicators from 1 to 9 in Table 1) and those indicators are mainly related to Energy and Emissions categories. The other suggested indicators (numbered from 10 to 30 in Table 1) by the EPBD revision have a limited implementation: they are mostly related to Building Technology category (BT 16 – BT 17 – BT 18) and integrated only in nine countries (AT, BE, BG, HR, IE, CZ, FI, PT, ES).

The energy performance class (E1) and the calculated primary energy use in kWh/m^{2}year (E2) are the two out of 30 indicators implemented in all the EPC templates across Europe. However, a predominant number of countries have implemented them without a full compliance definition to EU regulation, preferring instead to use their own developed independent and national standards.

The Summer Thermal Comfort category - identified in the work - presents only one indicator, named "Results of the analysis on overheating risk", which has been implemented in four countries (BE, FR, IT, NL), underlying that even if there is not a common definition and rating on this topic, the topic of comfort is increasing its relevance concerning the energy efficiency.

Moving from results per indicator to the country-by-country analysis, the Compliance Score value of the CCM (reported in Annex 2) presented in the methodology of the work (section 2), shows that 11 MSs (AT, BE, BG, FR, DE, IE, IT, ES, SK, SE) register a value greater than 11, demonstrating that only one-third of the EU Member States have implemented at least one-third of the proposed indicators by the EPBD revision, but without a common EU definition.

Based on the results obtained by the CCM matrix with Quantitative and Burden Costs features, further conclusions have been drawn up and summarized in the following two boxes respectively on indicators related to Indoor Air Quality and on additional Burden Costs deriving from the indicators' inclusion in the EPC.

Box 5. Indoor air quality indicators of the EPC template

Three out of 30 indicators proposed by the EPBD revision belong to the Indoor Air Quality topic as suggested indicators:

- presence of fixed sensors that monitor the levels of indoor air quality (indicator no. 20 - IAQ 1);
- presence of fixed controls that respond to the levels of indoor air quality (indicator no. 21 - IAQ 2);
- operational fine particulate matter (PM2.5) emissions (indicator no. 27 - IAQ 3).

The IAQ 1 is the unique IAQ indicator already implemented only in the Sweden EPC template for monitoring the radon level. The other two indicators on IAQ are not implemented in any country.

The present study reports also a rough estimation of additional Burden Costs potentially resulting from the inclusion of new indicators into the EPC template that might impact the overall cost for both the assessor and the building owner. This analysis has been conducted by authors through interviews with experts and stakeholders belonging to seven selected countries, using the methodology described in section 2.1.2. Further information has been also collected analyzing the most relevant research carried out in the frame of the EU research topic "Next-generation of Energy Performance Assessment and Certification".

Box 6. Additional Burden Costs deriving from the indicators' inclusion in the EPC.

Referring to the seven selected countries (Denmark, France, Germany, Italy, Luxembourg, Slovakia and Spain), three out of the 30 indicators, being already implemented in the EPC template, do not compute additional burden costs:

- energy performance class (indicator no. 1 - E 1);
- calculated annual primary energy use in kWh/m^2year (indicator no. 2 - E 2);
- operational greenhouse gas emissions (kg CO_2/m^2year) (indicator no. 8 – GHG 1).

The higher additional burden costs have been evaluated for three categories related to: Emissions, IAQ, and SRI for the indicators which request a dedicated training (GHG 4 and GHG 5 indicators) or expertise in managing additional tools and sensors by assessor to monitor and gather real consumptions (IAQ 1, IAQ 2, SRI 5 and SRI 7).

Sometime the implementation difficulties experienced are inherent in the complexity of the indicator assessment, the lack of a common definition or calculation method, the non-homogeneous building features, and typologies. Those facts have contributed to the picture described into this report which underlines significant differences on EPC indicators' implementation between EU MSs.

As to the synergies between the EPC template proposed by the EPBD revision and the latest voluntary buildings-related schemes and tools (namely Smart Readiness Indicator, Level(s), Building Renovation Passport and Digital Building Logbook), the study reveals in general a high difficulty in collecting deep information and data about the structure and the core indicators of the above-mentioned tools, since a consensus on their respective definitions and their use is still missing. Consequently, even the level of knowledge and implementation/testing of the selected tools highlights a non-homogeneous situation across Europe, clearly represented in the qualitative feature of the Tools' matrix (Annex 8). At the same time, the matrix registers a very high interest in all of them (quantitative feature of the Tools' matrix – Annex 7). The level of implementation across Europe of those tools depends mainly on the local initiatives and government decisions, so the results of the analysis highly depend on the data availability in literature and periodic reports of such ongoing experiences (i.e. tester or research projects).

The developed methodology presented in section 0, allowed to draft a vision on the topic of the present document – synergies between EPC indicators and the selected tools, even if they are not available for all the EU MSs and not detailed at the same level per each tool analyzed. The background knowledge and the experience of the authors on the topic and the rigorous methodological steps allowed to populate all the matrix necessary for completing the comparison and identify the possible synergies and most interesting topics under investigation on the ongoing initiatives.

The results are clearly pointing out that both BRP and DBL should and could be fed automatically by EPC data without any user interference having respectively 26 and 21 out of 30 indicators in common, most of them already implemented and others that can be computable from the existing ones. This vision has been stated also in the final report of the "Technical study on the possible introduction of optional building renovation passports", which suggested the creation of interconnection between EPC, BRP and DBL data, already feasible at the time of the document based on the analysis of their results.

From the recent SRI Platform Plenary Stakeholder meetings (Dec. 2021 and Nov. 2022) the need arose to share and identify common implementation paths and good practices starting from ongoing experiences with Member States, that have already started implementing the Smart Readiness Indicator, with existing tools and regulations such as National Building Renovation Plans (NBRPs), Energy Performance Certificates (EPCs) and Building Renovation Passports (BRPs). The envisaged evolution of the current EPC schemes should aim to: (i) enhance their value and data quality, (ii) become complementary and interoperable with BRPs; (iii) provide valuable recommendations' interventions for the existing building stock to increase the renovation rate and (iv) support the decarbonisation path with a life cycle assessment in line also with the Level(s) framework.

Finally, through a literature review and desk research of behavioural science studies, the study has highlighted some of the main behavioural factors underlying the choice of an efficient dwelling, and how leveraging these factors can make an EPC effective at increasing the choice of an efficient dwelling. More particularly, the study identified three main categories of behavioural tools, the so-called nudges, which EPC designers and energy efficiency market actors can exploit by vary systematically the content, the layout and the wording of the EPC. This study's insights are based on previous empirical and experimental evidence. However, they only aim to provide a direction and cannot be generalised. In particular, an evidence-based approach should always be followed, where any proposed change to the framing of the EPC is validated in the specific context through the use of experiments on the target population (Troussard & van Bavel, 2018).

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List of abbreviations and definitions

BC	Burden Costs
BRP	Building Renovation Passport
BT	Building Technology
CCM	Cross Comparative Matrix
CS	Compliance Score
DBL	Digital Building Logbook
E	Energy
EC	European Commission
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
GHG	Green House Gas
GWP	Global Warming Potential
IAQ	Indoor Air Quality
LCA	Life Cycle Assessment
MEPS	Minimum Energy Performance Standard
MS	Member State
RES	Renewable Energy Sources
SM	Synergy Matrix
SRI	Smart Readiness Indicator
STC	Summer Thermal Comfort
TDS	Tool and Data Source
TM	Tool Matrix

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Annexes

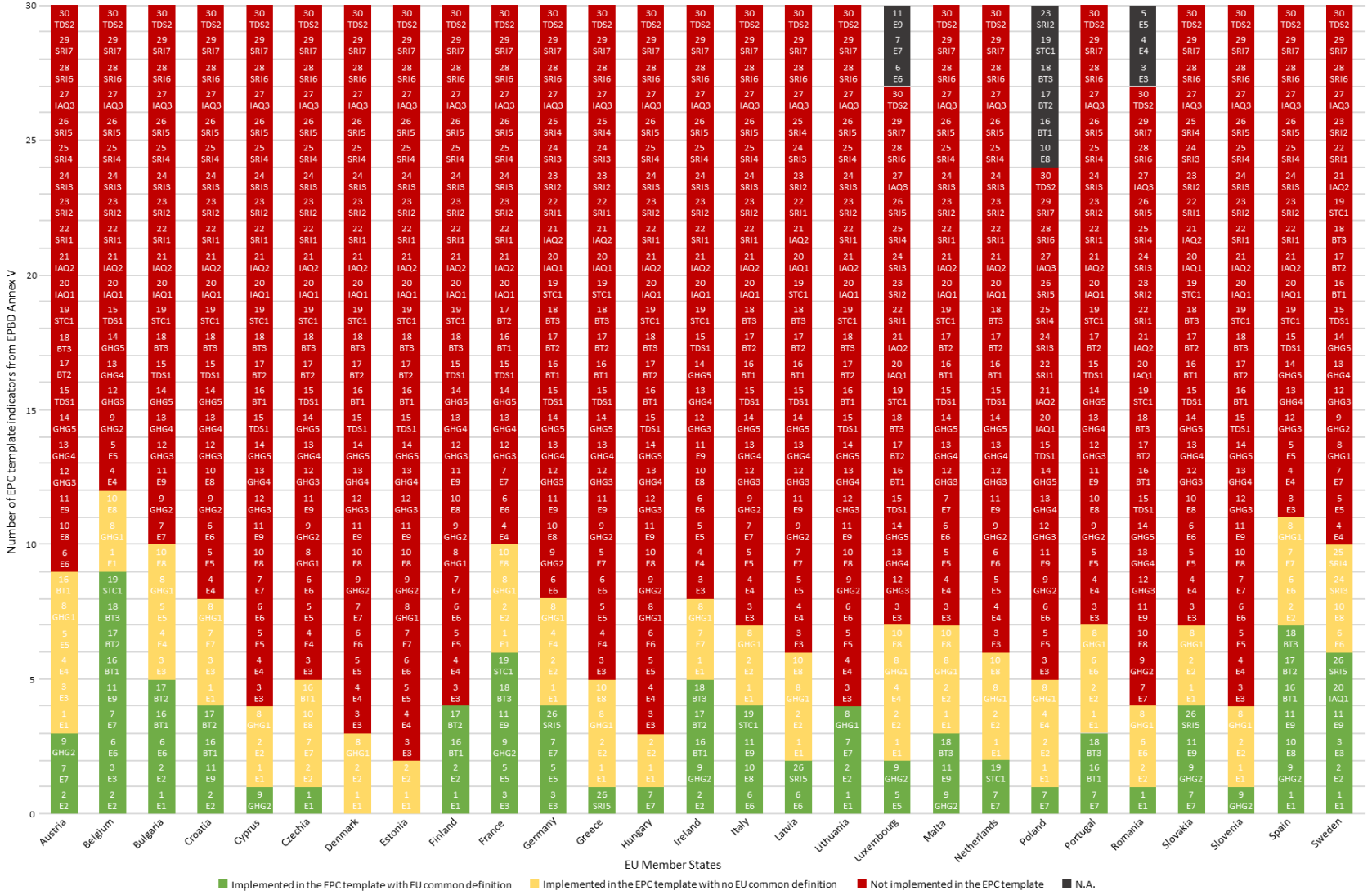
Annex 1. Cross Comparative Matrix: qualitative data feature – Source: Sesana, et al. (2024)

