BuiltHub

# Stakeholder needs and technical requirements for the BuiltHub

A synthesis from EU policy, survey, and interviews

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# 1. Introduction

## 1.1. Overview of the project

The “Dynamic EU building stock knowledge hub - BuiltHub" is a 4-year European Project funded under the Horizon 2020 programme of the European Union. The project seeks to develop a roadmap to continuously gather and enhance the data needed to inform building-related policies and business through a community and its data hub. It seeks to inform and positively disrupt policy and market decision-making through a continuously community-enhanced evidence base. The BuiltHub community and its IT platform serving as data analytics and knowledge exchange hub shall change the way knowledge on the EU building stock is developed and shared with the full range of building stakeholders from across Europe.

## 1.2. Aim and objective

BuiltHub aims to create a continuous and durable flow of reliable building stock data at the EU and national levels. BuiltHub will be executed and tested through its datahub, established as an online platform with powerful data analytics to create an added value for stakeholders. Stakeholders play an important role in the development of the concept for the BuiltHub platform, therefore, the objective of this report is to capture and consolidate their feedback outlining their needs and corresponding technical requirements for the BuiltHub platform. Combined research methods (e.g. literature review, survey and interviews) have been used in this study to meet this objective.

# 2. Methodology

A three-level investigation was set up to understand and establish the stakeholder needs and technical requirements for the BuiltHub platform and community, which included:

1. **EU Legislations review** (section 2.1)
2. **EU-wide online survey of stakeholders** (section 2.2)
3. **EU expert interviews** (section 2.3)

A review of EU legislation (e.g., directives, regulations) has been conducted to identify the needs and technical requirements related to building stock data and its use.

The direct feedback has been collected from stakeholders using engagement methods such as surveys and interviews focusing on the EU stakeholders’ needs and requirements for the BuiltHub platform. The findings of this work will feed into the development of services related to data assembly, data processing and analysis, IT infrastructure and business case for exploitation.

Following these, an additional analysis for interpreting the needs and into technical requirements for BuiltHub was conducted using Quality Function Deployment (QFD) method (see section 2.4) using only the survey results.

Details for each methodological aspect are given in the Sections 2.1, 2.2, 2.3, and 2.4 followed by a discussion of results for each aspect in Section 3, 4, 5, and 6. The nature of findings consolidated in this report may not be too specific due to the broad scope of the investigation, however, authors have tried to encapsulate relevant information from the above sources.

## 2.1. EU legislations review

Existing EU legislation (e.g., directives, policies, and regulations) have been reviewed to check whether they create needs and requirements for building-related data or data that are connected to reduce GHG emissions from buildings. To establish certain needs that are well recognised in these documents a review is conducted that includes the following sources.

- the Energy Performance of Buildings Directive (EBPD; 2010/31/EU amended by directive 2018/844/EU),
- the Energy Efficiency Directive (EED; 2012/27/EU amended by 2018/844/EU and 2018/2002)
- the Renewable Energy Sources Directive (RESD, 2018/2001/EU)
- the Open Data Directive, i.e., a directive on open data and the re-use of public sector information (PSI); (PSI, 2019/1024)

The objective of the review is to identify which building data needs and requirements originate from European legislation. BuiltHub is aiming at providing centralised, high-quality data to its users. BuiltHub strives to include data on buildings and other relative aspects[1] in view of their decarbonisation. Several pieces of European legislation include requirements from the Member States, for example for measuring the progress of EU building stock decarbonisation, and how that could be facilitated with such a data hub. By presenting its usefulness for addressing the above-mentioned pieces of European legislation, this part of the report shall motivate the participation in BuiltHub and engagement of stakeholders such as policy makers in Member States as well as national and subnational authorities related to the building stock and its transition to net zero.

[1] These aspects include interactions of the buildings with the energy system, with the social system (energy poverty) and with the neighbourhoods (urban planning) as well as with the economic system (investment and cost-effectiveness).

## 2.2. EU wide online survey of stakeholders

### *2.2.1. Stakeholder categorisation and selection*

In the initial exercise of stakeholder analysis (T2.1), a comprehensive stakeholder registry was developed followed by stakeholder mapping and analysis. For the project, it is important to recognise stakeholders' role in BuiltHub by understanding how they will use the data, what data they can provide and under which conditions. It is also investigated how they support the project or use and disseminate the project results and knowledge. For this purpose, three stakeholder types were defined in the project:

1. **Lead-Users**, expected to contribute data and use knowledge and results from BuiltHub in return,
2. **End-Users**, supposed to exploit the platform, or
3. **Multipliers**, expected to disseminate the results and enlarge the stakeholder community.

Lead-users will be able to directly feed their data into the BuiltHub platform and to apply BuiltHub analysis results for their purposes. For example, this could be a real estate developer or building stock manager from an organisation singling out possible green energy technology solutions based on their building stock data provided to BuiltHub. Lead-users are, hence, mainly owning and providing data in exchange for a service, i.e., transforming their data into knowledge.

End-users on the other hand, will mainly exploit the platform and its results in their activities by consulting the data fed in by others. In doing so, they would engage to assess the platform usability and effectiveness. In some cases, they may feed their own data into BuiltHub, thereby also becoming lead users. For example, this could be a regional energy agency or energy department looking to revise their renovation benchmark and targets or policy scheme.

Finally, Multipliers will disseminate BuiltHub achievements, thereby enlarging the related engaged community and boosting the building stock transformation. All stakeholders, including multipliers, will be contacted and receive information about the knowledge gathered through the data platform.

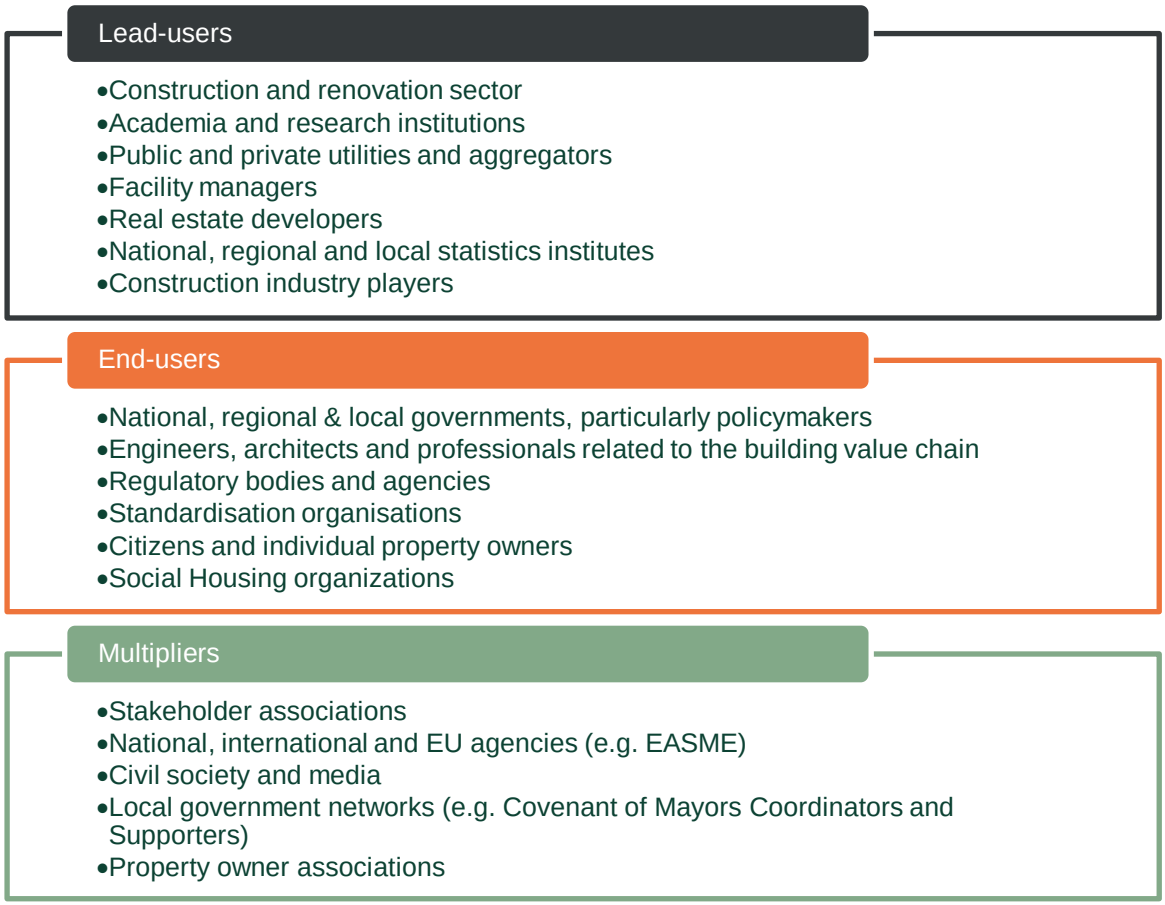


**Figure 1: Stakeholder types by the stakeholder's role for the project**

The stakeholders collected in the registry were mapped to these types as shown in Figure 1. The classification of organisations under lead-users, end-users and multipliers does not strictly define their function and they may have interchangeable roles as well. As a part of Task 2.1, stakeholder invitations were sent out to become a part of the BuiltHub community. About 195 stakeholders registered their consent for participation in BuiltHub project engagements, therefore, only these were shortlisted for participation and were invited for the survey and interviews.

### *2.2.2. Data collection and sample size*

The user survey was conducted during March-April 2021 using online interviewing methodology (i.e., Computer Assisted Web Interviewing; CAWI) using Survey Monkey. An online access panel was used for pre-recruited individuals (195) who have agreed to take part in research from the initial stakeholder registry[2]. A total of 133 stakeholders took part in the survey out of which the completion rate was 71% i.e., 94 stakeholders completed the survey, therefore, only these were included in the analysis of this report and the remaining 62 were

[2] Task 2.1: Stakeholder registry

rejected due to incompleteness. The average time taken to complete the survey by the stakeholders was 13 minutes.

### *2.2.3. Profile of respondents*

The stakeholders who were invited to participate in the survey included the target group of lead-users, end-users, and multipliers (refer Section 2.2.1). Selection of target group was done to reach out relevant stakeholders who would engage in building stock data-related transactions. Table 2 below shows the distribution of participants by their organisation.

**Table 1: Distribution of respondents by type of organisation**

| **Organisations** | **% of responses (n=94)*** |
|---|---|
| Universities/ academia | 54% |
| Research and policy consulting | 10% |
| Civil society (e.g. NGOs, community groups, unions etc.) | 9% |
| Design firms or consultancy | 7% |
| Public authorities and policy makers | 5% |
| National and European institutions/ departments | 3% |
| National, international and EU agencies | 3% |
| Construction industry player and other industry | 3% |
| Public and private utilities | 1% |
| Other | 2% |
| Construction companies and industry consulting firms | 1% |
| Property owner associations | 1% |
| **referred as the total sample size of survey* | |

54% of respondents stems from academia and 10% from research and policy consulting. These stakeholders would potentially feed and also use the data on BuiltHub. Also, other respondents who would like to feed the data, exploit the platform and its results are Design firms and consultancies (7%) and public authorities and policy makers (5%). Among others, respondents are from Civil society (9%) and National, international, and EU agencies (3%). Overall, the sample represents a good composition of organisations that would play the role of the three set of stakeholders (lead-users, end-users and multipliers).

### *2.2.4. Questionnaire development*

The objective of the questions was to help partners identify stakeholders needs in order to define the technical requirements for the development of the BuiltHub platform and to build and maintain a sustainable community of data providers. The survey questionnaire was developed in collaboration with project partners (EURAC, TU WIEN, SYMPRAXIS and EVERIS) based on five key areas:

1. Stakeholders' community engagement

2. Data assembly
3. Data processing and analytics
4. IT infrastructure development
5. Platform business cases for exploitation and sustainability

The questionnaire was composed of multiple-choice, multiple answer, grid, Likert-scale, dropdown, and open-end questions; see the complete list of questions in Annex I. Different types of questions enabled capturing a diverse perspective of the stakeholders towards establishing needs and technical requirements within the objective of this report.

The questionnaire was prepared in English and the survey was conducted across Europe (EU27).

## 2.3. EU expert Interviews

To study and identify more in detail specific stakeholders needs, 11 experts were chosen (described below) for semi-structured interviews with a duration of 60 minutes. These experts were also asked to identify datasets not known to the consortium.

Initially, 42 people out of survey respondents were selected to be interviewed based on their response to a survey question that asked for their interest in sharing data with BuiltHub, these respondents indicated a ‘high’ level of interest. Before sending invitations for interviews a further shortlisting was done from the 42 respondents using the following criteria:

- Prioritisation based on high professional experience
- Achieving a gender balance based on GA
- Geographical representation in the EU

As a result, a list of 21 respondents were finalised, and these were invited for interviews. A total of 11 interviews were finally conducted with 30% female interviewees and 8 nationalities. A semi-structured interview was prepared for the participants (see Annex II). The interviews were recorded based on the consent provided by the interviewee and were transcribed. Within the context of this report, the consolidated transcripts were analysed through deductive analysis [1] using the structure and pre-determined approach. The data was analysed by mapping the connections with the specific categories/ themes pre-defined in the semi-structured format. Following steps were applied during the analysis:

1. Reading of the transcripts and making notes to identify thematic discourse
2. Annotation of the transcripts by labelling relevant words, phrases, or sentences. The labels referred to actions, activities, concepts, differences, opinions, processes, and other relevant contents. This helped in organising the data.
3. Conceptualising and segmenting the data to align with critical categories identified in the first step.
4. Analysis of the segmented data to understand co-relations, differences, and deviations.
5. Development of the results based on the analysis of the content (step 1-4) and reporting them under the pre-determined structure.

