BuiltHub

# DELIVERABLE 3.1: Inventory structure and main feature and datasets

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BuiltHub

# Disclaimer



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# Abbreviations:

| | |
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| AB | Apartment Block |
| BSO | Building Stock Observatory |
| CDD | Cooling Degree Days |
| DH | District Heating |
| DHW | Domestic Hot Water |
| EC | European Commission |
| EED | Energy Efficiency Directive |
| EPBD | Energy Performance of Buildings Directive |
| EPC | Energy Performance Certificate |
| EU | European Union |
| FEC | Final Energy Consumption |
| GA | Grant Agreement |
| GHG | Green House Gas |
| H2020 | Horizon 2020 Project |
| HDD | Heating Degree Days |
| HP | Heat pump |
| LPG | Liquefied Petroleum Gas |
| MFH | Multi-family House |
| MS | Member State |
| RED | Renewable Energy Directive |
| RES | Renewable Energy Sources |
| SC | Space Cooling |
| SFH | Single-family House |
| SH | Space Heating |
| UED | Useful Energy Demand |

# Note for the reader:

Please note that in this report energy consumption is intended as “Final energy consumption” (FEC) which can be defined as the energy input of the device providing energy in desired form (e.g. in the case of space cooling the final energy consumption is the energy input provided to the cooling machine). On the other hand, when speaking about energy demand, please note that it is meant as “Useful energy demand” (UED), defined as the useful effect provided by the energy consuming device considered (e. g in the case of space cooling the useful energy demand is the net heat removed from the space/process to be cooled) [4].

Finally, a clarification regarding the meaning of database and dataset has to be done. In the following text, the term database is intended as a set of data organized and accessible using a database management system. In contrast, the term dataset is intended as a set of data which most times consists of one table in a database or, if not organized in a database, as a group of similar data [2].

# 1. Executive summary

The more and more critical issues related to climate change and natural resources deployment is strongly influencing the policies of the European Union (EU), pushing towards the development of more sustainable and green economies. The European Green Deal is one of the most iconic examples among the plans taken by the EU for damping its impact on the environment by reducing its energy consumptions, increase the efficiency of energy production systems and energy consuming sectors and by the decarbonization of all its processes. In order to address policies for reaching the aforementioned targets it is necessary to have a clear snapshot and a monitoring system of several sectors. One of the most energy consuming ones is the one related to the building stock of the residential and non-residential sector, responsible for about 40% of the EU energy consumption and around 36% of greenhouse gas (GHG) emissions. The Building Stock Observatory (BSO), launched in 2016, had the function of collecting building related data for the whole EU, however, the BSO database is nowadays characterized by a high percentage of data lacks and by other problems that this deliverable is reporting. The Horizon 2020 (H2020) BuiltHub Project aims to analyze the BSO, provide a feedback and a possible list of relevant indicators as well as build a community of data providers and data users allowing a continuous flow of data for the filling of data lacks in the BSO regarding the selected indicators. More details about these processes and project are addressed in this report.

The scope of this report (Deliverable D3.1 of Work Package 3 – Data Assembly) is to provide an overview on the status quo of the Building Stock Observatory (BSO) database and data mapper, so to create a more complete list of the most relevant indicators required in relation to energy consumption and building stock condition of the residential and non-residential sectors. Once listed the aforementioned indicators, fundamental for the work, among others, of European policy makers, a list of 30 datasets for the provision of these data has to be provided as required by the Grant Agreement (GA) of the Horizon 2020 BuiltHub Project. Detailed metadata have to be provided as well. The list of datasets for filling the gaps of the chosen indicators list can serve as starting point for the identification of possible stakeholders to engage and involve in the BuiltHub community, guaranteeing so a continuous flow and update of the available data. This process could also serve as an input for the digitalization of several data sources provided by national entities or research centers, so to allow an automatic transfer of data from one repository to another.

The BSO analysis brought to light several problems, which reduce the efficacy of the BSO itself in addressing the scope for which it was created in 2016. Among these problems it is possible to mention the high number of lacks in available data, especially for the non-residential sector, the not properly addressed metadata related to the data provided and the impossibility to display multiple indicators at the same time, not allowing so the possibility to compare or download several indicators together. More details concerning the BSO analysis are reported in chapter 3 of this report. A fulfilling and extended explanation of the choice of the indicators considered more relevant by the Consortium and their prioritization is instead reported in chapter 4. The majority of the chosen indicators is strictly related to the building stock status quo (e.g., clustering in construction vintages, information about occupancy and households, energy consumptions, construction elements main features) but information related to energy market and financial parameters for energy investments are provided as well.

Finally, in chapter 5 and Annex A, information related to the datasets and metadata chosen for filling the data lacks are reported, providing datasets not only for building stock related topics, but also related to socio-economic and climatic information.

# 2. Introduction

Climate change and natural resources deployment are nowadays one of the most relevant threats worldwide [3]. The reduction of the impact we have on the environment is one of the most challenging goals of the current century. Governments and policy makers from all over the world are aware of these issues and are trying to push towards a more sustainable development of our economies [1]. One of the most important plans at European level for developing a new, greener and more sustainable growth strategy is the European Green Deal [5]. Through this action plan carried out by all Member States (MS), Europe is trying to transform the Union in a modern, resource-efficient and competitive economy. The European Green Deal covers multiple macro areas pushing toward the decarbonization of these sectors within year 2050. In order to reach this target, the following actions are foreseen to be taken by all sectors of our economy:

- Investments in environmental-friendly technologies
- Development of cleaner, cheaper and healthier forms of private and public transport
- Support industry innovation
- Increase of the energy efficiency of buildings
- Energy sector decarbonization
- Improvement of global environmental standards

For reducing its carbon-footprint the EU took important effort and measures such as the reduction of greenhouse gas (GHG) emissions by more than 20% if compared to the levels of 1990, the increase in the share of energy produced by renewable energy sources (RES) by more than 20% if compared to the levels of year 2020 and the increase in energy efficiency so to gain a reduction higher than 20% in primary energy consumption [6], [7]. The purpose of reducing the GHG emission was increased to -40% within 2030 and has been now enhanced to a reduction of -55% according to the European Green Deal announced in September 2020 [8]. Several national policies have been designed for pushing constant and permanent energy efficiency improvements, so to increase the production of RES to 32% [9]. Higher and more ambitious targets have been set for 2050. An example is the target of reducing GHG emissions by 80-95% within 2050, so to fulfill the Paris Conference of Parties 2021 agreement [10].

In order to develop correct and futuristic policies several projects have been launched in the last few years. The Horizon 2020 (H2020) BuiltHub project focuses on the features and performances of the buildings, allowing the collection of important data and knowledge having a potential positive disruptive effect on the design by the EC of effective policies targeting buildings in view of the 2050 strategy and the European Green Deal [11].

In order to address effective policies, reliable and comprehensive data on the EU Building stock need to be provided. The reasons for focusing on the renovation and on a greener development of the building stock in Europe are multiple: First of all, buildings are responsible in the European Union for about 40% of its energy consumption and 36% of greenhouse gas emissions, representing so a clear obstacle in reaching the carbon-neutrality within 2050. The status quo of the building stock in Europe shows that around 75% of the buildings can be considered inefficient, resulting in high energy losses. The renovation of the building stock from an energy point of view could represent a big step forward in the reduction of the emissions and in reaching the decarbonization target of the European Green Deal. A clearer knowledge in the building stock characteristics could lead to an improvement in the energy renovation rates for the single MSs, which at the moment amounts to less than 1% of the national building stock (Member State rates vary from 0.4% to 1.2%) [12].

In order to keep track and keep monitored the characteristics and the energy performances of the European building stock, the EU Building Stock Observatory (BSO) [13] was launched in 2016. It had to provide complete data for all the MSs of the Union, analyzing and displaying them in a user-friendly format. Examples of monitored aspects by the BSO are:

- Energy efficiency-related parameters in buildings in EU countries and in the EU as a whole.
- Certifications schemes and their implementation.
- Economical parameters related to renovation of buildings [12].

However, as reported in chapter 3.3 Limitations of the building stock observatory, the BSO presents several limitations reducing its potential and its efficacy. For this reason, new projects have been launched, so to be able, among others, to provide a better service for reaching the Green Deal targets.

BuiltHub aims to provide not only a well-structured collection approach but also a benefits-based engagement strategy targeted to data and metadata providers, so to guarantee a continuous flow of building stock related data and metadata [11]. The added value information/knowledge that will be provided by BuiltHub will be used for convincing data owners to feed-in data to the BuiltHub project, trying so to enlarge as much as possible the community related to the project itself guaranteeing a continuous and always larger data flow.

This deliverable provides a complete report on the work carried out in analyzing the current state of the Building Stock Observatory [13] (please see chapter 3. Building stock observatory analysis17) and in the evaluation and prioritization of the indicators which could help in the development of well targeted policies (please see chapter 4. Indicators choice and prioritization). Furthermore, the metadata for the thirty most used datasets for the collection of the chosen indicators has been reported (more information can be found in chapter 5. Metadata identification and in Annex A).

# 3. Building stock observatory analysis

The first step done in order to address the target of Work Package 3 (WP3 – Data Assembly) of the BuiltHub project has been the analysis of the status quo of the Building Stock Observatory. First, the target of the BSO and its structure have been taken into account for a better comprehension of the project itself, then a data lack analysis has been performed for understanding if and which data where mainly missing. Finally, the limitations of the BSO itself have been analyzed for providing a better service and an improvement feedback.

## 3.1. Introduction to the building stock observatory

The Building Stock Observatory (BSO) [13] is a platform launched in 2016, collecting and displaying data related to the European building stock trying to provide not only the European Commission (EC) but also stakeholders, policy makers, national authorities and investors with comprehensive and detailed knowledge on Europe's building stock [14]. The main goal of the BSO was to provide data in user-friendly form for monitoring the building stock development, energy efficiency changes in the performance of buildings and the impact of the different buildings sectors on the energy consumptions [12]. One of the catalysts for the development of the BSO (under the service contract ENER/C3/2014-54) has been the review process of most of the EU legislations in 2016 – among which it is possible to mention the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED) and the Renewable Energy Sources Directive (RED) [15]. This project was therefore meant for monitoring and providing data for periodic evaluations of the impact that building policies and strategies had. The main purpose of the project can be summarized in the following focal points:

- Guarantee the monitoring of the EU27+UK building stock establishing a methodological framework for addressing important information to building energy efficiency policy makers.
- Collect data and provide a snapshot of the status quo of the European buildings stock.
- Create a portal for the dissemination of the collected knowledge.
- Develop and implement a strategy for the continuous monitoring of the buildings stock.

The BSO is considered to be an "essential piece" of the EU building energy efficiency policies given its monitoring and support scope for the EPBD implementation, for several articles of the EED (i.e. Art. 4-5) and of the RED (i.e. Art. 13- 14) [15]. The targets of the BSO are more than policy makers, in fact it also serves to researchers, industry, financial communities and an even wider range of stakeholders for finding specific data for supporting their work. The BSO provides indicators for a wide range of topics among which as example there are characteristics of the building stock, of the type of envelopes the buildings have, the heating/cooling systems they implemented and the energy performance certifications they obtained. Indicators for financial and social aspects have been taken into consideration in the

BSO as well. More details concerning the structure of the BSO itself and so explaining the aggregation level of the data and the specific types of indicators provided is reported in the following chapter (chapter 3.2 Structure of the building stock observatory) [15].

