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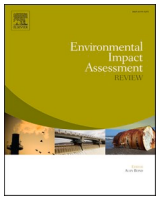

A new functionality for the digital building logbook: Assessing the progress of decarbonisation of national building sectors

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ABSTRACT

The EU has set itself demanding objectives to achieve complete decarbonisation by 2050. The building sector plays an important role for this purpose, hence monitoring its progress towards decarbonisation is essential to identify measures that work and to readjust policies when necessary. However, collecting information to monitor the building sector is a complex task due to the scarcity and low quality of available data. The European digital building logbook (DBL) has great potential in this regard because it allows the collection of data at the building scale, which could be combined at a national level. Thus, this paper proposes a new functionality for the DBL -as an enabler for the collection of data for the assessment of the progress of the main EU policy objectives related to the building sector decarbonisation-, and it evaluates the potential of the DBL for it. To do so, the main policy objectives were associated to a set of progress indicators –mandatory and optional- and matched to DBL indicators. Mandatory indicators are for all Member States and they have been included in the 2023 amended version of the proposal for the Energy Performance of Buildings Directive recast. Optional indicators are considered country-specific in this paper and are sourced from various literature references. Here we have studied the optional progress indicators for the case of Spain. Results show that the DBL has great potential to contribute to the collection of more than half of the mandatory indicators and a very high share of the optional ones for Spain.

1. Introduction

The European Union (EU) aims to be climate-neutral by 2050, what implies an economy with net-zero greenhouse gas (GHG) emissions. Specifically, a roadmap for the period 2021–2030 was set through the 2030 climate and energy framework, whose key targets include reducing GHG emissions by 55% compared to 1990 levels, achieving a rate of 32% of renewable energy, and 32.5% improvement in energy efficiency (European Commission, 2020a).

To achieve this ambitious challenge, the commitment of all the society clusters and economic sectors is necessary. Specifically, buildings have great relevance because they constitute the largest energy end-use sector (Remeikienė et al., 2021) and use large amounts of materials (Scrucca et al., 2023). The fact that a large part of the European building stock was built prior to the introduction of energy performance standards makes that almost 75% of it is inefficient according to current building standards (European Commission, 2023). For this reason, renovating buildings is key to achieve the decarbonisation goals (European Commission, 2023; Gómez-Gil, 2022). However, the current renovation rate is very low -around 1% per year (European Commission, 2023) and 0.2–0.3% when referring to deep renovation (European Commission, 2019a; Geikins et al., 2022)-.

Monitoring the actual progress of the building sector decarbonisation in general and of the renovation evolution in particular is crucial (Beltrán-Velamazán et al., 2021) not only to determine where we are and where and when we should arrive, but also to know the state of the building stock in terms of energy performance, conservation, accessibility and users' habits.

To monitor buildings decarbonisation and renovation progress it is essential to establish assessment frameworks based on progress indicators. One of the first frameworks presented in the European regulation was the voluntary guiding framework from Commission

Abbreviations: BRP, Building Renovation Passport; DBL, Digital Building Logbook; EC Study, Study on the Development of a European Union Framework for Buildings' Digital Logbook; EED, Energy Efficiency Directives; EPBD, Energy Performance of Buildings Directive; EPC, Energy Performance Certificate; EU, European Union; GHG, Greenhouse Gas; GIS, Geographic Information Systems; LTRS, Long-term renovation strategies; MS, Member States.

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Recommendation (EU) 2019/786 (European Commission, 2019b), that included progress indicators and milestones. It has the goal of guiding Member States (MS) in the assessment of their national long-term renovation strategies (LTRS), as stated in Directive (EU) 2018/844 (European Parliament and Council of the European Union, 2018).

In 2021 the proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (EPBD) (recast) was published (European Commission, 2021a). This proposal states that each MS must prepare a building renovation plan with the goal of decarbonising its building stock by 2050. Those plans must include a framework of measurable progress indicators to assess the evolution of the process. A template for the assessment framework was published (European Commission, 2021b), and it includes a set of mandatory and optional indicators. In 2022 a new version of the proposal for the directive was published (European Commission, 2022), and the previous framework was slightly modified. Lately, in March 2023, the amended version of the proposal for the EPBD recast was published and modified the framework again (European Commission, 2023; Beltran-Velamazan et al., 2023).

Although most of the MS established a renovation roadmap within their long-term renovation strategies (LTRS), complying with Directive (EU) 2018/844, just a few included progress indicators and indicative milestones to assess it. One of the reasons is the lack of data on their building stocks or the difficulty to retrieve them (Arbulu et al., 2022; Beltrán-Velamazán et al., 2022; Green Building Council Spain, 2021a), as claimed by the governments of Lithuania (Government of the Republic of Lithuania, 2021) and Luxembourg (Gouvernement du Grand-Duché de Luxembourg, Ministère de l'Énergie et de l'Aménagement du territoire, 2020).

To solve the problem of data loss, asymmetry, and unavailability, one of the measures that the EU will implement is the digital building logbook (DBL). Even though national-scale DBLs have existed for years in several countries (Blum, 2001, 2019; Espinoza-Zambrano et al., 2023), the first reference to the DBL as a European-scale tool appeared in the "Renovation Wave" strategy in 2020 (European Commission, 2020b). Its first official definition was published in the proposal for the EPBD recast in 2021, and was updated in the 2023 amended version of the proposal, keeping the idea that the DBL is a common repository for all relevant data of a building. It is expected that it will help increase the renovation rate by making it easier to share the information on buildings among the stakeholders of the construction sector, to increase transparency, to reduce the risk for investors and to raise awareness about the importance of renovation (Gómez-Gil et al., 2022a). Additionally, it will serve other purposes related to building maintenance or operation (Gómez-Gil et al., 2022b, 2023; Malinovec Puček et al., 2023).

As the implementation of a European DBL is a priority for the EU, several research groups have been working on the definition of the tool. A review of four of the main initiatives so far, iBRoad-Log (Libório et al., 2018; Sousa Monteiro et al., 2018), ALDREN BuildLog (Salvalai et al., 2019), X-tendo Logbook (Toth et al., 2020) and the Study on the Development of a European Union Framework for Buildings' Digital Logbook (EC Study) (European Commission et al., 2020, 2021), was conducted in (Gómez-Gil et al., 2022a), and their strengths and weaknesses were highlighted. One of the main findings of the study was that the functionalities of the DBL are not fully clear.

Two DBL functionalities are currently being researched in the scientific literature: a) the DBL as a digital logbook that can be used to design and develop the renovation roadmap of a building (Fabbri et al., 2016; Sesana et al., 2020); and b) the DBL as a digital repository to design and develop the operation and maintenance plan of a building (Signorini et al., 2021). This paper proposes a new and innovative functionality for the DBL: a digital repository that enables the assessment of the progress of the main EU policy objectives related to the building sector decarbonisation. The implementation of the DBL is a great opportunity to use digital data not only for the sake of a single building, but also to obtain and exploit data at a larger scale, such as regional, national or European. Thus, the research conducted in this paper explores, for the first time, the relationship between the DBL and the decarbonisation progress indicators. The main research questions of this paper are: What are the progress indicators that could help measure the progress of the EU policy decarbonisation objectives? What indicators should the DBL include to become an enabler of the assessment of the decarbonisation progress of buildings in the EU? What are the more relevant progress and DBL indicators? What DBL indicators are necessary for the mandatory progress indicators? How can the optional progress and DBL indicators be defined? What is the potential of the DBL to measure the progress of decarbonisation? To what extent the existing European DBL models already include the indicators enabling to measure the progress of decarbonisation?