INDICATORS	EU MEMBER STATES			AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE
	NO.	CATEGORY																												
RECOMMENDED	1	E	1	Additional classes above A	Classification in seven classes from A+ to F	✓	additional class above A	division of class B in two sub-classes	✓	classification in ten classes from A2020 to G	classification in eight classes from A to H only for non-residential buildings	✓	classification in nine classes from A to I only for non-residential buildings	classification in nine classes from A+ to H	classification in nine classes from A+ to G with subdivision also for class B	classification in twelve classes from AA++ to JJ	classification in fifteen classes with subdivision also for classes B, C, D and E	division of class A in four sub-classes	no division in specific classes	additional classes above A	classification in nine classes from A+ to I	no division in specific classes for residential buildings	additional classes above A	no division in specific classes	classification in eight classes with subdivision also for class B	✓	division of class A in three sub-classes	classification in seven classes with subdivision also for class B	✓	✓
				A++ - G	A+ - F	A - G	A+ - G	A - G	A - G	A (2020, 2015, 2010 levels) - G	A - H	A - G	A - G residential; A - I non-residential	A+ - H	A+ - G	AA++ - JJ	A1 - G	A4 - G	Sliding scale	A++ - G	A+ - I	sliding scale dwellings; A - G non-dwellings	A++++ - G	Sliding scale	A+ - F	A - G	A0 - G	A1 - G	A - G	A - G
	2	E	2	✓	✓	✓	✓	defined as primary energy consumption	only non-renewable primary energy	defined as calculated energy use	defined as weighted specific energy use	✓	defined as primary energy consumption	defined as primary energy demand	only non-renewable primary energy	defined as primary energy consumption	✓	only non-renewable primary energy	in the sliding scale only primary energy for heating	defined as primary energy consumption	defined as total primary energy requirement	defined as energy use (no specification if primary energy)	defined as primary fossil energy consumption	only non-renewable primary energy demand	defined as primary energy needs	defined as annual specific energy consumption (no specification if primary energy)	defined as global primary energy	only non-renewable primary energy	only non-renewable primary energy	✓
				kWh/m²year	kWh/m²year	kWh/m²	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	ratio between evaluated building and reference building in %	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year	kWh/m²year
	3	E	3	defined as primary energy requirements	✓	defined as energy consumption	defined as required energy (no specification if primary energy)	not in use	not in use	not in use	not in use	not in use	✓	✓	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	✓
				kWh/year	kWh/year	MWh	kWh/year	not in use	not in use	not in use	not in use	not in use	kWh	kWh	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	kWh
	4	E	4	defined as final energy demand	not in use	defined as specific energy consumption for required energy (no specification if final energy)	not in use	not in use	not in use	not in use	not in use	not in use	not in use	defined as final energy demand	not in use	not in use	not in use	not in use	not in use	not in use	only for heating and domestic hot water	not in use	not in use	defined as final energy demand	not in use	N.A.	not in use	not in use	not in use	not in use
				kWh/m²year	not in use	kWh/m²	not in use	not in use	not in use	not in use	not in use	not in use	not in use	kWh/m²year	not in use	not in use	not in use	not in use	not in use	not in use	kWh/m²year	not in use	not in use	kWh/m²year	not in use	N.A.	not in use	not in use	not in use	not in use
	5	E	5	defined as final energy requirement	not in use	defined as energy consumption for required energy (no specification if final energy)	not in use	not in use	not in use	not in use	not in use	not in use	✓	✓	not in use	not in use	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	not in use
				kWh/year	not in use	MWh	not in use	not in use	not in use	not in use	not in use	not in use	kWh	kWh	not in use	not in use	not in use	not in use	not in use	not in use	kWh	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	not in use
	6	E	6	not in use	✓	✓	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	✓	✓	not in use	N.A.	not in use	not in use	not in use	divided in energy produced for regulated uses and other uses	defined as energy consumption from renewable sources	not in use	not in use	only for electric energy	for solar heating and solar cell systems
				not in use	-	MWh	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	kWh	kWh/m²year	not in use	N.A.	not in use	not in use	not in use	not in use	kWh/year	kWh/m²year	not in use	not in use	kWh/year	kWh/year
	7	E	7	✓	✓	not in use	share of renewable energy in total delivered energy	not in use	sun and environment energy	not in use	not in use	not in use	not in use	✓	not in use	✓	only in the potential impact of the recommended energy upgrades	not in use	not in use	defined as ratio between renewable and non-renewable energy consumption	N.A.	not in use	✓	✓	✓	not in use	✓	not in use	only for thermal energy	not in use
				%	%	not in use	%	not in use	%	not in use	not in use	not in use	not in use	%	not in use	%	%	not in use	not in use	-	N.A.	not in use	%	%	%	not in use	%	not in use	%	not in use
	8	GHG	1	defined as equivalent CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as specific annual emission	defined as CO_2 emissions	not in use	defined as calculated CO_2 emissions	not in use	not in use	defined as CO_2 emissions	defined as greenhouse gas emissions	defined as CO_2 emissions (calculated and actual)	not in use	defined as calculated annual CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	defined as equivalent CO_2 index	defined as CO_2 emissions	defined as CO_2 emissions	defined as CO_2 emissions	not in use
				kg/m²year	kg/year	t/year	kg/m²year	$kgCO_2/m^2$year	not in use	-	not in use	not in use	$kgCO_2/m^2$year	$kgCO_{2eq}/m^2$year	not in use	not in use	not in use	$kgCO_2/m^2$year	kg/m²year	$kgCO_2/m^2$year	$kgCO_2/m^2$year	$kgCO_2/m^2$year	kg/m²year	$kgCO_2/m^2$year	-	t/year	$kgCO_2/m^2$year	kg/m²year	kg/m²year	$kgCO_2/m^2$year	not in use
	9	GHG	2	✓	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	Sliding scale	not in use	not in use	not in use	A+ - I	Sliding scale dwellings; A - G non-dwellings	not in use	not in use	not in use	not in use	Sliding scale	Sliding scale	A - G	not in use
				A++ - G	not in use	not in use	not in use	Sliding scale	not in use	not in use	not in use	not in use	A - G	not in use	not in use	not in use	Sliding scale	not in use	not in use	not in use	A+ - I	Sliding scale dwellings; A - G non-dwellings	not in use	not in use	not in use	not in use	Sliding scale	Sliding scale	A - G	not in use
SUGGESTED	10	E	8	not in use	main energy carrier and main type of element	energy use, main energy carrier and main type of element	not in use	not in use	main energy carrier	not in use	not in use	not in use	main type of element	not in use	energy use and energy carrier	not in use	not in use	everything apart from peak load	main type of element	not in use	energy use, main energy carrier and main type of element	main type of element	main type of element	N.A.	not in use	not in use	not in use	not in use	not in use	everything apart from peak load	main energy carrier
				not in use			not in use	not in use	-	not in use	not in use	not in use		not in use		not in use	not in use		-	not in use	-		-	-	N.A.	not in use	not in use	not in use	not in use			
	11	E	9	not in use	type of renewable energy production system	not in use	type of renewable energy production system	not in use	not in use	not in use	not in use	not in use	type of renewable energy production system	not in use	not in use	not in use	not in use	type of renewable energy production system and main energy carrier	not in use	not in use	N.A.	type of renewable energy production system	not in use	not in use	not in use	not in use	type of renewable energy source	not in use	type of renewable energy production system	type of renewable energy production system
				not in use	-	not in use	-	not in use	not in use	not in use	not in use	not in use	-	not in use	not in use	not in use	not in use	-	not in use	not in use	not in use	-	not in use	not in use	not in use	not in use	-	not in use	-	-
	12	GHG	3	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	13	GHG	4	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	14	GHG	5	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	15	TDS	1	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	16	BT	1	defined as medium U-value (no specification if only opaque)	✓	✓	✓	not in use	defined as building envelope U-value (no specification if only opaque)	not in use	not in use	✓	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	✓	not in use	not in use	not in use	✓	not in use
				W/m²K	W/m²K	W/m²K	W/m²K	not in use	W/m²K	not in use	not in use	W/m²K	not in use	not in use	not in use	not in use	W/m²K	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	W/m²K	not in use	not in use	not in use	W/m²K	not in use
	17	BT	2	not in use	✓	✓	✓	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	not in use	✓	not in use
				not in use	W/m²K	W/m²K	W/m²K	not in use	not in use	not in use	not in use	W/m²K	not in use	not in use	not in use	not in use	W/m²K	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	not in use	W/m²K	not in use
	18	BT	3	not in use	✓	not in use	not in use	not in use	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	not in use	✓	not in use	N.A.	✓	not in use	not in use	not in use	✓	not in use
				-	-	not in use	not in use	not in use	not in use	not in use	not in use	not in use	-	not in use	not in use	not in use	-	not in use	not in use	not in use	not in use	not in use	-	not in use	N.A.	-	not in use	not in use	not in use	-	not in use
	19	STC	1	not in use	✓	not in use	not in use	not in use	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	✓	not in use	not in use	not in use	not in use	not in use	✓	N.A.	not in use	not in use	not in use	not in use	not in use	not in use
				not in use	-	not in use	not in use	not in use	not in use	not in use	not in use	not in use	-	not in use	not in use	not in use	not in use	-	not in use	not in use	not in use	not in use	not in use	-	N.A.	not in use	not in use	not in use	not in use	not in use	not in use
	20	HQ	1	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	radon measurements
	21	HQ	2	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	22	SRI	1	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	23	SRI	2	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	not in use	not in use	not in use
				not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	N.A.	not in use	not in use	not in use	not in use	not in use	not in use
	24	SRI	3	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	in recommendation measures
				not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	-
	25	SRI	4	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	in recommendation measures
				not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	-
	26	SRI	5	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	for heating and domestic hot water	electric, thermal and total energy	not in use	not in use	not in use	defined as energy accounting for heating and domestic hot water	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	for heating	not in use	not in use	for heating, cooling and domestic hot water
				not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	kWh	kWh/m²year	not in use	not in use	not in use	kWh/m²year	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	kWh/m²year	not in use	not in use	kWh
	27	HQ	3	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	28	SRI	6	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	29	SRI	7	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use
	30	TDS	2	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use	not in use