## 3.2. Structure of the building stock observatory

The BSO includes more than 250 indicators considered useful in supporting policy making decisions, which can be grouped in 10 main thematic areas: building stock characteristics, building renovation, nearly Zero-Energy Buildings, energy consumption, building shell performance, technical building systems, certification, financing, energy poverty and energy market. The aforementioned areas are described in the following bullet points, also providing an idea of the type of indicators they are represented by:

1. **Building stock characteristics**

In this area indicators providing a clear picture of the complete building stock of the EU27+UK have been collected. All information related to building stock is expressed not only in number of dwellings, but also in number of buildings, useful floor area and share of building stock. The BSO also provides further clustering such as construction vintages, ownership, size, occupancy level, building type and location.

2. **Building renovation**

Parameters related to renovation of buildings are mainly divided in three indicators: i.e. “Normal” renovation (just a part of the building shell is renovated), “Major” renovation (full economic energy potential is reached by the renovation) and finally “Deep” renovation (According to the EPBD, major renovation is defined as one affecting 25% of the building envelope or where the total cost related to the building envelope or the technical building systems is 25% or more of the value of the building) [16]. Data for building renovation are few and really fragmentated.

3. **Nearly Zero-Energy Buildings (NZEBs)**

Indicators concerning the number of NZEB certifications and buildings present in the European building stock have been reported in the BSO.

4. **Energy consumption**

Indicators related to energy consumption are mainly divided by end-use and by energy carrier, so to provide a clear idea of where energy is used and from where it is coming. The main sectors for which energy consumption has been evaluated are space heating and cooling, domestic hot water (DHW) preparation, ventilation, lighting, cooking and other appliances. The energy mix covered is the one for electricity generation and also takes into account district heating (DH) and renewable sources.

5. **Building shell performance**

The main indicator provided by the BSO for characterizing the building shell performance is the thermal transmittance (U-Value), provided for windows, external walls, roof, floor, skylights and doors and clustered according to the different construction vintages. Furthermore, information concerning the type of glazing installed and air tightness of the building are provided.

6. **Technical building systems**

The BSO provides indicators related to the type of technical systems used in buildings not only for space heating but also for DHW preparation, lighting, and ventilation. The results can be shown either in total amount of dwellings installing a certain technical system or in a share of the building stock installing the same technical system considered. When available, also information concerning conventional and condensing boilers, solar heating systems and heat pumps have been provided in form of share in the total number of systems.

7. **Certifications**

Energy performance certifications (EPCs) are of great importance for the European policies, thus some indicators related to them have been collected within the BSO. They generally indicate the absolute number of labels per category (A-G) but also when available the building stock data shares of labels. Concerning certification, a high number of data lacks in the BSO has been noticed.

8. **Financing**

One of the most important actions to evaluate for improving the European building stock is the financing of the energy efficiency renovation actions. For this reason, two indicators such as the average investments for renovation (deep and major renovation) and the energy savings achieved per renovation type have been taken into consideration by the BSO. These allow the policy makers to have a preview of the capital cost for owners willing to invest in energy-related renovations. In addition to this, information concerning different financing sources used to finance energy-related renovation activities are provided. More specifically the sources are private debt financing (loans), grants, energy performance contracting, public funding (dedicated credit lines), fiscal incentives and energy efficiency supplier obligations.

9. **Energy poverty**

Energy poverty is generally referred to the situation when a household cannot afford to keep their home adequately warm, but this definition can change according to the different member states of the EU [11]. The BSO tries to provide indicators quantifying this issue so to provide a snapshot of the energy poverty situation in each member state. A more detailed list of indicators present in the BSO can be found in the dataset itself [13].

### 10. Energy market

Indicators concerning energy market are indicators able to give a background information required for the evaluation of energy-related social issues. Among these indicators it is of interest to mention the average floor area and rooms per person or the ability of consumers of switching tariffs for the provision of energy [15].

The macro areas explained in the previous bullet points are further clustered in residential sector, non-residential sector and total number whenever it is possible (according to the type of indicator chosen). Furthermore, different subdivisions have been provided for the residential sector, divided in:

- Single-family units (again subdivided in detached and semi-detached units).
- Multi-family units.

And for the non-residential sector, divided in:

- Offices private and public
- Wholesale and retail trade
- Hotels and restaurants
- Health care buildings
- Educational buildings

This is the general structure of the building stock database [9], provided by the Consortium who launched the BSO in 2016 trying to fit as much as possible the requirements of the EPBD (Energy Performance of Buildings Directive), of the EED (Energy Efficiency Directive) and of the RED (Renewable Energy Directive) articles. However, as it will be explained in the next chapter (chapter 3.3. Limitations of the building stock observatory) the BSO presents some limitations lowering its efficacy

## 3.3. Limitations of the building stock observatory

For a better comprehension of the status quo of the BSO and as reported in the Grant Agreement (GA) of the BuiltHub project, the BSO has been manually analyzed. A schematization of the BSO structure has been created and reported in csv format. The general structure is reported in Figure 1: Building Stock Observatory - General structureFigure 1 and a more detailed explanation has been already given in chapter 3.2. Structure of the building stock observatory.

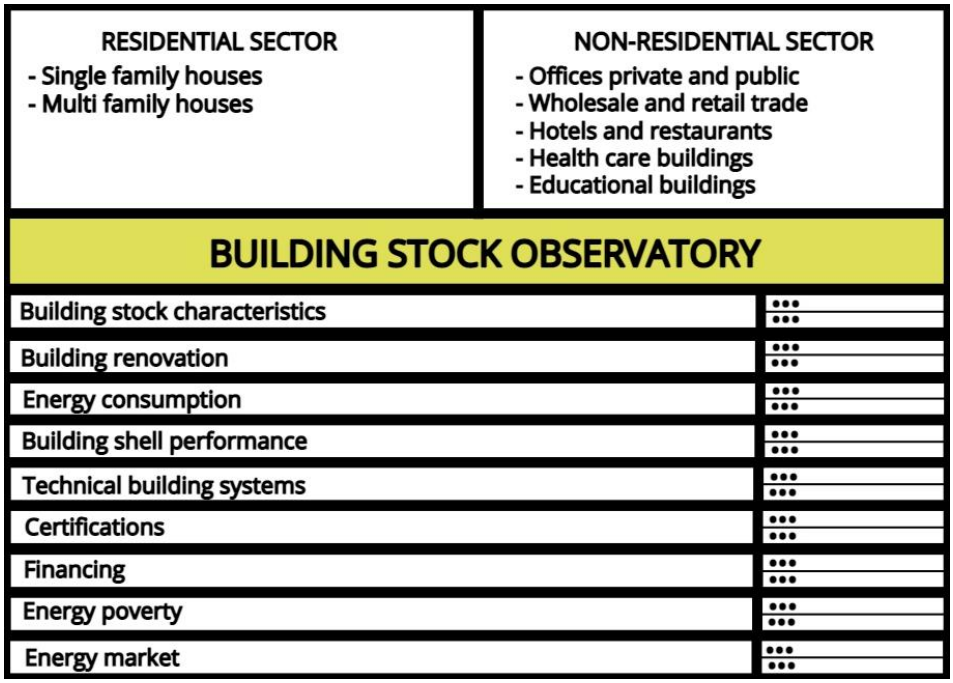


**Figure 1: Building Stock Observatory - General structure**

For every single indicator and sub-indicator present in the list, further information has been collected: more specifically, data concerning the spatial and temporal availability have been reported. In this way it has been possible to have an idea of which data lacks are present in the BSO. Data lacks represent one of the biggest limitations of the BSO and developing a roadmap for a better, more complete and continuous data provision is so considered one of the most important actions to take for improving the service. More details concerning the problem of the data lacks are provided in chapter 3.3.1. Data availability.

As a result of the BSO analysis it has been possible not only to identify data lacks, but also understand which problems are present in relation to interesting indicators missing (please see chapter 3.3.2. Integration of new indicators) and related to a poor explanation and description of the indicators reported in the BSO itself (please see chapter 3.3.3. Indicators description). The BSO shows limitations also concerning the infographic, which could probably be improved (please see chapter 3.3.4. Infographic and display personalization). Furthermore, data are displayable and downloadable only as single indicators, not allowing an intuitive and rapid comparison among different indicators. Finally, one of the biggest limitations of the BSO is the metadata provision, which is fundamental for guaranteeing transparency and for allowing users to backtrack the sources and the original data and data providers (please see chapter 3.3.5. Metadata provision).

### 3.3.1. Data availability

As already explained in the previous chapter a manual control on the data availability in the BSO has been performed, obtaining a csv file reporting data distribution within the database itself. Considerations from identified data lacks have been reported in this chapter, starting from the residential sector:

- The first limitation that can be found in the BSO dataset is related to the million square meters ($Mm^2$) of buildings built, which are reported for single and multi-family houses (SFHs and MFHs) but are not split by construction vintages. Having an information concerning the millions square meters built per construction period would provide a wider range of options for the evaluations of new indicators and parameters.
- Analogously, in relation to the useful surfaces of the buildings in the building stock the BSO provides the division between detached and semi-detached units (single-family units) but no data is provided by the database for this subdivision.
- Concerning data related to building permits for new constructions, data are available for all MSs of the EU but not for Italy. What is however most relevant is the absence of data related to buildings demolitions, which is a fundamental indicator in order to have a clear comprehension of the European buildings stock evolution.
- The air tightness data for the building shell performance evaluation are not present for any country. Furthermore, transmittance values (U-values) for doors and skylights, as well as a mean value for the whole building, are not reported.
- The macro area related to building stock systems is characterized by a large amount of data lacks both from a spatial point of view (data for few countries only) and from a temporal point of view (time series are highly fragmented). This problem affects all types of technical systems considered in the BSO (e.g. stoves, fireplaces, boilers, heat pumps).
- The same problem described in the previous point affects the section related to technical systems for the preparation of DHW.
- Almost no data is provided concerning energy consumption for cooking.
- Energy consumption for lighting clustered in the different typologies of lamps used in residential buildings does not present any data available.
- Data concerning space cooling systems, as their use is continuously growing in households of the EU, will become more important in the future and already represents an important factor in the energy consumption of buildings [17]. However, numerous data lacks can be found in the indicators related to space cooling technologies.
- Indicators related to the smart metering of buildings are present in the list of the BSO but almost no data is available in the related datasets.

- Energy Performance Certificates represent one of the most important measures for the control of the energy performance of the European building stock. However, the datasets concerning Energy Performance Certificate (EPC) related indicators are almost empty: only few data and for few countries are present (the majority of the data provided are related to the UK).
- All financial indicators are mostly empty except for parameters related to financial performances (total volume of investments renovation for both residential and non-residential sectors and total volume of energy related investments in renovation both for non-residential and residential sectors concerning all levels of renovation – light, deep and major renovation). Furthermore, data related to energy poverty are reported.
- The macro area related to energy market indicators is characterized by almost empty datasets. The only ones providing exhaustive data are the ones related to the final costs for electricity and natural gas provision for households.

