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# Applicability of the European Union's Building Renovation Assessment Framework in Spain

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***Abstract* – The energy renovation of buildings is one of the main keys to achieve the decarbonisation objectives of the European Union (EU). In response, the Commission Recommendation (EU) 2019/786 proposed an assessment framework based on Measurable Progress Indicators (MPIs) to assess the decarbonisation. The objective of the study is to analyse the applicability of the MPIs in Spain; for this, the study analyses the viability of the MPIs and carries on the prioritization of the MPIs. Thus, the methodology is developed in three stages: (1) analysis of data availability the viability of each MPI; (2) prioritization of the MPIs by and expert round table (ERT); (3) applicability analysis of the prioritizing MPIs. Firstly, the analysis of viability shows that the data availability and the quality is limited, with many data source entities and big diversity of data features and quality. Secondly, the expert round table prioritized 8 MPIs regarding the EU's targets in building renovation. Thirdly, the applicability evaluation finds out many barriers but also identifies the key points to launch the MPIs base assessment framework. The study identifies the entities that could likely carry on the data collection and other challenges like the digital building logbook (DBL) or the monitorization towards the efficient assessment of the renovation of the building.**

***Keywords* – Decarbonising; EPBD; European policy; long term renovation strategy (LTRS); measurable progress indicator (MPI); national building stock.**

| **Nomenclature** | | |
|---|---|---|
| EPBD | Energy Performance of Building Directive | – |
| EPC | Energy performance certificate | – |
| ERT | Expert round table | – |
| EU | European Union | – |
| KPI | Key performance indicator | – |
| LTRS | Long term renovation strategy | – |
| MPI | Measurable progress indicator | – |
| MS | Member state | – |
| RTD | Research and technological development | – |

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# 1. INTRODUCTION

## *1.1. Context*

Buildings are responsible of about the 40 % of energy consumption and the 36 % of the greenhouse gas emission in the European Union (EU), taking into account all the life stages of the buildings [1]. According to the European Commission, today around 75 % of the EU building stock is inefficient, with only 0.4 % to 1.2 % of buildings renovated per year [1]. To meet the challenge this rate needs to be at least doubled [1], and to achieve such an increase in the rate of renovation, the main tool available to member states is the implementation of legal mechanisms; the main one is the Energy Performance of Buildings Directive (EPBD), with the latest update by Directive (EU) 2018/844.

The main measures of the last version were wider explained by the 'Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation' [2], including the 'Article 2a (2)' that sets a framework to assess and develop the Long Term Renovation Strategies (LTRS) of the member states. The assessment framework is based on measurable progress indicators (MPI) to guide the assessment of the decarbonisation of the building stock towards the EU's targets. The MPIs are derivate from the text of the 'Article 2a (2)' of the EPBD (Directive (EU) 2018/844) and organized in two sections: The 'section 1' refers to the introductory paragraph where key points are presented regarding the EU's targets; and the 'section 3' discusses the assessment of mechanisms that can support the renovation process of the third paragraph, excluding the second paragraph [2].

This study is part of the research project LOCAL-REGEN, where previous studies have been conducted on the assessment frameworks of European research and technological development (RTD) projects [3], as well as on the barriers and challenges of the MPIs within the assessment framework of the Commission Recommendation (EU) 2019/786 [2], by analysing their concordance with the evaluation framework of European RTD projects [4]. This second study found low data availability and reliability as the main barriers, along with the need to prioritize and shortlist the large amount of MPIs [4]. Following this, the present study investigates the applicability of the MPIs based assessment framework of the Commission Recommendation (EU) 2019/786 in the Spanish context focusing in the data availability and the prioritization.

## *1.2. Objectives*

The objective of the study is to analyse the efficient applicability of the MPIs of the assessment framework proposed by the Commission Recommendation (EU) 2019/786 [2] in Spain. The analysis involves evaluating the viability of the MPIs in terms of data quality and prioritizing the relevant ones for an efficient assessment of the national building stock renovation, upon the findings of the previous study [4]. This enables the evaluation of the assessment framework's applicability and the correlation between indicator relevance and data availability and quality. By doing so, the study aims to identify the barriers and challenges as key factors towards an efficient and relevant assessment of the national stock renovation process for the development of LTRSs.

# 2. METHODOLOGY

In order to follow the objective, the study is developed in a 3-stage methodology, analysing the viability of the MPIs, prioritizing the MPIs and finally evaluating the applicability of the MPIs (Fig. 1).

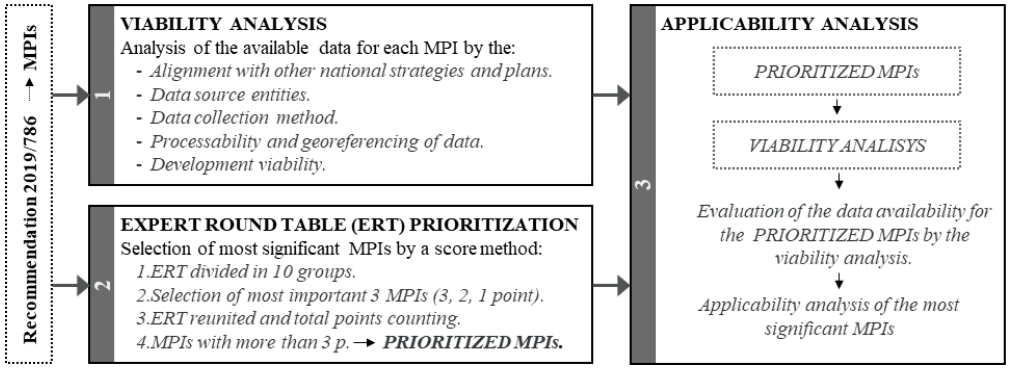


Fig. 1. Methodology algorithm for the applicability analysis of the MPIs.

The first stage analyses the viability in terms of data availability of the MPIs identified in the Commission Recommendation (EU) 2019/786 [2]. Firstly, The MPIs are listed, numbered and classified in scopes and two main sections following the exact definitions and classification of the Commission Recommendation (EU) 2019/786. The numbering of the MPIs is done in order of appearance, the scopes are identified with letters of the alphabet and the sections are identified with numbers. Secondly, the viability analysis is carried out to test the possibility to develop each MPI and its data quality by evaluating five parameters for each MPI: 'Alignment with national strategies and plans', 'Data source entities', 'Data collection method', 'Processability and georeferencing of data', and 'Development viability'. The parameter 'Alignment with national strategies and plans' evaluates the correlation of the MPI with any existing and present national initiative led by official entities. The 'Data source entities' identifies the agents that can provide the data to develop the MPI on a national scale. The 'Data collection method' analyses the method used by the data source entities to acquire the data to develop the MPI. The 'Processability and georeferencing of data' evaluates the possibility of processing and automating the data reading and determining whether the data is georeferenced. Finally, the parameter 'Development viability' evaluates the feasibility of developing and applying the MPI based on the data availability and quality, classifying them as 'Complete', 'Partial' or 'Non-viable'.