Annex 2. Cross Comparative Matrix: quantitative data feature – Source: Sesana, et al. (2024)

INDICATORS	NO.	CATEGORY		AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	CS per indicator	N.A.
RECOMMENDED	1	E	1																												33	0
	2	E	2																												34	0
	3	E	3																												11	1
	4	E	4																												5	1
	5	E	5																												8	1
	6	E	6																												12	1
	7	E	7																												21	1
	8	GHG	1																												22	0
	9	GHG	2																												18	0
SUGGESTED	10	E	8																												14	1
	11	E	9																												16	1
	12	GHG	3																												0	0
	13	GHG	4																												0	0
	14	GHG	5																												0	0
	15	TDS	1																												0	0
	16	BT	1																												16	1
	17	BT	2																												12	1
	18	BT	3																												12	1
	19	STC	1																												8	1
	20	IAQ	1																												2	0
	21	IAQ	2																												0	0
	22	SRI	1																												0	0
	23	SRI	2																												0	1
	24	SRI	3																												1	0
	25	SRI	4																												1	0
	26	SRI	5																												10	0
	27	IAQ	3																												0	0
	28	SRI	6																												0	0
	29	SRI	7																												0	0
	30	TDS	2																												0	0
	CS per MS			12	21	15	12	5	6	3	2	8	16	12	6	4	13	11	8	4	9	10	8	6	10	5	11	5	18	16	256	/
	N.A.			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	6	0	3	0	0	0	0	/	12

Annex 3: Overview of the implementation of the EPC indicators proposed by Annex V of EPBD revision across EU – Source: Sesana, et al. (2024)



Source: Figure elaborated by the authors.

Annex 4. Cross Comparative Matrix on Burden Costs – Source: Sesana, et al. (2024)

INDICATORS	SELECTED EU MEMBER STATES								
	NO.	CATEGORY		DK	FR	DE	IT	LU	SK	ES
RECOMMENDED	1	E	1							
	2	E	2							
	3	E	3	+			+	+	+	+
	4	E	4	++	++		++	+	++	++
	5	E	5	+			+		+	+
	6	E	6	+	+	+		+	+	
	7	E	7	+	+		+	+		
	8	GHG	1							
	9	GHG	2		+	+	++		+	
SUGGESTED	10	E	8	++	++	+	+	+	+	+
	11	E	9	+	+	+	+	+	++	++
	12	GHG	3	+	+	+	++	+	+	+
	13	GHG	4	+++	+++	+++	+++	+++	+++	+++
	14	GHG	5	+++	+++	+++	+++	+++	+++	+++
	15	TDS	1	+	+	+	+	+	+	+
	16	BT	1	+	+	+	+	+	+	
	17	BT	2	+	+	+	+	+	+	
	18	BT	3	+	+	+	+	+	+	+
	19	STC	1	+++		+++		+++	+++	+++
	20	IAQ	1	+++	+++	+++	++	+++	+++	+++
	21	IAQ	2	+++	+++	+++	++	+++	+++	+++
	22	SRI	1	+	+	+	+	+	+	+
	23	SRI	2	+	+	+	+	+	+	+
	24	SRI	3	+	+	+	+	+	+	+
	25	SRI	4	++	++	++	++	++	++	++
	26	SRI	5	++	+++	++	+++	+++	++	+++
	27	IAQ	3	+++	+++	+++	+++	+++	+++	+++
	28	SRI	6	+	+	+	+	+	+	+
	29	SRI	7	+++	+++	+++	+++	+++	+++	+++
	30	TDS	2	+	+	+	+	+	+	+

Annex 5. Data sources for the CCM population and analysis - Source: Sesana, et al. (2024)

Project name and period	EU funding programme	Consortium partners' countries	Objective and main outcomes	Reference documents
crossCert - Cross Assessment of Energy Certificates in Europe (2021-2024).	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; BG; HR; DK; DE; EL; MT; PL; SI; ES; UK.	The crossCert project aims at creating a product testing methodology for new EPC approaches to improve accuracy and usability of the EPCs, people-centric designs, and homogeneity across Europe. The crossCert project is based on a bottom-up approach which uses test cases, compare and analyze the results between different approaches, elaborate policy recommendations and engage networks and alliances for analysis and for outreach. crossCert will also use the cross-assessment exercise to conduct research and issue guidelines on: training and education, EPC promotion and marketing, adapting EPCs investor needs, linking next-generation of EPCs to energy audits, logbooks and Building Renovation Passports and EPCs and one-stop shops for building renovation.	D2.4 EPC cross-testing procedure.
E-DYCE - Energy flexible DYnamic building Certification (2020-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	DK; DE; EL; IT; CH.	E-DYCE will combine innovative approaches with established and widely available tools to create a methodology capable of implementing scalable and adaptable dynamic energy performance certification (DEPC) through a technology neutral methodology for dynamic labelling adaptable to any type of building. The project includes communication with the final user and validation in pilot buildings. E-DYCE will be compatible to existing and emerging EPC methods, or can function as a stand-alone DEPC labelling process.	D1.1 EPC regional report.
ePANACEA - Smart European Energy Performance AssessmeNT And CErtificAtion (2020-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; BE; FI; DE; EL; ES.	The objective of the ePANACEA project is to develop a holistic methodology for energy performance assessment and certification of buildings. ePANACEA comprises the creation of a prototype 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. The project will also involve the end-user through thematic workshops and demonstrate the methodology through case studies.	Next generation of EPCs and Quality Convergence across the EU: Implementation of Innovative Certification Schemes.
EPC Recast - Energy Performance Certificate Recast (2020-2023).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	BE; FR; DE; IT; LU; SI; ES.	To reach the EU decarbonisation objectives, it is urgent to trigger more investments targeting energy retrofit for buildings. Energy Performance Certificates (EPCs) represent a relevant instrument supposed to be strongly structuring for the assessment of buildings energy performance, decision support regarding energy retrofit projects, development and articulation of financing instruments (public and private), benchmark of building assets and market value recognition. EPC RECAST project will set a well-structured process and a toolbox supporting the	D1.10 EPC RECAST Certificate and Renovation Roadmap.

			development, implementation and validation of a new generation of Energy Performance Assessment and Certification, with a deliberate focus on residential buildings, more specifically existing ones, for which retrofit is one of the most challenging and pressing issue.	
EUB SuperHub - European Building Sustainability performance and energy certification Hub (2021-2024).	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; HR; FR; DE; HU; IE; IT.	The EUB SuperHub project will support the evolvement of the certification process in the EU by development of a scalable methodology to view, assess and monitor the buildings through their lifecycle (embedded energy, costs etc.). Energy performance assessments and certificates of buildings need to evolve to reflect the technological development, the needs of the society, and within the EU, they must be consistent throughout Member States. Holistic view of buildings, social and technological shifts in the society require a change in the way we observe and handle the built environment helping incentives to yield in energy efficiency and investments.	Quality, usability and visibility of energy and sustainability certificates in the real estate market.
iBRoad - Individual Building (Renovation) Roadmaps (2017-2020).	Horizon 2020 - EE-11-2016-17 - Overcoming market barriers and promoting deep renovation of buildings.	AT; BE; BG; DE; EL; PL; PT; RO; SE.	iBROAD intends to explore, design, develop and demonstrate the concept of individual building renovation roadmaps, as a tool outlining deep step-by-step renovation plans with customised recommendations for individual buildings, combined with a repository of building-related information. The project will develop an integrated concept, and produce modular tools, suitable for differing national conditions. The iBROAD innovative concept and tools will be tested in some partner. iBROAD's implementation, beyond the project duration, will strongly support building owners in step-by-step deep renovation, while avoiding lock-in effects.	Factsheet for EU countries (Poland, Portugal and Romania). Current use of EPCs and potential links to iBRoad.
IDEAL EPBD - Improving Dwellings by Enhancing Actions on Labelling for the EPBD (-).	Intelligent Energy Europe Programme.	-	In countries where the EPBD directive has been implemented for a while, the energy label seems to have little motivational impact on people to improve the energy performance of their home. IDEAL-EPBD aims to investigate why the response of households towards the energy label has been limited, in particular trying to determine: the reasons behind whether or not homeowners take the energy label into account, the reasons behind whether or not homeowners take up the additional proposed measures. The results of the investigations are being used to develop policy recommendations and action plans for improving the effectiveness of the energy certificates and other activity in the field of energy savings in the residential sector.	Deliverable 3.1 Country Specific Factors - Report of Findings in WP3.
QualDeEPC - High-quality Energy Performance Assessment and Certification in Europe Accelerating Deep Energy Renovation	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and	BE; BG; DE; EL; HU; LV; ES; SE.	The QualDeEPC project is aiming to both improve quality and cross-EU convergence of Energy Performance Certificate (EPC) schemes, and the link between EPCs and deep renovation. The objective of the project is to improve the practical implementation of the	D4.2 Development of Standard EPC.