The data lacks are mostly the same for the non-residential sector, but some differences can be noticed:

- Data concerning the number of buildings in the non-residential sector are generally present for all subsectors (offices, trade, educational buildings, health care buildings, hotels and restaurants). Data for the subdivision in private and public offices are not provided by the BSO as indicated.
- Data related to the construction vintages of the different subsectors of the non-residential sector (e.g. offices, trade and retail buildings, educational buildings, health care buildings, hotels and restaurants) are not available, which is arguably one of the biggest limitations in the BSO dataset.
- Data related to the useful surface built for the non-residential sector is provided and clustered in the different non-residential subsectors.
- In regard of data related to building permits in the non-residential sector almost no data are provided. Furthermore, as for the residential sector, no indicators are reported for the evaluation of the amount of buildings/useful surface demolished.
- Data for the thermal transmittance of the main construction components are reported but as for the residential sector, no data for doors and skylights thermal transmittances and air tightness are reported.
- Concerning all indicators related to the buildings technical systems almost no data is present in the database of the BSO. Most of the few data present in this macro area are data for Denmark.
- For the non-residential sectors, as well as for the residential one, data related to the number of buildings and the amount of useful surface certified to be part of a near zero

energy building (NZEB) are present. Concerning energy performance certifications a few data are present for a limited number of countries of the EU, but almost no information related to the effective class-specific numbers of certifications emitted is given (class A, B, C, D and higher than D).

- Energy consumption values are given for all end uses for almost all countries of the EU, but only for about half of the member states are provided specific data for space heating and for less member states are available energy consumption values for cooking, for space cooling and for DHW preparation. Clustered data for the different subsectors of the non-residential sector are not provided.

- In the macro area related to financial indicators, there are no data present in the relative datasets. The only data present for almost all the EU Member States are related to financial performances (total volume of investments renovation for both residential and non-residential sectors and total volume of energy related investments in renovation both for non-residential and residential sectors concerning all levels of renovation – light, deep and major renovation).

### 3.3.2. Integration of new indicators

As discussed internally by the Consortium of the H2020 BuiltHub project a number of indicators are missing. These indicators can be classified in two different categories:

- Indicators related to buildings demolition:

In the BSO a variety of indicators related to the building permits have been collected both in terms of useful surface built and dwellings/houses built. These indicators also present different clustering. However, no information concerning the buildings demolition has been provided. This represents an important missing factor for the final evaluation of the European building stock.

- Indicators related to heated/cooled surfaces:

In the BSO, indication concerning the useful surfaces of the building stock is provided. However, specific consumptions and specific values for heated or cooled floor areas divided by construction vintages are not provided. These are fundamental data for a proper evaluation of the SH and SC energy consumptions in the building stock analysis.

As it will be explained in chapter 4. Indicators choice and prioritization and reported in chapter 4.4. Indicators choice - complete list, indicators for covering both the two aforementioned areas have been introduced.

### 3.3.3. Indicators description

One of the most important aspects in the data provision is the clearness of the data itself. Data should always be provided of a clear explanation of their meaning and of how they have been eventually collected and in which conditions they can be used. The BSO does not always provide indications and descriptions concerning the displayed indicator, especially when in the dataset related to the chosen indicator there are no data. In this last case neither the title and

description of the indicator nor the unit of measurement used are displayed. More clarity should be addressed by the platform of the BSO itself. This would allow an easier use of the platform by the users and would also allow a higher-quality data provision by the stakeholders involved.

### 3.3.4. Infographic and display personalization

One of the main services provided by the BSO should be to give the possibility to users to analyze and process the data collected in the BSO database, both for research and policy making purposes. The possibility to compare and combine different indicators and different nations can so be considered a milestone for the BSO project. For the data display two different platforms have been created: on one hand there is the BSO database, providing data in form of tables downloadable in csv format. On the other hand, there is the BSO data mapper, providing the same data of the BSO database but in form of EU geographic charts or bar charts, downloadable in jpeg or pdf format. Creating a single data repository without splitting the two aforementioned services would represent a benefit for the final users, which could change format of the data without changing platform. This represents a secondary limitation, however, the main limiting factor of the data display and of the infographic is another.

As noticed during the BSO analysis it is not possible to compare and combine different indicators in a single table/chart. In both the BSO dataset and BSO data mapper indicators can be displayed only one at a time, not allowing the graphical or tabular comparison of different indicators. Furthermore, more indicators cannot be combined for creating new indicators as required by users. For example, having the data for useful surfaces of the residential sector building stock and values of total energy consumption for the same sector, it is not possible to display the energy consumption per square meter. The implementation of such functionalities could improve the efficacy of the services provided by the BSO. The same issue is reflected in the data download: indicators can be downloaded only one at a time, resulting in an important limitation for the final users.

### 3.3.5. Metadata provision

In the BSO, data are collected from multiple sources, which are only referenced by a hyperlink next to the related data. Most of the hyperlinks shown do not link to the original source of the data but to the database/platform from which the data have been collected. In order to guarantee transparency and accurate data provision, complete metadata have to be provided. Metadata need to report not only the link to the source of data but also authors, methodologies for calculation, reference year, publication year and more information (for more details about the format of the metadata implemented by the H2020 BuiltHub Project please see chapter 5. Metadata identification). The provision of complete metadata not only guarantees a better service to the final users, but also allows a better identification of possible stakeholders and data providers allowing so a potential higher quality continuous data flow to the platform. The provision of a roadmap for obtaining higher quality metadata and the creation of a community of possible data providers is one of the most important goals of the H2020 BuiltHub project.

# 4. Indicators choice and prioritization

After performing a complete analysis of the BSO comprehensive of the data availability and limitations analysis, the H2020 BuiltHub Consortium team working on Work Package 3 (WP3) – Data Assembly – started a selection procedure for the isolation of the most important and relevant indicators for future policy making. In this chapter the selection parameters as well as the final table containing the chosen indicators (Table 17) are reported.

## 4.1. Introduction to the indicators choice

The list of the indicators to focus on by the H2020 BuiltHub project Consortium has been drawn up by selecting the most relevant indicators present in the BSO, providing a detailed clustering and adding the indicators considered to be missing in the BSO itself. As stated by the GA a list of possible datasets and related metadata for providing data to fill a database containing the chosen indicators had to be provided and thus is reported in Annex A. The provision of data for the chosen indicators has been prioritized on three different levels:

- **Topic prioritization:**

To all chosen indicators has been associated a different priority level: High for high priority indicators, which are the ones to dedicate most of the efforts, medium priority and finally low priority indicators. The complete list of chosen indicators and related prioritization level can be found in Table 17. The priority level has been identified by the BuiltHub Consortium according to factors such as data availability and importance of the indicator for possible future EU policies.

- **Spatial prioritization:**

As stated by the GA, data for the EU27+UK and its 16 associated countries had to be addressed for the different indicators. It has been decided to initially focus the efforts on the provision of data for the EU27+UK and in a second step for the other 16 associated countries.

- **Granularity prioritization:**

Data at different granularity level are subject of investigation. It has been decided to work at an initial stage of the work on nationally aggregated values (NUTS0) and eventually proceed in a second moment to a higher granularity level (NUTS1, NUTS2, …).

A more detailed indication on the choice and prioritization (topic prioritization) of the indicators is reported in the next chapter (see chapter 4.2. Introduction to the indicators choice).

## 4.2. Introduction to the indicators choice

This chapter introduces the most important indicators and the reasons for their choice by the H2020 BuiltHub Consortium. Indicators and clustering are reported in tables (please see tables from Table 1 to Table 16). The indicators will be reported in the following chapters, indicating the macro areas they are covering. Please note that only the indicators related to the residential sector have been reported. As it will be explained in chapter 4.3 Indicators clustering, the

indicators for the non-residential sector are the same of the residential one, but with a different clustering. Note that a complete list of the chosen indicators can be found in chapter 4.4 Indicators choice - complete list.

### 4.2.1. Building stock characteristics

The first indicators taken into account by the Consortium are the ones related to the building stock composition at European level. Among the most important indicators for the description of the building stock there is the number of dwellings built. As shown by Table 1 the number of dwellings has been clustered both according to the type of building considered, by occupancy factors (e.g., ownership, persons per units, secondary residences) and by construction vintages.

**Table 1: Indicators schematization - building stock characteristics - number of dwellings clustering choice**

| Indicators schematization - building stock characteristics - number of dwellings clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Number of dwellings | By typology | | | | | | |
| | Total | Single-family | Multi-family | Apartment blocks | | | |
| | Share of permanently occupied | | | | | | |
| | Total | Single-family | Multi-family | Apartment blocks | | | |
| | Share of secondary residences | | | | | | |
| | Share of dwellings occupied by | | | | | | |
| | Owners | | Tenants | | | | |
| | By construction vintages | | | | | | |
| | Before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |
| | Persons per household | | | | | | |
| | 1 person | 2 persons | 3 persons | 4 persons | >5 persons | | |

Providing information concerning the number of dwellings cannot be considered satisfying since no information related to the size of the dwellings themselves is given. For this reason, as shown in Table 2 indicators related to the total floor area of dwellings have been provided following the same clustering as the one shown in Table 1 (by typology of building and by construction vintages).

**Table 2: Indicators schematization - building stock characteristics - total area of dwellings clustering choice**

| Indicators schematization - building stock characteristics - total area of dwellings clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total floor area of dwellings | By typology | | | | | | |
| | Total | | Single-family | | Multi-family | | Apartment blocks |
| | By construction vintages | | | | | | |
| | Before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |

It has been decided not to provide only data about the number of dwellings and millions of square meters of built surface covered, but also about the number of buildings (please see Table 3). The clustering of these indicators is the same used for number of dwellings and useful surface.

**Table 3: Indicators schematization - building stock characteristics - total number of buildings clustering choice**

| Indicators schematization - building stock characteristics - total number of buildings clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total number of buildings | By typology | | | | | | |
| | Total | | Single-family | | Multi-family | | Apartment blocks |
| | By construction vintages | | | | | | |
| | Before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |

As already mentioned in chapter 3.3.2 Integration of new indicators, one of the limitations of the BSO is the absence of indicators related to the demolition of buildings, which is required for completing the information given by the indicators related to building permits. For this reason, keeping the subdivision in total, single-family houses, multi-family houses and apartment blocks, indicators related to the square meters of useful surface and annual share of newly built/demolished buildings have been added. Please see Table 4.

**Table 4: Indicators schematization - building characteristics - building permits and buildings demolition clustering choice**

| Indicators schematization - building characteristics - building permits and buildings demolition clustering choice | | | | |
|---|---|---|---|---|
| Building permits and buildings demolition | Square meters of useful surface by typology | | | |
| | Total | Single-family | Multi-family | Apartment blocks |
| | Annual share of new/demolished dwellings | | | |
| | Total | Single-family | Multi-family | Apartment blocks |

The last information provided by the indicators of the macro area “Building stock characteristics” is related to further indicators not provided by the BSO (as explained in chapter 3.3.2 Integration of new indicators). These indicators are referred to the amount of useful surface (expressed in million square meters) which is covered by the effect of SH systems (heated floor area) or SC systems (cooled floor area). Such indicators are useful in order to assess or provide further information concerning specific energy consumptions per square meter. The clustering follows again the subdivision per typology of building and per construction vintages as shown in Table 5.