The second stage involves analysing the relevance of the MPI in relation to the renovation objectives of the EU. The prioritization process is based on an expert round table (ERT) comprising members from different national organizations focused on the energy efficiency in buildings. As the working method, the ERT is introduced to the EU's energy policy and the assessment framework proposed by the Commission Recommendation (EU) 2019/786 [2] inside the context of LOCAL-REGEN project, and the list of MPI is presented. The ERT is divided into 10 groups, with the task of prioritizing the MPIs regarding the objectives of the EU's energy policy. Each group selects the most relevant three MPIs, and the rankings are assigned points: three points for the most relevant, two for the second, and one for the third. Subsequently, the ERT convenes for a discussion on the prioritization process, and the points are awarded to the MPIs accordingly. The MPIs receiving a score of equal to or higher than 4 points (indicating that at least two groups have considered them very relevant) are considered the prioritizing MPIs.

In the third stage, the prioritized MPIs of the previous stage undergo a comprehensive evaluation for their applicability in the context of Spain. This analysis involves examining the relationship between the priority assessment fields and the feasibility of the MPI that can measure them. To achieve this, the viability parameters (analysed in the first stage) of the

prioritizing MPIs (selected in the second stage) are interpreted, evaluating the degree of applicability of the MPIs in the assessment framework of the Commission Recommendation (EU) 2019/786 [2]. Moreover, the study identifies the viable MPIs, as well as their data quality and features. Additionally, it investigates the barriers and challenges to of the non-viable or partially viable MPIs considered relevant. Furthermore, this stage also serves to identify the key entities and the key factors towards the efficient assessment of the renovation of the national building stock.

## 3. RESULTS

### *3.1. Viability Analysis of the MPIs*

The MPIs are listed and numbered following the scheme presented in the text of the Commission Recommendation (EU) 2019/786 [2]. Seventy MPIs have been identified and classified into 12 scopes divided into two sections (Annex I includes list of MPIs numbered).

#### *3.1.1. Alignment with Other National Strategies and Plans*

One of the most significant parameters for studying the viability of MPIs at the national level in Spain is the 'Alignment with other national strategies and plans'. Eight national plans and strategies are identified (Fig. 2). The main one, related to 49 MPIs from 9 scopes, is the latest 2020 update of the 'Long-term strategy for energy rehabilitation in the building sector in Spain', the ERESEE 2020 [5], drafted as the national LTRS at the request of the European legislation; this latest update was published after Recommendation (EU) 2019/786 [2], so the indicator-based assessment framework was already contemplated, hence, they have a high degree of alignment. More aligned strategies and plans are also identified, such as the 'Long Term Decarbonisation Strategy 2050' (EDLP) [6], developed by the Ministry for Ecological Transition and Demographic Challenge (MITECO) [7]; this strategy is connected with eight MPIs from five scopes in indicators related to energy impact. In addition, as another plan of a more general nature, is the 'Recovery, Transformation and Resilience Plan' (PRTR) [8], connected with six MPIs from four scopes, for the assessment of strategic measures to promote the energy improvement of buildings. It is also worth highlighting the presence of specific plans such as the 'National Strategy Against Energy Poverty' (ENPE) [9], elaborated also by MITECO, which makes use of common indicators for the assessment of energy poverty, aligned with the indicators that measure the energy poverty, five MPIs from two scopes. The 'National Housing Plan' (PEV) [10] also deals with specific targets, coinciding with two MPIs dealing with public investments in the energy improvement of residential buildings. Finally, with a lower significant relation, but also remarkable, other national strategies and plans have been identified, like the 'National Integrated Energy and Climate Plan' (PNIEC) [11], the 'Action plan for the implementation of the 2030 agenda' [12], and the 'Strategic Plan for Vocational Training in the Education System 2019–2022' (PEFPSE) [13]. Likewise, 12 MPIs do not have any alignment with national plans or strategies.

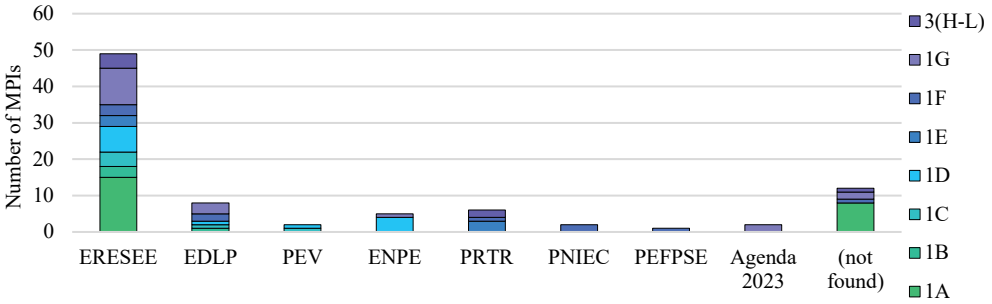


Fig. 2. Number of aligned MPIs to national strategies and plans, by scopes. Plans and strategies: ERESEE: Long renovation strategy of Spain [5]; EDLP: Long term decarbonisation strategy [6]; PEV: National housing plan [10]; ENPE: National strategy against energy poverty [9]; PRTR: Recovery, transformation and resilience plan [8]; PNIEC: National integrated energy and climate plan [11]; PEFPSE: Strategic plan for vocational training in the education system [13]; Agenda 2030: Action plan for the implementation of the 2030 agenda [12].

### *3.1.2. Data Source Entities*

In terms of the 'Data source entities', 13 entities are identified as potential data sources to feed the development of the MPI answering 49 out of the 70 MPIs, being 21 the MPIs without any potential data source (Fig. 3). The most common data source entity is the National Statistics Institute (INE) [14] that provides data for 22 MPIs, 10 of them from the scope '1A' as the characterization of the national building stock. The ministries of the Spanish Government also are a potential data source, with data for 18 MPIs, being the Ministry of transport and the Ministry of environment (MITECO) [7] the biggest data sources related with energetic and environmental MPIs.