Fig. 1 shows the research concept of this paper. The DBL should include indicators to provide data which allow to measure the progress of the EU policy decarbonisation objectives by means of progress indicators. In order to define a framework of progress and DBL indicators for this purpose, the analysis of the EU policy decarbonisation objectives can help us to identify progress indicators, which can also help us identify DBL indicators.

2. Materials and methods

Indicators can be defined as parameters, or values derived from parameters, which provide information about a phenomenon (Organisation for Economic Co-Operation and Development, 1993) and help measure progress towards a goal (United Nations publication, 2007).

In this research, the phenomenon to be monitored is the decarbonisation of national building sectors, and the main users of the proposed indicators framework may be public administrations, which will be able to make decisions based on it.

When proposing an assessment framework, it is preferable to have fewer well-defined and collectable indicators rather than including numerous unattainable indicators (Gómez-Gil et al., 2022a). In this case, we propose prioritising the indicators based mainly on the most relevant European objectives regarding decarbonisation.

The methodology conducted to define the mentioned framework and explore the contribution of the DBL to the assessment of decarbonisation, comprised the following main steps (Fig. 2):

1. Identification and prioritisation of the European policy objectives regarding the decarbonisation of national building sectors.
2. Identification and assignment of progress indicators for the assessment of the EU policy objectives, and their prioritisation.
3. Identification and classification of DBL indicators and analysis of the contribution of the digital building logbook to the collection of the progress indicators.

Additionally, we have conducted a final research step consisting of comparing the DBL indicators required to measure the progress of EU policy objectives, with the indicators in the already existing European DBL models.

2.1. Identification and prioritisation of the European policy objectives regarding the decarbonisation of national building sectors

To identify the main goals and priorities of the European policy regarding the building sector, the main directives, strategies, and initiatives were analysed. The documents considered were divided into four groups:

a. The 2023 amended version of the proposal for the EBPD recast (European Commission, 2023) which, upon final approval, will represent the coming regulatory framework of decarbonisation in the building sector.

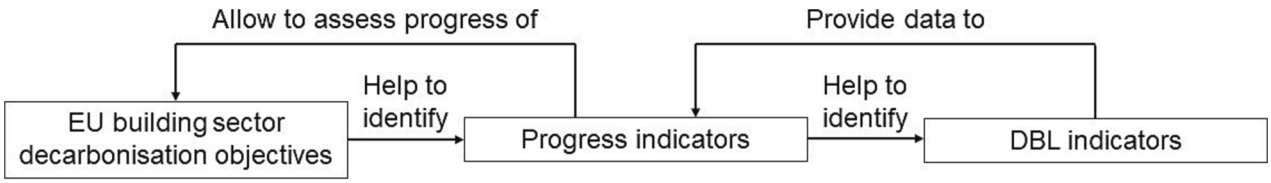

Fig. 1. Research concept.

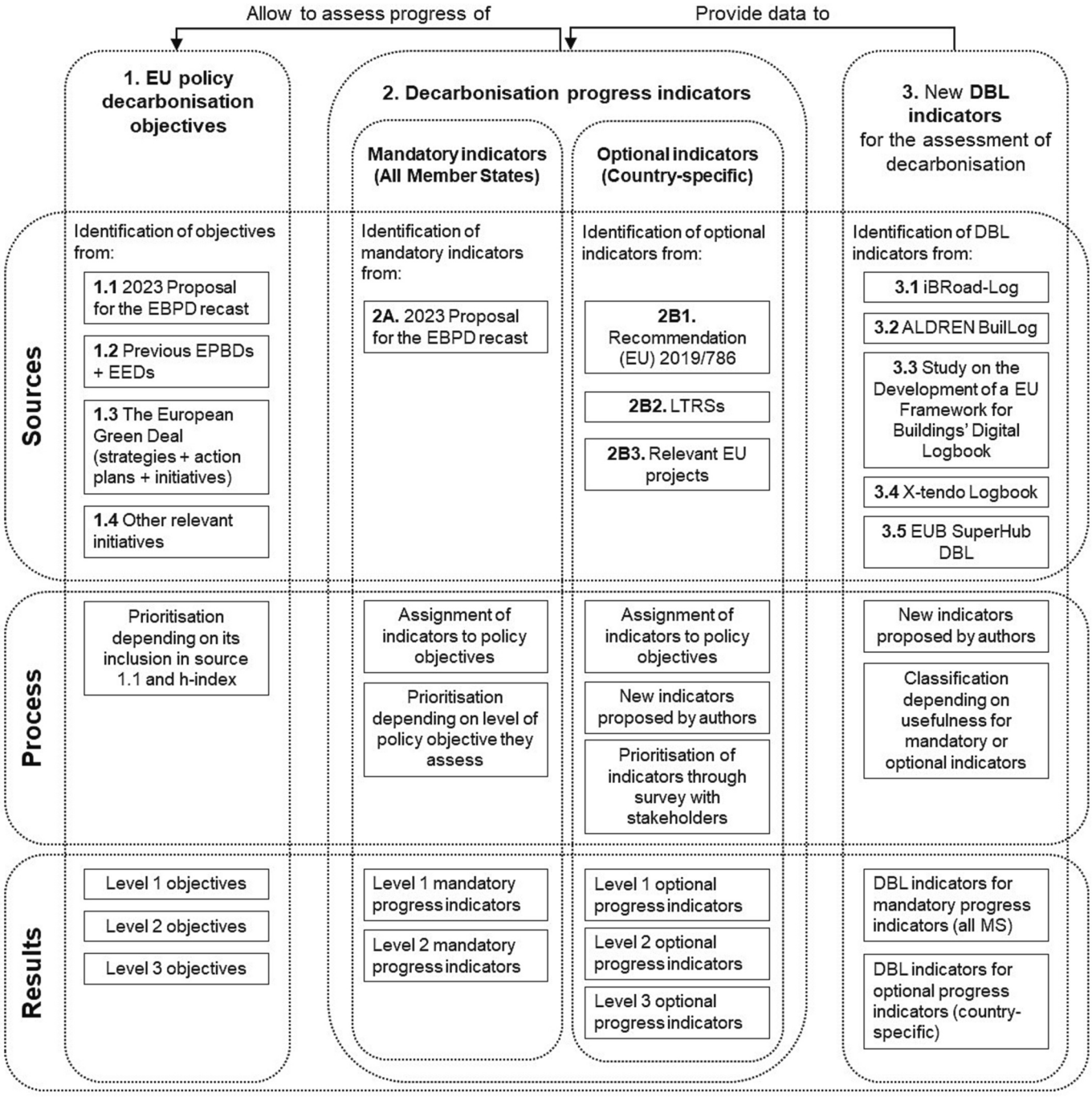

Fig. 2. Research approach to build the assessment framework to measure the progress of EU policy decarbonisation objectives.

b. The legislative European framework regulating the Energy Performance of Buildings including the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED) and their recommendations, which represent the existing and past regulatory framework of decarbonisation in the building sector: Directive 2010/31/EU (European Parliament, 2010), Directive 2012/27/EU (European Parliament, 2012), Directive (EU) 2018/2002 (European Commission, 2018), Directive (EU) 2018/844 (European Parliament and Council of the European Union, 2018) and Recommendation (EU) 2019/786 (European Commission, 2019b).

c. The European Green Deal (European Commission, 2019c) and its strategies, action plans and initiatives, which are the strategies and action plans to which the proposal for the EPBD recast is giving a response: A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives (European Commission, 2020b); Powering a climate-neutral economy: An EU Strategy for Energy System Integration (European Commission, 2020c); A hydrogen strategy for a climate-neutral Europe (European Commission, 2020d); the Circular Economy Action Plan (European Commission, 2020e); the EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' (European Commission, 2021c); the European Climate Pact (European Commission, 2020f) and the New European Bauhaus: Beautiful, Sustainable, Together (European Commission, 2021d).
d. Other current initiatives and documents, which are other strategies and action plans dealing with topics related to the decarbonisation of the building sector: the 2030 Digital Compass: the European way for the Digital Decade (European Commission, 2021e); Regulation (EU) 2021/1119 (European Commission, 2021f); Next Generation EU priorities (European Union, 2023) and European research flagships.