**Table 5: Indicators schematization - building characteristics - buildings cooled/heated floor area clustering choice**

| Indicators schematization - building characteristics - buildings cooled/heated floor area clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cooled/Heated floor area | By typology | | | | | | |
| | Total | | Single-family | | Multi-family | | Apartment blocks |
| | By construction vintages | | | | | | |
| | Before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |

The prioritization of the aforementioned indicators has been done according to the knowledge about the data availability and the importance of the indicator itself. More specifically all indicators but not the ones related to building permits/demolition and number of secondary residences have been classified as highly important indicators. A medium priority level has been given to the others. For a more detailed explanation see Table 17.

### 4.2.2. Building shell performances

The second macro area considered by the Consortium has been the one related to the performances of the envelope of buildings. More specifically, the information related to the specific values of thermal transmittance of doors and skylights have been considered marginal

and thus excluded by the research. Values of thermal transmittance of the most relevant buildings components (i.e., external walls, windows, floors and roofs) have been implemented and clustered according to the construction vintages (for more information please see Table 6). Information related to the building envelope performance is clearly of high priority, since through a proper insulation of the building high energy savings can be reached.

**Table 6: Indicators schematization - building shell performances - thermal transmittance of buildings construction elements clustering choice**

| Indicators schematization - building shell performances - thermal transmittance of buildings construction elements clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Thermal transmittance (U-Value) for external walls, roofs, floor and windows | By construction vintages | | | | | | |
| | Before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |
| | Mean value | | | | | | |

### 4.2.3. Technical building systems

This macro area collects indicators related to the technical systems used in buildings, especially concerning space heating (see Table 7) and preparation of domestic hot water (DHW) (see Table 8). The deepest analysis of the status quo of the technical systems employed in both residential and non-residential sector has been carried out on space heating technical systems. The reason for focusing on space heating is that it is the most energy consuming process in the buildings sector. Among all energy consuming processes in the European residential sector space heating is the most consuming one (responsible for about 68% of the total energy consumption). Excluding the Mediterranean countries, space heating represents 60-80% of the total energy consumption in the residential sector [17]. Considering not only the residential and non-residential sectors, the primary energy consumption in the EU amounts to around 1800 Mtoe/y (2010). This consumption is mainly caused by heating and cooling applications (about 900 Mtoe/y, not only related to building space heating and cooling but also industrial heat) [18].

Indicators related to space heating technical building systems are expressed in number of dwellings or share of dwellings having a certain heating system or energy source. More information concerning the fuels and the space heating technologies selected are reported in Table 7. High priority has been set for the most employed technical systems for space heating (boilers and heat pumps) and for the choice of the fuel. For the other indicators a medium priority has been set (for more information please see Table 17).

**Table 7: Indicators schematization - technical building systems - space heating technical systems clustering choice**

| Indicators schematization - technical building systems - space heating technical systems clustering choice | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| space heating technical systems | Number of dwellings with | | | | | | | |
| | Traditional boilers | | Condensing boilers | | Combi boilers | | | |
| | Share of dwellings with | | | | | | | |
| | Traditional boilers | | Condensing boilers | | Combi boilers | | | |
| | Number of buildings with | | | | | | | |
| | Heat pumps | | | | Reversible heat pumps | | | |
| | Share of dwellings with space heating based on | | | | | | | |
| | Solar | Stove | Fireplace | District Heating | Local SH | Heat pumps | Reversible heat pumps | |
| | Number of dwellings with space heating based on | | | | | | | |
| | Electricity | Fuel oil | Kerosene | LPG | Natural gas | Thermal energy | Coal | Biomass |

The preparation of domestic hot water is the second most consuming process in the residential sector, thus indicators related to it have been chosen. According to data collected by Eurostat water heating ranks second in the shares of energy consumption with a share of about 13% [17]. The main technology employed for DHW preparation, together with space heating, is the boiler (condensing boilers accounting for about 9% of the total EU27+UK consumption for space and domestic hot water energy consumption, while non-condensing boilers account for about 67%) [19]. The following Table 8 gives an indication on the chosen indicators for DHW preparation.

**Table 8: Indicators schematization - technical building systems - domestic hot water preparation technical systems clustering choice**

| Indicators schematization - technical building systems - domestic hot water preparation technical systems clustering choice | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Domestic hot water (DHW) heating systems | Share of buildings producing DHW basing on | | | | | | | | |
| | Electricity | Fuel oil | Gas | Kerosene | LPG | Coal | Solar thermal | Coal | Other |

Among the other energy consuming processes in a building there is lighting, which is provided completely through electrical systems thus not of interest for this macro area, cooking, which represents a marginal energy consumption process, and cooling, which is becoming an increasingly relevant energy consuming process, but which is covered for more than 99% by vapour compression technologies [20]. Further technical aspects of a building that can have an impact on the energy consumption of the building itself are the glazing systems and the introduction of smart metering systems. Metering systems have been divided in “Collective metering” when controlling the whole building and “Individual metering” for single dwelling metering systems. More information is given by Table 9.

**Table 9: Indicators schematization - technical building systems - domestic hot water preparation technical systems clustering choice**

| Indicators schematization - technical building systems - domestic hot water preparation technical systems clustering choice | | | |
|---|---|---|---|
| Building characteristics | Type of glazing - share of buildings having | | |
| | High performance double glazing | Triple or quadruple glazing | |
| | Share of buildings having smart metering systems | | |
| | Total | Collective metering | Individual metering |

Among the possibilities for reducing the environmental impact of the energy consumption in a building there is the possibility to install on site renewable energy generation systems. The most relevant are photovoltaic systems, solar heaters, renewable heat pumps, biomass fed systems, wind and geothermal energy systems. The following Table 10 provides indications about the indicators chosen. To these indicators a medium-to-low priority has been set (for more information please see Table 17).

**Table 10: Indicators schematization - technical building systems - On site renewable energy generation clustering choice**

| Indicators schematization - technical building systems - On site renewable energy generation clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Renewable energy on site generation | energy generation by type | | | | | | |
| | Solar heaters | Photovoltaic | Geothermal | Wind | Biomass | Heat pumps | Others |
| | Share of renewable energy produced by | | | | | | |
| | Solar heaters | Photovoltaic | Geothermal | Wind | Biomass | Heat pumps | |

The last aspect selected by the Consortium for this macro area is the evaluation of the share and of the useful surface of buildings annually undergoing major renovation. The indicators have been clustered as usual in single-family houses, multi-family houses and apartment blocks (Table 11).

**Table 11: Indicators schematization - technical building systems - buildings undergoing major renovation clustering choice**

| Indicators schematization - technical building systems - buildings undergoing major renovation clustering choice | | | | |
|---|---|---|---|---|
| Buildings undergoing major renovation | Share of buildings | | | |
| | Total | Single-family | Multi-family | Apartment Blocks |
| | Total | | | |
| | Total | Single-family | Multi-family | Apartment Blocks |

### 4.2.4. Building stock characteristics

Information concerning energy consumption in buildings is fundamental for addressing proper policies at a European level. It is important to have a subdivision among the different end uses of the energy. The subsectors evaluated and taken into consideration by the clustering are the most energy consuming ones: space heating, domestic hot water preparation, cooking, lighting and finally space cooling consumption. It has been decided to cluster the different energy consuming processes both by fuel employed and by type of buildings in which they are installed (single-family houses, multi-family houses and apartment blocks). The following indicators (shown in Table 12) are collected in terms of million tons of oil equivalent (Mtoe) and are marked with high priority.

**Table 12: Indicators schematization - buildings energy consumption - total energy consumption clustering choice**

| Indicators schematization - buildings energy consumption - total energy consumption clustering choice | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total energy consumption in residential sector | All end uses energy consumption by fuel | | | | | | |
| | Total | Gas | Oil | Coal | Electricity | Heat | Renewable |
| | Space heating energy consumption by fuel | | | | | | |
| | Total | Gas | Oil | Coal | Electricity | Heat | Renewable |
| | Domestic hot water energy consumption by fuel | | | | | | |
| | Total | Gas | Oil | Coal | Electricity | Heat | Renewable |
| | Energy consumption for cooking | | | | | | |
| | Total | Gas | Oil | Coal | Electricity | Heat | Renewable |
| | Total energy consumption for lighting systems | | | | | | |
| | Total energy consumption for space cooling | | | | | | |
| | All end uses energy consumption by building typology | | | | | | |
| | Total | | Single-family | | Multi-family | | Apartment blocks |
| | Space heating energy consumption by building typology | | | | | | |
| | Total | | Single-family | | Multi-family | | Apartment blocks |

Indicators on energy consumption are mostly interesting if related to other quantities, such as the number of dwellings or useful surface interested by the considered energy consumption itself. In this way it is possible to collect indicators such as the energy consumption per dwelling or energy consumption per square meter, useful for assessing energy consumptions in specific cases. The clustering by type of building (single-family houses, multi-family houses, apartment blocks) and by construction vintages has been taken into account for a more precise use of the collected data. More details on the specific indicators clustered are reported in Table 13.

**Table 13: Indicators schematization - buildings energy consumption - specific final energy consumption clustering choice**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Specific energy consumption in residential sector | All end uses energy consumption per building by type of building | | | | | | |
| | Total | Single-family | Multi-family | Apartment blocks | | | |
| | All end uses energy consumption per dwelling | | | | | | |
| | Space heating energy consumption per dwelling | | | | | | |
| | Energy consumption for cooking per dwelling | | | | | | |
| | Lighting energy consumption per dwelling | | | | | | |
| | Space cooling energy consumption per dwelling | | | | | | |
| | All end uses energy consumption per square meter by type of building | | | | | | |
| | Total | Single-family | Multi-family | Apartment blocks | | | |
| | Space heating energy consumption per square meter by type of building | | | | | | |
| | Total | Single-family | Multi-family | Apartment blocks | | | |
| | Space cooling energy consumption per square meter by type of building | | | | | | |
| | Total | Single-family | Multi-family | Apartment blocks | | | |
| | Space heating energy consumption per m² for residential sector by construction vintages | | | | | | |
| | before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |
| | Space cooling energy consumption per m² for residential sector by construction vintages | | | | | | |
| | before 1945 | 1945-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2010 | after 2010 |

### 4.2.5. Building stock characteristics

Energy performance certificates are important for policy makers, especially if reported in time series, for understanding the change in energy performance of the building stock in time. For this reason, it has been decided to report some indicators (medium priority) clustering both the number of buildings and the useful surface covered in the different energy performance classes (A, B, C, D and >D). Information concerning passive houses (low priority) will be collected as well (clustering in Table 14).

**Table 14: Indicators schematization - energy performance certificates - energy performance certificates clustering choice**

| Indicators schematization - energy performance certificates - energy performance certificates clustering choice | | | | | |
|---|---|---|---|---|---|
| Energy performance Certificates (EPCs) | Share of energy performance certificates (based on the number of buildings) by class | | | | |
| | A | B | C | D | >D |
| | Share of energy performance certificates (based on the square meters covered) by class | | | | |
| | A | B | C | D | >D |
| | Passive houses voluntary energy certifications (number) | | | | |

### 4.2.6. Financing parameters

The following indicators have been selected for providing knowledge to policy makers in order to let them design effective and efficient policies concerning the building stock renovation, the need to provide incentives or funding for specific interventions and to understand how effective the taken measures are in terms of energy savings. Among the indicators the Consortium selected there are indicators related to investments in buildings renovation and energy savings achieved (both for total and energy related renovations). Indicators addressing information about overall and average-per-building values are provided in relation to buildings renovation investments.