The Institute for Energy Diversification and Saving (IDAE) [15] also provides data for seven MPIs, most of them from the '1A' scope, answering the energetic characterization of the building stock. Similar to other entities, the Cadastre [16] and the Public Finance [17] also provide data for MPIs related to the national stock characterization and economic investment.

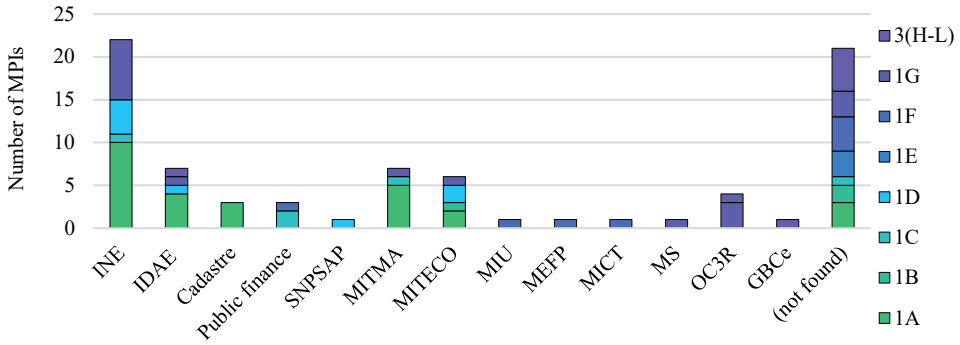


Fig. 3. Data source entities for the MPIs, indicating the number of MPIs for each data source entity classified by scopes of the MPIs. Data Sources: INE: National statistics institute [14]; IDAE: Institute for energy diversification and saving [15]; Cadastre [16]; Public Finance [17]; SNPSAP: National Publicity System for Public Subsidies and Aid [18]; MITMA: Ministry of transport, mobility, urban agenda [21]; Ministry of MITECO: Ministry of environment [7]; MIU: Ministry of universities [22]; MEFP: Ministry of education and vocational training [23]; MICT: Ministry of industry commerce and tourism [24]; MINECO: Ministry of economy and digital transformation [25]; MS: Ministry of health [26]; OC3R: 'Observatorio Ciudad 3R' organization [19]; GBCe: Green Building Council España [20].

Additionally, on a smaller scale, the National Publicity System for Public Subsidies and Aid (SNPSAP) [18] offers data about public investments; besides, as another types of entities, the organizations 'Observatorio Ciudad 3R' (OC3R) [19] and 'Green Building Council España' (GBCe) [20] also provide usable data for certain MPIs.

### *3.1.3. Data Collection Method*

The 'Data collection method' plays an important role in the data quality evaluation. This parameter involves analysing the data collection method used by the entities to collect data. The study has identified four main groups of data collection methods for the 49 MPIs with available data sources, while the other 21 MPIs are categorized as 'no available data' (Fig. 4).

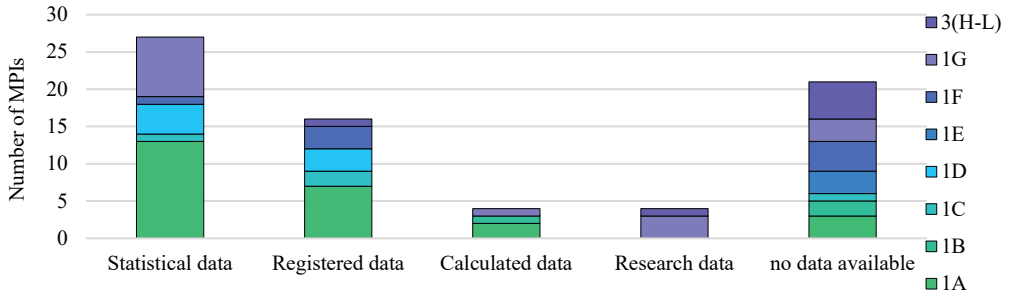


Fig. 4. Data collection methods for the MPI, indicating the number of MPIs for the data recompilation method of the data found, classified by scopes of the MPIs.

The collection method is directly linked to the data source, being the same type for each source entity. The data provided by the main data source, the INE, together with some data of IDAE and certain ministries, like MITMA, MEFP, MITECO and MS, are 'statistical data'; statistical collection methods are used for more than the half of the MPIs with available data, 27 MPIs. The second most used collection method is the 'registered data', linked to 15 MPIs, which is directly measured by the data recorded by the responsible entities like the Cadastre, IDAE, the Public finance, and the ministries of MINECO, MITECO, MIU and MICT. The 'registered data' can be considered very accurate and reliable as it provides the direct measurement of the official data. Most of the 'registered data' belongs to the evaluation scope of '1A' that evaluates the physical and energetic characterization of the national building stock, linked to the data provided by the registry of the cadastre and IDAE respectively. For instance, the MPI number 37 evaluates the '% of buildings with the lowest energy classes' and the data from the energy performance certificates (EPC) is registered by IDAE and MITECO, which can be directly used to develop the MPI with the exact measurement, independently the reliability of EPCs. The study has also found 'calculated data' considered as official data, which are theoretical unlike the previous data collection methods, provided by the IDAE and the ministry of MITECO, related to five energetic and environmental MPIs. The accuracy of 'calculated data' is difficult to define but in certain evaluation fields where it is not possible to register of measure it can be a good solution. Finally, the entities OC3R and GBCe provide 'research data' for four MPIs, obtained from research works, with a similar nature to the calculated data but without being official. In the same way as the calculated data, even if the accuracy of these theoretical data is difficult to define, they can be a good solution.

### 3.1.4. Processability and Georeferencing of Data

In terms of data quality is important to evaluate the processability and georeferencing of data to develop the MPIs. The study has considered the data processable when the data source offers the option to export or download the data in files based in text that can be read by a machine (.txt, .json, .xlsx, .csv or similar). This way 31 MPIs have processable data against the 19 non-processable, without taking into account the MPI without available data (Fig. 5). This feature is linked to the data source entity; all the data coming from the INE and Public finance is processable in a normalized format that can make easier the process of data importation. Furthermore, other entities offer some processable data like IDAE, SNPSAP and the ministries of MITECO, MIU, MEFP, MINECO and MICT. In terms of georeferencing, only one data for one MPI is georeferenced (Fig. 5), the MPI number 61, assessing the 'GDP growth in the construction sector' provided by the INE.