(2019-2023).	Certification.		assessment, issuance, design, and use of EPCs as well as their renovation recommendations, in the participating countries and beyond. The project will include the analysis of existing EPC schemes and the development and testing of concrete proposals and tools for enhanced EPC assessment The QualDeEPC project will stimulate changes by intensive dialogue involving the important stakeholders at all levels from the very beginning and by disseminating its findings among the relevant target audiences in Europe.	
TIMEPAC - Towards Innovative Methods for Energy Performance Assessment and Certification of Buildings (2021-2024).	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; HR; CY; DE; IT; SI; ES.	TIMEPAC will contribute to improving existing energy certification processes, moving from a single, static certification to more holistic and dynamic approaches that consider: the data generated in the overall energy performance certification process and throughout all the building lifecycle; buildings as part of a built environment, connected to energy distribution and transport networks and buildings as dynamic entities, continuously changing over time. TIMEPAC will demonstrate the feasibility of combining EPC databases with other data sources to make certification more effective and reliable and will validate the methodology in six countries.	Deliverable 1.1 Context analysis of EPC generation.
X-tendo - eXTENDing the energy performance assessment and certification schemes via a mOdular approach (2019-2022).	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	AT; BE; DK; EE; EL; IT; PL; PT; RO; UK.	X-tendo will support public authorities to transition to next-generation energy performance certification (EPC) schemes, including improved compliance, reliability, usability and convergence. The X-tendo toolbox will contain ten innovative EPC features ranging from a smartness and a comfort indicator to building logbooks and how to improve EPC databases. A selection of twenty-nine test projects in nine different member states will demonstrate the potential of each feature as part of more reliable next-generation EPC schemes across the EU.	Energy Performance Certificates. Assessing their status and potential.

Annex 6. Data sources for the analysis of synergies between EPCs and other tools

Table A11. Summary of the public initiatives used as data sources for the analysis.

EU MSs	Name	State of progress	Description	Outcomes/tools
DE	Gëbaudepass	In place - Voluntary	The Gëbaudepass provides a description of the key features and characteristics of a property, focussing on the technical information of the dwelling. The Gebaeudepass is a voluntary initiative that is also included in the Hausakte.	Gëbaudepass consists in a Digital Building Logbook, valid at a regional level.
DE	Hausakte	In place - Voluntary	In the Hausakte all important documents from the planning and construction phase are collected. This is where the owner stores all information for later repairs, extensions and modernisations. Hausakte contains Gëbaudepass (first chapter) and the Energy Performance Certificate (second chapter)	Hausakte is intended as a Digital Building Logbook, valid at a regional level.
ES	Libro del Edificio	In place - Mandatory	The "Libro del Edificio" is a collection of all the documentation that comprises the history of the buildings including technical, judicial, administrative incidences. Its finality is to make owners aware of all the information, data and instructions needed to improve the utilisation of the building, its construction elements and its installation.	The Libro del Edificio is presented as a series of documents collected into a unique paper as a Building Logbook, valid at a regional level.
PT	Livro de obra	In place - Mandatory	The Livro de obra contains all relevant facts related to the execution of licensed construction or object.	It consists in a series of documents collected into a unique paper that works as a Building Logbook, valid at a national scale.
NL	Opleverdossier	In place - Voluntary	An Opleverdossier is a dossier of information on a residential property that provides insight into the technical quality of that property or building, as well as guidance on maintenance.	Opleverdossier is a collection of documents that is kept in hard copy as a Building Logbook, valid at a national level.
IT	Fascicolo del fabbricato	In place – voluntary in general, mandatory only if specified in municipality's hygiene regulation	Fascicolo del Fabbricato is a tool for monitoring the built environment conservation with the aims of minimising risks and plan over time maintenance and refurbishment.	Fascicolo del fabbricato is the collection of a series of documents collected in a unique paper. Its compulsoriness depends on the local level hygiene regulation.
FI	Real estate service manual	In place - Mandatory	Real estate service manual must include the intended use and properties of the building, building elements, building equipment and information about proper maintenance and operation practices. Building projects cannot be completed without the manual.	Real estate service manual consists in a Digital Building Logbook, valid at a national scale.
BE, Flanders	Woningpas	In place - Mandatory	Woningpas has been developed by the Flemish government as a logbook that contains all the building data collected by an on-site audit, and the official	The Woningpas is intended as a Digital Building Logbook and a Building Renovation Passport, valid at national

			documentation of renovation works carried out in Flanders. The main goal is to provide a tailored renovation plan complementary to the EPC guiding as well as the owner to a higher level of awareness of the renovation strategies to apply and the operation mode of the house.	scale and accessible to owners or third parties after authorisation.
DK	BedreBolig	In place - Voluntary	BedreBolig is a public scheme destined to facilitate energy-efficient renovation measures by offering a holistic view of the process. BedreBolig focuses on homeowners by helping them to create an energy plan including facts about the current energy consumption of the home, priority lists of most relevant measures to be undertaken, tips for energy-efficient behaviour and financial planning.	BedreBolig consists in a series of documents collected into a unique paper that works as a Building Logbook and as a Building Renovation Passport, valid at a national scale, focusing on the levels of energy consumption of buildings.
DE	Sanierungsfahrplan	In place - Voluntary	Individueller Sanieringsfahrplan (iSFP) has been developed as user friendly and reliable tool considering long and short-term actions for a single-family house and multi-family house. It provides, through a face-to-face approach, tailored measures, starting from a standardized format.	The Sanierungsfahrplan is considered as a Building Renovation Passport valid at a regional level. The renovation roadmap is composed by an overview of all the action planned.
EE	Ehitisregister	In place - Mandatory	Ehitisregister is a digital building register that assembles, stores and discloses information about buildings under construction and use.	Ehitisregister consists in a Digital Building Logbook valid at a national level. It lies on a map of Estonia showing all the building registered.
BE	Dossier d'intervention ultérieure	In place - Mandatory	The DIU contains the useful elements for safety and health which must be considered during any building intervention in Belgium, and that is adapted to the features of the structure.	DIU consists in a series of documents collected into a unique paper that is intended as a Building Logbook, valid at a national level.
EL	Electronic building ID	In place - Mandatory	The Electronic building ID consists in a series of files that capture the current condition of the building and its permits and monitor all its changes during the property's lifetime.	The Electronic building ID is a collection of documents (building permit, energy efficiency, construction inspection certificate, floor plans, etc.) that is kept in hard copy in the building as a Building Logbook, valid at a national level.
SE	Klimatdeklaration	In place - Voluntary	Klimatdeklaration introduces the requirement of climate declaration for new buildings from January 2022 as part of the Swedish Government plan to reduce climate impact from buildings during construction.	Klimatdeklaration consists in a Digital Building Logbook valid at a national level.
FR	Carnet d'Information du Logement	In place - Mandatory	The purpose of the Carnet d'Information du Logement is to facilitate information and monitoring of work to improve the energy performance of housing. The information contained in the booklet therefore relates exclusively to improving the building's energy performance.	Carnet d'Information du Logement is a collection of documents that is kept in hard copy in the building and on digital level as a Building Logbook, valid at a national scale.
NL	CB-23 (Circular	Under	CB-23 is a national platform which will provide guidelines and packages to	CB-23 will be introduced as a

	Construction 2023)	development	develop building logbooks in a circular prospective for the construction sector.	Digital Building Logbook and as Building Renovation Passport, valid at a national level.
AT	Austrian national test phase SRI	Under development	The focus of the test phase is to benchmark the SRI methodology against other methods developed in Austria with a focus on energy flexibility. A large number of different building typologies are examined and assessed on the basis of detailed documented buildings from Austrian regions or the federal government.	Tester of the official European Smart Readiness Indicator scheme.
HR	Croatian national test phase SRI	Under development	The test phase will be conducted thanks to a recently selected project of the EU Programme for the Environment and Climate Action (LIFE). The test phase aims at exploring the potentials and opportunities for SRI in the Croatian context and at contributing to the overall development and refinement of the SRI calculation methodology.	Tester of the official European Smart Readiness Indicator scheme.
CZ	Czech national test phase SRI	Under development	During the test phase the common SRI methodology is applied, and depending on the sensitivity of the results, some adaptations may be undertaken in a later phase.	Tester of the official European Smart Readiness Indicator scheme.
DK	Danish national test phase SRI	Under development	The purpose is to investigate potentials and opportunities for the SRI in a Danish context. Assessors from Danish Technological Institute (DTI) will conduct the SRI assessment for 25-30 buildings, including offices, dwellings, multi-family homes, educational institutions – old and new, and with different energy supplies.	Tester of the official European Smart Readiness Indicator scheme.
FI	Finnish national test phase SRI	Under development	The SRI test phase in Finland consists in external assessors that are going to be trained in order to conduct SRI assessments for a target of 150 buildings of different types. The test phase should last around two years, comprising a social impact assessment and an evaluation of the suitability of the scheme to Finland.	Tester of the official European Smart Readiness Indicator scheme
FR	French national test phase SRI	Under development	SRI assessments are going to be conducted by independent third parties: EPC assessors are going to be recruited and trained for that purpose by CEREMA, who will in turn deliver formal SRI certificates. The target is to assess at least 30 buildings as a first step.	Tester of the official European Smart Readiness Indicator scheme
Various Countries	Test phase of the Level(s) framework	Finished	In April 2018, the European Commission officially opened the two-year testing phase for Level(s) in various EU Countries (AT; BE; DE; DK; EL; ES; FI; FR; HR; IT; MT; NL; PT; SE; SI). The aim of the testing phase has been to support stakeholders across the construction and real estate value chain, from investors, to developers, designers and manufacturers; to test the tool on their building projects. The	The pilot test phase of the European framework Level(s) has been conducted by volunteer recruitment and the only data available about this activity specify at national level which country has been a tester without specifying the stakeholder typology of the test/initiative (e.g. public

			feedback from the testing phase informs the final version of the Level(s) framework.	institution or private entity).