**Table 15: Indicators schematization - financing parameters - Financing economical parameters clustering choice**

| Indicators schematization - financing parameters - Financing economical parameters clustering choice | | | | |
|---|---|---|---|---|
| Financing - Economic parameters | Investments in buildings renovation by type of building | | | |
| | Total | Single-family | Multi-family | Apartment blocks |
| | Energy related investments for buildings by type of building | | | |
| | Total | Single-family | Multi-family | Apartment blocks |
| | Average investments per building by type of building | | | |
| | Total | Single-family | Multi-family | Apartment blocks |
| | Average energy related investments per building by type of building | | | |
| | Total | Single-family | Multi-family | Apartment blocks |
| | Energy savings achieved by type of building | | | |
| | Total | Single-family | Multi-family | Apartment blocks |
| | Average energy cost savings achieved by type of building | | | |
| | Total | Single-family | Multi-family | Apartment blocks |

### 4.2.7. Energy market

Finally, for giving the possibility to extract information related to the cost for energy provision in the residential and non-residential sectors starting from the indicators reporting the final energy consumptions, data for the cost of energy per unit of energy delivered are required. These indicators need to be collected using the same subdivisions as for the indicators related to energy consumption to give the possibility to provide costs assessments. For this reason, the energy prices for the most common fuels employed in the buildings sector have been collected (please see Table 16).

**Table 16: Indicators schematization - energy market - average energy price clustering choice**

| Indicators schematization - energy market - average energy price clustering choice | | | | | |
|---|---|---|---|---|---|
| Energy market | Average energy price by type of fuel | | | | |
| | Natural gas | Electricity | Coal | Fuel oil | Biomass |

## 4.3. Indicators clustering

It has been decided to ignore the subdivision in detached and semi-detached single-family buildings proposed by the BSO for two main reasons: the first is the lack in data availability in literature, the second is the low importance of this information for the policy makers in terms of decarbonization goals. Concerning the residentials sector, whenever possible, it has been used a subdivision related to the number of dwellings present in a building, more specifically it has been decided to use the subdivision in:

- Single-family buildings
- Multi-family buildings
- Apartment blocks

In the BSO, as already shown in chapter 3.2 Structure of the building stock observatory, the only subdivision present was between single and multi-family buildings. The category of apartment blocks is comprehensive of all those buildings having more than four floors. This subdivision has been considered since the difference in terms of energy performance indicators and will help for the future analysis on circular economy for contributing to building stock decarbonization. Concerning the non-residential sector, the clustering remains unchanged, but the category “Other non-residential buildings” has been added to take into account also all buildings excluded by the previous clustering. More specifically, this category is comprehensive of warehouses, transportation and garage buildings, military barracks, agricultural buildings (farms, greenhouses), and sport facilities (e.g., sport halls, swimming pools, and gyms). The new subdivision of the non-residential sector is the following:

- Offices
- Wholesale and retail trade buildings
- Hotels and restaurants
- Health care buildings
- Educational buildings
- Other non-residential buildings

Finally, it has been decided not to focus on the collection of data related to “All buildings” comprehensive of both residential and non-residential sectors, which can be derived by the collected data for the two separate sectors.

## 4.4. Indicators choice - complete list

Here it follows the complete list of chosen indicators for the residential sector, divided in the macro areas of building stock characteristics, building shell performances, technical buildings systems, building energy consumption, certifications, economical parameters and energy market. The same types of indicators have been selected for the services sector, but with a different clustering system, as already explained in chapter 4.3 Indicators clustering. The priority of each indicator (high-medium-low) as given by the consortium of the BuiltHub project has been reported too. Please note that partial variations in this list may be possible in the future.

**Table 17: Complete list of the indicators with related unit of measurement and prioritization level developed by the Horizon 2020 BuiltHub project Consortium (Work Package 3 - Data Assembly). Please note the abbreviation for the prioritization level (H=high, M=medium, L=low)**

| INDICATORS - RESIDENTIAL SECTOR | UNIT | PRIORITY | | |
|---|---|---|---|---|
| | | H | M | L |
| BUILDING STOCK CHARACTERISTICS | | | | |
| Total number of dwellings | Thousands | X | | |
| Number of single-family dwellings | Thousands | | | |
| Number of multi-family dwellings | Thousands | X | | |
| Number of apartment blocks dwellings | Thousands | | | |
| Number of permanently occupied dwelling | Thousands | X | | |
| Number of single-family dwelling permanently occupied | Thousands | | | |
| Number of multi-family dwelling permanently occupied | Thousands | X | | |
| Number of apartment blocks dwelling permanently occupied | Thousands | | | |
| Number of secondary residences | Thousands | | X | |
| Share of dwellings built between before 1945 | Share (%) | | | |
| Share of dwellings built between 1945 and 1969 | Share (%) | | | |
| Share of dwellings built between 1970 and 1979 | Share (%) | | | |
| Share of dwellings built between 1980 and 1989 | Share (%) | X | | |
| Share of dwellings built between 1990 and 1999 | Share (%) | | | |
| Share of dwellings built between 2000 and 2010 | Share (%) | | | |
| Share of dwellings built after 2010 | Share (%) | | | |
| Share of owner-occupied dwellings | Share (%) | X | | |
| Share of tenants occupied dwellings | Share (%) | | | |
| Share of dwellings with single-person households | Share (%) | | | |
| Share of dwelling occupied by 2 persons | Share (%) | | | |
| Share of dwelling occupied by 3 persons | Share (%) | X | | |
| Share of dwelling occupied by 4 persons | Share (%) | | | |
| Share of dwelling occupied by more than 5 persons | Share (%) | | | |
| Total floor area of dwellings | Mm2 | X | | |
| Total floor area of single-family dwellings | Mm2 | X | | |

| | | | | |
|---|---|---|---|---|
| Total floor area of multi-family dwellings | Mm2 | | | |
| Total floor area of apartment blocks dwellings | Mm2 | | | |
| Share of total Mm2 residential built before 1945 | Mm2 | | | |
| Share of total Mm2 residential built between 1945 and 1969 | Mm2 | | | |
| Share of total Mm2 residential built between 1970 and 1979 | Mm2 | | | |
| Share of total Mm2 residential built between 1980 and 1989 | Mm2 | X | | |
| Share of total Mm2 residential built between 1990 and 1999 | Mm2 | | | |
| Share of total Mm2 residential built between 2000 and 2010 | Mm2 | | | |
| Share of total Mm2 residential built after 2010 | Mm2 | | | |
| Building permits - m² of useful floor area | Mm2 | | X | |
| Building permits - m² of useful floor area for single-family dwellings | Mm2 | | | |
| Building permits - m² of useful floor area for multi-family dwellings | Mm2 | | X | |
| Building permits - m² of useful floor area for apartment blocks dwellings | Mm2 | | | |
| Annual share of new dwellings in total residential stock | Share (%) | | X | |
| Annual construction of single-family dwellings | Share (%) | | | |
| Annual construction of multi-family dwellings | Share (%) | | X | |
| Annual construction of apartment blocks dwellings | Share (%) | | | |
| Buildings demolition - m² of useful floor area | Mm2 | | X | |
| Buildings demolition - m² of useful floor area for single-family dwellings | Mm2 | | | |
| Buildings demolition - m² of useful floor area for multi-family dwellings | Mm2 | | X | |
| Buildings demolition - m² of useful floor area for apartment blocks dwellings | Mm2 | | | |
| Annual share of demolished dwellings in total residential stock | Share (%) | | | |
| Annual demolished -single family dwellings | Share (%) | | X | |
| Annual demolished multi-family dwellings | Share (%) | | | |
| Annual demolished apartment blocks dwellings | Share (%) | | | |
| Total number of Buildings | Thousands | X | | |

| | | | | |
|---|---|---|---|---|
| Total number of single-family buildings | Thousands | | | |
| Total number of multi-family buildings | Thousands | X | | |
| Total number of apartment blocks buildings | Thousands | | | |
| Share of buildings built before 1945 | Share (%) | | | |
| Share of buildings built between 1945 and 1969 | Share (%) | | | |
| Share of buildings built between 1970 and 1979 | Share (%) | | | |
| Share of buildings built between 1980 and 1989 | Share (%) | X | | |
| Share of buildings built between 1990 and 1999 | Share (%) | | | |
| Share of buildings built between 2000 and 2010 | Share (%) | | | |
| Share of buildings built after 2010 | Share (%) | | | |
| Cooled floor area - total | Mm2 | X | | |
| Cooled floor area – single-family houses | Mm2 | | | |
| Cooled floor area – multi-family houses | Mm2 | X | | |
| Cooled floor area - apartment blocks | Mm2 | | | |
| Cooled floor area - built before 1945 | Mm2 | | | |
| Cooled floor area - built between 1945 and 1969 | Mm2 | | | |
| Cooled floor area - built between 1970 and 1979 | Mm2 | | | |
| Cooled floor area - built between 1980 and 1989 | Mm2 | X | | |
| Cooled floor area - built between 1990 and 1999 | Mm2 | | | |
| Cooled floor area - built between 2000 and 2010 | Mm2 | | | |
| Cooled floor area - built after 2010 | Mm2 | | | |
| Heated floor area - total | Mm2 | X | | |
| Heated floor area – single-family houses | Mm2 | | | |
| Heated floor area – multi-family houses | Mm2 | X | | |
| Heated floor area - apartment blocks | Mm2 | | | |
| Heated floor area - built between before 1945 | Mm2 | X | | |

| | | | | |
|---|---|---|---|---|
| Heated floor area - built between 1945 and 1969 | Mm2 | | | |
| Heated floor area - built between 1970 and 1979 | Mm2 | | | |
| Heated floor area - built between 1980 and 1989 | Mm2 | | | |
| Heated floor area - built between 1990 and 1999 | Mm2 | | | |
| Heated floor area - built between 2000 and 2010 | Mm2 | | | |
| Heated floor area - built after 2010 | Mm2 | | | |
| BUILDING SHELL PERFORMANCES | | | | |
| Energy efficiency value of residential building external walls | W/m² °C | | | |
| U-value external walls residential buildings built before 1945 | W/m² °C | | | |
| U-value external walls residential buildings built between 1945-1969 | W/m² °C | | | |
| U-value external walls residential buildings built between 1970-1979 | W/m² °C | | | |
| U-value external walls residential buildings built between 1989-1989 | W/m² °C | X | | |
| U-value external walls residential buildings built between 1990-1999 | W/m² °C | | | |
| U-value external walls residential buildings built between 2000 and 2010 | W/m² °C | | | |
| U-value external walls residential buildings built after 2010 | W/m² °C | | | |
| Energy efficiency value of residential building floors | W/m² °C | | | |
| U-value floors residential buildings built before 1945 | W/m² °C | | | |
| U-value floors residential buildings built between 1945-1969 | W/m² °C | | | |
| U-value floors residential buildings built between 1970-1979 | W/m² °C | | | |
| U-value floors residential buildings built between 1989-1989 | W/m² °C | X | | |
| U-value floors residential buildings built between 1990-1999 | W/m² °C | | | |
| U-value floors residential buildings built between 2000 and 2010 | W/m² °C | | | |
| U-value floors residential buildings built after 2010 | W/m² °C | | | |
| Energy efficiency value of residential building roofs | W/m² °C | | | |
| U-value roofs residential buildings built before 1945 | W/m² °C | | | |
| U-value roofs residential buildings built between 1945-1969 | W/m² °C | X | | |
| U-value roofs residential buildings built between 1970-1979 | W/m² °C | | | |