The profiles of interview participants are given below in Table 2:

**Table 2: Profile of interviewees**

| Interviewee code | Organisation type | Experience (years) | Country |
|---|---|---|---|
| IN01 | Universities/ academia | 11-20 | Spain |
| IN02 | Civil society (e.g., NGOs, community groups, unions etc.) | Over 30 | Hungary |
| IN03 | Research and policy consulting | 21-30 | Romania |
| IN04 | Universities/ academia | 11-20 | Italy |
| IN05 | Universities/ academia | 11-20 | Germany |
| IN06 | Universities/ academia | 11-20 | Romania |
| IN07 | Civil society (e.g., NGOs, community groups, unions etc.) | 11-20 | Bulgaria |
| IN08 | Universities/ academia | 11-20 | Romania |
| IN09 | National and European institutions/ departments | 6-10 | Italy |
| IN10 | National and European institutions/ departments | 21-30 | Belgium (Flanders) |
| IN11 | Research and policy consulting | 6-10 | Belgium |

## 2.4. Meeting the needs: Quality Function Deployment (QFD)

One of the tools that have been regarded as very successful in meeting the needs and technical requirements of customers/ stakeholders is QFD (Quality Function Deployment) [2]. The system can be understood by defining each of the terms in 'Quality Function Deployment' within the context of QFD.

- Quality – What do customers need
- Function - What must be done - Focusing the attention
- Deployment - Who will do it, When

QFD is a process used to define customer needs and convert them into detailed design/technical specifications and plans to produce the product (or service) that fulfill those

needs. For example, a customer wants a light and easy to hold coffee mug, these needs can be translated into technical specifications such as using metal/ plastic instead of ceramic and designing a holding loop instead of none. QFD has been used for the development of software and services along with a wide range of problem areas in the architecture and construction industry [3].

In the context of BuiltHub, QFD is used to focus on the needs of the multiple stakeholders and use them to outline the technical requirements[3] for delivery of different services meeting the needs of stakeholders [4]. The basic QFD House of Quality (see Figure 2) is the tool that drives the process using a relationship matrix where a client/stakeholder needs, and technical/design requirements are related to each other so that the required quality can be achieved using important technical requirements. As shown in Figure 2, a basic House of Quality (HOQ) comprises of six main parts. The stakeholder's interests and their importance rating are given by the stakeholders. The technical/design requirements are the set of options available for the stakeholder and a co-relation matrix describes their relationship with each other. Since the scope of the current study is preliminary, co-relation matrix between technical requirements is not used in the analysis. The main part of the HOQ is the relationship matrix where the relevant technical requirements can be linked with the stakeholder needs. The assessment results section is where the priority of each technical requirement is calculated in relation to each other.

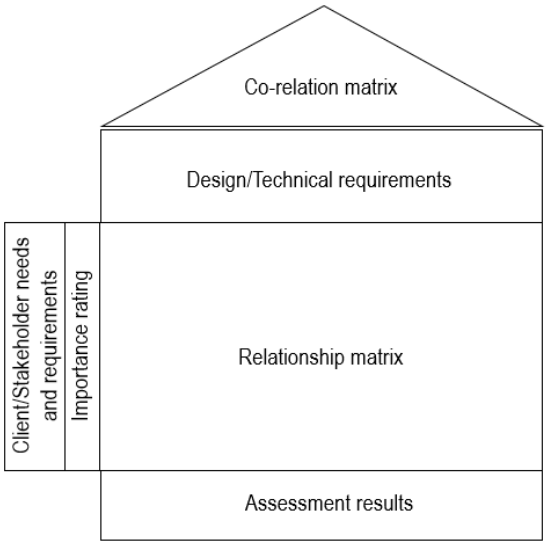


**Figure 2: A QFD House of Quality**

### *2.4.1. Relevance and application to BuiltHub*

HOQ is utilised for BuiltHub in order to understand the real issues and prioritise the action areas connected with data availability, types, accessibility, quality, benefits in development of solutions for stakeholders. Determining the technical requirements for the development of

[3] Technical requirements are a broader term that includes technical characteristics and specifications for BuiltHub platform and is used considering the scope of work in this task and preliminary application of the QFD concept.

targeted data-related services in BuiltHub by using these relationships will enhance the interaction of IT platform/ infrastructure and its usage by stakeholders.

HOQ will assist in meeting the specific interests of the stakeholders based on the importance assigned to them from survey results. Survey results (Section 4) are used to structure the HOQ in QFD analysis (Section 6) due to quantitative nature of results. Furthermore, expert feedback from EURAC , TUW , EVERIS , and SYMPRAXIS are also used in this analysis. In this report, the QFD (HOQ) is used to bridge the gap of built-in interaction between the stakeholder needs and technical requirements required for the development of BuiltHub platform. As the project is in its preliminary stage, the QFD is conducted to outline and emphasize the key priority areas to support the development of BuiltHub IT platform, analysis, services, and communication.

# 3. EU legislations review results

## 3.1. Energy Performance of Buildings Directive (EPBD, Directive (EU) 2018/844)

The EPBD was enacted first in 2002 and has been revised in 2010 and again in 2018 (Figure 3). A big change in the latest revision was the introduction of the requirement for long-term renovation strategies.

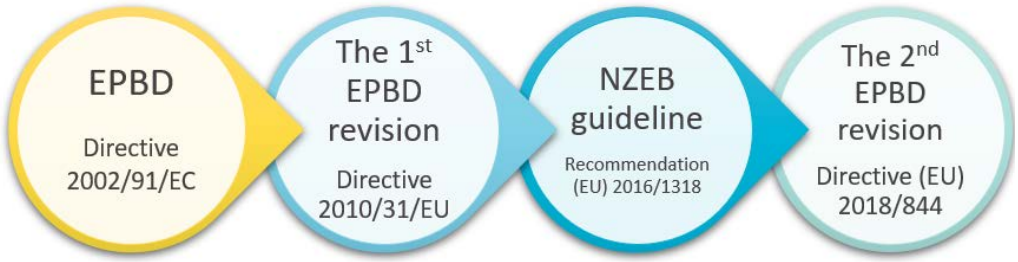


**Figure 3: Evolution of the EPBD**

The EBPD includes requirements on buildings performance including equipment and efficiency measures and introduces the EPC; it also includes to consider the efficiency measures' cost, the climate, and the energy system. These data are necessary to calculate the energy performance (Article 3, Directive 2010/31/EU)[5], establish long-term renovation strategies (Article 2a, Directive 2018/844)[6], evaluate cost-optimality (Article 5) to set minimum requirements for energy performance (Article 4, Directive 2010/31/EU), issue energy performance certificates (Article 11, Directive 2010/31/EU).

The EPBD allows the Member States to decide whether they want to collect these data on a national level or a regional level. In the latter case, the results of the regional analysis but not the data themselves would need to flow into the national policy process. However, national, regional, and local authorities would need physical systems and processes to collect such data and methodologies to monitor and analyse them. In the following paragraphs, a description is provided in detail how the requirements in the different Articles are related to a data need.

Article 3 of the EBPD (Directive 2010/31/EU) requires Member States to apply specific methodology to calculate the energy performance of buildings. Such methodology should take into account European standards and shall be consistent with relevant EU legislation, including Directive 2009/28/EC [7] following the common general framework[4]. The framework requires consideration of building-specific thermal characteristics and performance of the HVAC systems. Member States can decide to apply the methodology nationally or regionally. Data needed to comply are:

- typical use of the building
- building's thermal characteristics; thermal capacity[5]; insulation; passive heating; cooling elements; thermal bridges
- heating and domestic hot water systems; air conditioning (A/C); ventilation; lighting; solar PV systems and solar protection; design, positioning, and orientation of the building; outdoor climate
- primary energy factors per energy carrier

To fulfill Article 4 of the EPBD (Directive 2010/31/EU), Member States needs to the determine cost-optimal level as an orientation for setting minimum energy performance requirements for new and existing buildings or building units. The cost optimality is dependent on the following aspects[6].

- future climate –temperature, solar radiation, and wind
- future use of the building
- thermal characteristics and HVAC equipment
- current cost of energy efficiency measures and the future energy savings they achieve
- future cost of fuels
- general indoor climate

For the cost-optimality calculations, the data listed above are needed to determine the minimum energy performance requirements. These data are required by the different climate regions, except for primary energy factors they may be used on national level or as a regional

[4] As set out in Annex I of EPBD 2010/31/EU

[5] The thermal capacity depends on the material composition of the building element. Hence, the material composition of all building elements helps to determine the thermal capacity.

[6] Additionally, for the owner's decision making, the local rental and real-estate market determines the cost-efficiency. For the determination of cost-optimality on national level, this aspect is not included. This means data needed do not include the ownership structure of the building stock, i.e., the different economic conditions of different owners.

annual weighted average. The indoor climate shall be taken into account to avoid possible negative effects such as inadequate ventilation.

According to Article 5 (Directive 2010/31/EU) Member States need to use the comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements (established in accordance with Annex III of the directive (Directive 2010/31/EU). It also defines the granularity of the calculation to distinguish new and existing buildings and different categories of buildings.

According to Article 17 (Directive 2010/31/EU), Member States shall ensure that qualified or accredited experts conduct the inspections of HVAC systems and issue the EPCs. To implement this Member States can establish certification schemes and choose to set up lists or databases of accredited experts.

In the EPBD the national aggregation is needed to comply with the requirement for long-term renovation strategies, which was introduced in Article 2a of the EPBD in 2018 by Directive 2018/844. It shall give an overview of the national buildings stock, identify cost-effective approaches, and give an overview of policies and initiatives to decarbonise the building stock in order to achieve the long-term 2050 goal of reducing greenhouse gas emissions by 80%-95% compared to 1990. To deliver the Green Deal the commission proposes a renovation rate of at least 3%, 49% renewables by 2030 and and increase of the use of renewable energy in heating and cooling of +1.1 percentage points annually[7].

To comply with the EPBD, data describing the building stock and the climate may be collected and analysed centrally or decentrally, i.e. on national, regional or local level. In the latter case, the results of the decentral analysis would flow into the national policy process.

## 3.2. Energy Efficiency Directive (EED; 2012/27/EU amended by Directive (EU) 2018/844)

The EED was first enacted in 2012 and supersedes the Directive 2004/5/EC on promotion of cogeneration and the Directive 2006/32/EC on energy end-use efficiency and efficiency services. The Directive 2012/27/EU [9] also amends the Directive 2009/125/EC on Ecodesign and the Directive 2010/30/EU [10] on energy labelling. The latest amendment of the EED was enacted in 2018 through Directive (EU) 2018/844 (Figure 4).

[7] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

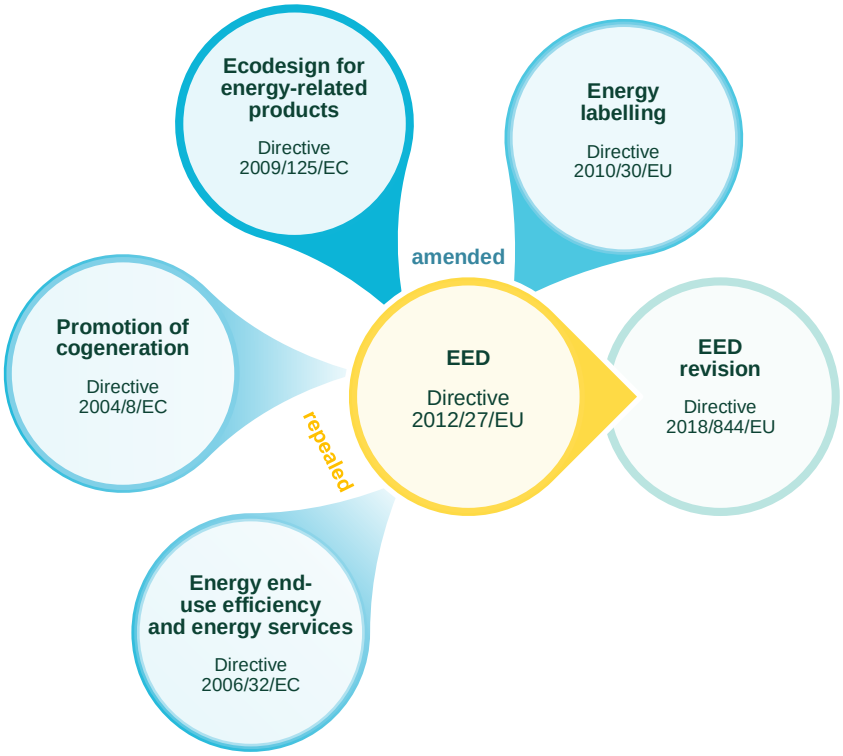


**Figure 4: Evolution of EED**

Article 4 of Directive (EU) 2012/27/EU requires Member States to establish a long-term strategy for mobilising investments[8] in renovation of the national building stock. In that strategy, Member States shall provide an overview of the national building stock, identify cost-effective approaches to renovations, and estimate expected energy savings. To fulfil these requirements (Article 4 of Directive (EU) 2018/844) Member States need to collect representative data on the building stock and on the energy savings and the cost of renovation measures.

Building stock energy savings need to be calculated also when Member States decide on energy efficiency obligation schemes according to Article 7, paragraph 1 of the Directive 2012/27/EU. Specifically, the calculation of the target, the quantity of new savings, and its phasing over time, need the modelling of the building stock and data on the efficiency measures and their cost. The more detailed the data the better the target will reflect the actual savings potential. Without an obligation scheme, Member States need to explain how savings, monitoring and verification can be achieved. Specifically for monitoring aspects, central databases carry administrative advantages.

## 3.3. Renewable Energy Directive

The recast of the RED (Article 15, 4, RED 2018/2001) [11] requires Member States to calculate and use minimum levels of renewable energy in new buildings and existing buildings that are subject to major renovation. These minimum levels shall be calculated to

[8] Part of the National Energy Efficiency Action Plans.

be technically, functionally, and economically feasible. For such a calculation and minimum levels that are technically, functionally, and economically feasible it is necessary to know the local building stock[9] and the availability of renewable energy sources and further data such as costs of technologies and their availability in the market.

Furthermore, it would be of great benefit to building owners and installers to have maps freely available that indicate accessibility to efficient district heating and cooling and to renewable energies. Geothermal resources, as well as district heating infrastructure could be indicated and made available on-demand to the building owner and installer or developer.

## 3.4. Open Data Directive

The Open Data Directive, i.e., the directive on open data and the re-use of public sector information (PSI); (PSI, 2019/1024) [12] stimulates innovation in products and services to promote open data. It establishes a set of minimum rules around the re-use of public sector information. Such information is, for example, existing documents held by the public sector[10] and research data.