Next, the identified objectives were classified in three levels -level 1 (high presence), level 2 (medium presence), and level 3 (low presence)- according to their presence in the mentioned documents. To establish the mentioned classification (Fig. 3), the following principles were considered:

a. The goals that do not appear in the 2023 amended version of the proposal for the EPBD recast were considered **level 3 objectives**, because the EPBD is called to pave the way for the future of the construction sector, therefore, the objectives that are not included in it have little chance of being addressed in the near future.
b. To classify the indicators addressed in the 2023 amended version of the Proposal of the EPBD recast into levels 1 and 2, we used the h-index method (Hirsch and Buela-Casal, 2014). This method was applied by putting in order all the objectives from the most cited to the least cited ones. The h-index is the number in which the order number coincides with the number of citations. Thus, objectives above the h-index, −those whose number of citations is higher than their position in the list- were considered **level 1 objectives**, whereas those below the h-index were considered **level 2 objectives**.

2.2. Identification and assignment of progress indicators for the assessment of the EU policy objectives, and their prioritisation

The objective of this second stage was to find progress indicators to assess each EU objective from the previous step. To do so, relevant assessment frameworks were analysed, including the frameworks from the 2023 amended version of the Proposal for the EPBD recast (European Commission, 2023), the one from Commission Recommendation (EU) 2019/786 (R) (European Commission, 2019b), several relevant European projects (O), such as Build Upon[2] (World Green Building Council, 2023), and LTRSs from different EU countries (L) to identify suitable progress indicators for each objective.

Some authors suggest that assessment frameworks should include 'core' or 'mandatory' and 'complementary' or 'optional' indicators, which should be applicable to all MS or specific to certain countries, respectively (Halla et al., 2022). Mandatory indicators address common EU priorities, whereas optional indicators adapt to the particularities of each country (Libório et al., 2018; Fingleton and Jammet, 2021; Green Building Council Spain, 2021b). As previously mentioned, the 2023 amended version of the proposal for the EPBD recast (European Commission, 2023) also incorporates mandatory and optional indicators. This consideration was also applied in this work in this step.

Progress mandatory indicators from the mentioned 2023 amended version of the Proposal for the EPBD recast (European Commission, 2023) were directly considered mandatory indicators in this paper, since they have been designed for all the EU countries.

On the other hand, to identify the optional indicators of the framework, a survey was prepared, assigning the progress indicators that came from the remaining frameworks, or were proposed by the authors, to the corresponding EU objectives. Since each MS has different needs, the survey should be conducted separately in each country.

2.2.1. Application to the case of Spain

This paper applies the above-mentioned methodology to identify national optional indicators in Spain, drawing from indicators found in various sources, as detailed in Appendix A. Spain's building sector has specific characteristics that need to be considered. One noteworthy characteristic is that Spain has the second-highest number of multi-family buildings in Europe (Eurostat, 2021), and the stock was mainly built as neighbourhoods of open building form typologies (Garrido-Piñero and Mercader-Moyano, 2017). This fact presents challenges related to horizontal property or accessibility in buildings, which are country-specific.

To ensure that all these issues are addressed, a survey was conducted with seventeen Spanish experts with extensive knowledge of the national building stock, assessment frameworks, and the decarbonisation of the building sector. Seven of the experts belong to public administrations or renovation promoters, and ten belong to the academia. In geographical terms, there were representatives from different regions from Spain, specifically Andalusia, Aragon, the Basque Country,

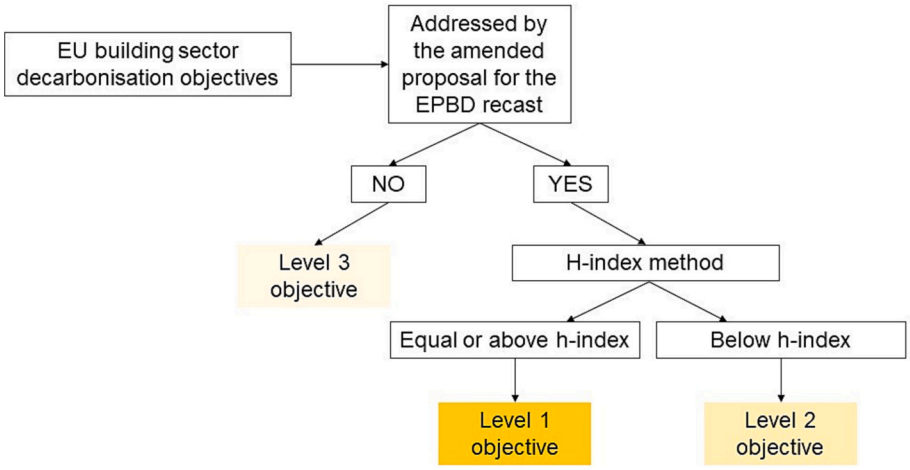

Fig. 3. Prioritisation criteria for the classification of the European policy objectives.

Community of Madrid, Community of Valencia, and Navarre.

Participants were asked to prioritise the given indicators by assigning a score from 1 to X to each indicator, where 1 represents the most relevant indicator and X represents the least relevant one.

As stated previously, it is desirable to have a small set of well-defined and collectable indicators. For this reason, the number of progress indicators was reduced by assigning a percentage of relevance to each one, calculated using the following equation:

$$\%of\ relevance = 100 - \left[\frac{(score\ obtained - minimum\ possible\ score)}{(maximum\ possible\ score - minimum\ possible\ score)}\ x100\right]$$

Using this percentage of relevance, the indicators were also classified into three levels of relevance. Indicators with a percentage of relevance greater than or equal to 67% were considered relevance level 1 progress indicators, whereas those with a score between 34% and 66% were classified as relevance level 2 progress indicators. Indicators with a relevance percentage lower than or equal to 33% were classified as relevance level 3 progress indicators. The results for the case of Spain can be seen in Appendix A. Optional indicators for other MS can be obtained applying the same methodology.

In the case of the optional indicators, there were no level 1 progress indicators associated to all the EU objectives. For this reason, when no level 1 progress indicators existed, the most relevant level 2 indicators were considered.

With those premises, the three-level framework of Table 1 was proposed.

2.3. Identification and classification of DBL indicators and analysis of the contribution of the digital building logbook to the collection of the progress indicators

As mentioned in Section 1, several MS expressed their difficulty to gather progress indicators to assess their renovation strategies due to the lack of available data. The DBL can be helpful in this matter since it collects all the relevant information on buildings. Using the information hosted in the DBL, moving to larger scales is easy, either numerically or by Geographic Information Systems (GIS), since the DBL will include the cadastral reference and geo coordinates of each building.

In this research phase, we analysed to what extent the DBL can contribute to the collection of the indicators that make up the assessment framework defined in the previous stage, which includes mandatory and optional indicators for Spain. To do so, firstly, we determined whether each progress indicator could be collected through the DBL and, secondly, we identified which data the DBL must provide to make this possible.

Table 1
Proposed assessment framework based on mandatory and optional -for the case of Spain- progress indicators.