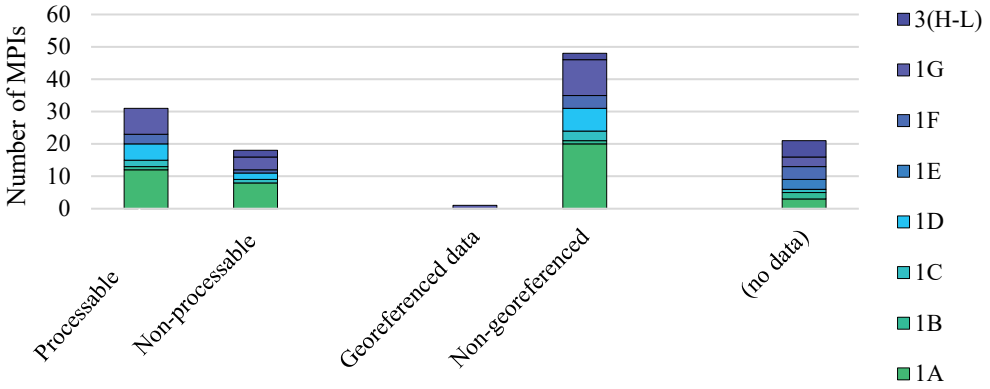


Fig. 5. Processability and georeferencing of data, indicating the number of MPIs for processable, non-processable, georeferenced and non-georeferenced data.

### 3.1.5. Development Viability

Finally, taking into account the previous analysis and researching the quality of the available data, the development viability of the MPIs is evaluated in accordance with the requirements of the Commission Recommendation (EU) 2019/786 [2]. The analysis considers the following features of the available data for each MPI: data update frequency, last update, data transmission channel, source data processing method, data accuracy, measurement scale and the possible data limitations. The results show that 21 MPIs are viable to develop, 14 MPIs are possible to develop partially and 35 MPIs are not possible to develop (Fig. 6).

In scope '1A', which pertains to the 'Overview of the national building stock', it is not possible to fully develop a large number of MPIs, specifically nine out of 23 are completely viable. These MPIs deal with the quantification of the building stock according to certain characteristics and energy aspects. On the other hand, four of the 23 MPIs can be partially developed. Finally, 10 of the 23 MPIs cannot be developed due to the lack of data in fields such as refurbished floor area, EPC and nearly zero energy buildings.

For scope '1B' about the 'Determining cost-effective approaches to reforms' it is not possible to find data for the two MPIs concerning the cost-effectiveness. In contrast, the MPI no. 11 measuring the 'Total energy saving potential' allows the complete development.

The scope '1C' that evaluates the 'Policies and actions aimed at stimulating deep and economically profitable renovations of buildings' is not feasible in Spain, as it is not possible

to develop any MPI in a complete way, and only two out of four MPIs can be developed partially. This is due to, on the one hand, the segregation of data in different entities which makes it impossible to make a conclusive measurement; and, on the other hand, there are no enough available data on the development of the role of building renovation policies.

Regarding scope '1D', the 'Overview of policies and actions targeting the least efficient building segments of the national building stock', the available data enable the complete development of all indicators addressing fuel poverty. However, there are enough no available data about public investments dedicated to tackling these problems and neither about the percentage of dwellings with low energy efficiency.

An example that identifies barriers on the assessment of building renovation is the scope '1E' about the 'Policies and actions for all public buildings', under which it is not possible to develop any of the 3 MPIs that make up the scope.

Another challenging scope is the '1F', the 'Summary of national initiatives to promote smart technologies and well-connected buildings and communities, as well as training and education in the building and energy efficiency sectors'. In this case it is not possible to develop half of the MPIs, 4 out of 8, and two only partially, as there are data collection difficulties in terms of investments in smart technologies. Only one indicator has been fully developed, which deals with the number of installers skilled in new technologies and working practices.

Scope '1G' on 'Estimation, based on real data, of expected energy savings and wider benefits such as health, safety and air quality' contains a wide range of indicators assessing the energy, social, economic and welfare domains. In the energy field there are several barriers, and only some of them can be partially developed; in the social field some of the indicators can be completely developed thanks to statistical data; and in the case of the welfare indicators it contains the most feasible indicators to develop derived from statistical data and health reports.

Finally, in the 'section 3', the scopes '3H', '3I', '3J', '3K', and '3L', which deals with the evaluation 'To support the mobilisation of investments in renovation necessary to achieve the objectives referred to in section 1', it is not possible to develop any of the indicators proposed, although they are explicitly mentioned in national plans and strategies.

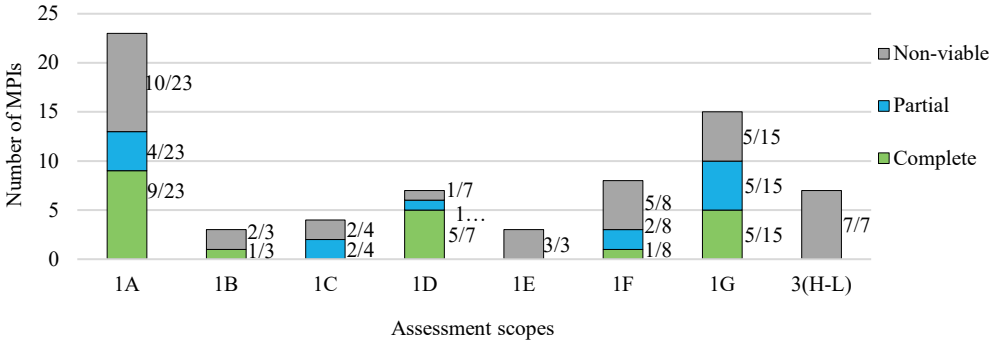


Fig. 6. Viability to develop the MPI, indicating the level of viability of the MPI grouped by assessment scopes and classified into three viability levels: complete viability, partial viability and non-viable.