The information shall be re-usable for commercial and non-commercial purposes[11]. Concerns relating to intellectual property rights, personal data protection, and confidentiality, security, and legitimate commercial interests, shall be considered following the principle of 'as open as possible, as closed as necessary'.

The Member States have extensive national or regional and local databases or files with information on the properties and buildings in their land registers or similar. These data are invaluable for an accurate picture of the building stock. In addition, the history of building permits would provide key information on the building's orientation, geometry, and potentially building energy performance. First steps in that direction have been made within the "Energy Pilot" project[12] connected to the INSPIRE directive[13].

## 3.5. Summary

Different European legislation requires the Member States to plan, implement and monitor efficiency measures in the buildings stock and increase the use of renewable energy sources. The EBPD requires Member States to set up a methodology for energy performance calculations. This methodology is applied for setting minimum energy performance standards for new construction and major renovations at cost-optimal levels. The calculation approach is applied when calculating energy performance certificates and when establishing long-term renovation strategies. The EED requires Member States to submit a long-term strategy for

[9] Building characteristics such as size, age and material composition can vary and influence the technical, functional and economic feasibility.
[10] In detail, documents held by public sector bodies of the MS and by public undertakings for example those in the energy sector which are providing services in the general interest. (Article 1)
[11] In accordance with Chapters III and IV
[12] https://inspire.ec.europa.eu/pilot-projects/inspire-energy-pilot/440
[13] https://inspire.ec.europa.eu/about-inspire/563; https://inspire-geoportal.ec.europa.eu/

mobilising investments within their National Energy Efficiency Action Plans (NEAPs) applying the principles of cost-optimality and estimating energy savings. The RESD demands setting minimum requirements for using renewable energy following technical, functional, and economic feasibility. All these requirements lead to the need for detailed analysis of the building stock, efficiency solutions, and renewable energy solutions under the constraints of local climate, resource availability and market conditions.

A large amount of data is needed to accommodate the requirements of European legislation: EBPD, RESD, and EED. The data needed for the above-mentioned analysis must describe the building stock, the climate, the accessibility of energy infrastructure and renewables and the cost of measures for energy efficiency and the use of renewables. For the optimal allocation of financing and resources, these data need to be available at the lowest administrative levels.

The Member States can decide on one central database or regional and local databases and analysis. On one hand, national analysis will reduce the total effort for analysis and database maintenance. On the other hand, regional and local handling will increase the decentralised responsibility and the information flow on regional and local diversity in building stock, energy infrastructure, economic welfare, and accessibility to renewable energy. In the latter case, orchestrating the contributions of different regions will be necessary.

In any case, a harmonised approach to data collection and analysis for the European directives would ease the burden for public authorities and support the needs of policymakers. Harmonised data from building to district and national level could improve the interoperability and the implementation of the different directives.

# 4. Stakeholders survey results

## 4.1. Experience levels and geographical representation of respondents

In the total sample of respondents (n=94) about 40% have an experience of 11-20 years, 17% for 21-30 years, and about 9% were over 30 years. The majority of respondents were highly experienced in their respective organisations as shown in Figure 5 below. This fundamentally strengthens the validity of the sample in terms of informed inputs by experienced respondents.

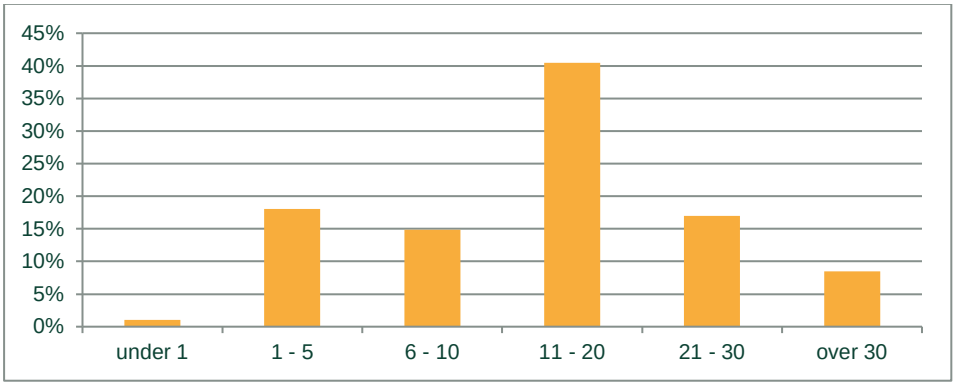


**Figure 5: Respondent's years of experience (n=94)**

As shown in Figure 6, a high number of respondents of the survey are from Italy (20%), Spain (7%), Belgium (9%), Portugal (9%) and Germany (7%). Based on respondent organisations' activity majority of them work in the regions of Southern Europe (49%) and Central Europe (47%) followed by West (41%) and other regions of Europe with the lowest in East Europe (28%). A few other responses were also received from non-EU countries such as Albania, Montenegro, and Switzerland.

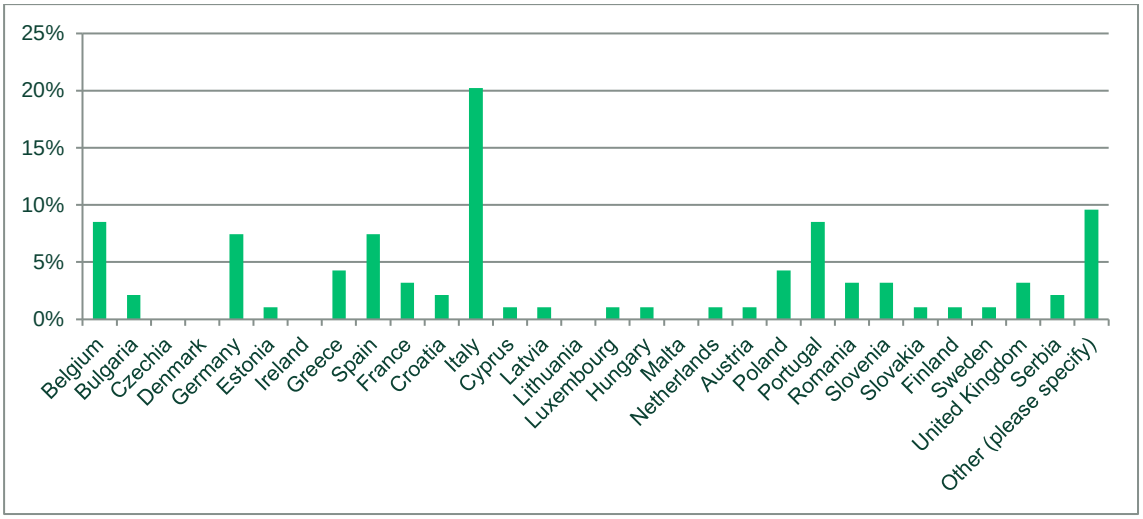


**Figure 6: Geographical representation of the sample**

## 4.2. General interest in datahub and its services

The BuiltHub survey respondents were asked regarding the purpose of BuiltHub and their interest in such a datahub and its services (Figure 7). More than 86% of respondents agreed for the need of a user-friendly platform to exchange buildings related data around Europe. About 57% also showed interest to engage in a community to support building stock transformation using data.

With such an overwhelming interest, BuiltHub's main objective to establish a robust, continuous, and durable flow of reliable building data at EU level is being supported. It is interesting to note that about 17% respondents agreed that they are ready to pay fees for data services, if needed. Among these respondents about 44% consider access to benchmarks, scenarios, plans and goals as extremely important benefit for their organisation and 88% actively use/ provide/ rely on building stock related data. Having a central database or single hub was felt very necessary by approximately 51% of respondents so that it is available to everyone without looking for them in other decentralised sources or federated databases. Open-access data and funding opportunities for monitoring and data collection were also mentioned by some respondents as crucial for a datahub.

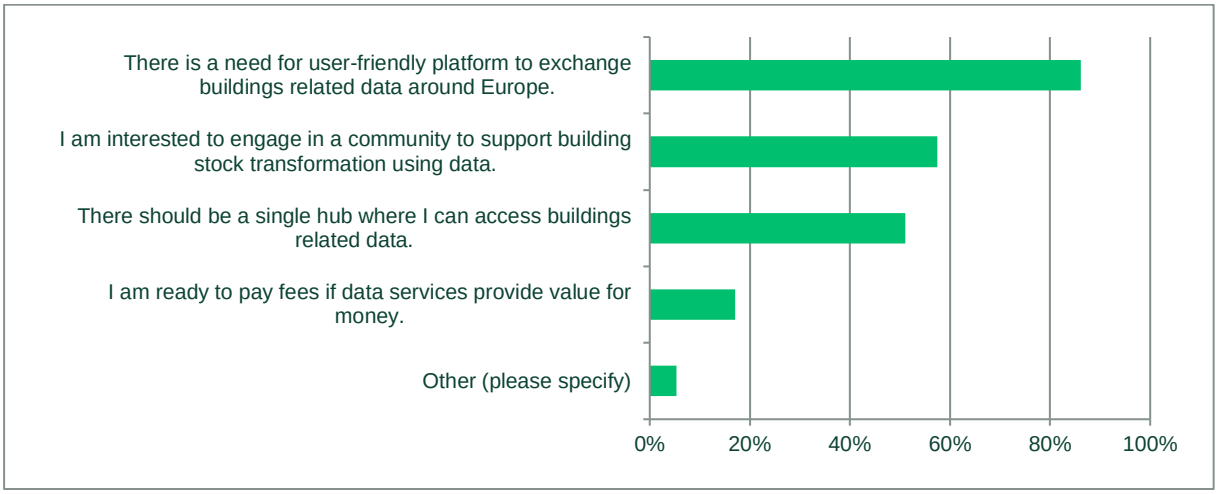


**Figure 7: General interest of stakeholders in datahub and its services (n=94)**

## 4.3. Functions and benefits of data sharing hub and community

The increasing volume of non-personal sectoral data and public data in Europe, combined with technological change in how the data is stored and processed, will constitute a potential source of growth and innovation that should be tapped. Data is at the centre of transformation and will bring enormous benefits with data-driven innovation [13]. The stakeholders were asked to provide their opinion on such aspects (see Figure 8).

Majority of respondents regarded services like data collection/ storage (76%), analysis/ processing (67%) together with data community building, sharing and exchange (67%) as extremely important. Access to more data was expressed as important by about 49% of respondents. Often the presentation of infographics and visualisations are considered effective in data presentation and this aspect was found to be important for more than 54% of respondents. Based on the results, 27% of respondents expressed willingness regarding the exchange of information with data providers. A significant share of stakeholders (40%) also expressed their interest in jointly analysing datasets.

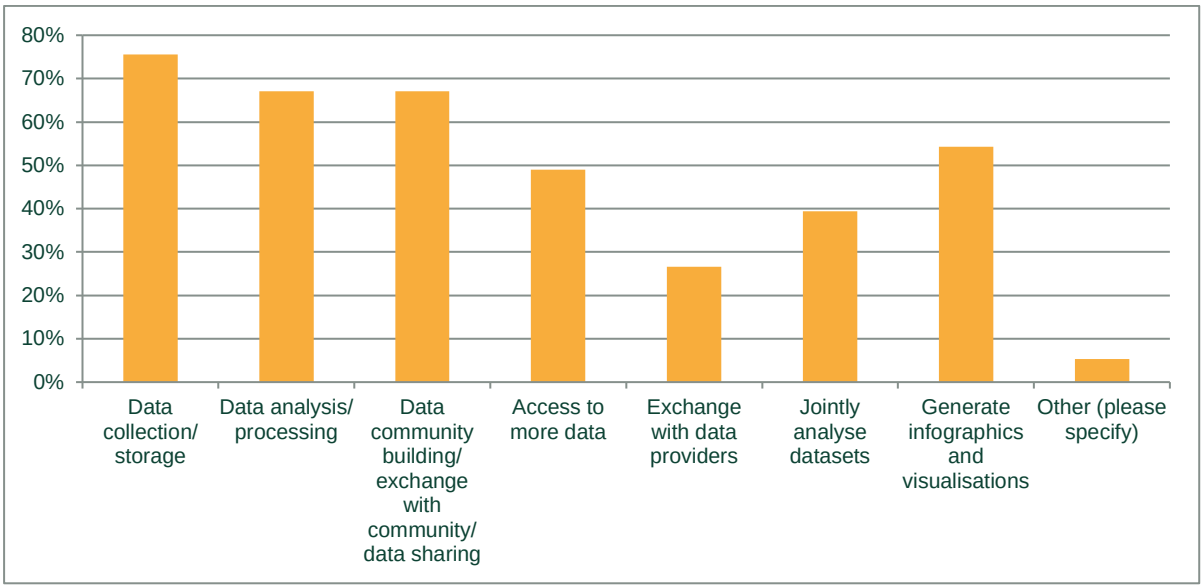

**Figure 8: Ideal functions and benefits of a data-sharing hub and community (n=94)**

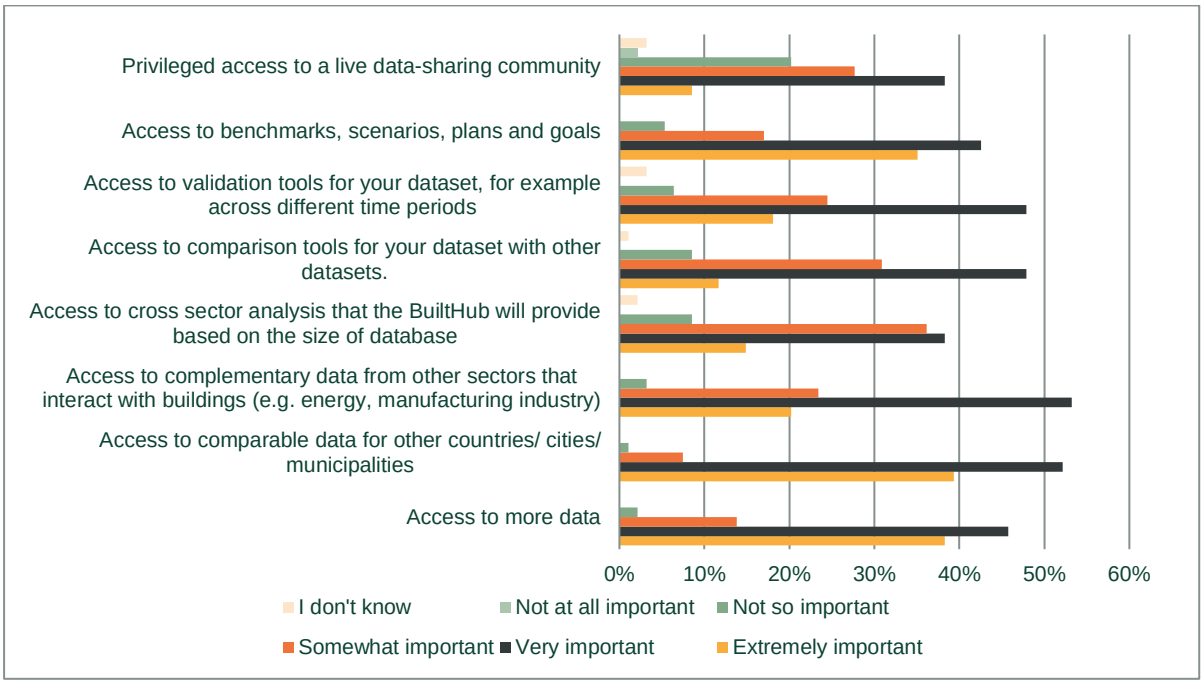


**Figure 9: Benefits considered important for respondents' organisation (n=94)**

As shown in Figure 9, access to more data is recognised by most respondents as very important (46%). It was found that more than 30% of these respondents are with an experience of 11—20 years and were those who expressed the need for a user-friendly platform to exchange building-related data. Most of these respondents are also interested in using data for research and analysis (94%). Respondents who expressed the need to access more data as extremely important (38%) are mostly (76%) not a member of any data-sharing community or datahub. Respondents who considered privileged access to a live data-sharing community extremely important (>28%) and very important (>38%) are found to be more interested in using the data for training and education, research and analysis and analyse future pathways and explore energy efficiency solutions.