	Mandatory progress indicators (for all MS)	Optional indicators (for Spain)
Level 1	Indicators from the framework suggested by the 2023 amended version of the proposal for the EPBD recast, which address level 1 objectives	Relevance level 1 or 2 indicators according to the survey with experts, which address level 1 objectives
Level 2	Indicators from the framework suggested by 2023 amended version of the proposal for the EPBD recast, which address level 2 objectives	Relevance level 1 or 2 indicators according to the survey with experts, which address level 2 objectives
Level 3	No indicators in this category	Relevance level 1 or 2 indicators according to the survey with experts, which address level 3 objectives

2.4. Comparison of the DBL indicators required to measure the progress of EU policy objectives with the indicators in the already existing European DBL models

The data fields that the DBL must contain were compared with the indicators suggested by the main existing European DBL initiatives (Table 2): the iBRoad-Log (Libório et al., 2018; Sousa Monteiro et al., 2018), the ALDREN BuildLog (Salvalai et al., 2019), the X-tendo Logbook (Toth et al., 2020), the EUB SuperHub DBL (Malinovec Puček et al., 2023), and the EC Study (European Commission et al., 2020, 2021) to determine the level of alignment between them.

3. Results

In this section the results obtained applying the methodology explained above are presented.

3.1. Identification and prioritisation of the European policy objectives regarding the decarbonisation of national building sectors

In Table 3 the results obtained in stage 1 are shown. The objectives identified following the methodology explained in section 2.1 are displayed in "general objectives" column; the category of each indicator is shown in the second column; the order number is displayed in the third column, and the number of citations of each objective is in the fourth column. In the first column, each goal is assigned an ID. The remaining columns show the number of documents where each objective is addressed within each group.

As displayed in Table 3, all the level 1 goals belong to the environmental and social categories, whereas all the financial objectives are considered level 2 or 3 objectives.

Among the most recurring topics (level 1) we can find carbon

Table 2
Summary of the European DBL models considered in the study.

DBL Initiative	Project title	Project website	Number of indicators in the DBL
iBRoad-Log	Individual Building (Renovation) Roadmaps	https://ibroad-project.eu/	68
ALDREN BuildLog	Alliance for Deep RENovation in Buildings	https://aldren.eu/	88
X-tendo Logbook	eXTENDing the energy performance assessment and certification schemes via a mOdular approach	https://x-tendo.eu/	216
EUB SuperHub DBL	European building sustainability performance and energy certification hub	https://eubsuperhub.eu/	234
Study on the Development of a European Union Framework for Buildings' Digital Logbook	–		83

Table 3
Objectives of the European policy regarding the building sector, classified according to their given relevance. Level 1 objectives are highlighted dark grey, level 2 goals are highlighted light grey and level 3 objectives are white. Abbreviations: 'E' refers to environmental objectives, 'S' refers to social goals, and 'F' refers to financial objectives.

Goal ID	Cat.	Ord.	Cit.	General objectives	EPBD Recast	EPBD+EED	Green Deal	Others
E1	E	1	13	Reducing whole life-cycle carbon emissions in buildings	1	3	8	1
E2	E	2	12	Increasing the use of renewable energies	1	3	5	3
E3	E	3	11	Reducing energy consumption / demand (renovation + improving the efficiency of buildings systems)	1	5	5	0
E4	E	4	11	Increasing energy/deep renovation rates	1	5	3	2
S1	S	5	11	Reducing energy poverty	1	4	4	2
S2	S	6	11	Spurring digitalisation across the construction value chain	1	1	6	3
E5	E	7	10	Creating "smart buildings", including the Smart Readiness Indicator, automation systems, self-regulation, and monitoring systems to improve energy efficiency	1	4	3	2
S3	S	8	10	Increasing social engagement for climate action	1	4	4	1
S4	S	9	10	Providing training for energy efficiency professionals (auditors, certifiers, installers…)	1	2	4	3
S5	S	10	9	Increasing technical assistance for renovation / energy efficiency and creation of one-stop shops	1	4	3	1
F1	F	11	9	Guaranteeing financing for renovation and energy efficiency through policies (reinforcing information, legal certainty, tax incentives and financial instruments)	1	3	4	1
F2	F	12	9	Creating green jobs / fostering construction sector through energy renovation	1	1	4	3
E6	E	13	9	Adopting circular and nature-based solutions/products, reuse and improve the management of construction and demolition waste material	1	0	6	2
S6	S	14	8	Ensuring high air quality and protection against harmful substances (asbestos, radon)	1	3	4	0
E7	E	15	8	Implementing energy communities	1	3	3	1
E8	E	16	8	Ensuring good water management	1	1	4	2
E9	E	17	7	Implementing zero-energy and positive buildings	1	5	1	0
E10	E	18	7	Equipping buildings with recharging points for e-mobility	1	1	3	2
E11	E	19	6	Improving buildings documentation, including EPCs, energy audits, BIM, BRPs and DBLs	1	3	2	0
F3	F	19	6	Implementing sustainable financing products (green mortgages, green loans, and green bonds)	1	3	2	0
F4	F	21	5	Increasing private financing for an efficient housing stock	1	2	2	0
E12	E	22	5	Improving worst-performing buildings	1	2	0	2
F5	F	23	5	Guaranteeing affordable efficient housing for everyone	1	1	2	1
E13	E	23	5	Making buildings healthier, greener, and more resilient to extreme natural events	1	1	2	1
S7	S	25	5	Making buildings more accessible	1	0	2	2
F6	F	26	4	Increasing public financing to create energy efficient buildings	1	3	0	0
F7	F	26	4	Creating public-private partnerships for an efficient housing stock	1	3	0	0
E14	E	28	4	Equipping buildings with bike parking	1	0	1	2
S8	S	29	3	Ensuring thermal, acoustic, and visual comfort for citizens	1	1	1	0
S9	S	29	3	Improving fire and seismic safety	1	1	1	0
S10	S	31	9	Conducting research and innovation on energy efficiency	0	1	5	3
F8	F	32	6	Monetizing energy efficiency improvements, reducing risk perception, and adding value to renovated properties	0	4	2	0
F9	F	33	3	Rewarding best-performing projects with a higher grant rate	0	2	1	0

emissions, renewable energies, renovation, energy poverty, energy efficiency, digitalisation or smart buildings. Other more recent objectives have level 2, because they are only included in the amended version of the proposal for the EPBD recast. This is the case for example of circularity on the construction sector, water management or energy communities.

3.2. Identification and assignment of progress indicators for the assessment of the EU policy objectives, and their prioritisation

In this section the results obtained applying the methodology explained in Section 2.2 are presented (Table 4). The results consist of the development of an assessment framework made up of a set of mandatory and optional progress indicators for Spain classified in three groups -level 1, level 2 and, level 3- according to their priority.

The group of mandatory progress indicators (designated with the prefix "M" in Tables 4 and 5) consists of seventeen indicators. Ten of them evaluate five level 1 objectives, whereas seven indicators assess three level 2 goals. Blank cells were left when there are no progress indicators from the amended version of the proposal for the EPBD recast. This is the case for all level 3 objectives.

Regarding optional indicators (designated with the prefix "S" in Tables 4 and 7) for Spain, twenty-five indicators were selected. Sixteen of them are level 1 indicators, whereas nine of them are level 2 indicators that were considered because in those cases there was neither a mandatory indicator nor a level 1 indicator to assess the objective. When an optional indicator coincided with a mandatory one it was only entered in the mandatory indicators column. Further details can be consulted in Appendix A.

Most of the level 1 objectives have a mandatory indicator assigned, which means that the assessment framework proposed in the 2023 amended version of the proposal for the EPBD recast is well aligned with the priority European objectives for the near future.

Regarding optional indicators for Spain, several indicators were coincident with mandatory indicators, which reflects that the results of the survey conducted through experts are also aligned with the European priorities and framework.

3.3. Identification and classification of DBL indicators and analysis of the contribution of the digital building logbook to the collection of the progress indicators

In this section it is studied which of the progress indicators could be collected gathering data from the DBL and, when this is possible, it is determined which information the DBL must contain to allow it.