### *3.2. Expert Round Table (ERT) Based Prioritization of the MPIs*

According to the previous study about the MPIs [4], also part of LOCAL-REGEN project, is necessary to shortlist and prioritize them by selecting the significant indicators in order to make an efficient the assessment framework. To study the relevance of the MPIs in line with the targets of the EU's policy, an ERT consisting of 39 professionals from different national organizations focused in the energy efficiency in buildings carried out the prioritization of the MPIs for the Spanish context. The ERT was stablished as one of the tasks within the LOCAL-REGEN project, as the workshop titled 'Strategies for decarbonisation of the building stock towards European Union objectives' at the international conference EESAP-13 [27]. The ERT was formed by members from various entities, including University of Zaragoza, University of Seville, Alokabide (Public company in charge of social renting), Tekniker, Polytechnic University of Madrid, University of Valladolid, EIBHO company, CAVIAR research group (EHU/UPV), ENEDI research group (EHU/UPV) and other independent professionals. The prioritization process was involved dividing the ERT in 10 groups, followed by discussions before awarding the points. The ERT prioritized eight MPIs that scored equal or higher than 4 points (Table 1).

As a result, the most relevant MPIs selected were the ones assessing the environmental impact and the energetic behaviour, namely the MPIs no. 30, 51 and 56, from the scopes '1A' and '1G'. Another prioritized field is the energetic evolution of the building stock, quantifying the renovation process by the MPIs no. 15, 37 and 38. Social aspects also have been prioritized by the MPI no. 33 assessing the energy poverty. Finally, the MPI no. 41 evaluates the integration of new technologies as the key towards the efficient use of energy as one possible strategy to reduce the energetic consumption of the buildings as it was reasoned in the ERT. The selected MPIs can be considered the expected ones, which are similar to the current trends of the KPIs used in the assessment methods of the European RTD projects investigated in the previous study [4], predominating the energetic and environmental indicators and including social aspects together with the integration of new technologies but with a lower importance level.

TABLE 1. SELECTED MPIS FOR THE ERT BASED PRIORITIZATION PROCESS

| MPI | Scope | Definition | Score |
|---|---|---|---|
| 30 | 1C | Energy savings from deep renovations | 11 |
| 15 | 1A | Annual % of renovated buildings per renovation type | 7 |
| 33 | 1D | Energy poverty indicator | 6 |
| 51 | 1G | Actual energy savings achieved | 5 |
| 56 | 1G | Reduction of whole life carbon | 5 |
| 37 | 1D | % of buildings in lowest energy classes | 4 |
| 38 | 1E | $m^2$ of renovated public buildings per building type | 4 |
| 41 | 1F | No of buildings quipped with 'building energy management systems' or similar | 4 |

### *3.3. Applicability Analysis of the Priority MPIs*

When analysing the viability of the prioritizing MPIs (Table 1) in depth and considering the viability factors studied in Section 3.1, several levels of viability are identified (Table 2). The analysis reveals that the development of the MPIs is only complete in three cases, one MPI is partially viable and the rest four MPIs are non-viable due to the lack of data or poor quality.

The completely viable MPIs are linked to the data sources of the INE, MITECO and IDAE, with the data provided by the INE being processable, namely the MPIs no. 15, 33 and 37. Besides, the MPI no. 51, which assesses the 'Actual energy savings achieved', is partially viable due to the low reliability of the data provided by *'Observatorio Ciudad 3R'*. The data collected through research work, indirectly calculated from non-official raw data, is not considered viable for the assessment, as it contradicts the Commission Recommendation (EU) 2019/786 [2], which emphasizes the importance of consistent and reliable data for determining measurable indicators. On the other hand, the four non-viable MPIs are the no. 30, 56, 38 and 41, which do not have any potential data source, but they are aligned with the national strategies and plans ERESEE, EDLP and PRTR. Both MPIs no. 30 and 56, assessing the 'energy savings from deep renovations' and the 'reduction of whole life carbon' are directly linked with the energetic and environmental targets; moreover, they are also aligned with ERESEE 2020, which analyses current energy consumption, energy savings and emissions in the residential, public tertiary and private tertiary sectors and sets savings targets for the decade 2020–2030 in chapter 6 [5]. Likewise, the objectives of EDLP are also linked to the mentioned MPIs no. 30 and 56, emphasizing the need to reduce the primary and final energy consumption and external energy dependence, in line with European Commission's target for 2030 from a 40 % reduction in emissions compared to 1990 to 55 % [6]. Similarly, the MPI no. 38, which assess the '$m^2$ of renovated public buildings' is also related to ERESEE 2020, which diagnoses the energy consumption of the public buildings in chapter 2.5 and proposes new renovation strategies for the public sector buildings in chapter 8.3 [5]. Furthermore, the 'Recovery, transformation and resilience plan' (PRTR) includes a programme to promote the renovation of public buildings [8], which is completely aligned with the MPI no. 38; this programme is articulated through transfers and aid to the regional and local administration, accompanied by advisory, coordination and support measures [8]. Lastly, the fourth non-viable MPI, the no. 41, assesses the 'No of buildings equipped with building energy management systems or similar smart systems' and is linked to the EDLP. This strategy expresses the importance of manageable renewable technologies, storage systems, smart grids, as well as demand-side management mechanisms [6], however, no further data or proposals are provided.

TABLE 2. VIABILITY PARAMETERS OF THE PRIORITIZED MPIS

| MPI | Alignment with national strategies | Data source entity | Collection method | Process. of data | Georef. of data | Development viability of the MPI |
|---|---|---|---|---|---|---|
| 15 | ERESEE | INE | Statistical | Yes | No | Complete |
| 33 | ERESEE, ENPE | INE | Statistical | Yes | No | Complete |
| 37 | ERESEE, EDLP | MITECO, IDAE | Registered | No | No | Complete |
| 51 | ERESEE, EDLP | OC3R | Research | No | No | Partial |
| 30 | ERESEE, EDLP | (not found) | (no data) | (no data) | (no data) | Non-viable |
| 38 | ERESEE, PRTR | (not found) | (no data) | (no data) | (no data) | Non-viable |
| 41 | EDLP | (not found) | (no data) | (no data) | (no data) | Non-viable |
| 56 | ERESEE, EDLP | (not found) | (no data) | (no data) | (no data) | Non-viable |

## 4. DISCUSSION

The results show that there is a high correlation between the requirements of the EU and the national strategies and plans, with the national LTRS, the ERESEE, as the main strategy aligned with EU's energy policy. However, there is a big lack of data availability for the application of the MPIs, even if it is taken into account only the 49 MPIs aligned with the ERESEE 2020, being only viable the development of 17 of them. In terms of data collection method, this study has considered acceptable the ones based in registered data, statistical data and calculated data, limiting the data coming from official entities, and not considering the data provided by research or similar non-official data collection methods due to the unknown reliability. The quality of data according to the processability shows that the main data sources do provide processable data but certain entities that have the data that could be used do not offer this possibility, like Cadastre, MITMA, MITECO and the Public finance. Besides, the georeferencing is almost null, making unviable to segregate the assessment locally.