## 4.4. Sources, datasets, and services relevant for BuiltHub

An ultimate benefit of datahubs and communities is the availability of data under one hub. Organisations are increasingly using existing data to generate additional values. With the introduction of EU directive on open data and the re-use of public sector information (EU/ 2019/1024) it has become much easier to access and re-use public sector data which promotes evolution towards a data-based society [12]. Data analysis has become indispensable to organisations, and they need efficient long-term data architectures to support them in the ongoing effort to stay on top of current data-related challenges. Often there are no functionalities that could provide customised services creating value for the organisations [15].

Among the options given to the respondents, benchmarking of data (>53%), compliment or cross-referencing with other data (50%) and check/clean/validate data (49%) were found to be

very valuable for their organisations (see Figure 10). Noticeably, responses suggest a great interest in the stories (case studies, scenarios and plans) as extremely valuable (30%) for the organisation's datasets. Of these respondents most of them found building renovation related data (>61%) and building logbooks/renovation passports/roadmaps datasets (>64%) as extremely valuable for BuiltHub.

Most of the respondents (68%) who considered benchmarking very valuable prefer using Excel file format for their purpose and would prefer to use or share the most recent data. Visualisation of data is not among the top responses probably due to the fact that there are many online and offline software/ platforms that offer this service to data users[14].

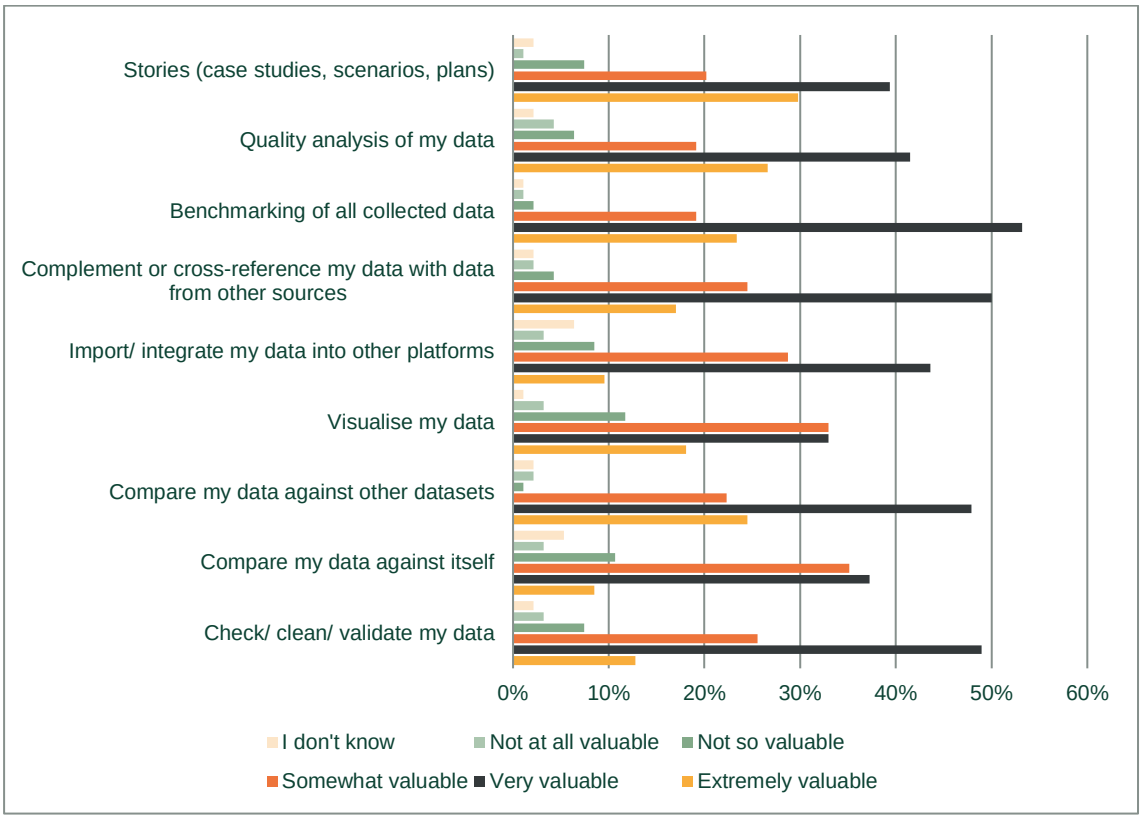


**Figure 10: Data related services considered valuable for the organisations dataset(s) (n=94)**

Respondents were also asked regarding the datasets and data sources that they consider useful for BuiltHub. Many stakeholders require European level data for their use in the building sector and other allied sectors such as energy and manufacturing. The data ranges from energy efficiency targets, energy-efficient buildings, building stock, energy consumption, certification, financing, energy market etc.[15] EU Statistics is pointed as extremely useful by more than 51% of the stakeholders (see Figure 11). Most of these respondents actively use

[14] An Overview of the Best Data Visualization Tools | Toptal

[15] Energy | Energy (europa.eu)

building stock related data (>77%) and are not a member of any data-sharing community (65%).

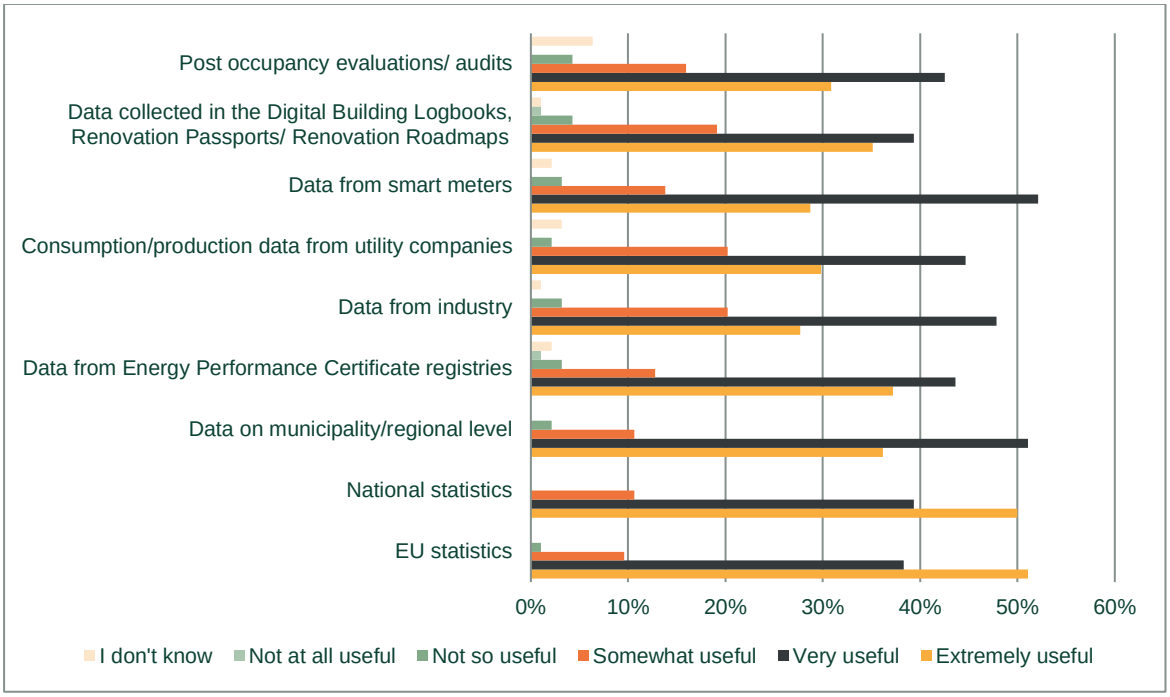


**Figure 11: Dataset(s) or datasource(s) considered useful for BuiltHub to establish access with (n=94)**

Data from smart meters was pointed as very useful by more than 52% of respondents and extremely important by 29%. In 2018, it was estimated that about 80% of European consumers would receive a smart meter for electricity by 2020. This is primarily based on the mandates by the European Commission to promote the development of secure smart grids enabling communication and interoperability. Smart meters allow consumers to reap benefits such as compare their energy consumption based on historical data and receive dynamic energy pricing services [16]. Smart metering system deployment gives Member States an opportunity to empower consumers, to enable the grid digitalisation and to foster the integration of European energy markets.

Local and regional authorities, as well as local civil society, are closest to EU citizens, and are therefore in a position to develop 21st-century service models in line with emerging needs in their communities[16]. As found from other results, data at regional and local level is found to be of importance to most stakeholders (>30%). From the open-end answers, few respondents expressed concern over the harmonisation of data. While others pointed out data regarding workforce of the building sector, wider benefits of renovation and environmental performance data as useful.

Eleven thematic areas were presented to the stakeholders to ask their preferences and rank them based on the relevance to their organisations. As can be observed in Figure 12, building renovation (52%), nearly zero-energy buildings (48%), $CO_2$ emissions (47%) and indoor

[16] delivering-sdgs-local-regional-level.pdf (europa.eu)

environmental quality (38%) followed by building stock characteristics (37%) and smart technologies (33%) are extremely relevant for the organisations. A mixed response was observed on the energy market (45%) and electric vehicle readiness of buildings (44%) which were assessed as somewhat relevant. Respondents who indicated building renovation theme as extremely important have shown interest in the EU statistics (61%), National statistics datasets (60%) and data from Energy Performance Certificate registries (51%). Respondents also highlighted the need for information in the construction and demolition waste generation and recycling, macroeconomic data and carbon reduction scenarios and trajectories.

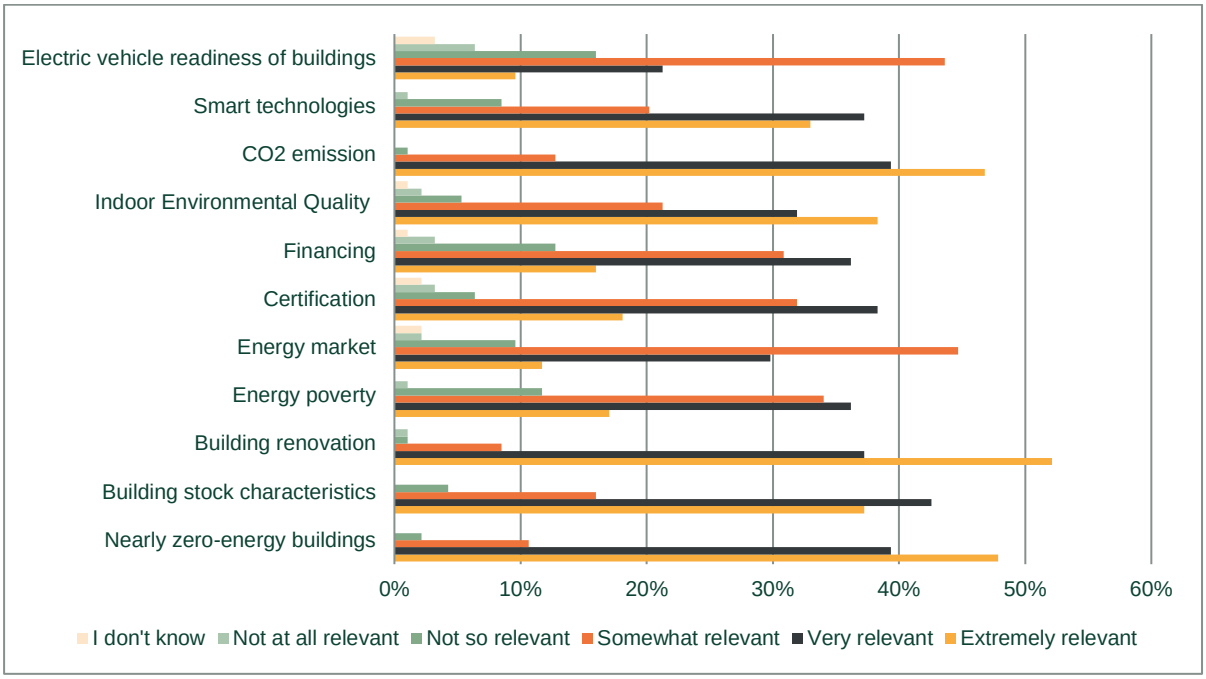


**Figure 12: Thematic areas relevant for organisations**

From the results of other inquiries, it was found that more than 62% of respondents use external sources to develop or update an approach for environment protection or sustainability for their organisation such as business strategies, local, regional, or national government policies. This indicates that there is dearth of data and well recognised within the building sector. As shown in Figure 13, most of the organisations use open data platforms (85%) and scientific publications (76%). Legislation websites are also commonly used by 56% whereas digital libraries are only accessed by 46% of respondents. Some of the other sources include national statistics and professional association databased.