Table 5 shows the relationship between EU policy objectives, mandatory progress indicators, and DBL indicators. The right column of Table 5 represents the DBL indicators required to collect a given progress

Table 4
Proposal of the three-level assessment framework for Spain. Optional level 2 indicators appear with *.

	Goal ID	Mandatory progress indicators (for all MS)	Optional indicators (for Spain)
Level 1	E1	-ME1A_Annual operational greenhouse gas emission reduction (kgCO2eq/(m2.y): per building type, including public buildings. -ME1B_Annual operational greenhouse gas emissions (kgCO2eq/(m2.y): per building type, including public buildings.	–
	E2	-ME2A_Share of renewable energy in the building sector (thermal energy) for different uses/on-site/off-site. -ME2B_Share of renewable energy in the building sector (electric energy) for different uses/on-site/off-site.	–
	E3	-ME3A_Primary and final annual energy consumption (ktoe) and (annual demand in ktoe and seasonal peak demand in GWh/day) per building type/end use. -CE3B_Energy savings (ktoe) per building type/public buildings.	-SE3A_Energy savings from deep renovations -SE3B_Reduction of annual energy consumption per end use/per building type
	E4	-ME4A_Annual renovation rates: number and total floor area (m2) per building type/to nearly zero-energy and to zero-emission building/levels/per renovation depth (weighted average renovation)/deep renovations/public buildings.	–
	E5	–	*SE5A_No. of buildings equipped with building water + energy management systems (BEMSs) or similar smart systems per building type
	S1	-MS1A_% of people/households affected by energy poverty (disaggregated by gender). -MS1B_Proportion of disposable household income spent on energy (disaggregated by gender). -MS1C_% reduction of people affected by energy poverty.	–
	S2	–	*SS2A_No. and % of companies taking actions for their digitalisation
	S3	–	-SS3A_No. of households renovating/willing to undergo energy renovation in their dwellings
	S4	–	*SS4A_No. of graduated students: university courses with focus on energy efficiency and related smart technologies
Level 2	E6	-ME6A_Annual life-cycle GWP reduction (kgCO2eq/(m2.y)) per building type.	–
	E7	–	-SE7A_No. of people/dwellings participating in energy communities, by geographical location
	E8	–	*SE8A_Amount and % of reduction in water consumption from public supply network achieved through deep renovation
	E9	-ME9A_Number of buildings: NZEBs. -ME9B_Total floor area (m2): NZEBs.	–
	E10	–	-SE10A_Ratio of number of dwellings to number of charging points
	E11	-ME11A_Number of EPCs per building type (including public buildings)/per energy performance class.	–
	E12	–	-SE12A_No., % and m2 of buildings in lowest energy classes
	E13	–	*SE13A_No. of buildings/dwellings that have obtained an efficiency certification such as Verde, Passivhaus, Leed, Breeam, etc.
	E14	–	-SE14A_Ratio of number of dwellings to number of bike parking slots
	S5	–	*SS5A_No. of households supported by one-stop shops
	S6	–	-SS6A_Average/aggregate indoor air quality index (IAQIs) and thermal comfort index (TCI)
	S7	–	-SS7A_% of multifamily buildings with barriers for persons with disabilities
	S8	-MS8A_Population living in inadequate dwelling conditions (e.g. leaking roof) or with inadequate thermal comfort conditions (disaggregated by gender).	–
	S9	–	*SS9A_No. of refurbishment-related reinforcements on support structures
	F1	–	-SF1A_Total investment in energy renovation
	F2	-MF2A_Increase of GDP (share and billion Euros). -MF2B_Creation of new jobs.	–
	F3	–	*SF3A_Ratio of sustainable financing products to conventional financing products used for building renovation
	F4	–	-SF4A_Public and private investments in deep renovations
	F5	–	-SF5A_Public investments in policy addressing the issues mentioned (split incentives, energy poverty, etc.)
	F6	–	-SF4A_Public and private investments in deep renovations -SF6A_Public incentives for deep renovation.
	F7	–	*SF7A_% of renovation/energy efficiency works founded through public-private partnership initiatives
Level 3	S10	–	-SS10A_Budget of national research programmes in the field of building energy efficiency
	F8	–	-SF8A_Direct savings associated to energy renovation
	F9	–	-SF9A_No. of initiatives to make good practices in energy efficiency and renovation more visible

indicator. The codification of DBL indicators is further explained in Table 6.

As presented in Table 5 and Fig. 4, through the DBL, data could be collected to evaluate seven out of the ten level 1 mandatory indicators proposed in this paper, whereas four out of seven level 2 mandatory indicators could be collected. In total, eleven out of seventeen mandatory indicators can be collected via the DBL.

According to the results, the least collectable indicators are those

Table 5
Relationship between EU policy objectives, mandatory progress indicators, and DBL indicators.

Level	Goal ID	Indicator ID	Is the indicator collectable through the DBL?	Data needed ID
Level 1	E1	ME1A	Yes	D1, D6
		ME1B	Yes	D1, D6
	E2	ME2A	Yes	D2, D5, D7
		ME2B	Yes	D2, D5, D7
	E3	ME3A	Yes	D1, D2, D4, D5
		ME3B	Yes	D1, D2, D4, D5
	E4	ME4A	Yes	D1, D3, D10, D11
	S1	MS1A	No	–
		MS1B	No	–
		MS1C	No	–
Level 2	E6	ME6A	Yes	D12
	E9	ME9A	Yes	D5, D7, D11
		ME9B	Yes	D3, D5, D7, D11
	E11	ME11A	Yes	D1, D8, D9
	S8	MS8A	No	–
	F2	MF2A	No	–
		MF2B	No	–

Table 6
Indicators needed for the DBL to collect the mandatory progress indicators.

Data ID	Data
D1	Building type
D2	Use of the building
D3	Area of the building
D4	Energy conversion factor
D5	Energy consumption (pre and post renovation) by source
D6	GHG emissions (pre and post renovation)
D7	Amount of on-site renewable energy generation and type
D8	Energy performance certificate
D9	Energy performance class
D10	Is this building renovated? If yes, year, type and depth of the renovation
D11	Is this building a nZEB?
D12	LCA Report (pre and post renovation)

that belong to the social category, since some of them imply collecting data on personal aspects of the dwellings' inhabitants, which conflicts with data protection policies. The definition of the DBL implies that the logbook will accompany the dwelling/building throughout its entire life, so the aforementioned data could be exposed to third parties, such as future owners of the home.

To collect the indicators mentioned in Table 5, the DBL must contain twelve indicators (Table 6).

Regarding Spain optional indicators, four out of six level 1 indicators, fifteen out of sixteen level 2 indicators, and one out of three level 3 indicators could be gathered using data from the DBL. In total, twelve out of twenty-five of the optional indicators can be collected via the DBL (Table 7 and Fig. 5).

Table 7 shows the relationship between EU policy objectives, optional progress indicators for the case of Spain, and DBL indicators. The right column of Table 7 represents the DBL indicators required to collect a given progress indicator. The codification of DBL indicators is further explained in Table 8.

Once again, environmental indicators are the most collectable ones compared to social and financial progress indicators. In this case, the reason is that these indicators do not refer to the characteristics of buildings, which is the type of information that DBLs can contain. These indicators refer to other areas of the building sector, such as the academic, research, or national labour market.

To collect those indicators, the DBL should contain fifteen additional indicators, which can be found in Table 8.

3.4. Comparison of the DBL indicators required to measure the progress of EU policy objectives with the indicators in the already existing European DBL models

The study of the alignment of mandatory progress indicators with existing DBL models included the iBRoad-Log, the ALDREN BuildLog, the X-tendo Logbook, the EC Study, and the EUB SuperHub DBL. Results (Table 9) show that the proposed set of data fields is very aligned with the EUB SuperHub DBL and the iBRoad-Log, where 67% of the indicators are coincident, followed by the X-tendo Logbook, with 58% of identical data fields. On the contrary, 50% and 33% of the indicators from the EC Study and from the ALDREN BuildLog are coincident respectively.