The low viability of MPIs does not necessarily mean the impossibility of applying an efficient assessment using all the MPIs, as demonstrated in the previous study, which shows that not all them should necessarily be applied [4]. The ERT prioritization is the solution proposed to evaluate the effectiveness and importance of the MPIs. Thus, the study considers important to contrast the applicability analysis of the prioritized MPIs and the analysis of concordance with key performance indicators (KPI) of the European RTD projects carried out by the previous work [4]; this is because the RTD projects reflect the assessment that currently is feasible to apply aligned with the EU targets. This way is possible to identify the key indicators that are possible to apply, and also the indicators that can be relevant but that are not often applied due to certain barriers. The ERT selected the most prioritizing three MPIs the no. 30, 51 and 56 from the assessment scopes '1A' and '1G', which assess the energetic and environmental field. This coincides with the study about the KPIs of the European RTD projects, which identifies the scopes '1A' and '1G' of the EU's regulations as the third and second scopes with the highest degree of concordance with the RTD projects [4]. However, the applicability analysis shows that none of these three energetic and environmental MPIs are viable to develop due to the lack of reliable data; particularly, only for the MPI no. 51 about the 'actual energy savings achieved' was identified a data source, but it was considered partially viable due to the low reliability of data. This result matches with the mentioned previous work [4], which identified the differences between calculated and actual energy savings as the barrier for such indicators as it demonstrated the study by Burman E., *et al.* [28]. Besides, the MPI no. 56 about the 'Reduction of whole life carbon', do not have any available data, but there are several studies about the life cycle analysis in the renovation of buildings that analyse the scope and boundaries [29], the application of life cycle perspective in district level [30]. The relevance of the social field by the evaluation of the energy poverty is also prioritized with the MPI no. 33, and it also coincides with European RTD projects as the most applied indicator in the social field according to the previous study [4], that identified different methodologies for the evaluation [31]. This MPI was categorized as completely viable, being processable, with the statistical data provided by the INE [14]; however, this data is not georeferenced, so it could be interesting in order to make possible the detection of vulnerable zones. On the other hand, the prioritized MPIs no. 15, 37 and 38, about the quantifying of the renovation process, did not have the same importance in the mentioned previous study, which did not find any significant concordance with the RTD projects' assessment frameworks. In contrast, two of these are viable to develop by the statistical data from the INE [14] and the registered data of construction licences from

MITMA [21]. Finally, the prioritized field of the integration of new technologies by the MPI no. 41 so not coincide with RTD projects [4], so this particular indicator may be not as interesting in the RTD projects as in the assessment of the national stock. Moreover, the applicability analysis shows that the development of this MPI, no. 41, is not viable, and there is no correlation with the ERESEE 2020 [5].

According to the results, the study suggests the need to quantify and assess the renovation process of the national building stock, being the national public administration the responsible to develop an efficient assessment framework. The study identifies the main entities with available data as well as the strategies with the key points to develop the evaluation of certain assessment fields. The study suggests initiatives like the improvement of existing data collection entities like INE (entity that offer data for most of MPIs and with the highest degree of processability), which can enlarge the evaluation field and cover a major area in terms of the assessment for the building renovation process. Moreover, entities that are responsible of the national strategies aligned with the fields that need to be assessed could also be responsible of the assessment of certain fields, like MITECO, that elaborated the EDLP [6], strategy aligned with four prioritizing MPIs that are not possible to develop completely. Furthermore, the nowadays European RTD projects as well as the scientific literature offer many mechanisms to challenge the development of MPIs. The digital building logbook (DBL) has been applied in many European projects [32], [33] that propose the building passport as alternative to promote national data sources [34]. Nowadays there are also of advanced calculation tools and methods [35], [36] that can be used to calculate the MPIs. Moreover, the techniques based on monitorization and calibration can improve the reliability of data to cover the so-called energy performance gap [37], [38].

## 5. CONCLUSION

The study aims to address the need of assessing the renovation of the national building stock analysing the effective application of the MPIs of the Commission Recommendation (EU) 2019/786 [2]. The results show that a significant portion of the whole MPIs based framework present a low viability in terms of data availability, as well as data fragmentation across various entities with diverse data collection methods, updates, formats, and data quality. Despite this, the eight MPIs prioritized by the ERT exhibit a strong concordance with the KPIs used in the main European RTD projects, suggesting that certain MPIs can be effective in assessing the renovation of the national building stick. Nevertheless, the study reveals that the applicability level of the eight prioritized MPIs is low due to the low data availability and quality.

In conclusion, the study identifies the main barriers for the effective applicability of the MPIs, highlighting the fragmentation of data and the lack of structured data collection methods. Besides, the study also points the key points for the development of the assessment framework based on MPIs; potential entities are identified that already collect reliable and high-quality data, like INE and MITECO, which can expand their scope to cover the assessment needs. Moreover, new technologies like the DBL and monitoring can improve the data availability and reliability.