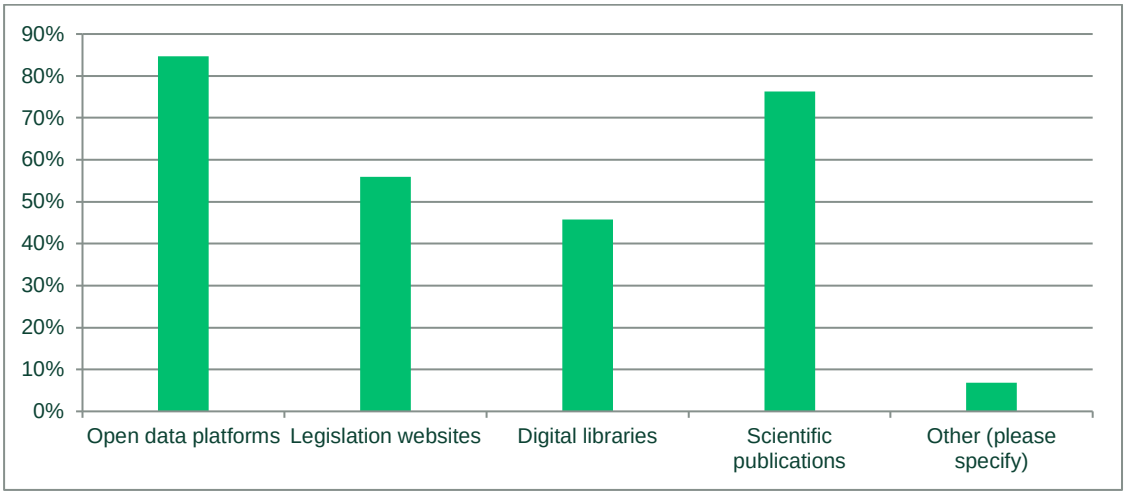


**Figure 13: Sources used to develop environmental approach**

## 4.5. Building stock related data applications

Building stock related data generally include meteorological and socio-economic data, building characteristics (typology, thermophysical, etc.), technical services and systems, smart readiness (building's e-mobility, etc.), renewable energy technologies, audits, indoor environmental quality, energy consumption, investments for operation, maintenance, and renovation, financing schemes and subsidies, energy market, and emissions among others.

To understand the major purpose applications of building stock related data the respondents were given several choices. Based on the results in Figure 14, it is clear that most respondents use the data for research and analysis (90%), calculation of scenarios/pathways (59%) and prediction or forecasting (52%). These responses are clearly influenced by the majority of respondents that come from academia/ universities (54%) in comparison to other organisations such as public authorities and policy makers (5%) or National and European Institutions (3%). However, in totality, very few use the data for visualisation (20%) and risk assessment (17%). About 40% of respondents consider applications such as benchmarking, performance measurement and decision-making as crucial for their organisations.

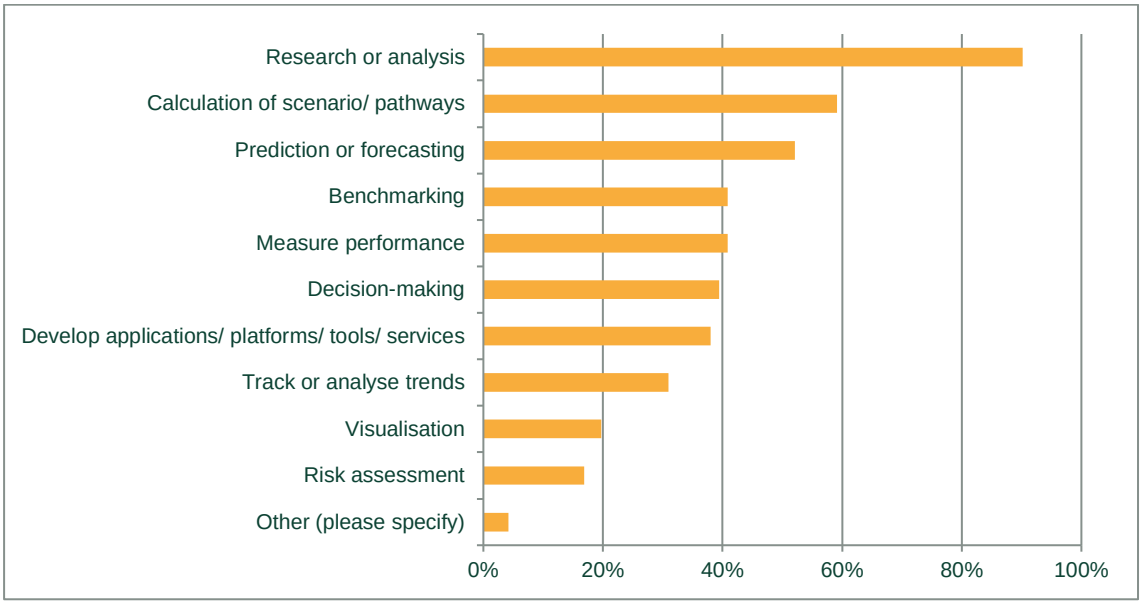


**Figure 14: Purpose for which organisation use/ provide/ rely on building stock related data (n=71)**

Approximately 62% of respondents are not a part of any data-sharing community which is a huge untapped potential for BuiltHub and an opportunity to initiate the development of such a datahub community that could be used efficiently.

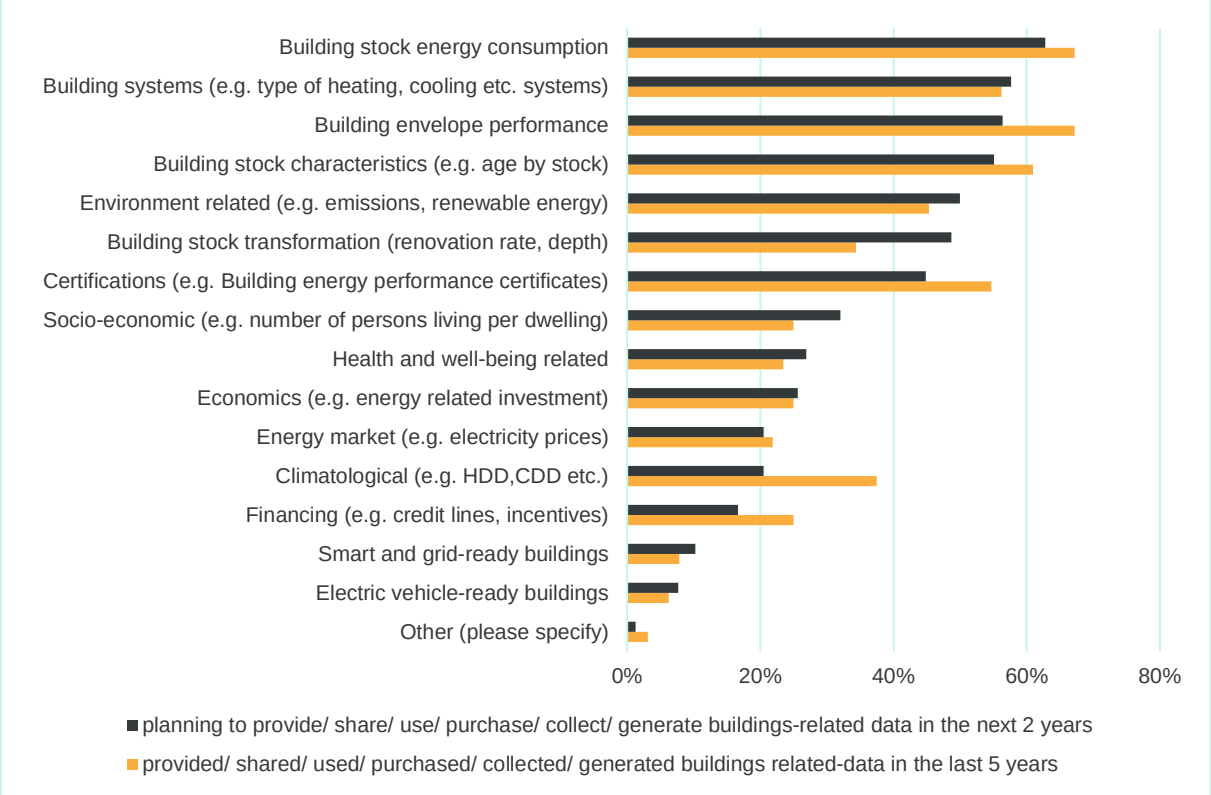


**Figure 15: Type of data organisations engaged with in the last 5 years (n=78) or planning to in the next 2 years (n=64)**

As shown in Figure 15, stakeholders were also inquired regarding the data that they engaged with in the last 5 years or planning to in the next 2 years. It is interesting to note that in the past

5 years maximum responses worked with data related to building stock energy consumption (67%), building envelope performance (67%), and building stock characteristics (61%). Organisations also dealt with building energy certification (55%) data to a greater extent. Energy Performance Certificates are an important source of information regarding the performance of the building stock.[17] Environment related data such as emissions or renewable energy were also accessed by 45% of the respondents.

Not many differences were noted regarding the data engagement in the past 5 years and plans for the next 2 years. In the near future, stakeholders are more interested to engage with socio-economic data (32%), building stock transformation data (49%), health and well-being related data (27%) and environment related data (50%). All these areas have lack of data as identified by H2020 strategic plan 2021-2024 [17] and respondents see the need for such data for their use and analysis. These results provide useful insight into efforts that may be placed in data gathering exercise for the data hub.

## 4.6. Stakeholder expectations and willingness to support BuiltHub

Buildings sector applications of data is varied, and respondents were asked to select multiple options that they would consider for their use if received from BuiltHub (Figure 16). Since most respondents are from universities/ academia it was observed that their interest in using data is more towards training and education (66%), research and analysis (56%), health and well-being (68%), life-cycle assessment (52%), design processes (52%) and environmental decision-making (48%). For research and policy consulting, evidence backing (25%) and economic decision-making (19%) are top priorities, but health and well-being are of least interest (3%).

The construction industry sector showed a higher interest in product or service development (17%) whereas design firms or consultancy showed less interest in the same (6%) along with measure impact of policies (5%). Civil society actors are seen most interested in measuring the impact of policies (17%), evidence backing (15%) with the least interest in health and well-being and calculation of advanced parameters. National, international EU agencies are seen interested in almost all categories of the intended use of data and they are the only ones apart from universities that are member of data sharing communities or datahubs.

[17] Energy Performance Certificates | Energy (europa.eu)

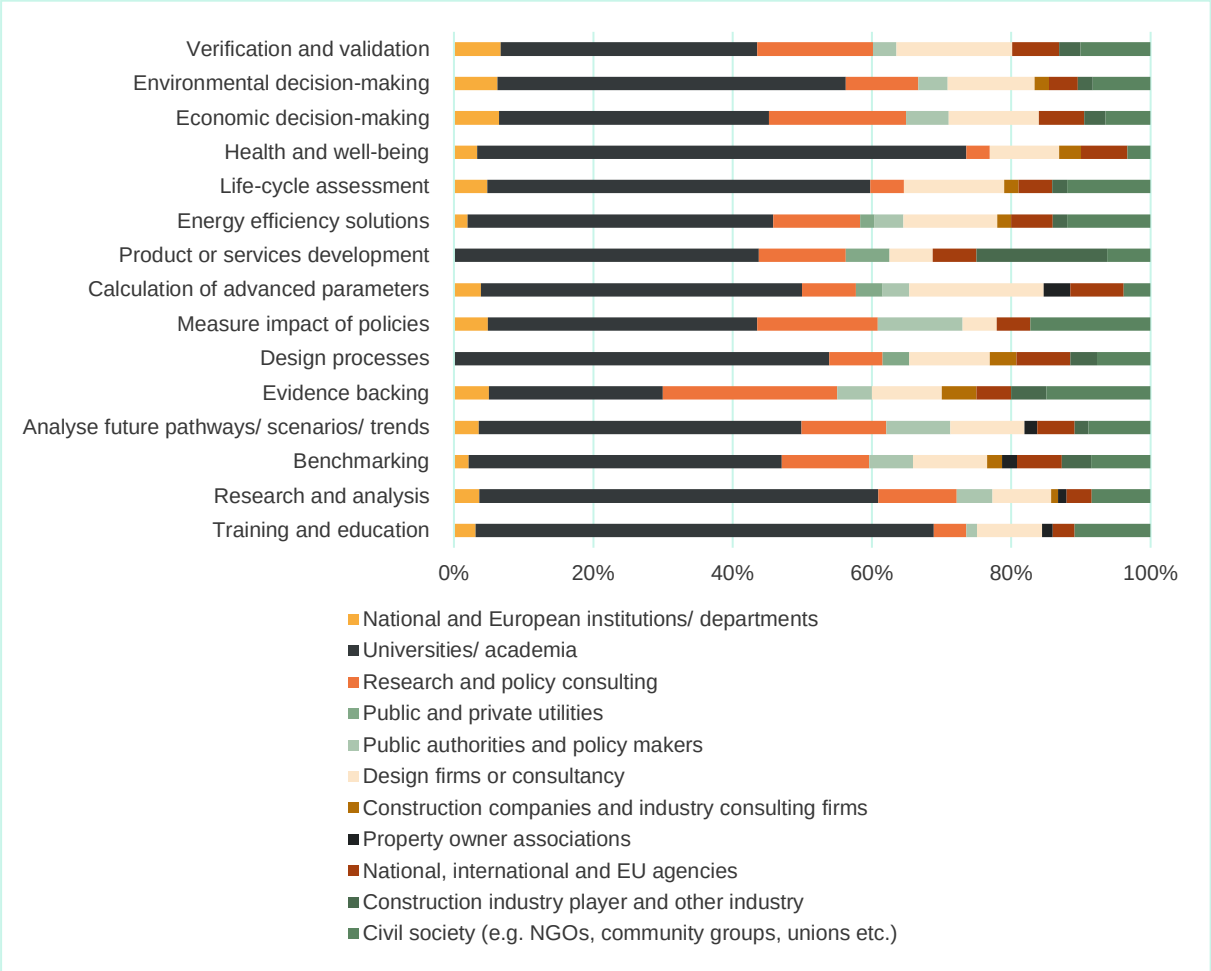


**Figure 16: Intended use of data by the organisations received from BuiltHub (n=94)**

Stakeholders were asked with an open-end query which questions would they like the datasets to answer or where more quantitative evidence is needed. A variety of responses were received that can be categorised mainly as below:

- Life-cycle assessment, embodied energy, and environmental impact evaluation
- Circularity, reuse of materials and impact of bio-based solutions
- Real energy consumption
- Building renovation and nZEBs at building and district levels
- Building materials, components, service life
- Renovation rates, demolition rates
- Heritage buildings
- Health and indoor conditions
- Building and construction sector progress (training, digitalisation etc.)
- Climate change
- Growth in construction technology (automation, renewable etc.)