| | | | | |
|---|---|---|---|---|
| U-value roofs residential buildings built between 1989-1989 | W/m² °C | | | |
| U-value roofs residential buildings built between 1990-1999 | W/m² °C | | | |
| U-value roofs residential buildings built between 2000 and 2010 | W/m² °C | | | |
| U-value roofs residential buildings built after 2010 | W/m² °C | | | |
| Energy efficiency value of residential building windows | W/m² °C | | | |
| U-value for windows residential buildings built before 1945 | W/m² °C | | | |
| U-value for windows residential buildings built between 1945-1969 | W/m² °C | | | |
| U-value for windows residential buildings built between 1970-1979 | W/m² °C | X | | |
| U-value for windows residential buildings built between 1989-1989 | W/m² °C | | | |
| U-value for windows residential buildings built between 1990-1999 | W/m² °C | | | |
| U-value for windows residential buildings built between 2000 and 2010 | W/m² °C | | | |
| U-value for windows residential buildings built after 2010 | W/m² °C | | | |
| TECHNICAL BUILDINGS SYSTEMS | | | | |
| Share of dwellings with condensing boilers | Share (%) | | | |
| Number of dwellings with condensing boilers | Thousands | | | |
| Share of dwellings with conventional boilers | Share (%) | X | | |
| Number of dwellings with conventional boilers | Thousands | | | |
| Number of dwellings with combi boilers | Thousands | | | |
| Number of dwellings with heat pumps | Thousands | | | |
| Share of dwellings with heat pumps | Share (%) | X | | |
| Share of dwellings with reversible heat pumps | Share (%) | | | |
| Share of dwellings with solar heating system | Share (%) | X | | |
| Share of dwellings with a stove | Share (%) | | X | |
| Share of dwellings with a fireplace | Share (%) | | | |
| Share of dwellings with District heating system | Share (%) | | X | |
| Share of dwellings with Local space heating | Share (%) | | X | |
| Number of dwellings with heating on electricity | Thousands | X | | |
| Number of dwellings with heating on fuel oil | Thousands | | | |

| | | | | |
|---|---|---|---|---|
| Number of dwellings with heating on kerosene | Thousands | | | |
| Number of dwellings with heating on LPG | Thousands | | | |
| umber of dwellings with heating on natural gas | Thousands | | | |
| Number of dwellings with heating by solar thermal energy | Thousands | | | |
| Number of dwellings with heating on coal | Thousands | | | |
| Number of dwellings with heating on biomass | Thousands | | | |
| Number of residential dwellings with electric heaters (not heat-pump) for water heating | Thousands | | | |
| Share of residential dwellings with water heaters using fuel oil | Share (%) | | | |
| Share of residential dwellings with gas water heaters | Share (%) | | | |
| Share of residential dwellings with water heaters using kerosene | Share (%) | | | |
| Share of residential dwellings with water heaters using liquefied petroleum gas | Share (%) | X | | |
| Number of residential dwellings with other water heaters | Thousands | | | |
| Share of residential dwellings with water heaters using solar thermal energy | Share (%) | | | |
| Share of residential dwellings with water heaters using biomass | Share (%) | | | |
| Share of residential dwellings with water heaters using coal | Share (%) | | | |
| Share of residential dwellings with a combi boiler | Share (%) | X | | |
| Number of residential dwellings with water heater/boiler | Thousands | | | |
| Share of residential dwellings with high performance double glazing | Share (%) | | X | |
| Share of residential dwellings with triple and quadruple glazing | Share (%) | | | |
| Share of residential buildings with smart metering systems | Share (%) | | | |
| Collective metering | Share (%) | | X | |
| Individual metering | Share (%) | | | |
| On site energy generation with solar heaters in residential buildings | Mtoe | | | |
| On site energy generation with wood or biomass heaters in residential buildings | Mtoe | | X | |
| On site energy generation with solar PV in residential buildings | Mtoe | | | |
| On site energy generation with geothermal in residential buildings | Mtoe | | | |

| | | | | |
|---|---|---|---|---|
| On site energy generation with wind in residential buildings | Mtoe | | | |
| On site energy generation with micro-CHP in residential buildings | Mtoe | | | |
| Other on-site energy generation in residential buildings | Mtoe | | | |
| Renewable electricity generation by PV panels for residential | Mtoe | | X | |
| Share of solar PV in total energy consumption buildings | Share (%) | | | |
| Renewable electricity generation by wind for residential | Share (%) | | | X |
| Renewable energy generation by biomass for residential | Mtoe | | X | |
| Share of wood or biomass heaters (or biofuel) in total energy consumption buildings | Share (%) | | | |
| Renewable energy generation by heat pumps for residential | Mtoe | | X | |
| Share of geothermal in total energy consumption buildings | Share (%) | | | |
| Renewable energy generation by solar for residential | Mtoe | | X | |
| Share of solar heaters in total energy consumption buildings | Share (%) | | | |
| Annual share of residential buildings undergoing major renovation (total) | Share (%) | | X | |
| Annual share of residential buildings undergoing major renovation (single-family houses) | Share (%) | | | |
| Annual share of residential buildings undergoing major renovation (multi-family houses) | Share (%) | | X | |
| Annual share of residential buildings undergoing major renovation (apartment blocks) | Share (%) | | | |
| Annual amount of Mm2 of residential buildings undergoing major renovation (total) | $Mm^2$ | | | |
| Annual amount of Mm2 of residential buildings undergoing major renovation (single-family houses) | $Mm^2$ | | X | |
| Annual amount of Mm2 of residential buildings undergoing major renovation (multi-family houses) | $Mm^2$ | | | |
| Annual amount of Mm2 of residential buildings undergoing major renovation (apartment blocks) | $Mm^2$ | | | |
| BUILDING ENERGY CONSUMPTION | | | | |
| All-end-uses Total Energy consumption for residential sector | Mtoe | X | | |
| All-end-uses Gas consumption for residential sector | Mtoe | | | |

| | | | | |
|---|---|---|---|---|
| All-end-uses Oil consumption for residential sector | Mtoe | | | |
| All-end-uses Coal consumption for residential sector | Mtoe | | | |
| All-end-uses Electricity consumption for residential sector | Mtoe | | | |
| All-end-uses Heat consumption for residential sector | Mtoe | | | |
| All-end-uses Renewable energy consumption for residential sector | Mtoe | | | |
| All-end-uses Energy consumption of single-family residential sector | Mtoe | | | |
| All-end-uses Energy consumption of multi-family residential sector | Mtoe | | X | |
| All-end-uses Energy consumption of apartment blocks residential sector | Mtoe | | | |
| Space heating Total Energy consumption for residential sector | Mtoe | | | |
| Space heating Gas consumption for residential sector | Mtoe | | | |
| Space heating Oil consumption for residential sector | Mtoe | | | |
| Space heating Coal consumption for residential sector | Mtoe | X | | |
| Space heating Electricity consumption for residential sector | Mtoe | | | |
| Space heating Heat consumption for residential sector | Mtoe | | | |
| Space heating Renewable consumption for residential sector | Mtoe | | | |
| Space heating Energy consumption of single-family residential sector | Mtoe | | | |
| Space heating Energy consumption of multi-family residential sector | Mtoe | X | | |
| Space heating Energy consumption of apartment blocks residential sector | Mtoe | | | |
| Water heating Total Energy consumption for residential sector | Mtoe | | | |
| Water heating Gas consumption for residential sector | Mtoe | | | |
| Water heating Oil consumption for residential sector | Mtoe | | | |
| Water heating Coal consumption for residential sector | Mtoe | X | | |
| Water heating Electricity consumption for residential sector | Mtoe | | | |
| Water heating Heat consumption for residential sector | Mtoe | | | |
| Water heating Coal consumption for residential sector | Mtoe | | | |
| Cooking Total Energy consumption for residential sector | Mtoe | | | X |
| Cooking Gas consumption for residential sector | Mtoe | | | |

| | | | | |
|---|---|---|---|---|
| Cooking Oil consumption for residential sector | Mtoe | | | |
| Cooking Coal consumption for residential sector | Mtoe | | | |
| Cooking Electricity consumption for residential sector | Mtoe | | | |
| Cooking renewable energy consumption for residential sector | Mtoe | | | |
| Electricity consumption of lighting for residential sector | Mtoe | X | | |
| Water consumption for residential sector | Mm2 | | X | |
| Space cooling energy consumption for residential sector | Mtoe | X | | |
| Total energy consumption per building | kWh/building | X | | |
| Total energy consumption per building – single-family buildings | kWh/building | | | |
| Total energy consumption per building – multi-family buildings | kWh/building | | | |
| Total energy consumption per building - apartment blocks | kWh/building | | | |
| Total Energy consumption per dwelling in residential sector | kWh/dwelling | X | | |
| Space heating energy consumption per dwelling for residential sector | kWh/dwelling | X | | |
| Water heating energy consumption per dwelling for residential sector | kWh/dwelling | X | | |
| Cooking energy consumption per dwelling for residential sector | kWh/dwelling | | | X |
| Lighting energy consumption per dwelling for residential sector | kWh/dwelling | X | | |
| Water consumption in residential sector | m3/dwelling | | | X |
| Energy consumption per m² for residential sector | kWh/m2 | X | | |
| Energy consumption per m² for residential sector (single-family houses) | kWh/m2 | | | |
| Energy consumption per m² for residential sector (multi-family houses) | kWh/m2 | | | |
| Energy consumption per m² for residential sector (apartment blocks) | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector | kWh/m2 | X | | |
| Space heating energy consumption per m² for residential sector (single-family houses) | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector (multi-family houses) | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector (apartment blocks) | kWh/m2 | | | |

| | | | | |
|---|---|---|---|---|
| Space heating energy consumption per m² for residential sector buildings built before 1945 | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector buildings built between 1945-1969 | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector buildings built between 1970-1979 | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector buildings built between 1980-1989 | kWh/m2 | | X | |
| Space heating energy consumption per m² for residential sector buildings built between 1990-1999 | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector buildings built between 2000 and 2010 | kWh/m2 | | | |
| Space heating energy consumption per m² for residential sector buildings built after 2010 | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector (single-family houses) | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector (multi-family houses) | kWh/m2 | X | | |
| Space cooling energy consumption per m² for residential sector (apartment blocks) | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector buildings built before 1945 | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector buildings built between 1945-1969 | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector buildings built between 1970-1979 | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector buildings built between 1980-1989 | kWh/m2 | | X | |
| Space cooling energy consumption per m² for residential sector buildings built between 1990-1999 | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector built between 2000 and 2010 | kWh/m2 | | | |
| Space cooling energy consumption per m² for residential sector buildings built after 2010 | kWh/m2 | | | |
| CERTIFICATIONS | | | | |
| Residential number of EPCs (Energy Performance Certificates) | Thousands | | X | |