Source: Table elaborated by the authors using the references and sources specified into the document.

Table A12. Summary of the private initiatives used as data sources for the analysis.

Company responsible	Name	State of progress	Description	Outcomes/tools
Eigenheim Manager - DE	Eigenheim Manager	In place - Voluntary	The Eigenheim Manager is an online app that supports homeowners by registering information and helping achieving specific goals within the house.	Eigenheim Manager consists in a Digital Building Logbook and as a Building Renovation Passport.
Bundesverband Deutscher Fertigbau e.V. - DE	QDF Hausakte	In place - Mandatory	The house file serves as the central documentation system for the building owner of prefabricated houses, including all the features of the house. In the house file you can see the representation, updating and archiving of property information by the owner in the foreground.	QDF Hausakte is intended as a Digital Building Logbook and as a Building Renovation Passport. It's mandatory only for prefabricated houses.
Madaster Foundation - NL	Madaster	In place - Voluntary	The Madaster Platform is designed as a public, online library of materials of the built environment. The Madaster Platform facilitates registration, organisation, storage and exchange of data. It links the identity of materials to a location and registers this in a material passport.	Madaster consists in a Digital Building Logbook and as a Building Renovation Passport, regarding the materials of a building.
BASTA non-profit company – SE	BASTA Loggbok	In place - Voluntary	BASTA is a web-based tool that enables the user to easy store information on construction materials, which make it possible to trace certain materials.	Madaster is intended as a Digital Building Logbook and as a Building Renovation Passport, regarding the materials of a building.
Villaagarnas Riksforbund - SE	Min Villa	In place - Voluntary	Min Villa is a private service provided by the house owner association for homeowners to store and track the buildings performance.	Min Villa is a collection of documents regarding the maintenance of the building, that is kept as a Digital Building Logbook and as a Building Renovation Passport.
ProduktKollen AB - SE	Produktkollen	In place - Voluntary	ProduktKollen is a digital tool containing information on construction materials and the level of construction works to improve the energy performance of housing	Produktkollen consists in a Digital Building Logbook and a Building Renovation Passport.
ImmoPass – BE; LU	ImmoPass	In place - Voluntary	ImmoPass performs an analysis of the condition of a building. An independent architect identifies the problems of a property and provides a cost estimate for their solution. The ImmoPass technical audit will assess the technical health of the building, highlight the work needed in the short, medium and long term, with an initial estimate of budgets.	ImmoPass is intended as a Digital Building Logbook.

Finnish Green Building Council - FI	Building Passport	In place - Voluntary	Building Passport is an accessible, visual tool that presents the key indicators in environmental efficiency, along with images and the basic facts of the property. The key indicators measured by the Building Performance Indicators can easily be presented in the BP, either for the pre-design or occupancy phases.	Building Passport consists in a Building Renovation Passport.
Cìclica and Green Building Council España - ES	PAS-E	Under development	PAS-E is a new Spanish project which is creating a network of professionals that will develop a strategy to align with the EU directive 2018/884 by developing building's passports that will improve living conditions and reduce the environmental impact of the buildings' lifecycle.	PAS-E will be introduced as a Digital Building Logbook and as Building Renovation Passport, valid at a national level.

Source: Table elaborated by the authors using the references and sources specified into the document.

Table A13. Summary of the research projects considered as sources for the analysis.

Project name	Funding programme	Period	Consortium partners' countries	Objective and main outcomes
BAMB - Buildings as Material Banks: Integrating Materials Passports with Reversible Building Design to Optimise Circular Industrial Value Chains.	Horizon 2020 - WASTE-1-2014 - Moving towards a circular economy through industrial symbiosis.	2015 – 2019	BE; DE; NL; PT; SE.	The aims of BAMB are the prevention of construction and demolition waste, the reduction of virgin resource consumption and the development towards a circular economy through industrial symbiosis. Key of the project is to improve the value of materials used in buildings for recovery by developing and integrating two complementary value adding frameworks, Building Materials Passports, and reversible building design. The material passport framework can potentially be included in Building Logbooks to extend buildings life span and enable disassembling components at the end of the building life.
Plan Transition Numérique dans le Bâtiment	Plan Transition Numérique dans le Bâtiment	2016 – 2018	FR.	These projects are part of the French Plan Transition Numérique dans le Bâtiment (Digital Transition Plan in Buildings) is a French plan composed by a series of experimental projects (Bazimo; Be-in-Home; Le carnet numérique du logement; CANEL; CasBa; Homebook; IMMOBOX; Mon carnet logement; Mon logement numérique; Wiki-Habitat), wanted by the national government, to develop Digital Building Logbook solutions. The purpose of the projects is to promote the uptake of digital building logbooks and use the lessons learned to write an implementation decree to make digital building logbooks mandatory.
Passeport Efficacitè Energetique – P2E	The Shift Project	2016 – 2021	FR.	The Energy Efficiency Passport (P2E) is a tool developed that offers a Building Renovation Passport, aiming to make it a relevant first step in the household renovation process.
ALDREN - ALliance for Deep RENovation in buildings Implementing the European Common Voluntary Certification	Horizon 2020 - EE-11-2016-2017 - Overcoming market barriers and promoting deep	2017 – 2020	BE; DE; ES; FR; IT; SK.	The ALDREN objectives are to achieve higher renovation rates and better renovation quality by overcoming market barriers and preparing the ground for investment. These objectives are integrated in a consistent, common way in a

Scheme, as back-bone along the whole deep renovation process.	renovation of buildings.			Building Renovation Passport and a Digital Building Logbook, to ensure the results and effective financing also in case of step-by-step renovation.
iBROAD - Individual Building (Renovation) Roadmaps.	Horizon 2020 - EE-11-2016-17 - Overcoming market barriers and promoting deep renovation of buildings.	2017 – 2020	AT; BE; BG; DE; EL; PL; PT; RO; SE.	iBRoad aims at creating a tool for the development of individual building renovation roadmaps for single-family houses: the combination of occupant's needs, together with the building information, allow the development of a long-term renovation plan that will consider the building as a whole. In the optic of the project, the Digital Building Logbook can provide an insight on the building status and be used to formulate the renovation roadmap.
Ilmastoviisaat Taloyhiöt - controlling energy waste in buildings with IoT sensors	6Aika Programme	2018 – 2020	FI.	The project Ilmastoviisaat Taloyhiöt aims to develop common policies and practices for the collection, ownership, and sharing of residential apartment buildings' data, using a Digital Building Logbook, to make this information accessible and to enable companies to develop a new kind of service business for this customer segment. GBC Finland in partnership with private companies' studies how the data can be used to reduce energy consumption and GHG emissions by analysing data collected through IoT sensors.
BE-REEL! - Belgium Renovates for Energy Efficient Living.	LIFE Programme.	2018 – 2024	BE.	BE REEL!'s goal is to ensure that Belgium is on track to achieve the 2050 renovation goals. BE REEL! Project aspires to increase the renovation rate in Belgium by developing, testing, evaluating, refining, and demonstrating the most appropriate structural measures, implementing a Building Renovation Passport.
DigiPLACE - Digital Platform for Construction in Europe	Horizon 2020 - DT-ICT-13-2019 - Digital Platforms/Pilots Horizontal Activities.	2019 – 2021	BE; DE; ES; FR; IT; NL; SI.	DigiPLACE is a framework which aims to create a common digital platform that will integrate technologies, standards, applications and services of the digital construction industry. Building Logbooks are part of the EU key project goals.
X-Tendo - eXTENDing the energy performance assessment and certification schemes via a mOdular approach.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2019 – 2022	AT; BE; DK; EE; EL; IT; PL; PT; RO.	X-tendo is an European project that intends to support EU public authorities in the transition to next-generation energy performance certification schemes. One of the key outputs of the project is the X-tendo toolbox, a freely available online hub, which contains ten next-generation EPC features ranging from Smart Readiness Indicator and a comfort indicator to Digital Building Logbooks and how to improve EPC.
U-CERT - Towards a new generation of user-centred EPC.	Horizon 2020 - LC-SC3-EE-5 2018 Next-generation of Energy Performance Assessment and Certification.	2019 – 2022	BE; BG; DK; EE; ES; FR; HU; IT; NL; RO; SE; SI.	The EU-funded U-CERT project aims to make the certification schemes more practical and reliable via a holistic and user-centred approach, by including new parameters like Smart Readiness Indicator (SRI).
BIM4EEB - BIM based fast toolkit for Efficient rEnovation in Buildings.	Horizon 2020 - LC-EEB-02-2018 - Building information modelling adapted to efficient renovation (RIA).	2019 – 2022	BE; CY; DE; ES; FI; IE; IT; PL; SE.	In BIM4EEB the Digital Building Logbook is part of the project. The aim of the project is to foster the renovation industry by developing an attractive and powerful BIM-based toolset able to support the supply chain over the life span of a building.
LIFE LEVEL(S) - Life for Lca Lcc Level(s).	LIFE Programme.	2019 – 2022	DE; FI; FR; HR; IE; IT; NL.	The Life Level(s) project is directed towards mainstreaming sustainable buildings in Europe through greater awareness and use of the specified indicators within the framework of