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## REFERENCES

[1] European Commission. Energy efficiency in buildings. Brussels: EC, 2020.
[2] Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation (notified under document C(2019) 3352). *Official Journal of the European Union* 2019:L 12/34.
[3] Arbulu M., Grijalba O., Oregi X. Analysis of Energy Retrofit Assessment Methodologies in Buildings by European Research Projects. *Environ. Clim. Technol.* 2021:25(1):265–280. https://doi.org/10.2478/rtuect-2021-0019
[4] Arbulu M., et al. Barriers and challenges of the assessment framework of the Commission Recommendation (EU) 2019/786 on building renovation by European RTD projects. *Energy Build.* 2022:269:112267. https://doi.org/10.1016/j.enbuild.2022.112267
[5] Ministry of Transport Mobility and Urban Agenda. Government of Spain. ERESEE 2020. Update of the long-term Strategy for Energy Rehabilitation in the Building Sector in Spain. 2020. [Online]. [Accessed 01.03.2023]. Available: https://www.mitma.es/el-ministerio/planes-estrategicos/estrategia-a-largo-plazo-para-la-rehabilitacion-energetica-en-el-sector-de-la-edificacion-en-espana (in Spanish)
[6] Ministry for the Ecological Transition and the Demographic Challenge. Estrategia de Descarbonización a Largo Plazo 2050 (Long-Term Decarbonization Strategy 2050). Madrid: MITECO, 2020. (in Spanish)
[7] Ministry for the Ecological Transition and the Demographic Challenge [Online]. [Accessed 02.02.2023]. Available: https://www.miteco.gob.es (in Spanish)
[8] Government of Spain. Plan de Recuperación, Transformación y Resiliencia (Recovery, Transformation and Resilience Plan). Madrid: GS, 2021. [Online]. (in Spanish)
[9] Ministry for the Ecological Transition and the Demographic Challenge. Government of Spain. Estrategia Nacional Contra la Pobreza Energética 2019-2024 (National Strategy Against Energy Poverty 2019-2024). Madrid: Ministry for Ecological Transition, 2019. (in Spanish)
[10] Ministry of Transport Mobility and Urban Agenda. Government of Spain. Plan Estatal De Vivienda (State Housing Plan). [Online]. [Accessed 02.12.2021]. Available: https://www.mitma.gob.es/vivienda#Plan_Estatal_de_Vivienda_2018-2021 (in Spanish)
[11] Ministry for the Ecological Transition and the Demographic Challenge. Government of Spain. Plan Nacional Integrado de Energía y Clima 2021–2030 (National Integrated Energy and Climate Plan 2021–2030). Madrid: MITECO, 2020. (in Spanish)
[12] Ministry of Social Rights and Agenda. Plan de Acción para la Implementación de la Agenda 2030 (Action Plan for the Implementation of the Agenda 2030). Madrid: MITECO, 2018. (in Spanish)
[13] Ministry of Education and Vocational Training. Government of Spain. I Plan Estratégico de Formación Profesional del Sistema Educativo 2019–2022 (Strategic Plan for Vocational Training of Education system 2019–2022). Madrid: MITECO, 2019. (in Spanish)
[14] Statistics National Institute [Online]. [Accessed 02.02.2023]. Available: https://www.ine.es/en/index.htm
[15] Instituto para la Diversificación y Ahorro de la Energía (Institute for the Diversification and Saving of Energy) [Online]. [Accessed 02.02.2023]. Available: https://www.idae.es/en/home
[16] Catastro. Sede Electrónica del Catastro (Electronic Office of the Cadastre). [Online]. [Accessed 02.02.2023]. Available: https://www.sedecatastro.gob.es/ (in Spanish)
[17] Agencia Tributaria. Tax Agency [Online]. [Accessed 02.02.2023]. Available: https://sede.agenciatributaria.gob.es/Sede/en_gb/inicio.html
[18] SNPSAP. National Public Subsidies and Aid System [Online]. [Accessed 02.02.2023]. Available: https://www.pap.hacienda.gob.es/bdnstrans/GE/es/convocatorias (in Spanish)
[19] OC3R. City Observatory 3R [Online]. [Accessed 02.02.2023]. Available: http://www.observatoriociudad3r.com (in Spanish)
[20] GBCe. Green Building Council Spain [Online]. [Accessed 02.02.2023]. Available: https://gbce.es/ (in Spanish)

[21] MITMA. Ministry of Transport, Mobility and Urban Agenda [Online]. [Accessed 02.02.2023]. Available: https://www.mitma.gob.es/ (in Spanish)
[22] MIU. Ministry of Universities [Online]. [Accessed 02.02.2023]. Available: https://www.universidades.gob.es/ (in Spanish)
[23] MEFP. Ministry of Education and Vocational Training [Online]. [Accessed 02.02.2023]. Available: https://www.educacionyfp.gob.es/ (in Spanish)
[24] MINCOTUR. Ministry of Industry, Trade and Tourism [Online]. [Accessed 02.02.2023]. Available: https://www.mincotur.gob.es/ (in Spanish)
[25] MINECO. Ministry of Economic Affairs and Digital Transformation [Online]. [Accessed 02.02.2023]. Available: https://portal.mineco.gob.es/ (in Spanish)
[26] MS. Ministry of Health [Online]. [Accessed 02.02.2023]. Available: https://www.sanidad.gob.es/ (in Spanish)
[27] EESAP-13. International Conference in Energy Efficiency and Sustainability in Architecture and Planning. 2022 [Online[. [Accessed 01.02.2023]. Available: https://eesap.eu/index.php/en/home/
[28] Burman E., Mumovic D., Kimpian J. Towards measurement and verification of energy performance under the framework of the European directive for energy performance of buildings. *Energy* 2014:77:153–163. https://doi.org/10.1016/j.energy.2014.05.102
[29] Oregi X., Hernandez P., Hernandez R. Analysis of life-cycle boundaries for environmental and economic assessment of building energy refurbishment projects. *Energy Build.* 2017:136:12–25. https://doi.org/10.1016/j.enbuild.2016.11.057
[30] Lausselet C., Crawford R. H., Brattebø H. Hybrid life cycle assessment at the neighbourhood scale: The case of Ydalir, Norway. *Clean. Eng. Technol.* 2022:8:100503. https://doi.org/10.1016/j.clet.2022.100503
[31] Longo D., et al. Energy Poverty and Protection of Vulnerable Consumers. Overview of the EU Funding Programs FP7 and H2020 and Future Trends in Horizon Europe. *Energies* 2020:13(5):1030. https://doi.org/10.3390/en13051030
[32] iBroad project. CORDIS [Online]. [Accessed 11.12.2021]. Available: https://cordis.europa.eu/project/id/754045
[33] ALDREN project [Online]. [Accessed 01.03.2023]. Available: https://aldren.eu/
[34] Gómez-Gil M., et al. The Digital Building Logbook as a gateway linked to existing national data sources: The cases of Spain and Italy. *J. Build. Eng.* 2023:63:105461. https://doi.org/10.1016/j.jobe.2022.105461
[35] Iturriaga E., et al. A MILP optimization method for energy renovation of residential urban areas: Towards Zero Energy Districts. *Sustain. Cities Soc.* 2021:68:102787. https://doi.org/10.1016/j.scs.2021.102787
[36] Carreras F., Steinmaurer G. Influence of Data Reduction Methods on Economic Evaluation of Energy-Communities. *Environ. Clim. Technol.* 2022:26(1):1310–1322. https://doi.org/10.2478/rtuect-2022-0099
[37] Pagliaro F., et al. Assessing building energy performance and energy policy impact through the combined analysis of EPC data – The Italian case study of SIAPE. *Energy Policy* 2021:159:112609. https://doi.org/10.1016/j.enpol.2021.112609
[38] Motuzienė V., et al. Energy Performance Gap Analysis in Energy Efficient Residential Buildings in Lithuania. *Environ. Clim. Technol.* 2021:25(1):610–620. https://doi.org/10.2478/rtuect-2021-0045