It should be noted that the lack of alignment with the ALDREN BuildLog may be due to the fact that only indicators on technical aspects of the building were developed in the project.

The same comparison was established between the indicators required to collect the optional progress indicators for Spain and the DBL initiatives mentioned in the previous paragraph (Table 10). As in the previous case, the EUB SuperHub DBL is the most aligned initiative, with 53% of coincident data fields, followed by the EC Study, with 47% of coincident indicators, and the iBRoad-Log, with also 47% of equivalent indicators. Next, the X-tendo Logbook shares 40% of the indicators, whereas the ALDREN BuildLog is the least aligned with 13%.

In this case, the alignment between the DBL initiatives and the progress indicators is lower, which makes sense because those frameworks were designed to be applicable to the whole EU and not to a specific country.

4. Discussion

The DBL represents a viable option for the generation of data that allow the assessment of the progress of the European policy objectives for national building sectors using progress indicators.

Through the DBL, data could be collected to evaluate a very high share of level 1 and level 2 mandatory progress indicators, most of which belong to the environmental category, followed by the social one.

Regarding optional indicators for the case of Spain, the majority of level 1 and 2 indicators and almost half of level 3 could be evaluated through this tool.

It should also be noted that there is a notable alignment between the data fields proposed for the DBL to collect the mandatory progress indicators and the indicators from existing DBL initiatives, highlighting the similarities with the EUB SuperHub DBL, the iBRoad-Log, and the EC Study. The alignment is reduced when the indicators of those DBL models are compared with the data fields to evaluate the optional indicators for the case of Spain.

Through this research a further step has been taken towards the definition of this tool, identifying, and exploring, for the first time, this new functionality. However, this work presents some limitations, some of which are due to the study itself and others are a consequence of external factors. These include:

- The version of the EPBD analysed is not the final one, thus, it may suffer some changes that should be considered when the final document is approved.
- The paper presents results of optional indicators for the case of Spain. However, the sets of indicators for the rest of the MS need to be obtained by applying the explained methodology.
- Some of the indicators cannot be collected due to the lack of available data in some countries (Gómez-Gil et al., 2023). This issue should be the subject of future research.
- New strategies and action plans can be released in the future that will alter the prioritisation of objectives, and therefore of progress and DBL indicators. Therefore, this framework is temporarily valid, although the results can be updated following the method.

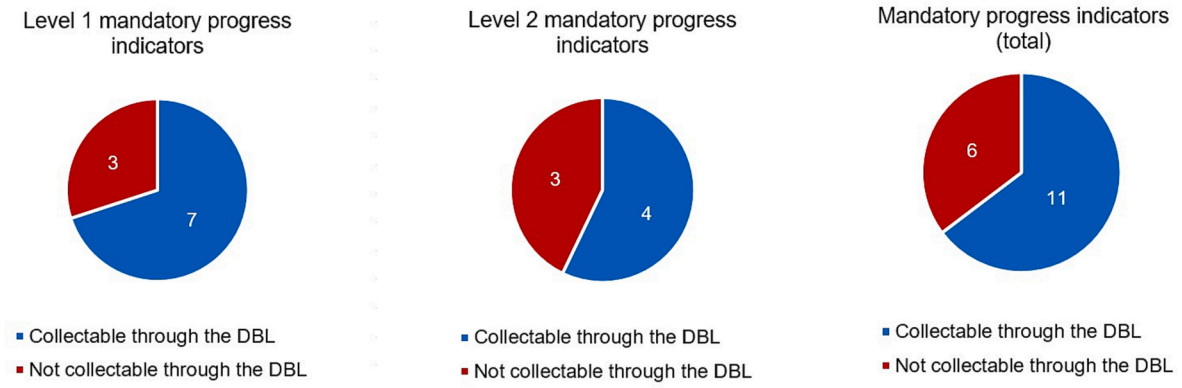

Fig. 4. Number of mandatory progress indicators collectable/not collectable through the DBL.

Table 7
Relationship between EU policy objectives, optional progress indicators for the case of Spain, and DBL indicators.

Level	Goal ID	Indicator ID	Is the indicator collectable through the DBL?	Data needed ID
Level 1	E3	SE3A	Yes	D5, D10
		SE3B	Yes	D1, D2, D5
	E5	SE5A	Yes	D13
	S2	SS2A	No	–
	S3	SS3A	Partially	D10
	S4	SS4A	No	–
Level 2	E7	SE7A	Yes	D23, D24
	E8	SE8A	Yes	D10, D25
	E10	SE10A	Yes	D14, D15
	E12	SE12A	Yes	D3, D9
	E13	SE13A	Yes	D16
	E14	SE14A	Yes	D14, D17
	S5	SS5A	Yes	D10, D18
	S6	SS6A	Yes	D26
	S7	SS7A	Yes	D1, D19
	S9	SS9A	Yes	D10
	F1	SF1A	Yes	D10, D20
	F3	SF3A	Yes	D10, D22
	F4	SF4A	Yes	D10, D20, D21
	F5	SF5A	No	D10, D21
	F6	SF6A	Yes	D10, D21
	F7	SF7A	Partially	D20, D21, D22
Level 3	S10	SS10A	No	–
	F8	SF8A	Yes	D10, D5, D27
	F9	SF9A	No	–

Table 8
Additional indicators needed for the DBL to guarantee the collection of the optional progress indicators for the case of Spain.

Data ID	Data
D13	Is this building equipped with smart systems? If yes, which ones?
D14	Number of dwellings in the building
D15	Number of charging points for electric vehicles
D16	Is this building sustainability level certified? If yes, which scheme was used?
D17	Number of bike parking slots
D18	Was the promoter of the renovation supported by a one-stop shop?
D19	Is this building fully accessible? if not, which barriers does it have?
D20	Total budget of the renovation
D21	Were public funds used in the renovation?
D22	Were sustainable financing products used in the renovation?
D23	Location of the building
D24	District heating access
D25	Saving water strategies implemented in the renovation
D26	Monitoring data (Temperature, Co2, RH)
D27	Energy bills

- This methodology has the only purpose to identify the data that can be gathered through the DBL to monitor the national building sectors' decarbonisation progress. The DBL must include more administrative and technical data so that it can fulfil its other functionalities (Gómez-Gil et al., 2022b, 2023) and should consider the introduction of data from new technologies (Gómez-Gil et al., 2022c).

5. Conclusions

This paper has the objective to explore the potential of the DBL to provide data that allows the collection of progress indicators that evaluate the main European policy objectives regarding the decarbonisation

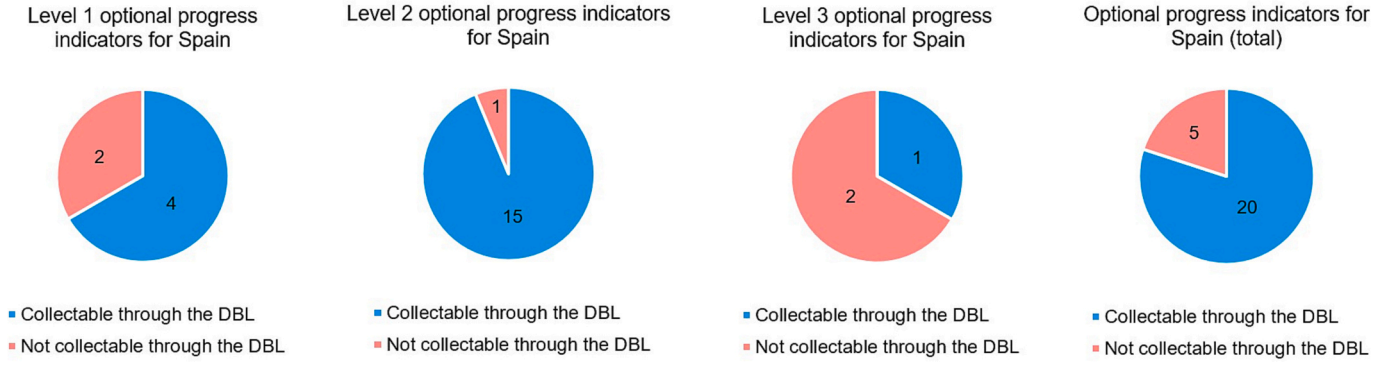

Fig. 5. Number of optional progress indicators for Spain collectable/not collectable through the DBL.