				Level(s), a set of common European Union indicators to address life cycle environmental performance of buildings.
Stadt der Zukunft - Auf dem Weg zum Plus-Energie-Quartier	Open4innovation Programme	2020	AT.	The Stadt der Zukunft technology programme pursues the mission of enabling the implementation of plus-energy districts through research and development of technologies, system integration, new solutions and with the help of digitalisation. One of the projects included in Stadt der Zukunft consists in the analysis of the Smart Readiness Indicator, to prepare a national specification of the EU-proposed SRI for Austria and to provide a basis for national policy implementation.
D^2EPC - Next-generation Dynamic Digital EPCs for Enhanced Quality and User Awareness.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	AT; CY; DE; EL; ES; LT; NL.	The EU-funded D^2EPC project aims to develop the next generation of dynamic EPCs for buildings. It is based on the 'digital twin' concept to advance building information modelling and a new set of energy, environmental, financial and well-being indicators, including Smart Readiness Indicator.
E-DYCE - Energy flexible DYnamic building Certification.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	DE; DK; EL; IT.	The EU-funded E-DYCE project is developing a methodology for dynamic EPC intended to replace or be used in conjunction with the current static or steady-state methodology. It will consider the temporal nuances of energy use on scales of minutes, hours and days rather than annual averages, providing better opportunities to suggest more effective energy-efficient behaviours to consumers. It's taking into consideration various parameters, including Smart Readiness Indicator.
ePANACEA - Smart European Energy Performance AssessmeNt And CErtificAtion.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	AT; BE; DE; EL; ES; FI.	The ePANACEA project aims to create a holistic methodology for energy performance assessment and certification of buildings. To this end, it will develop a Smart Energy Performance Assessment Platform that will use the most advanced techniques in dynamic and automated simulation modelling, Smart Readiness Indicator, big data analysis, machine learning and inverse modelling. ePANACEA also investigates how the EPC schemes make the link towards the Building Renovation Passport and the Digital Building Logbook to further stimulate cost-effective deep energy renovations.
EPC RECAST - Energy Performance Certificate Recast.	Horizon 2020 - LC-SC3-EE-5-2018-2019-2020 - Next-generation of Energy Performance Assessment and Certification.	2020 – 2023	BE; DE; ES; FR; IT; LU; SK.	The EPC RECAST project develops a well-structured process and a toolbox that will support the development, performance and validation of new EPCs with particular focus on existing residential buildings with high retrofit needs. For this purpose, the project analyses the relationship between EPC and several techniques, such as Smart Readiness Indicator, Building Renovation Passport and Digital Building Logbook.
e-Construction - Study for the application of assessment principles for the carbon footprint of construction works in Estonia.	RITA programme	2021	EE.	The project consists in the study of a methodology that can be introduced to the Estonian construction sector, to reduce the level of global warming potential (GWP) over the life of a building. The proposed calculation method is based on Level(s) and the internal best practice on carbon footprint assessment.
crossCert - Cross Assessment of Energy	Horizon 2020 - LC-SC3-B4E-4-2020 -	2021 - 2024	AT; BG; DE; DK; EL; ES; HR; MT;	The crossCert project has the goal to create a product testing methodology for new EPC

Certificates in Europe.	Next-generation of Energy Performance Assessment and Certification.		PL; SI.	approaches. The aim will be to improve the accuracy and usability of the EPCs and boost homogeneity across Europe. To do so, the project follows a series of research, like linking next generation of EPCs to energy audits, Digital Building Logbooks and Building Renovation Passports.
EUB SuperHub - European Building Sustainability performance and energy certification Hub.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 – 2024	AT; DE; FR; HR; HU; IE; IT.	The EUB SuperHub project supports the creation of a harmonised certification process in the EU by developing a scalable methodology to view, assess and monitor the buildings throughout their life cycle. To reach this purpose, the project includes the analysis of the Level(s) framework and the Smart Readiness Indicator scheme. EUB SuperHub also aims to create a building passport, based on the existing Building Renovation Passport and Digital Building Logbook.
iBRoad2EPC - Integrating Building Renovation Passports into Energy Performance Certification schemes for a decarbonised building stock.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 – 2024	AT; BE; BG; DE; EL; ES; PL; PT.	The iBRoad2EPC project explores energy performance assessment schemes and certification practices with the aim of promoting and showcasing the integration of Building Renovation Passport elements into EPC schemes. Specifically, it will adapt the Building Renovation Passport model developed within the concluded iBROAD project with the scope to integrate it with the EPC tool.
TIMEPAC - Towards innovative methods for energy performance assessment and certification of buildings.	Horizon 2020 - LC-SC3-B4E-4-2020 - Next-generation of Energy Performance Assessment and Certification.	2021 – 2024	AT; CY; DE; ES; HR; IT; SI.	The EU-funded TIMEPAC project aims to improve the current energy performance certification (EPC) system by transitioning from a single, static certification to one that is more holistic and dynamic. This new approach considers buildings as dynamic entities that never stop changing. TIMEPAC combines EPC databases with other data sources to make certification more effective and reliable. TIMEPACs approach will consider integrating Smart Readiness Indicators and sustainability indicators in EPC and creating Building Renovation Passports from data repositories.
PnPE^2 – Portale Nazionale sulla Prestazione Energetica degli Edifici.	PnPE^2 – Portale Nazionale sulla Prestazione Energetica degli Edifici.	2021 – 2025	IT.	The PnPE^2 portal is a tool that offers citizens, businesses and public administration a set of services in the field of energy efficiency. It works as a Digital Building Logbook and allows to monitor progress towards national targets for energy efficiency, for the integration of renewable energy in buildings, and for the elaboration of strategies and promotion programmes related to the energy redevelopment of the country's real estate stock.
SmartLivingEPC - Advanced Energy Performance Assessment towards Smart Living in Building and District Level.	Horizon Europe - HORIZON-CL5-2021-D4-01-01 - Advanced energy performance assessment and certification.	2022 – 2025	AT; BE; CY; DE; EL; ES; IE; IT; NL	SmartLivingEPC project aims to deliver a certificate which will be issued with the use of digitized tools and retrieve the necessary assessment information for the building shell and building systems from BIM literacy, including enriched energy and sustainability related information for the as-designed and the actual performance of the building. SmartLivingEPC certificate will be fully compatible with Digital Building Logbooks, as well as with Building Renovation Passports to allow the integration of the building energy performance information in digital databases.
CHRONICLE - Building Performance Digitalisation and	Horizon Europe - HORIZON-CL5-2021-D4-01-01 -	2022 – 2025	DK; EL; ES; IE; IT.	CHRONICLE will deliver a holistic, life-cycle performance assessment framework and tool-suite for different building variants, supporting

Dynamic Logbooks for Future Value-Driven Services.	Advanced energy performance assessment and certification.			sustainable design, construction and/or efficient renovation and investment decision making. It will be methodologically integrate ongoing initiatives, like EPCs, Level(s), Smart Readiness Indicator, under the umbrella of the Digital Building Logbook concept.
SRI-ENACT - Co-creating Tools and Services for Smart Readiness Indicator Uptake.	LIFE Programme.	2022 – 2025	AT; BE; BG; CZ; EL; ES; HR; RO.	SRI-ENACT provides a holistic solution to facilitate the Smart Readiness Indicator uptake in Europe, by engaging stakeholders in the co-creation of national-tailored SRI implementations and the development of the SRI-ENACT toolkit, encompassing SRI assessment and decision support tools to promote informed decision making for smartness upgrades. Beyond the methodological and technological outcomes, SRI-ENACT will deliver a package for the training and certification of the prospective SRI auditors.
SRI2Market - Paving the way for the adoption of the SRI into national regulation and market.	LIFE Programme.	2022 – 2025	AT; CY; ES; FR; HR; PT.	The SRI2MARKET project will improve the knowledge and capabilities of six Member States (Austria, Croatia, Cyprus, France, Portugal, and Spain) with regards to the introduction of the Smart Readiness Indicator in their national regulation and market.
easySRI - Improving and demonstrating the potential of SRI.	LIFE Programme.	2022 – 2025	AT; CY; EL; IE; IT; NL.	easySRI project aims to enable a smooth and extendable web platform that offers services for the automated calculation of the Smart Readiness Indicator. easySRI aims to introduce additional parameters that address energy efficiency and financial dimensions. Furthermore, the project aspires the update of current standards as well as the inclusion of its outcomes in new or future standards and will investigate links with other EU initiatives such as EPCs, building logbooks and renovation passports to maximize the use of SRI concept in EU policies in the fields of energy and buildings.
Smart² - Smart Tools for Smart Buildings: Enhancing the intelligence of buildings in Europe.	LIFE Programme.	2022 – 2025	BG; DE; CY; EL; IT; RO.	The project Smart², aims to develop and deliver the appropriate tools and applications, which will enable the promotion and establishment of intelligence assessment of buildings in Europe, through buildings Smart Readiness Indicator scheme. Smart² will also enable the smartness assessment of buildings with the use of real time data, based on the in-use assessment method, focusing on interoperability gaps and cybersecurity aspects. Aspects of integrating SRI in Digital Building Logbooks will also be investigated, with the aim to allow the future integration of the SRI certificate and its background information.