| | | | | |
|---|---|---|---|---|
| Share of residential EPCs (Energy Performance Certificates) of class A | Share (%) | | X | |
| Share of residential EPCs (Energy Performance Certificates) of class B | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class C | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class D | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class >D | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class A related to the m2 covered | Share (%) | | X | |
| Share of residential EPCs (Energy Performance Certificates) of class B related to the m2 covered | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class C related to the m2 covered | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class D related to the m2 covered | Share (%) | | | |
| Share of residential EPCs (Energy Performance Certificates) of class >D related to the m2 covered | Share (%) | | | |
| voluntary certification - passive house - number of residential buildings | Number of buildings | | | X |
| FINANCING - ECONOMICAL PARAMETERS | | | | |
| Financing performance - Investments in renovation for residential buildings | Mio/EUR year | | X | |
| Financing performance - Investments in renovation for residential buildings (single-family houses) | Mio/EUR year | | | |
| Financing performance - Investments in renovation for residential buildings (multi-family houses) | Mio/EUR year | | | |
| Financing performance - Investments in renovation for residential buildings (apartment blocks) | Mio/EUR year | | | |
| Financing performance - Energy related investments in residential sector | Mio/EUR year | | X | |
| Financing performance - Energy related investments in residential sector (single-family dwellings) | Mio/EURyear | | | |
| Financing performance - Energy related investments in residential sector (multi-family dwellings) | Mio/EUR year | | | |
| Financing performance - Energy related investments in residential sector (apartment blocks) | Mio/EUR year | | | |

| | | | | |
|---|---|---|---|---|
| Financing performance - Average investments in residential sector | EUR/m2 | | | |
| Financing performance - Average investments in residential sector (single-family dwellings) | EUR/m2 | | X | |
| Financing performance - Average investments in residential sector (multi-family dwellings) | EUR/m2 | | | |
| Financing performance - Average investments in residential sector (apartment blocks) | EUR/m2 | | | |
| Financing performance -Average energy renovation investments in residential sector | EUR/m2 | | | |
| Financing performance Average energy renovation investments in residential sector (single-family dwellings) | EUR/m2 | | X | |
| Financing performance - Average energy renovation investments in residential sector (multi-family dwellings) | EUR/m2 | | | |
| Financing performance -Average energy renovation investments in residential sector (apartment blocks) | EUR/m2 | | | |
| Financing performance - Energy saving achieved in residential sector by renovation | EUR/m2 | | | |
| Financing performance - Energy saving achieved in residential sector by renovation (single-family dwellings) | EUR/m2 | | X | |
| Financing performance - Energy saving achieved in residential sector by renovation (multi-family dwellings) | EUR/m2 | | | |
| Financing performance - Energy saving achieved in residential sector by renovation (apartment blocks) | EUR/m2 | | | |
| Financing performance - Average Energy cost savings for retrofit in residential sector | Mio/EUR year | | | |
| Financing performance - Average Energy cost savings for retrofit in residential sector (single-family dwellings) | Mio/EUR year | | X | |
| Financing performance - Average Energy cost savings for retrofit in residential sector (multi-family dwellings) | Mio/EUR year | | | |
| Financing performance - Average Energy cost savings for retrofit in residential sector (apartment blocks) | Mio/EUR year | | | |
| ENERGY MARKET | | | | |
| Average energy price of natural gas | EUR/kWh | X | | |
| Average energy price of fuel oil | EUR/kWh | X | | |
| Average energy price of coal | EUR/kWh | X | | |

| | | | | |
|---|---|---|---|---|
| Average energy price of electricity | EUR/kWh | X | | |
| Average energy price of biomass | EUR/kWh | X | | |

# 5. Metadata identification

The aim of this deliverable is to address the work done in relation to BuiltHub Task 3.1 (WP3), providing a comprehensive list of building stock-related datasets available in Europe. The datasets provided by the Consortium and briefly described in Annex A are the 30 datasets more utilized for filling the chosen indicators (please see chapter 4 Indicators choice and prioritization). Furthermore, it was required to report datasets for the EU28+16, which has been done but mainly focusing on the provision of data for the EU27+UK as agreed internally by the Consortium and described in chapter 4 Indicators choice and prioritization. The same concept applies to the provision of data at different granularity (required were datasets for LAU2, NUTS3, and NUTS0 levels) where the Consortium focused on providing first NUTS0 level datasets, but some more disaggregated data (NUTS3, LAU2) are included as well. Furthermore, it has been required to provide datasets not only by international sources, but also national and local sources. Among the reported datasets both online public and private datasets have been added. As indicated in the GA the datasets cover three main macro areas:

1. **Building stock related datasets:** this is the most important macro area covered by the BuiltHub project. Data for both the residential and non-residential sector are required. Topics such as occupancy, final use, energy consumptions of buildings, construction elements main features, technical systems installed are among the information covered by such datasets. The datasets related to the building stock are marked in Table 18 as TYPE A.

2. **Socio-economic datasets:** datasets containing socio-economic data are considered of interest since they can be combined with the datasets of type A (Building Stock related Datasets) providing for example information about the living conditions in buildings of a certain country in relation with the wealth of its population. These datasets are marked in Table 18 as TYPE B.

3. **Climate related datasets:** these datasets collect information related to climatic conditions such as the air temperature, solar irradiation, cooling and heating degree days (CDD and HDD) or carbon dioxide (CO2) levels in the atmosphere. These data are useful to correlate information related to the building stock analysis and energy consumption data to the climatic conditions of the considered areas. In Table 18 such datasets are marked as TYPE C.

According to the GA of the H2020 BuiltHub project the metadata collection related to the datasets selected was a milestone of the project itself. The main metadata required by the GA, among others, were creators, year, link, content, origin, geographical extension, spatial granularity, time references, access conditions, and terms of use. In order to provide the best possible format for the metadata it has been decided to use the standards for the metadata description indicated in chapter 5.1 Metadata collection structure.

## 5.1. Metadata collection structure

Metadata collection is fundamental for reaching the goals set by the BuiltHub project. The metadata collected for the 30 selected datasets are based on the structure of two different schemes. The first scheme used as basis for the metadata collection is DataCite metadata scheme [21]. More specifically the properties to address according to DataCite are author(s), title, DOI, publisher and publication year, and finally resource type. Among the aforementioned metadata the BuiltHub Consortium employs all of them but not the information related to the publisher, which is considered to be marginal for the purpose of the project itself. Providing metadata in line with DataCite is an advantage since they will be coherent with the needs of large scientific repositories such as Zenodo. The main limitation of the DataCite scheme is the absence of semantic data related to the identified sources of information. For this reason, a second metadata scheme has been introduced: schema.org [22].

The schema.org metadata citation system introduces a description of the metadata itself, of the methodology and of the URL link at which it is possible to find complete information related to the methodology. In addition to the metadata cited also reference year/s for the available data, special information (available countries and granularity level of the provided data), accuracy and completeness will be provided. Finally, information related to the use of the provided data are reported as well. Among them it is possible to mention, when present, licenses and terms of use, accessibility and availability of the datasets chosen. A selection of the most important metadata collected is reported in ANNEX A, where the list of the 30 selected datasets is reported.

# 6. Annex A – LIST OF DATASETS

In this Annex the list of 30 datasets introduced and described in chapter 5 Metadata identification has been reported. Please note that this table is only a summarizing table extracted from the original csv file created by the H2020 BuiltHub project Consortium.

**Table 18: List of metadata related to the datasets identified by the Consortium of Horizon 2020 BuiltHub project concerning the provision of data for the chosen indicators**

| DATASET IDENTIFICATION | | | | | METHOD |
|---|---|---|---|---|---|
| TYPE | NAME | CONTENT | AUTHOR/S | DATASET URL | METHOD .URL |
| A | IEE TABULA project: Typology Approach for Building Stock Energy Assessment | Building stock data and other data focusing on technical systems for heating, cooling and domestic hot water production in different buildings types are the main outputs of this dataset. Final energy consumption and envelope performance data are available as well. | TABULA Project Consortium | http://webtool.building-typology.eu/#bm | https://episcope.eu/building-typology/overview/ |
| A | IEE EPISCOPE project: Focus of building stock monitoring | The main focus point of the EPISCOPE Project is the energy refurbishment of houses in 20 European countries. Interesting information collected concern the construction period (definition of different classes in each country) and the building type (single or multi-family house, terraced house and apartment block), as well as performance-related parameters. | EPISCOPE Project Consortium | https://episcope.eu/welcome/ | https://episcope.eu/monitoring/average-buildings/ |
| A | IEE ZEBRA2020 project: Nearly Zero-Energy Building Strategy 2020 | Building stock data including data for energy efficiency trends in buildings as well as data for net zero energy buildings. The project focused on the newly built buildings. This project focused on the creation of an observatory for monitoring the market uptake of nZEBs across Europe. It contains information related to energy performance certificates, materials employed for the buildings, energy performance and final energy consumption and more. | ZEBRA2020 Project Consortium | https://zebra-monitoring.enerdata.net/ | / |
| A | IEE ENTRANZE project | Policies to Enforce the TRAnsition to Nearly Zero Energy buildings in the EU27This dataset provides the mapping of several data coming from different sources. The main outputs of the projects are the mapping of building stock related data such as floor area of residential and non-residential buildings, heating/AC system data, and final energy consumption by sector and more. | ENTRANZE Project Consortium | https://entranze.enerdata.net/ | / |

| | | | | | |
|---|---|---|---|---|---|
| A | H2020 ODYSSEE - MURE project | Comprehensive monitoring of efficiency trends and policy evaluation in EU countries, Norway, Serbia and Switzerland. This dataset presents building stock related data including floor area of dwellings, final energy consumption by source, and stock of appliances and dwellings for the EU countries, Norway, Serbia and Switzerland. | ENERDATA | https://odyssee.enerdata.net/database/ | https://www.odyssee-mure.eu/faq/energy-efficiency-methodology/ |
| A | Horizon 2020 HotMaps project: Building stock analysis | Complete building stock analysis for the EU27+UK. Values related to final energy consumption and useful energy demand for space heating, space cooling and domestic hot water, construction materials and methodologies, technologies used and building stock data/information (thermal transmittance, building stock vintages and characteristics, household occupancy related data, etc.) can be found both for the residential and the non-residential sectors per building types and construction vintages. | Simon Pezzutto, Silvia Croce, Stefano Zambotti, EURAC | https://gitlab.com/hotmaps/building-stock/-/tree/master/data | https://gitlab.com/hotmaps/building-stock/-/blob/master/README.md |
| A | FP7 CommON-Energy Project: building stock | Building stock data including building sector data and final energy demand data for non-residential buildings, especially focusing on the trade sector (shopping malls, …) | Vienna University of Technology - Energy Economics Group (EEG) | https://eeg.tuwien.ac.at/commonenergy/floor-area-non-residential | / |
| A | JRC IDEES 2015 | The JRC IDEES (Integrated Database of the European Energy System) is focused on the incorporation in a single database of all necessary information for a better understanding of the off the European energy system dynamics. In this way it provides a way to better analyze both the past and to create the best possible basis for future policy assessments. JRC IDEES offers a set of disaggregated energy-environment-economy data, compliant with the EUROSTAT energy balances, as well as widely acknowledged data on existing technologies. It also contains a plausible decomposition of final energy consumption. | European Commission's Joint Research Centre (JRC) | https://data.jrc.ec.europa.eu/dataset/jrc-10110-10001/resource/f590b6f1-60e5-49a6-a972-60bc2b2e34b3 | https://op.europa.eu/en/publication-detail/-/publication/989282db-ad65-11e7-837e-01aa75ed71a1/language-en |