Table 9
Alignment between the proposed DBL indicators for the collection of mandatory progress indicators and the indicators suggested by existing DBL initiatives. Abbreviations: 'EC Study' refers to the Study on the Development of a European Union Framework for Buildings' Digital Logbook.

Data ID	iBRoad-Log	ALDREN BuildLog	EC Study	X-tendo Logbook	EUB SuperHub DBL
D1	X	X	–	–	X
D2	X	X	X	X	X
D3	X	X	X	X	X
D4	–	–	–	X	–
D5	X	–	X	X	X
D6	X	–	–	X	Partially
D7	X	X	X	Partially	X
D8	X	–	X	X	X
D9	X	–	X	X	X
D10	–	Partially	–	–	X
D11	–	–	–	–	–
D12	–	–	Partially	Partially	Partially

Table 10
Alignment between the proposed DBL additional data fields for the assessment of optional progress indicators in Spain and the indicators suggested by existing DBL initiatives. Abbreviations: 'EC Study' refers to the Study on the Development of a European Union Framework for Buildings' Digital Logbook.

Data ID	iBRoad-Log	ALDREN BuildLog	EC Study	X-tendo Logbook	EUB SuperHub DBL
D13	X	Partially	Partially	Partially	X
D14	X	–	–	–	–
D15	X	X	X	X	X
D16	–	–	–	–	X
D17	–	–	–	–	–
D18	–	–	–	–	–
D19	–	–	X	X	X
D20	–	–	–	–	X
D21	X	–	–	–	–
D22	X	–	–	–	–
D23	X	X	X	X	X
D24	X	–	X	X	X
D25	–	–	X	–	–
D26	–	–	X	X	Partially
D27	–	–	X	X	X

of national building sectors.

To do this, firstly, those objectives were identified, classifying them as environmental, social, and financial goals. Next, based on the literature and European regulations, a set of progress indicators was proposed to evaluate each objective. Those progress indicators were reduced and prioritised, establishing a group of 'mandatory' indicators applicable to the entire European Union and a group of 'optional' indicators, to be defined for each MS. The indicators proposed in the assessment framework from the 2023 amended version of the proposal for the EPBD recast were directly considered mandatory indicators, whereas to establish the set of optional indicators for Spain, a survey was conducted with Spanish experts.

Within each of the groups i.e., mandatory, and optional progress indicators, a classification was established between relevance level 1, level 2, and level 3 indicators, depending on both, the priority of the objective being assessed and the percentage of relevance of the indicator obtained from the survey results (this criterion only for optional indicators).

Once the final assessment framework was established, it was identified which of the progress indicators could be collected using data from the DBL, as well as the indicators that it should contain to make it possible.

To sum up, this research demonstrated that the DBL has great potential to provide data for the assessment of the studied EU policy objectives, and the DBL indicators proposed in this paper are well aligned with those in the existing European DBL models.

DBL indicators useful to develop mandatory progress indicators focus on building typology and use, degree of renovation, energy efficiency of the use phase, and LCA, whereas DBL indicators useful to develop optional progress indicators for Spain focus on broader aspects of renovation, such as level of smart preparation, bike parking, accessibility, budget, or water saving.

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CRediT authorship contribution statement

Marta Gómez-Gil: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Almudena Espinosa-Fernández:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – review & editing, Supervision. **Belinda López-Mesa:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Part of the data is confidential, and the rest is open data referenced in the paper

Appendix A. Survey Summary: Optional Progress Indicators for Spain

Table A1
Survey conducted among Spanish experts to determine the set of optional progress indicators for Spain. Abbreviations: 'E' refers to the 2023 amended version of the proposal for the EPBD recast; 'R' refers to Commission Recommendation (EU) 2019/786; 'L' means LTRS from EU countries; 'O' refers to other projects; 'P' are indicators proposed by the authors of this research. Relevance level 1 progress indicators are highlighted green, whereas relevance level 2 and 3 progress indicators are highlighted yellow and orange respectively.

Goal ID	EU general goals	Progress indicators	Source	% relev.	Score
E1	Reducing whole life-cycle carbon emissions in buildings	Annual operational greenhouse gas emission reduction (kgCO2eq/(m2.y): per building type, including public buildings	R+E	82	23
		GHG reductions in public buildings	L	9	48
		Reduction of GHG Space Heating and Cooling emissions	O	56	32
E2	Increasing the use of renewable energies	Share of renewable energy in the building sector (thermal energy) for different uses/on-site/off-site	O+E	56	37
		Share of renewable energy in the building sector (electric energy) for different uses/on-site/off-site	O+E	50	40
		Energy produced from renewable resources on site or nearby as a result of renovation	O+E	44	43
		Increase in production of renewable energies	P	38	46
E3	Reducing energy consumption/demand (due to renovation/improving the efficiency of buildings systems)	Primary and final annual energy consumption (ktoe) and (annual demand in ktoe and seasonal peak demand in GWh/day) per building type/end use	R+E	65	71
		Reduction of annual energy consumption per end use/per building type	P	67	67
		Total energy saving potential per building sector	R	34	118
		Energy savings from deep renovations	R	69	64
		Energy savings (ktoe) per building type, public buildings	R+E	69	65
		% energy imports for the Member State	R	11	153
		Improvement of Net Space Heating and Cooling Demand due to energy renovation	O	60	78
		Reduction in direct annual CO2 emissions from energy renovation	O	52	91
		EPB certification. Average performance of the stock	L	28	127
		Energy savings in public buildings	L	26	130
E4	Increasing energy/deep renovation rates	Annual renovation rate: number and total floor area (m2) per building type/public buildings/per renovation depth	R+E	75	30
		Renovated m2 per building type/per building size/per building age	R+E	47	44
		Annual renovation rate: number and total floor area (m2) to nearly zero-energy and to zero-emission building levels/deep renovations	R+E	63	36
		% and m2 of renovated public buildings per building type/per building size/climatic zone	R+P	6	65
E5	Creating "smart buildings", including the Smart Readiness Indicator, automation systems, self-regulation and monitoring systems to improve energy efficiency	No. of buildings equipped with building water + energy management systems (BEMSs) or similar smart systems per building type	R+L	66	27
		No. of buildings in each smart readiness class	P	44	34
		No. of buildings equipped with smart meters and sensors by type of building/geographical location/type of meter	E	41	35
E6	Adopting circular and nature-based solutions/products, reuse and improve the management of construction and demolition waste material	Annual life-cycle GWP reduction (kgCO2eq/(m2.y)) per building type	R+E	80	29
		Amount and % of recycled/reused construction materials	P	41	54
		Reduction of construction and demolition waste generation (CDW)	P	39	55
		Amount of construction and demolition waste produced per m2 renovated	L	36	57
		Amount and % of savings in materials achieved with the application of the principles of the circular economy	L	31	60
E7	Implementing energy communities	Trend in the number of dwellings connected to heating networks	L	24	30
		No. of people/dwellings participating in energy communities, by geographical location	L	88	18
E8	Ensuring good water management	Amount and % of reduction in water consumption from public supply network achieved through deep renovation	L	62	43
		No. of buildings equipped with water management systems	P	40	58
		% of reused/reclaimed water in buildings	P	53	49
		Total annual water consumption in buildings by final use and considering the type of building/construction period/size and climate zone/(non) potable uses/water sources used	L	51	50
		Total use of alternative sources of water in buildings, by type of source of 'renewable' water (rainwater, grey water, water for reuse from waste water treatment stations (WWTS)), and considering the type of building/construction period/size/climate zone/existence of uses outside the building	L	28	66
E9	Implementing zero-energy and positive buildings	Number of buildings: NZEBs	R+P+E	53	31
		Total floor area (m2): NZEBs	R+P+E	25	40
		Total and annual % of buildings undergoing deep and NZEB renovation	R	66	27
E10	Equipping buildings with recharging points for e-mobility	No. and % of buildings equipped with electric vehicle charging points per building type	L+P	25	28
		Ratio of number of dwellings to number of charging points	P	75	20