Source: Table elaborated by the authors using the references and sources specified into the document.

Annex 7. **Tools' Matrix: quantitative feature**

NAME	AT			BE			BG			HR			CY			CZ			DK		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI	1		9			5			3	1		4			5	1		1	1		4
Level(s)	1		1	1		0				1		2							1		1
BRP			6	1		7			2			3			2				1		1
DBL			6	2		9			2			2			2				1		3

NAME	EE			FI			FR			DE			EL			HU			IE		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI			2	1		1	1		4			7			8			2			3
Level(s)			1	1		1			2	1		2	1		1			1			3
BRP					1	1			3	1	2	9			4			1			2
DBL	1		2	1		3	1		6	2	2	10	1		6			1			3

NAME	IT			LV			LT			LU			MT			NL			PL		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI			9						1			1						3			1
Level(s)	1		3										1			1		1			
BRP			5			1						1			1	1	1	3			2
DBL	1		9								1	1			1	2	1	3		1	4

NAME	PT			RO			SK			SI			ES			SE		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI			2			4			1			2			8			1
Level(s)	1									1			1		1	1		
BRP			2						2			2		1	7		3	1
DBL	1		3			2			2			2	1		8	1	3	3

Annex 8. **Tools' Matrix: qualitative feature**

NAME	**AT**			**BE**			**BG**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI	Austrian national test phase SRI		X-Tendo; Stadt der Zukunft; D2EPC; ePANACEA; EUB SuperHub; TIMEPAC; SRI-ENACT; SRI2Market; EasySRI			X-Tendo; U-CERT; ePANACEA; EPC RECAST; SRI-ENACT			U-CERT; SRI-ENACT; Smart2
Level(s)	Test phase of the Level(s) framework		EUB SuperHub	Test phase of the Level(s) framework					
BRP			ePANACEA; crossCert; EUB SuperHub; iBRoad2EPC; TIMEPAC; SmartLivingEPC	woningpass		BAMB; ALDREN; BE-REEL!; Epanacea; EPC RECAST; iBRoad2EPC; SmartLivingEPC			crossCert; iBRoad2EPC
DBL			iBROAD; X-Tendo; ePANACEA; crossCert; EUB SuperHub; SmartLivingEPC	woningpass; Dossier d'intervention ultérieure	ImmoPass	BAMB; ALDREN; iBROAD; DigiPLACE; X-Tendo; BIM4EEB; ePANACEA; EPC RECAST; SmartLivingEPC			iBROAD; crossCert

NAME	**HR**			**CY**			**CZ**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI	Croatian national test phase SRI		EUB SuperHub; TIMEPAC; SRI-ENACT; SRI2Market			D2EPC; TIMEPAC; SRI2Market; EasySRI; Smart2	Czech national test phase SRI		SRI-ENACT
Level(s)	Test phase of the Level(s) framework		LIFE LEVEL(S); EUB SuperHub						
BRP			crossCert; EUB SuperHub; TIMEPAC			TIMEPAC; SmartLivingEPC			
DBL			crossCert; EUB SuperHub			BIM4EEB; SmartLivingEPC			

NAME	**DK**			**EE**			**FI**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI	Danish national test phase SRI		X-Tendo; U-CERT; E-DYCE; CHRONICLE			X-Tendo; U-CERT	Finnish national test phase SRI		ePANACEA
Level(s)	Test phase of the Level(s) framework		CHRONICLE			e-Construction	Test phase of the Level(s) framework		LIFE LEVEL(S)
BRP	Bedrebolig		crossCert					Building Passport	ePANACEA
DBL	Bedrebolig		X-Tendo; crossCert; CHRONICLE	Ehitisregister		X-Tendo; SmartLivingEPC	Real estate service manual		Ilmastoviisaat Taloyhiöt; BIM4EEB; ePANACEA

NAME	**FR**			**DE**			**EL**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI	French national test phase SRI		U-CERT; EPC RECAST; EUB SuperHub; SRI2Market			D2EPC; E-DYCE; ePANACEA; EPC RECAST; EUB SuperHub; TIMEPAC; Smart2			X-Tendo; D2EPC; E-DYCE; ePANACEA; CHRONICLE; SRI-ENACT; EasySRI; Smart2
Level(s)			LIFE LEVEL(S); EUB SuperHub	Test phase of the Level(s) framework		LIFE LEVEL(S); EUB SuperHub	Test phase of the Level(s) framework		CHRONICLE
BRP			ALDREN; EPC RECAST; EUB SuperHub	Sanierungsfahrplan	Eigenheim Manager; QDF Hausakte	BAMB; ALDREN; ePANACEA; EPC RECAST; crossCert; EUB SuperHub; iBRoad2EPC; TIMEPAC; SmartLivingEPC			ePANACEA; crossCert; iBRoad2EPC; SmartLivingEPC
DBL	Carnet d'Information du Logement		Plan Transition Numérique dans le Bâtiment; Passaport Efficacitè Energetique - P2E; ALDREN; DigiPLACE; EPC RECAST; EUB SuperHub	Hausakte; Gëbaudepass	Eigenheim Manager; QDF Hausakte	BAMB; ALDREN; Ibroad; DigiPLACE; BIM4EEB; ePANACEA; EPC RECAST; crossCert; EUB SuperHub; SmartLivingEPC	Electronic Building ID		iBROAD; X-Tendo; ePANACEA; crossCert; SmartLivingEPC; CHRONICLE

NAME	HU			IE			IT		
TYPE OF INITIATIVE	Public initiative	Private initiative	Research projects	Public initiative	Private initiative	Research projects	Public initiative	Private initiative	Research projects
SRI			U-CERT; EUB SuperHub			EUB SuperHub; CHRONICLE; EasySRI			X-Tendo; U-CERT; E-DYCE; EPC RECAST; EUB SuperHub; TIMEPAC; CHRONICLE; EasySRI; Smart2
Level(s)			EUB SuperHub			LIFE LEVEL(S); EUB SuperHub; CHRONICLE	Test phase of the Level(s) framework		LIFE LEVEL(S); EUB SuperHub; CHRONICLE
BRP			EUB SuperHub			EUB SuperHub; SmartLivingEPC			ALDREN; EPC RECAST; EUB SuperHub; TIMEPAC; SmartLivingEPC
DBL			EUB SuperHub			EUB SuperHub; SmartLivingEPC; CHRONICLE	fascicolo del fabbricato		ALDREN; DigiPLACE; X-Tendo; BIM4EEB; EPC RECAST; EUB SuperHub; PnPE2; SmartLivingEPC; CHRONICLE

NAME	LV			LT			LU		
TYPE OF INITIATIVE	Public initiative	Private initiative	Research projects	Public initiative	Private initiative	Research projects	Public initiative	Private initiative	Research projects
SRI						D2EPC			EPC RECAST
Level(s)									
BRP			SUNhINE						EPC RECAST
DBL								ImmoPass	EPC RECAST

NAME	**MT**			**NL**			**PL**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI						U-CERT; D2EPC; EasySRI			X-Tendo
Level(s)	Test phase of the Level(s) framework			Test phase of the Level(s) framework		LIFE LEVEL(S)			
BRP			crossCert	CB-23 (Circular Construction 2023)	Madaster	BAMB; SUNhINE; SmartLivingEPC			crossCert; iBRoad2EPC
DBL			crossCert	Opleverdossier; CB-23 (Circular Construction 2023)	Madaster	BAMB; DigiPLACE; SmartLivingEPC		Digital Building Passport	iBROAD; X-Tendo; BIM4EEB; crossCert

NAME	**PT**			**RO**			**SK**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI			X-Tendo; SRI2Market			X-Tendo; U-CERT; SRI-ENACT; Smart2			EPC RECAST
Level(s)	Test phase of the Level(s) framework								
BRP			BAMB; iBRoad2EPC						ALDREN; EPC RECAST
DBL	Livro de obra		BAMB; iBROAD; X-Tendo			iBROAD; X-Tendo			ALDREN; EPC RECAST

NAME	**SI**			**ES**			**SE**		
TYPE OF INITIATIVE	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**	**Public initiative**	**Private initiative**	**Research projects**
SRI			U-CERT; TIMEPAC			U-CERT; D2EPC; ePANACEA; EPC RECAST; TIMEPAC; CHRONICLE; SRI-ENACT; SRI2Market			U-CERT
Level(s)	Test phase of the Level(s) framework			Test phase of the Level(s) framework		CHRONICLE	Test phase of the Level(s) framework		
BRP			crossCert; TIMEPAC		PAS-E	ALDREN; ePANACEA; EPC RECAST; crossCert; iBRoad2EPC; TIMEPAC; SmartLivingEPC		Produktkollen; Min Villa; BASTA Loggbok	BAMB
DBL			DigiPLACE; crossCert	Libro del Edificio		ALDREN; DigiPLACE; BIM4EEB; ePANACEA; EPC RECAST; crossCert; SmartLivingEPC; CHRONICLE	Klimatdeklaration	Produktkollen; Min Villa; BASTA Loggbok	BAMB; Ibroad; BIM4EEB