| | | | | | |
|---|---|---|---|---|---|
| A | SET-Nav - Strategic Energy Roadmap | The project intends to support strategic decision making in Europe's energy sector, enhancing innovation towards a clean, secure and efficient energy system. | SET-Nav Consortium | http://www.set-nav.eu/ | / |
| A | H2020 ExcEED Project: building stock data | The ExcEED project (European Energy Efficient building district Database) takes the pulse of the actual energy consumed by last generation of buildings. The project answers the need for transparency and comparability of energy performance calculations. The scope of ExcEED is to create a European database for measured and qualitative data on beyond the state-of-the-art buildings and districts. | ExcEED Consortium | http://www.exceedproject.eu/ | / |
| A | FP7 iNSPiRe project: building stock analysis | The building stock analysis and data gathering exercise focused its attention on published literature and other sources, aiming to extrapolate information about the current residential and office building stock. Among the different data gathered it is possible to mention number and floor area of residential buildings/dwellings and office buildings / construction by type and age distribution / typology/ façade and glazing types / geometry / average floor area/ number of floors / U-value, thermal characteristic and performance of the buildings, by age / ownership and tenure i.e. number of social housing, owner occupied, private renting etc. / energy consumption and demand in terms of both, total and individual end-use including space heating, domestic hot water, cooling, lighting; fuel and heating system types and comfort requirements. Interest has been set on lighting-related data. | iNSPiRe Consortium | https://zenodo.org/record/3256270#.X_wayHqSnIU | https://zenodo.org/record/3256270#.X_wayHqSnIU |

| | | | | | |
|---|---|---|---|---|---|
| A | Energy consumption and energy efficiency trends in the EU-27+UK for the period 2000-2016 - FINAL REPORT | This report shows the present status of final energy consumption in the EU-27+UK focusing the results on the most energy consuming sectors: residential, tertiary, transport and industry. Therefore, the report demonstrates the energy consumption progress from 2000 to 2016 in the mentioned four sectors. There is a special focus on electricity and gas consumption, as they are the most important alternatives to oil. The report includes an analysis of the most important factors influencing final energy consumption trends such as economic growth, population, heating demand, household characteristics and energy prices. | European Commission's Joint Research Centre (JRC) – Tsemekidi Tzeiranaki Sofia, Bertoldi Paolo, Labanca Nicola et Al. | https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/energy-consumption-and-energy-efficiency-trends-eu-28-period-2000-2016 | / |
| A | Comprehensive study of building energy renovation activities and the uptake of nearly zero-energy buildings in the EU - FINAL REPORT | This study is focused on the delivery of a comprehensive analysis of the renovation activities and nearly zero-energy buildings (NZEB) uptake in the EU27+UK starting from 2012 up to 2016. Indicators in line with the Building Stock Observatory (BSO) have been applied. The main results are available for the EU27+UK and for each of the single Member States. | Directorate-General for Energy (European Commission), IPSOS, Navigant | https://op.europa.eu/en/publication-detail/-/publication/97d6a4ca-5847-11ea-8b81-01aa75ed71a1/language-en/format-PDF/source-119528141 | / |
| A | EUROSTAT: Final energy consumption in households | The final energy consumption in households is a measure of the total energy consumed by households as final users. In this dataset it is expressed in thousand tons of oil equivalent. | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/databrowser/view/t2020_rk200/default/table?lang=en | https://ec.europa.eu/eurostat/cache/metadata/en/t2020_rk200_esmsip2.htm |

| | | | | | |
|---|---|---|---|---|---|
| A | EUROSTAT: Final energy consumption in households by fuel | The share of seven types of fuel over the final residential energy consumption is reported in this dataset. The types of fuels considered are solid fossil fuels, other fuels, oil and petroleum products, natural gas, electricity, heat and renewables and biofuels. The share of each fuel is expressed in per cent of the total consumption. | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/databrowser/view/t2020_rk210/default/table?lang=en | https://ec.europa.eu/eurostat/cache/metadata/en/nrg_quant_esms.htm |
| A | EUROSTAT: Disaggregated final energy consumption in households | This dataset provides disaggregated values for the final energy consumption | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/databrowser/view/nrg_d_hhq/default/table?lang=en | https://ec.europa.eu/eurostat/cache/metadata/en/nrg_quant_esms.htm |
| A | ZENSUS 2011 | This dataset contains disaggregated data concerning a building stock analysis for Germany, information about the occupancy of the buildings and socio/economic related data. Information concerning the type of heating systems used are reported too. The goal of the 2011 Census is to provide the most accurate snapshot possible of basic data on the country's population and the employment and housing conditions. | Statistische Ämter des Bundes und der Länder 2020 | https://ergebnisse.zensus2011.de/# | https://www.zensus2011.de/EN/2011Census/Methodology/Methodology_node.html |
| A | DPE - Diagnostic de Performance Energetique | This dataset contains data regarding the distribution of Energy Performance Certifications at a granularity of NUTS3 level in France. | ADEME - Environment and Energy Management Agency | https://www.observatoire-dpe.fr/index.php/graphique/dpeParEtiquette | / |

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| A | Towards a sustainable Northern European housing stock - Sustainable Urban Areas 22 | This report contains complete data for a building stock analysis with data varying from State to State between 2000 and 2006. Data concerning material used and (heating, ventilation and cooling) systems installed are reported too. Construction/Demolition rates (1980-2004) have been added to the report. | Laure Itard, Frits Meijer - TU Delft | https://www.arct.cam.ac.uk/Downloads/towards-a-sustainable-northern-european-housing.pdf | https://www.arct.cam.ac.uk/Downloads/towards-a-sustainable-northern-european-housing.pdf |
| A | DEEP - De-risking Energy Efficiency Platform | The De-risking Energy Efficiency Platform (DEEP) is an open-source database for energy efficiency investments performance monitoring and benchmarking. The platform provides an exhaustive analysis on the performance of energy efficiency investments in order to support the assessment of the related benefits and financial risks. more in the detail it could be possible to extrapolate data concerning the energy savings per renovation type or per building type. | Launched by the Energy Efficiency Financial Institutions Group (EEFIG) in the context of its De-risking project | https://deep.eefig.eu/overview | https://deep.eefig.eu/static/pdf/DEEPUserGuideV1.pdf |
| A | Energy consumption and efficiency technology measures in European non-residential buildings | This paper provides an overview on the results of the data collected by the Green Building Program (GBP) and its main results from the launch in 2006 up to its completion in 2014. The paper focuses on building characteristics, energy performance, efficiency measures and energy savings. The paper categorizes the main technological measures related to envelope, appliances and systems. | Delia D'Agostino, Barbara Cuniberti, Paolo Bertoldi | https://www.sciencedirect.com/science/article/abs/pii/S037877881730676X | https://www.sciencedirect.com/science/article/abs/pii/S037877881730676X |
| A | Dataset of the publication: Europe's Building Stock and Its Energy Demand: A Comparison Between Austria and Italy | Building stock analysis data for Italy and Austria, evaluating also space cooling, space heating and final domestic hot water consumptions. | Pezzutto S., Haas F., Exner D., Zambotti S. | https://link.springer.com/chapter/10.1007%2F978-3-319-75774-2_3 | https://link.springer.com/chapter/10.1007%2F978-3-319-75774-2_3 |

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| A | National Housing Census: European statistical System | This dataset contains a variety of data collected in relation to the national census performed in 2011 by EU27+UK member states. More specifically it is possible to find data concerning households such as the number of components of single households at a granularity till NUTS3 level. | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/CensusHub2/query.do?step=selectHyperCube&qhc=false | / |
| B | Energy prices in 2019 - Household energy prices in the EU | This report provides the households prices both for electricity and natural gas for the second semester of year 2019, comparing these values with the ones of the previous year. | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/documents/2995521/10826603/8-07052020-AP-EN.pdf/2c418ef5-7307-5217-43a6-4bd063bf7f44 | https://ec.europa.eu/eurostat/web/energy/methodology/prices |
| B | EUROSTAT: GDP per capita in PPS | Gross domestic product (GDP) is a measure for the economic activity. The volume index of GDP per capita in Purchasing Power Standards (PPS) is expressed in relation to the European Union average set to equal 100 (EU27). If the index of a country is higher than 100, this country's level of GDP per head is higher than the EU average and vice versa. Please note that this index is thought for cross-country comparisons rather than for temporal comparisons. | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/databrowser/view/tec00114/default/table?lang=en | https://ec.europa.eu/eurostat/cache/metadata/en/nama10_esms.htm |
| B | EUROSTAT: Population on 1 January by age, sex and NUTS 2 region | This dataset provides a complete overview of the population of each NUTS2 region of the EU27+UK | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/databrowser/view/DEMO_R_D2JAN__custom_442767/default/table?lang=en | https://ec.europa.eu/eurostat/cache/metadata/en/demo_r_gind3_esms.htm |

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| C | EUROSTAT - Cooling and heating degree days | A complete dataset of the cooling and heating degree days at NUTS2 level is provided both on annual and on monthly basis | Statistical Office of the European Union (Eurostat) | https://ec.europa.eu/eurostat/web/energy/data/database | https://ec.europa.eu/eurostat/cache/metadata/en/nrg_chdd_esms.htm#stat_process15542838033348 |
| C | EDGAR (Emissions Database for Global Atmospheric Research) CO2 Emissions | Carbon Dioxide ($CO_2$) emissions by country and sector (Buildings, Transport, Other industrial combustion, Power Industry and other sectors) have been collected for the years between 1970 and 2018 and are reported expressed in $MtCO_2$/year. | Crippa, M., Oreggioni, G., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, E., Solazzo, E., Monforti-Ferrario, F., Olivier, J.G.J., Vignati, E. (Joint Research Centre) | https://github.com/openclimatedata/edgar-co2-emissions | https://op.europa.eu/en/publication-detail/-/publication/9d09ccd1-e0dd-11e9-9c4e-01aa75ed71a1/language-en |
| C | CORDEX - Regional climate model data on single levels for Europe | Climatic data for Europe expressed in daily, monthly and seasonal mean values as well as 3/6 hours resolution. Data for air temperature at 2 m, wind speed, atmospheric pressure and humidity can be found. | European Centre for Medium-Range Weather Forecasts | https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cordex-single-levels?tab=overview | https://cds.climate.copernicus.eu/toolbox/doc/index.html |
| C | PVGIS - Photovoltaic Geographical Information System | This GIS dataset contains data related to the solar radiation. It takes into account both day and night-time periods expressing the solar radiation raster map in W/m2. | Climate Monitoring Satellite Application Facility (CM SAF) | https://ec.europa.eu/jrc/en/PVGIS/downloads/CMSAF | https://ec.europa.eu/jrc/en/PVGIS/docs/methods |

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# Annex table of contents

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