To build a data community, strong support is needed from its members. Such a community is composed of trust, reliability, exchange, and innovative ambitions. Low availability of data for research and innovative uses resulting from transaction costs often greatly hinder data exchanges. These may arise with the difficulty to establish data exchange processes from a business/ organisational, legal, or technical side.

To gauge the level of willingness to share the data with BuiltHub, respondents were asked to share their opinion. Almost 50% of respondents or their organisations of the total respondents would like to share the data with BuiltHub either partially or completely, however, the rest 50% don't know. Since sharing of data is linked to many aspects such as privacy, organisational restrictions, compensation, internal agreements, etc., therefore the respondents were also asked to indicate the conditions under which they would be willing to share the data.

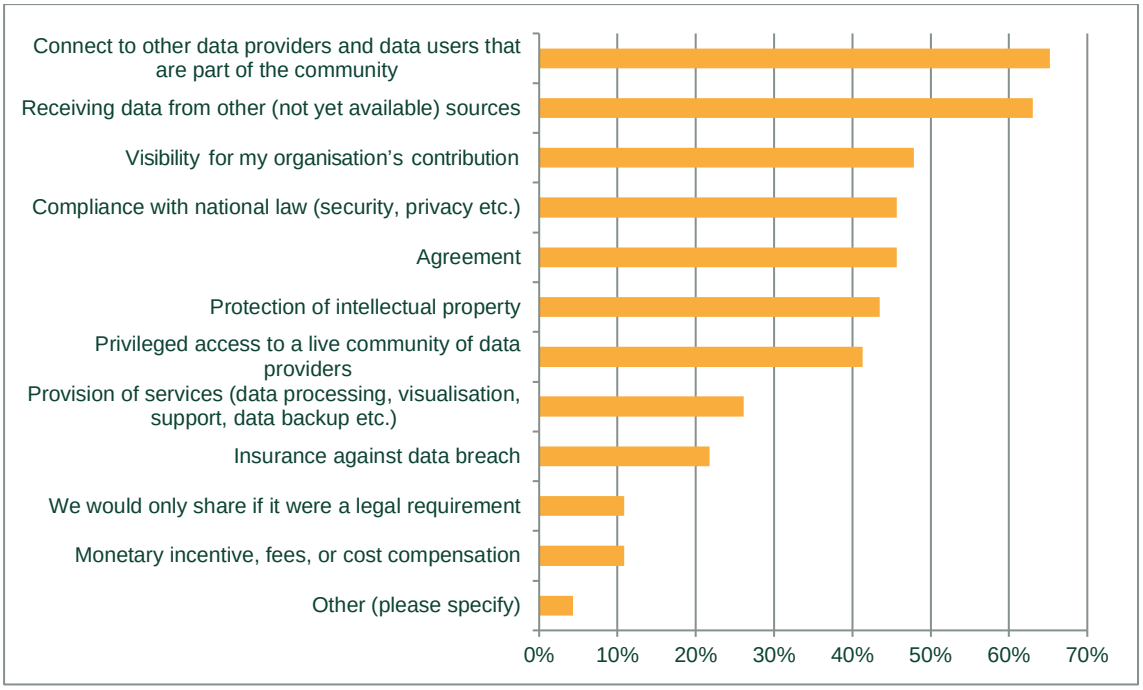


**Figure 17: Conditions under which respondents are willing to share data with BuiltHub (n=46)**

Based on the results presented in Figure 17, the majority of the respondents are looking to connect to the community of data providers and data users (65%) and are interested in receiving data from not yet available sources (63%). Since national laws restrict sharing of data, most of the respondents (46%) would be willing under those conditions. As a benefit, 48% organisations are willing to share the data in return of their visibility for their contribution. Almost >43% would like to make an agreement as well as have some intellectual property protection mechanism. Surprisingly, less than 11% of respondents are interested in any type of monetary compensation for sharing their data and another 11% would share only if it was a legal requirement. Overall, it is evident that most of the stakeholders are interested in sharing data with BuiltHub. These reasons are very valuable for a datahub to determine the best model for its operation and continuous use to its users. Relevant standards that support exchanges as well as trusted technical support infrastructures that make the data usable to users are still widely absent. Having these would essentially lower the technical adaptation costs as well as lower barriers for organisations.

# 5. Interview results

Based on a pre-defined structure for the interviews the results are presented and discussed below. The analysis of the interviews was conducted based on the methodology described in Section 2.3.

## 5.1. Stakeholder benefits and contributions to BuiltHub

### *5.1.1. Anticipated benefits by stakeholders from BuiltHub*

Stakeholders have a varied perspective of anticipated benefits from BuiltHub. The interviews inquired regarding the benefits of data-sharing platform for the organisations and their conditions for sharing data with BuiltHub. Almost all the participants emphasised a strong focus on exchange of data, especially with other public organisations and industry players. A common benefit that is anticipated is access to comparative data from other Member States, regions, sub-regions, and buildings. Participants from academia, research and policy consulting very much consider benefits in terms of quality, consistency, and reliable information available under one roof and authoritative control. It is strongly felt that community participation and feedback would play a crucial role in improving data related problems. Another expectation displayed was in terms of harmonisation of indicators and metrics used in building stock data (e.g., level of energy performance, district energy use), so that future challenges of comparison and uniformity in Member States can be simplified. Participants from National and European institutions and civil society expect to see new data renovation rates, annual variance in performance of buildings and individual analysis from other organisations. Some participants from the industry are also keen to see how BuiltHub can assist in taking the best actions and develop new products for the buildings sector.

### *5.1.2. On-boarding policy and decision-makers to BuiltHub*

A main objective of BuiltHub is to drive informed policy and decision-making in Europe. Some key recommendations that were given by participants from civil society and national institutions were towards making the platform simple and easy to use with a dedicated section for policymakers supported by visualisations, benchmarking, comparisons, and maps. Furthermore, the added value of the platform must be specified. This will create more awareness and increase the impact of data. Some of the participants indicated that the exchange of national data in a common reliable format or framework would enhance the impact of BuiltHub. Offering training and capacity building on how to use the platform for decision-makers was also mentioned by participants from policy consulting and national institutions.

### *5.1.3. Conditions to share data with BuiltHub*

Stakeholders collect, generate, and produce multiple types of buildings related data. However, there is often an interest in sharing such data on public domains or platforms openly and there are few requirements that participants outlined. Participants from universities indicated that they would like to know the objectives of private organisations before using their data and preferred that their data should not be used for commercial purposes. Civil society actors are more interested in networking and reach out to build partnerships. National institutions

participants indicated that scientific agreements on exchange, use of their data and privacy issues would be a part of their conditions. Among other conditions, participants said that the decision would be based on what is received back (e.g., business development, competitive edge etc.)

#### *5.1.4. Type of data organisations would like to share*

A range of building stock related data is available with the participants. Some of them are more regional and others are from individual pilots, while some of the data is open-source, especially from the national institutions. Regional data include energy performance of residential and tertiary buildings. Some participants have data on building stock characteristics (e.g., location, size, age, year of renovation etc.). Among other data available with university participants include detailed data from case studies and pilots on ventilation parameters, heating systems, IEQ, DHW and PV systems. There is also hesitation to share data due to recognised inconsistencies in data. Interesting data concerning renovation is also available with participants that they would like to share, e.g., no. of permits for deep-renovation, renovation rate, energy grant data, banking sector data and heat pump sales etc. Participants also seem interested in sharing data at the district level e.g., energy consumption, built-up area, district energy renovation etc. Future pathways and scenario related data on building stock with analysis of trends and expert assessments were among other types that could be shared.

## 5.2. Key data analysis for effective building stock transformation

#### *5.2.1. Data analysis BuiltHub should deliver*

BuiltHub seeks to provide added value to data through advanced analysis. However, participants from universities/academia were found to be less interested in deeper analysis of data (e.g., neural networks, simulation, and black box modelling) as they conduct it themselves and will not be useful. They highlighted that statistical and quality analysis of data would be interesting for them, additionally, routines or algorithms could be used on data if available from BuiltHub. Most of the participants expect to use the platform for diverse data which makes its own estimations (e.g., age of building stock, analysis per sqm.) and comparative analyses. A clear need could be established for policymakers and government bodies requiring clear and uniform analysis for comparison at country, regional and local level (e.g., NUTS) supported by maps, visualisations, and GIS related data. Energy balances, extrapolation solutions, dedicated dashboards for public bodies and impact analysis were among other key requirements that were highlighted. Some of the participants emphasised the need for analytics integrated with socio-economic data, checking of inconsistencies in data and advanced modelling options (e.g., financing in renovation, EPC based analysis).

#### *5.2.2. Establish links with other data communities*

Connecting policymakers through direct channels used by administrators can be good for community building in BuiltHub. Another direction mentioned by one of the participants from research and policy consulting is to connect the best practice policies with impact that could support policymakers in decision-making. Connecting to datahubs owned by private and small companies and organisations could be useful for BuiltHub. In order to establish links with other

data communities, a few participants highlighted that it is important to create or share a common format and harmonise with other providers. Data ontology and standards for data exchange must be defined by studying the existing programming interfaces. To enable connections, permissions must be given to set up links to other datahubs and provision of marketing opportunities to other providers would be a great incentive. Most importantly, the creation of a community that cares, sharing data in international communities, collaboration with existing EU projects, supporting initiatives like New European Bauhaus, setting up alliances with universities, energy agencies and professional organisations are key to move forward. Creation of a win/win situation for both parties is an effective reason to bring meaning to new links (e.g., banking sector would be interested in EPC database, housing sector would be interested in energy grant data, etc.). Building trust on quality and making it accessible would bring the competitive edge to other data communities that become a part of BuiltHub.

## 5.3. Data quality, transparency, and accessibility

### *5.3.1.* ***Quality requirements for data or analysis***

The availability of quality data in the building sector has been of great significance for stakeholders. Most of the participants consider the classification of quality for data (e.g., accuracy, completeness, timelines, consistency, etc.) with supporting quality control mechanisms (e.g., data format, data patterns, etc.) very important. Some of the participants said that they can do the quality check themselves, while a few said it is not easy to check everything. Several indicators of quality were mentioned that may be crucial for the datahub, such as source of data, description of uncertainties in data, scientific method used in data collection, accuracy of the data, assumptions in statistics, calculation method among others. A few participants could not identify specific requirements and offered to get it from their technical teams. Participants also outlines that ethical standard to protect personal and sensitive information (e.g. GDPR) must be followed with the provision of user feedback in order to maintain quality in data or analysis.

### *5.3.2.* ***Transparency and accessibility*** *in the* ***community***

In practice, data transparency means making the data collected both public and accessible to users. All the participants of the interviews regarded transparency and accessibility in data sharing extremely important to maintain credibility. Data providers in the community must take responsibility of data they provide, and methods used with underlying assumptions and should not make themselves anonymous. Some participants also questioned how transparency could be established while raising a concern that too much transparency is dangerous as it will expose a huge set of problems in the building stock data. Definition of the data model, scripts used in data processing, links to raw data and archiving at a single place would help in becoming transparent and accessible by the community. Participants from National institutions and academia expressed that the data platform must be accessible to all for sharing and using open data from research, while a few participants from research and policy consulting indicated that accessibility must be controlled to deal with issues of privacy (e.g., precise address of a property). Some of the measures suggested by participants to ensure transparency and accessibility were to develop a long-term engagement having data continuity, ensure data availability for public research and central regulation of BuiltHub to develop trust in the

community. Ownership of data with contact details, data interfaces with detailed documentation, and standard rules for the platform would be beneficial. Open-source access, user-friendly tools and provision of feedback were among other measures that participants consider useful for the datahub.

## 5.4. Filling the gaps in building sector data

### *5.4.1. Datasets and related services valuable for organisations*

Interview participants had common needs regarding data and services concerning renovation. Some of them would like to see data on different types of buildings, while others are interested in best practices such as renovation advice and experiences of communities in financing. Some key indicators or datasets related to renovation that were identified are depth of renovation, energy consumption in different timescales, renovation strategies, typical daily profile of consumption and renovation activity. In general, participants outlined the need for user behaviour related data, building stock data characteristics and performance per unit of sqm., socio-economic data, energetic performance of services, material composition, technical data on new technologies and their baseline performance. Organisations are also interested in analysing progress or trends in the building sector towards 2030/2050 goals and for developing long-term strategies. Among other requirements, participants would like innovative carbon calculators, details on energy and technology mix and baseline data on the performance of new technologies.

### *5.4.2. Need of quantitative evidence in building sector*

The interview participants expressed the need for quantitative evidence in several dimensions of the building sector based on their experiences. Quantitative evidence is required for material consumption in buildings and building stock usage (e.g., per capita sqm. /rooms). A significant need was described by participants on multiple benefits of renovation e.g., data on comfort, occupant satisfaction in building spaces, financial gains, and impact of the pandemic as well. Furthermore, socio-economic indicators are missing in building sector data due to privacy issues which most of the participants find useful. Another dimension is renovation where participants need to know the thresholds of performance, benchmarking, and quality of renovation (e.g., system to measure, level of contractors, etc.). More data and methodologies are required on realistic population based on probabilistic distributions and statistical references.