E11	Improving buildings documentation, including EPCs, energy audits, BIM, BRPs and DBLs	No. of EPCs per building type (including public buildings)/per energy performance class	R+E	57	39
		No. of energy audits carried out	L	10	63
		No. of renovation roadmaps carried out	L	57	39
		No. of building passports	L	65	35
E12	Improving of worst-performing buildings	No., % and m2 of buildings in lowest energy classes	R+L	76	21
		Consumption by inefficient buildings (class D and lower)	L	18	31
E13	Making buildings healthier, greener and more resilient to extreme natural events	No. of buildings/dwellings that have obtained an efficiency certification such as Verde, Passivhaus, Leed, Breeam, etc.	P	50	24
		No. of buildings that have been built/renovated following bioclimatic criteria	P	44	25
E14	Equipping buildings with bike parking	No. and % of buildings equipped with bike parking	P	24	30
		Ratio of number of dwellings to number of bike parking slots	P	76	21
S1	Reducing energy poverty	% of people/households affected by energy poverty (disaggregated by gender)	R+E	89	26
		Proportion of disposable household income spent on energy (disaggregated by gender)	R+E	45	64
		Arrears on utility bills	R	25	81
		Reduction in energy costs per household	R	46	63
		% reduction of people affected by energy poverty	P+E	54	56
		Public investments in policy addressing the issues mentioned (split incentives, energy poverty, etc.)	R	42	66
S2	Spurring digitalisation across the construction value chain	No. and % of companies taking actions for their digitalization	P		11
S3	Increasing social engagement for climate action	Awareness-raising initiatives (number, target audience reached, target audience taking action)	R	63	29
		No. of people committed to climate action	P	16	43
		No. of households renovating/willing to undergo energy renovation in their dwellings	P	75	24
S4	Providing training for energy efficiency professionals (auditors, certifiers, installers...)	No. of graduated students: university courses with focus on energy efficiency and related smart technologies	R	72	25
		No. of graduated students: professional/technical training (EPC certifiers, HVAC inspectors, etc.)	R	56	30
		No. of installers skilled in new technologies and working practices	R	31	38
S5	Increasing technical assistance for renovation / energy efficiency and creation of one-stop shops	One-stop shop initiatives in place	R	24	30
		No. of households supported by one-stop-shops	L	65	23
S6	Ensuring high air quality and protection against harmful substances (asbestos, radon)	Average/aggregate indoor air quality index (IAQIs) and thermal comfort index (TCI)	R	88	18
		Trend in asbestos removal in residential buildings	L	13	30
S7	Making buildings more accessible	Removal/prevention of accessibility barriers for persons with disabilities	R	18	31
		% of multifamily buildings with barriers for persons with disabilities	P	76	21
S8	Ensuring thermal, acoustic, and visual comfort for citizens	Population living in inadequate dwelling conditions (e.g. leaking roof) or with inadequate thermal comfort conditions (disaggregated by gender)	R+E	78	36
		Cost of avoided illnesses / Reduction in health costs attributable to energy efficiency measures (estimate)	R	46	63
		Disability Adjusted Life Year (DALY)/Quality Adjusted Life Year (QALY) improvements attributable to the improvement of building stock and living conditions	R	27	79
		Labour productivity gains from better working environment and improved living conditions	R	31	76
		Thermal comfort index, considering the type of building/construction period/size/climate zone	L	58	53
		Impact on the performance of the thermal comfort index after energy renovation in a building	L	52	58
S9	Improving fire and seismic safety	No. of refurbishment planning involving a fire safety expert	L	50	24
		No. of refurbishment-related reinforcements on support structures	L	56	23
S10	Conducting research and innovation on energy efficiency	Participation of national universities in international scientific research projects (e.g., H2020) on energy efficiency in buildings related topics	R	25	28
		Budget of national research programs in the field of building energy efficiency	R	75	20
F1	Guaranteeing financing for renovation and energy efficiency through policies (reinforcing information, legal certainty, tax incentives and financial instruments)	Public investments in policy addressing the issues mentioned (split incentives, energy poverty, etc.)	R	47	53
		Total investment in energy renovation	O	81	30
		Public incentives for deep renovation	R	65	41
		No. of dwellings with exemption from property tax	L	26	67
		Savings arising from access to tax benefits by owners of rented property	L	13	76

F2	Creating green jobs/fostering construction sector through energy renovation	Employment in the building sector (Nº of jobs created per EUR million invested in the sector)	R	58	34
		Increase of GDP (share and billion Euros)	R+E	33	45
		No. of expert workers in renovation and energy efficiency hired annually	P	58	34
		Creation of new jobs	P+E	49	38
F3	Implementing sustainable financing products (green mortgages, green loans and green bonds)	No. and % of dwellings renovated using sustainable financing products per type of product	P	50	24
		Ratio of sustainable financing products to conventional financing products used for building renovation	P	56	23
F4	Increasing private financing for an efficient housing stock	Public and private investments in smart technologies (including smart grids)	R	3	47
		Public and private investments in deep renovations	R	81	22
		Total annual private investment in energy renovation	O	63	28
F5	Guaranteeing affordable efficient housing for everyone	Public incentives for deep renovation	R	36	23
		Public investments in policy addressing the issues mentioned (split incentives, energy poverty, etc.)	R	79	17
F6	Increasing public financing to create energy efficient buildings	Public and private investments in smart technologies (including smart grids)	R	17	69
		Public and private investments in deep renovations	R	70	35
		Public incentives for deep renovation	R	69	36
		Public investments as percentage of total investments in energy saving	R	48	49
		Investment in energy efficiency renovation on the public building stock	R	42	53
F7	Creating public-private partnerships for an efficient housing stock	No. of public-private partnership initiatives	R	44	25
		% of renovation/energy efficiency works founded through public-private partnership initiatives	P	56	23
F8	Monetizing energy efficiency improvements, reducing risk perception, and adding value to renovated properties	Cost-effectiveness of main renovation measures (e.g., net present values, payback period, investment costs per annual savings) per building type/per climatic zone	R	56	47
		Decrease in perceived risk of energy efficiency operation	R	26	67
		No. of integrated/aggregated projects	R	22	70
		Direct savings associated to energy renovation	O	82	29
		Increase in property value attributable to the energy renovation of buildings	L	51	50
F9	Rewarding best-performing projects with a higher grant rate	No. of total renovation bonus energy premiums	L	32	40
		No. of initiatives/contests created to reward the most efficient projects	P	32	40
		No. of initiatives to make good practices in energy efficiency and renovation more visible	P	82	23

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