Annex 9. Synergies Matrix: quantitative feature

no.	CATEGORY		Indicator name	SRI	Level(s)	BRP	DBL
1	E	1	Energy performance class				
2	E	2	Calculated annual primary energy use in kWh/m^{2}year				
3	E	3	Calculated annual primary energy consumption in kWh or MWh				
4	E	4	Calculated annual final energy use in kWh/m^{2}year				
5	E	5	Calculated annual final energy consumption in kWh or MWh				
6	E	6	Renewable energy production in kWh or MWh				
7	E	7	Renewable energy in % of energy use				
8	GHG	1	Operational greenhouse gas emissions (kg CO_2/m^{2}year)				
9	GHG	2	Greenhouse gas emission class (if applicable)				
10	E	8	Energy use, peak load, size of generator or system, main energy carrier and main type of element for each of the uses: heating, cooling, domestic hot water, ventilation and in-built lighting				
11	E	9	Renewable energy produced on site, main energy carrier and type of renewable energy source				
12	GHG	3	Yes/no indication whether a calculation of the Global Warming Potential has been carried out for the building				
13	GHG	4	Value of life-cycle Global Warming Potential (if available)				
14	GHG	5	Information on carbon removals associated to the temporary storage of carbon in or on buildings				
15	TDS	1	Yes/no indication whether a renovation passport is available for the building				
16	BT	1	Average U-value for the opaque elements of the building envelope				
17	BT	2	Average U-value for the transparent elements of the building envelope				
18	BT	3	Type of most common transparent element (e.g., double glazed window)				
19	STC	1	Results of the analysis on overheating risk (if available)				
20	IAQ	1	Presence of fixed sensors that monitor the levels of indoor air quality				
21	IAQ	2	Presence of fixed controls that respond to the levels of indoor air quality				
22	SRI	1	Number and type of charging points for electric vehicles				
23	SRI	2	Presence, type and size of energy storage systems				
24	SRI	3	Feasibility of adapting the heating system to operate at more efficient temperature settings				
25	SRI	4	Feasibility of adapting the air conditioning system to operate at more efficient temperature settings				
26	SRI	5	Metered energy consumption				
27	IAQ	3	Operational fine particulate matter (PM2.5) emissions				
28	SRI	6	Yes/no indication whether a smart readiness assessment has been carried out for the building				
29	SRI	7	Value of the smart readiness assessment (if available)				
30	TDS	1	Yes/no indication whether a Digital Building Logbook is available for the building				

■ EPC indicator implemented in the tool ■ EPC indicator not implemented but computable in the tool ■ EPC indicator not implemented nor computable in the tool

Annex 10. Synergies Matrix: qualitative feature

				EPC indicators match and data source information for the computation in the respective tools			
no.	**CATEGORY**		**Indicator name**	**SRI**	**Level(s)**	**BRP**	**DBL**
1	E	1	Energy performance class	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	Indicator can be computed using **1.1** Use stage energy performance	DBL of the passport. Module ALDREN BRP - **Cover**.	**EPC rating** (alphabetic or scale data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
2	E	2	Calculated annual primary energy use in kWh/m^2year	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	DBL of the passport. Module ALDREN BRP - **Module 2 Building Performance**	Indicator can be computed using **total calculated heating and electricity consumption** (kWh/year). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
3	E	3	Calculated annual primary energy consumption in kWh or MWh	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 2 Building Performance**	Indicator can be computed using **total calculated heating and electricity consumption** (kWh/year). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
4	E	4	Calculated annual final energy use in kWh/m^2year	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 2 Building Performance**	Indicator can be computed using **total calculated heating and electricity consumption** (kWh/year). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
5	E	5	Calculated annual final energy consumption in kWh or MWh	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 2 Building Performance**	Indicator can be computed using **total calculated heating and electricity consumption** (kWh/year). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
6	E	6	Renewable energy production in kWh or MWh	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	DBL of the passport. Module ALDREN BRP - **Module 2 Building Performance**	**Renewable energy production** (kWh/year). Available for existing buildings, calculated by digital method. Indicator of the DBL Building operation and use data category.
7	E	7	Rnewable energy in % of energy use	Indicator can be computed using **H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 2 Building Performance**	
8	GHG	1	Operational greenhouse gas emissions (kg CO_2/m^2year)		Indicator can be computed using **1.2** Life Cycle Global Warming Potential	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Cover**	
9	GHG	2	Greenhouse gas emission class (if applicable)		Indicator can be computed using **1.2** Life Cycle Global Warming Potential	Indicator can be computed using other indicators of the DBL.	

CATEGORY:
- Energy
- Emissions
- Tool Data Source
- Building Technology
- Summer Thermal Comfort
- Internal Air Quality
- Smart Readiness Indicator

				EPC indicators match and data source information for the computation in the respective tools			
no.	**CATEGORY**		**Indicator name**	**SRI**	**Level(s)**	**BRP**	**DBL**
10	E	8	Energy use, peak load, size of generator or system, main energy carrier and main type of element for each of the uses: heating, cooling, domestic hot water, ventilation and in-built lighting	**H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 2 Building Performance**	Indicator can be computed using **heating systems and related energy carriers** and **technical building systems** (descriptive data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building descriprtions and characteristics data category.
11	E	9	Renewable energy produced on site, main energy carrier and type of renewable energy source	**H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use.	**1.1** Use stage energy performance	Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 2 Building Performance**	Indicator can be computed using **renewable energy systems** (descriptive data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building descriprtions and characteristics data category.
12	GHG	3	Yes/no indication whether a calculation of the Global Warming Potential has been carried out for the building		**1.2** Life Cycle Global Warming Potential		
13	GHG	4	Value of life-cycle Global Warming Potential (if available)		**1.2** Life Cycle Global Warming Potential		
14	GHG	5	Information on carbon removals associated to the temporary storage of carbon in or on buildings		**1.2** Life Cycle Global Warming Potential		
15	TDS	1	Yes/no indication whether a renovation passport is available for the building			Available	Indicator can be computed using **tailored renovation recommendations** (descriptive data). Available for existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
16	BT	1	Average U-value for the opaque elements of the building envelope			DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	**Building envelope** (U-value data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
17	BT	2	Average U-value for the transparent elements of the building envelope			DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	**Building envelope** (U-value data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building performance data category.
18	BT	3	Type of most common transparent element (e.g., double glazed window)			DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	**Façade types** and **windows and door types** (descriptive data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building descriprtions and characteristics data category.
19	STC	1	Results of the analysis on overheating risk (if available)	**V-2c** Heat recovery control: prevention of overheating		Module of comfort in the ALDREN BRP based on TAIL. Module ALDREN BRP - **Module 4 Comfort and well being**	
20	IAQ	1	Presence of fixed sensors that monitor the levels of indoor air quality	**V-6** Reporting information regarding IAQ		Module of comfort in the ALDREN BRP based on TAIL. Module ALDREN BRP - **Module 4 Comfort and well being**	Indicator can be computed using **behavioural insights** (descriptive data). Available for existing buildings, calculated by digital method. Indicator of the DBL Building operation and use data category.
21	IAQ	2	Presence of fixed controls that respond to the levels of indoor air quality	**V-6** Reporting information regarding IAQ		Module of comfort in the ALDREN BRP based on TAIL. Module ALDREN BRP - **Module 4 Comfort and well being**	

CATEGORY:
- Energy
- Emissions
- Tool Data Source
- Building Technology
- Summer Thermal Comfort
- Internal Air Quality
- Smart Readiness Indicator

				EPC indicators match and data source information for the computation in the respective tools			
no.	**CATEGORY**		**Indicator name**	**SRI**	**Level(s)**	**BRP**	**DBL**
22	SRI	1	Number and type of charging points for electric vehicles	**EV-15** EV Charging Capacity; **EV-16** EV charging Grid balancing; **EV-17** EV charging information and connectivity		DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	**Charging infrastructure for E-mobility** (yes/no data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Smart readiness data category.
23	SRI	2	Presence, type and size of energy storage systems	**H-1c** Storage and shifting of thermal energy; **H-1f** Thermal Energy Storage (TES) for building heating; **DHW-1a** Control of DHW storage charging (with direct electic heating of integrated electric heat pump); **DHW-1b** Control of DHW storage charging; **DHW-1d** Control of DHW storage charging (with solar collector and supplymentary heat generation; **C-1g** Control of Thermal Energy Storage (TES) operation; **E-3** Storage of (locally generated) electicity; **E-11** Reporting information regarding energy storage		DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	Indicator can be computed using **technical building systems, smart district potential** and **demand responce potential** (descriptive data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building desctiption and characteristics and Smart readiness data category.
24	SRI	3	Feasibility of adapting the heating system to operate at more efficient temperature settings	**H-4** Flexibility and grid interaction		DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	Indicator can be computed using **heating systems and related energy carriers** (descriptive data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building desctiption and characteristics data category.
25	SRI	4	Feasibility of adapting the air conditioning system to operate at more efficient temperature settings	**C-4** Flexibility and grid interaction		DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	Indicator can be computed using **cooling equipment** and **ventilation systems** (descriptive data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Building desctiption and characteristics data category.
26	SRI	5	Metered energy consumption	**H-3** Report information rearding heating system performance; **DHW-3** Report information rearding heating system performance; **C-3** Report information rearding heating system performance; **E-12** Reporting information regarding electricity consumption; **MC-13** Central reporting of TBS performance and energy use		DBL of the passport. Module ALDREN BRP - **Module 1 Building picture**	Indicator can be computed using **measured heating consumption** and **dynamic electricity consumption** (kWh/year). Available for existing buildings, calculated by dynamic method. Indicator of the DBL Building operation and use data category.
27	IAQ	3	Operational fine particulate matter (PM2.5) emissions	**V-6** Reporting information regarding IAQ	**4.1** Indoor Air Quality		**SRI results** (rating data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Smart readiness data category.
28	SRI	6	Yes/no indication whether a smart readiness assessment has been carried out for the building	Available		Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 1 Building picture**	**SRI results** (rating data). Available for both new and existing buildings, calculated by static method. Indicator of the DBL Smart readiness data category.
29	SRI	7	Value of the smart readiness assessment (if available)	Available		Indicator can be computed using other indicators of the DBL. Module ALDREN BRP - **Module 1 Building picture**	
30	TDS	1	Yes/no indication whether a Digital Building Logbook is available for the building			Available	Available

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