## 5.5. Important aspects for development of BuiltHub

### *5.5.1. Key action areas to drive BuiltHub forward*

A range of areas were highlighted by interviewees that may have highest impact in the development of data hub and community. Most importantly, the control and exchange of data, and open API with requisite support to the community (e.g., technical, sharing best practices, etc.) would form the backbone of the datahub. A robust business model with self-service applications to get what users need was highlighted as one of the key aspects for a successful

platform development. It is important to develop a critical mass of high-quality data to attract users from professionals, policymakers, national and legislative bodies. Every stakeholder has access to quality data which is transparent. User-friendliness of the platform having simple connections to open-access data and the capacity for anyone to query and download data would strengthen the BuiltHub platform engagement with the community.

#### *5.5.2. Interaction of BuiltHub with other initiatives and projects*

The interview participants expressed unclarity over the interaction of BuiltHub with other initiatives and projects since the platform is not yet developed. A few of them would like to use it for building connections and associations for their future projects or integrate it in their ongoing work. Most of the participants annotated that it would be useful to explore connections with ongoing EU projects e.g., X-tendo, e-SAFE, Life BE REEL, Kick Belgium and UCT calc. Participants from National and European institutions pointed towards existing EU Building Observatory, building connection with General Energy at European Commission and European Energy Award where the data belong to society and is transparent. They also advised to communicate regarding BuiltHub actions to Member States for their participation and cooperation.

# 6. Quality Function Deployment (QFD) analysis results

In order to study the relationships between the stakeholder needs and technical requirements for BuiltHub, a House of Quality was constructed using the inputs from the survey. It was followed by an additional analysis on the probability of meeting the needs relevant to various stages of the project.

Furthermore, key project partners provided an indicative feasibility assessment for the technical requirements that could potentially be delivered over the course of the project within the scope of the BuiltHub Grant Agreement. The analysis was carried out using MS Excel; snapshots are used further to explain the steps.

## 6.1. The House of Quality (HOQ)

The HOQ was constructed as shown in Figure 18 below for BuiltHub. Since this is a preliminary stage of the project to establish the stakeholder needs, therefore, a simpler HOQ was constructed where the co-relations between the technical requirements were not studied, as the project will proceed these technical requirements and their relationships will be further investigated and identified in more detail using stakeholder engagements. Key inputs and outputs of this analysis are presented below.

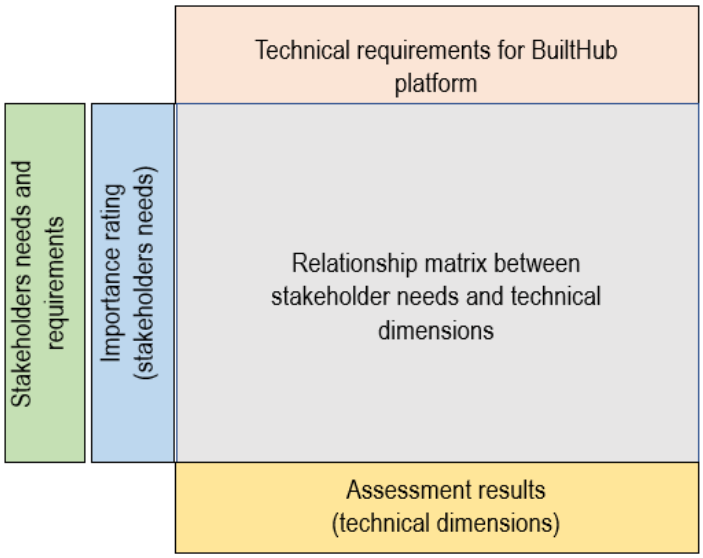


**Figure 18: House of Quality for stakeholder needs and technical requirements**

### *6.1.1. Stakeholder needs*

For BuiltHub to provide data related services/ products that are relevant to its key stakeholders i.e., lead-users, end-users and multipliers as identified in Section 2.2.1, it is crucial to gather stakeholder needs that form the foundation of the QFD HOQ. It is, therefore, the first area that was studied through the survey by reaching out to European stakeholders. In the survey questionnaire relevant stakeholder needs and technical requirements were listed with the flexibility to provide open-end answers. Based on the responses analysed, stakeholder needs were listed to form the HOQ (see Figure 19) as Y's (WHATs) representing voice of stakeholders.

| Stakeholder needs | |
|---|---|
| Y's (WHATs) | |
| | Importance |
| Data collection/ storage | 4 |
| Data analysis/ processing | 4 |
| Data community building/ exchange with community/ data sharing | 4 |
| Exchange with data providers | 2 |
| Jointly analyse datasets | 2 |
| Generate infographics and visualisations for data | 3 |
| Access to more data | 5 |
| Comparable data for other countries/ cities/ municipalities | 5 |
| Complementary data from other sectors that interact with buildings (e.g. energy, manufacturing industry) | 4 |
| Cross sector analysis that the BuiltHub will provide based on the size of | 4 |
| Comparison tools for your dataset with other datasets. | 4 |
| Quality analysis of data | 4 |
| Check/clean data | 4 |
| Import/ integrate data into other platforms | 4 |
| Validation tools for your dataset, for example across different time periods | 4 |
| Access to benchmarks, scenarios, plans and goals | 5 |
| Analysis for education, research and consulting | 5 |
| Analysis to do benchmarking | 3 |
| Analysis and visualisation to track future pathways/ scenarios/ trends | 3 |
| Evidence backing the analysis provided by BuiltHub | 2 |
| Quantitative analysis to measure impact of policies | 3 |
| Calculation of advanced parameters (e.g. indicators and composed indices) | 3 |
| Product/ services/ applications/ tools development | 3 |
| Analysis to find energy efficiency solutions | 3 |
| Life-cycle analysis | 3 |
| Analysis of impact on health and well-being | 2 |
| Economic quantification for decision-making | 2 |
| Environmental quantification for decision-making | 3 |
| Verification and validation of of their own data sets | 2 |
| Analysis to raise awareness and communication (e.g. mitigating climate change) | 2 |
| Measure performance (e.g. buildings, districts, grid) | 3 |
| Risk assessment of achieving climate goals | 3 |

**Figure 19: Stakeholder needs**

### *6.1.2. Stakeholder importance ratings*

In this step, an importance rating between 1-5 (5 being the highest and 1 being the lowest) was assigned to each stakeholder need (Figure 19) based on the survey results. The survey included questions where respondents either ranked or indicated their preferences on a Likert scale[18] which was translated into importance ratings. These importance ratings are used in the calculation of relative priorities that are further explained in the next sections. Technical requirements

### *6.1.3. Technical requirements for BuiltHub*

[18] Likert scales used in survey were converted to importance ratings using Relative Importance Index calculation method

In this step, a list of technical requirements (see Figure 20) was created referred as X's (HOWs) that are critical to BuiltHub development, and these were identified from the survey results and based on the input from partner experts that could be relevant for addressing the needs of the stakeholders.

| Technical requirements |
| --- |
| X's (HOWs) |
| Centralised cloud storage and upload |
| Application programming interface |
| Community posts, exchange, and uploads |
| Centralised data exchange and logs |
| Comparitive analytics |
| Visualisation dashboards |
| Repository of data |
| Integrated platform with regional statistics and data |
| Cross referencing of data |
| Analysis framework |
| Testing for validation |
| KPIs for benchmarking |
| Stories (case studies, scenarios, plans) |
| Membership options (licensing, access) |
| Sustainable hub model for all stakeholders |
| Cummunity support in testing |
| Energy related data (consumption, embodied, etc.) |
| Environmental impact data (product, process, service) |
| Health and well-being related data (IEQ, morbidity etc.) |
| Financing data (credit lines, incentives etc.) |
| Workforce capacity |
| Construction, demolitition, renovation data |
| Certifications data (voluntary and mandatory) |
| Smart technologies and smart readiness data |
| Circular, re-use and re-cycling data |
| Material and thermophysical properties data |
| Socio-economic data (energy poverty etc.) |
| Climatological data (HDD, CDD etc.) |
| Economic data (energy related investments etc.) |
| Visualisation and infographics |
| Analysis techniques and application |
| Web tools (public, policymakers, technical) |
| Modelling support |
| Feedback, survey and support |
| Periodic data |
| Granular data |

**Figure 20: Technical requirements to meet stakeholder needs**

These technical requirements refer to the aspects concerning the development of online datahub, technical framework (IT requirements, outputs, data format, etc.), data organisation and community building. Technical requirements for different needs of stakeholders would likely overlap and this is further analysed in Section 6.1.4.

### *6.1.4. Relationship matrix and relative priorities*

After defining the stakeholder needs- Ys (Section 6.1.1), importance ratings (Section 6.1.2) and technical requirements- Xs (Section 6.1.3), a relationship matrix is prepared as given in Figure 21, taking the shape of first House of Quality (HOQ1).

| | | Strength of relationship | | H | High | | M | Medium | | L | Low | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | X's (How's) | Technical requirements | | | | | | | | | | | |
| Y's (What's) Stakeholder needs | Importance | Centralised cloud storage and upload | Application programming interface | Community posts, exchange, and uploads | Centralised data exchange and logs | Comparitive analytics | Visualisation dashboards | Repository of data | Integrated platform with regional statistics and data | Cross referencing of data | Analysis framework | Testing for validation | KPIs for benchmarking | Stories (case studies, scenarios, plans) | Membership options (licensing, access) | User interface | Sustainable hub model for all stakeholders | Collaborative exchange with other projects | Artificial intelligence functions | Community support in testing |
| Data collection/ storage | 4 | H | M | | | L | | M | H | | | | | M | M | | M | L | M | |
| Data analysis/ processing | 4 | L | H | | H | L | | | | H | L | M | M | M | | | M | | H | |
| Data community building/ exchange with community/ data sharing | 4 | M | M | H | M | M | H | M | M | M | | | | L | H | H | H | H | L | M |
| Exchange with data providers | 2 | H | M | L | H | M | H | H | L | M | | | L | L | M | M | M | L | L | M |
| Jointly analyse datasets | 2 | M | H | L | L | M | M | M | L | M | H | L | M | L | L | L | M | M | L | |
| Generate infographics and visualisations for data | 3 | M | H | | | M | H | H | | | | | | L | | M | L | | L | M |
| Access to more data | 5 | M | H | L | L | M | H | H | H | M | | | | L | H | H | M | H | | |
| Comparable data for other countries/ cities/ municipalities | 5 | H | M | | | H | L | M | H | | | | L | L | L | | L | | L | L |
| Complementary data from other sectors that interact with buildings (e.g. energy, manufa | 4 | | | | | | | | | H | L | | | | L | | L | M | | |
| Cross sector analysis that the BuiltHub will provide based on the size of database | 4 | | | | | M | L | | | L | M | | L | M | | L | M | L | | |
| Comparison tools for your dataset with other datasets. | 4 | L | M | L | L | H | | L | L | L | | | L | L | | L | | | | L |
| Quality analysis of data | 4 | | | | L | M | | | | M | H | L | M | | | | | | H | |
| Check/clean data | 4 | M | | | H | | | M | | | M | M | | | L | | | | H | |
| Import/ integrate data into other platforms | 4 | H | H | | L | | L | M | M | | | H | | L | M | | M | L | | L |
| Validation tools for your dataset, for example across different time periods | 4 | | | | | | | M | | H | M | H | L | H | | | | | L | |
| Access to benchmarks, scenarios, plans and goals | 5 | | | | | | | | L | | | | L | H | L | M | | | | |
| Analysis for education, research and consulting | 5 | | | | | | | | | | L | | L | L | | | | | | |
| Analysis to do benchmarking | 3 | L | | | M | L | | M | | L | M | | H | | | | | | | |
| Analysis and visualisation to track future pathways/ scenarios/ trends | 3 | M | M | L | | H | H | H | H | M | L | L | M | H | | L | H | | | M |
| Evidence backing the analysis provided by BuiltHub | 2 | | | | | | | | | H | | M | | | | | | L | | L |
| Quantitative analysis to measure impact of policies | 3 | | | | | H | M | | | | M | | | M | | | | | | |
| Calculation of advanced parameters (e.g. indicators and composed indices) | 3 | | | | | | | | | | M | | L | | | | | | | |
| Product/ services/ applications/ tools development | 3 | M | H | | | Hh | H | | | | | | | M | | | M | L | | H |
| Analysis to find energy efficiency solutions | 3 | | | | | M | M | | | | L | | M | | | | | | | M |
| Life-cycle analysis | 3 | | | | | | | | | | | | | | | | | | | |
| Analysis of impact on health and well-being | 2 | | | | | | | | | | | | | | | | | | | |
| Economic quantification for decision-making | 2 | | | | | | | | | | | | | | | | | | | |
| Environmental quantification for decision-making | 3 | | | | | | | | | | | | | | | | | | | |
| Verification and validation of of their own data sets | 2 | | | | | L | L | | L | | | | M | | M | | M | | | L |
| Analysis to raise awareness and communication (e.g. mitigating climate change) | 2 | | | L | L | H | H | M | H | M | | | | M | | | M | L | L | L |
| Measure performance (e.g. buildings, districts, grid) | 3 | | | | | | | | | | | | | | | | | | | |
| Risk assessment of achieving climate goals | 3 | | | | | | M | | | | | | L | | | | | | | L |
| | | | | | | | | | | | | | | | | | | | | |

**Figure 21: Relationship matrix for Stakeholder needs and technical requirements for BuiltHub**

In the relationship matrix, the strength is the relationship between needs (Y's) and technical (X's) requirements is defined by putting either a **H (high, or strong)- score 9, M (medium)- score 3 or L (low, or weak)- score 1**, based on judgements from project consortium members. The results include the calculation Relative weight (priority) indicating the importance of each technical requirement in relation to another. This output indicates which technical requirement addresses more than one need of stakeholders and has a higher importance than the others.