# ANNEX 1

ANNEX 1 TABLE. LIST OF THE MEASURABLE PROGRESS INDICATORS (MPI) OF THE COMMISSION RECOMMENDATION (EU) 2019/786

| Assessment Scope | No. | Measurable progress indicator (MPI) |
|---|---|---|
| Section 1 | | |
| 1A) Overview of the national building stock, based, as appropriate, on statistical sampling and expected share of renovated buildings in 2020. | 1 | No of buildings per building type |
| | 2 | No of buildings per building age |
| | 3 | No of buildings per building size |
| | 4 | No of buildings per climatic zone |
| | 5 | No of dwellings per building type |
| | 6 | No of dwellings per building age |
| | 7 | No of dwellings per building size |
| | 8 | No of dwellings per climatic zone |
| | 9 | No of $m^2$ per building type |

| | | |
|---|---|---|
| | 10 | No of $m^2$ per building age |
| | 11 | No of $m^2$ per building size |
| | 12 | No of $m^2$ per climatic zone |
| | 13 | Annual energy consumption per building type |
| | 14 | Annual energy consumption per end use |
| | 15 | Annual % renovated buildings per renovation type |
| | 16 | Annual % renovated buildings per building sector (residential / non-residential) |
| | 17 | Renovated $m^2$ per building sector |
| | 18 | Renovated $m^2$ per building size |
| | 19 | Renovated $m^2$ per building age |
| | 20 | Number of EPCs per building type |
| | 21 | Number of EPCs per building class |
| | 22 | Number of 'nearly zero energy buildings' per building sector |
| | 23 | $m^2$ of 'nearly zero energy buildings' per building sector |
| 1B) Identification of cost-effective approaches to renovation relevant to the building type and climatic zone, considering potentially relevant trigger points, where applicable, in the life-cycle of the building. | 24 | Cost-effectiveness of main renovation measures per building type |
| | 25 | Cost-effectiveness of main renovation measures per climatic zone |
| | 26 | Total energy saving potential per building sector |
| 1C) Policies and actions to stimulate cost-effective deep renovation of buildings, including staged deep renovation, and to support targeted cost-effective measures and renovation, for example by introducing an optional scheme for building renovation passports. | 27 | Total and annual % of buildings undergoing deep and 'nearly zero energy buildings' renovation |
| | 28 | Public incentives for deep renovation |
| | 29 | Public and private investments in deep renovations |
| | 30 | Energy savings from deep renovations |
| 1D) Overview of policies and actions to target the worst-performing segments of the national building stock, split-incentive dilemmas and market failures, and an outline of relevant national actions that contribute to the alleviation of energy poverty | 31 | Public investments in policy addressing the issues mentioned |
| | 32 | % of rented houses with EPCs below a certain performance level |
| | 33 | Energy poverty: % of people affected |
| | 34 | Energy poverty: % of disposable household income spent on energy |
| | 35 | Energy poverty: arrears on utility bills |
| | 36 | Energy poverty: population living in inadequate dwelling conditions |
| | 37 | % of buildings in lowest energy classes |
| 1E) Policies and actions to target all public buildings. | 38 | m2 of renovated public buildings per building type |
| | 39 | m2 of renovated public buildings per building size |
| | 40 | m2 of renovated public buildings per climatic zone |
| 1F) Overview of national initiatives to promote smart technologies and well-connected buildings and communities, as well as skills and education in the construction and energy efficiency sectors. | 41 | No of buildings equipped with 'building energy management systems' or similar smart systems per building type (residential /non-residential) |
| | 42 | Public and private investments in smart technologies (including smart grids) |
| | 43 | Citizens participating in energy communities |
| | 44 | No of graduated students in university courses with focus on energy efficiency and related smart technologies |

| | | |
|---|---|---|
| | 45 | No of graduated students in professional/technical training (EPC certifiers, HVAC inspectors, etc.) |
| | 46 | No of installers skilled in new technologies and working practices |
| | 47 | Budget of national research programmes in the field of building energy efficiency |
| | 48 | Participation of national universities in international scientific research projects (e.g., H2020) on energy efficiency in buildings- related topics |
| g) Evidence-based estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality. | 49 | Reducción de los costes energéticos por vivienda |
| | 50 | Reduction in energy costs per household / decrease in energy poverty |
| | 51 | Actual energy savings achieved |
| | 52 | Average/aggregate indoor air quality indices (IAQIs) |
| | 53 | Thermal comfort index (TCI) |
| | 54 | Cost of avoided illnesses |
| | 55 | Reduction in health costs attributable to energy efficiency measures |
| | 56 | Reduction of whole life carbon |
| | 57 | Disability Adjusted Life Year (DALY)/Quality Adjusted Life Year (QALY) improvements attributable to the improvement of building stock and living conditions |
| | 58 | Labour productivity gains from better working environment and improved living conditions |
| | 59 | Reduction of emissions |
| | 60 | Employment in the building sector (No of jobs created per EUR million invested in the sector) |
| | 61 | GDP increase in the building sector |
| | 62 | % energy imports for the Member State (energy security measures) |
| | 63 | Removal/prevention of accessibility barriers for persons with disabilities |
| **Section 3** | | |
| 3A) The aggregation of projects, including by investment platforms or groups, and by consortia of small and medium-sized enterprises, to enable investor access as well as packaged solutions for potential clients. | 64 | No of integrated/aggregated projects |
| 3B) Reduction of the perceived risk of energy efficiency operations for investors and the private sector | 65 | Perceived risk of energy efficiency operation (survey-based) |
| 3C) Use of public funding to leverage additional private-sector investment or address specific market failures; | 66 | Public investments as percentage of total investments in energy saving |
| | 67 | Public-private partnership initiatives |
| 3D) Guiding investments into an energy efficient public building stock, in line with Eurostat guidance | 68 | Investment in energy efficiency renovation on the public building stock |
| 3E) Accessible and transparent advisory tools, such as one-stop shops for consumers and energy advisory services, on relevant energy efficiency renovations and financing instruments. | 69 | One-stop shop initiatives in place |
| | 70 | One-stop shop initiatives in place Awareness-raising initiatives (number, target audience reached, target audience taking action) |