Outputs from this HOQ already give a preliminary insight into the important technical requirements that must be the target during the development of BuiltHub platform and would increase the likeliness of meeting more needs of stakeholders.

## 6.2. Probability of meeting the stakeholder needs

A further analysis into the probability of meeting the stakeholder needs was conducted. A probability score was calculated for each need using the HOQ1 (see Figure 22), where Probability score (needs) = Sum of strength of relationships for each technical requirement (i.e., 1,3,9).

| Probability calculations | | |
|---|---|---|
| Stakeholder needs | Importanc | Probability score |
| Data collection/ storage | 4 | 40 |
| Data analysis/ processing | 4 | 52 |
| Data community building/ exchange with | 4 | 147 |
| Exchange with data providers | 2 | 151 |
| Jointly analyse datasets | 2 | 51 |
| Generate infographics and visualisations f | 3 | 58 |
| Access to more data | 5 | 161 |
| Comparable data for other countries/ citie | 5 | 44 |
| Complementary data from other sectors t | 4 | 17 |
| Cross sector analysis that the BuiltHub w | 4 | 21 |
| Comparison tools for your dataset with ot | 4 | 41 |
| Quality analysis of data | 4 | 39 |
| Check/clean data | 4 | 34 |
| Import/ integrate data into other platforms | 4 | 122 |
| Validation tools for your dataset, for exam | 4 | 35 |
| Access to benchmarks, scenarios, plans | 5 | 18 |
| Analysis for education, research and cons | 5 | 154 |
| Analysis to do benchmarking | 3 | 79 |
| Analysis and visualisation to track future | 3 | 205 |
| Evidence backing the analysis provided b | 2 | 36 |
| Quantitative analysis to measure impact | 3 | 50 |
| Calculation of advanced parameters (e.g. | 3 | 64 |
| Product/ services/ applications/ tools dev | 3 | 151 |
| Analysis to find energy efficiency solution | 3 | 58 |
| Life-cycle analysis | 3 | 56 |
| Analysis of impact on health and well-bei | 2 | 33 |
| Economic quantification for decision-maki | 2 | 49 |
| Environmental quantification for decision-r | 3 | 52 |
| Verification and validation of of their own c | 2 | 48 |
| Analysis to raise awareness and commur | 2 | 170 |
| Measure performance (e.g. buildings, dist | 3 | 25 |
| Risk assessment of achieving climate goa | 3 | 28 |

**Figure 22: Probability to accomplish the needs of stakeholders**

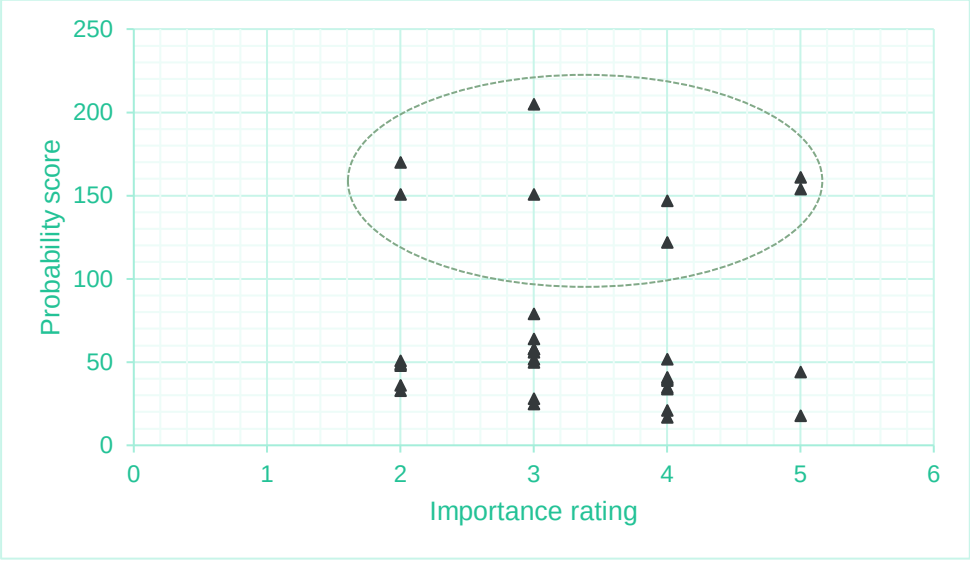


**Figure 23: Probability score for each stakeholder need**

A higher probability score for a need indicates that currently listed technical requirements (Section 6.1.3) are more likely to satisfy the stakeholders, whereas the ones with a lower score would need additional technical requirements to increase the probability of meeting the needs. This can also be observed in Figure 23 (plot between probability score and importance rating), where data points with high probability (>100) (encircled) are in a better position to be satisfied with the listed technical requirements. It is evident that it is not possible to meet all the

stakeholder needs within the scope of project duration, however, this probability analysis provided a vision to project partners and to align their further actions and satisfy the BuiltHub stakeholders and community.

## 6.3. Feasibility of achieving the technical requirements

Following the probability analysis, a feasibility analysis of technical requirements was also conducted (see Figure 24). Consortium partners provided their assessment for technical requirements that may be feasible (high, medium, low) to provide for the development of BuiltHub platform. In Figure 24, relative weights (priority) calculated in Section 6.1.3 (HOQ1) are also listed along with technical requirements. A lower relative weight indicates a lower priority of technical requirement for BuiltHub platform; thus, it would not be a top priority during the development.

| Feasibility assessment | | | | |
|---|---|---|---|---|
| Technical dimensions | Relative weights (priority) | Data assembly | Data processing and analysis | IT infrastructure and development |
| Centralised cloud storage and upload | 2.7% | | High feasibility | High feasibility |
| Application programming interface | 3.2% | | High feasibility | High feasibility |
| Community posts, exchange, and uploads | 0.7% | | High feasibility | Medium feasibility |
| Centralised data exchange and logs | 1.6% | | High feasibility | High feasibility |
| Comparitive analytics | 3.0% | | Medium feasibility | Medium feasibility |
| Visualisation dashboards | 2.8% | | High feasibility | High feasibility |
| Repository of data | 2.8% | | High feasibility | High feasibility |
| Integrated platform with regional statistics and data | 2.6% | | High feasibility | High feasibility |
| Cross referencing of data | 2.0% | | High feasibility | High feasibility |
| Analysis framework | 2.2% | | High feasibility | Low feasibility |
| Testing for validation | 1.3% | | Low feasibility | Low feasibility |
| KPIs for benchmarking | 1.5% | | Low feasibility | |
| Stories (case studies, scenarios, plans) | 2.6% | | High feasibility | High feasibility |
| Membership options (licensing, access) | 1.8% | | | High feasibility |
| User interface | 1.6% | | High feasibility | High feasibility |
| Sustainable hub model for all stakeholders | 2.2% | | Medium feasibility | |
| Collaborative exchange with other projects | 1.6% | | | High feasibility |
| Artficial intelligence functions | 1.9% | | Low feasibility | |
| Cummunity support in testing | 1.2% | | | Low feasibility |
| Energy related data (consumption, embodied, etc.) | 4.7% | High feasibility | | |
| Environmental impact data (product, process, service) | 3.2% | Medium feasibility | | |
| Health and well-being related data (IEQ, morbidity etc.) | 2.9% | Low feasibility | | |
| Emissions related data (CO2, GHG, embodied etc.) | 2.8% | High feasibility | | |
| Financing data (credit lines, incentives etc.) | 2.5% | Low feasibility | | |
| Workforce capacity | 1.3% | Low feasibility | | |
| Construction, demolitition, renovation data | 3.9% | High feasibility | | |
| Certifications data (voluntary and mandatory) | 3.5% | Medium feasibility | | |
| Smart technologies and smart readiness data | 2.9% | Low feasibility | | |
| Circular, re-use and re-cycling data | 1.5% | Low feasibility | | |
| Material and thermophysical properties data | 1.9% | High feasibility | | |
| Socio-economic data (energy poverty etc.) | 1.5% | Low feasibility | | |
| Climatological data (HDD, CDD etc.) | 1.3% | High feasibility | | |
| Economic data (energy related investments etc.) | 2.1% | Low feasibility | | |
| Building stock characteristics (age etc.) | 4.3% | High feasibility | | |
| Visualisation and infographics | 2.8% | | High feasibility | High feasibility |
| Analysis techniques and application | 2.5% | | High feasibility | High feasibility |
| Metrics of performance | 2.6% | | High feasibility | High feasibility |
| Web tools (public, policymakers, technical) | 1.8% | | High feasibility | |
| Modelling support | 1.9% | | Low feasibility | Low feasibility |
| Feedback, survey and support | 2.3% | | | Medium feasibility |
| Periodic data | 4.3% | Medium feasibility | | |
| Granular data | 1.9% | Low feasibility | | |

**Figure 24: Feasibility analysis for technical requirements**

## 6.4. Next steps

Any number of HOQs can be constructed to ensure an accurate understanding of what technical requirements are required to build services and products that meets the needs of the stakeholders. This process ensures high quality and dedicated management of the process that entails the benefits of a successful and acceptable solution by a broad range of stakeholders.

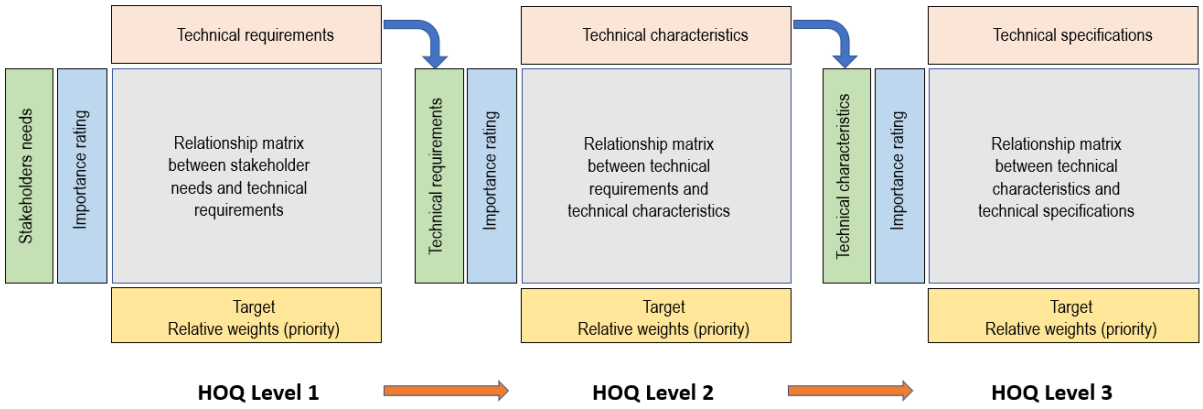


**Figure 25: Subsequent levels of House of Quality for detailed development of BuiltHub**

To be able to construct a datahub, many technical requirements must be met in extensive detail. However, as the project advances these details will become clearer. To support future work, as shown in Figure 25, HOQ1's technical requirements can be detailed into technical characteristics (HOQ2) followed by further detailing into technical specifications for BuiltHub platform and services. These subsequent HOQ's are very useful in meeting the required quality of product or services.

Probability and feasibility analysis conducted in Section 6.2 and 6.3 would guide the project partners to outline their priorities in the initial stage of the project and ensure that the development of BuiltHuB platform and community aligns with the stakeholder needs in the long run.

# 7. Overview of key findings

The three investigations (i) EU legislation review, (ii) Survey, and (iii) Interviews resulted in very interesting insights and findings that helped in establishing the stakeholder needs and technical requirements for BuiltHub that would be instrumental in meeting their needs.

To be able to use these findings effectively in the development of the BuiltHub platform and community, the stakeholder needs have been structured in four key categories (colour-coded and given below) that are directly relevant to each major project activity in the BuiltHub project, and these have been reported in Table 3 in detail. The description of each category is as follows

**1. Data assembly**

Data assembly refers to the actions of assembling and organising data/datasets and information for BuiltHub repository. It also includes the actions of identification, collection, and validation of datasets, building stock data inventory with climate and socio-economic data, description of sources and data gaps, new metadata, data quality criteria control, platform features, functionalities, and services, and embedding principles of circular economy.

**2. Data processing and analysis**

Data processing and analysis means to process, present, and visualise comprehensive information and knowledge related to the existing building stock. These include the application of machine learning algorithms and other data manipulation methods allowing flexibility to process different types of data. It mainly concerns populating building sector indicators, definitions, and datasets, developing calculation protocols, classification of datasets, data organisation, transformation and clustering, visualisation, and presentation.

**3. IT infrastructure and development**

This category concerns the architecture and technical specifications for BuiltHub platform, setting it up, its integration with different technical artefacts and its testing. Overall, it includes aspects such as BuiltHub platform architecture development, data ingestion from with existing databases, development of platform front-end interfaces, access controls, APIs, GUI, functional testing and validation of platform, user guidance, and controlling licensing and access.

**4. Sustainable community of data providers and users**

This category refers to the conceptualisation and definition of reasoning, methodology, schemes, relationships in support of a sustainable community of data providers and users under BuiltHub. It mainly concerns with value proposition for providers and users, feedback collection, continuous stakeholder engagement, developing client-centric strategies and value-added services, setting out pricing and agreements, and IP rights management)

The above categories have been mapped across several stakeholder needs in Table 3 below that were identified during the course of the investigation.

**Table 3: Overview of stakeholder needs**

| Key stakeholder needs | Data assembly | Data processing and analysis | IT infrastructure development | Sustainable community of data providers and users |
|---|---|---|---|---|
| Access to more data | ● | | | ● |
| One central and authoritative database (EU level) | ● | ● | ● | ● |
| Equipment cost and efficiency (EU level) | ● | ● | | |
| Energy system performance (EU level) | ● | ● | | |
| Building use, thermal characteristics, and systems | ● | | | |
| Cost (fuels, technologies, renovation measures) | ● | ● | | |

| | | | | |
|---|---|---|---|---|
| Financing data (e.g., credit lines, incentives) | ● | ● | | |
| Energy savings (renovation measures) | ● | ● | | |
| Harmonisation in data collection (national/regional) | ● | ● | ● | ● |
| Data analysis and processing | | ● | ● | ● |
| Analytics of impacts on health and well-being | ● | ● | | |
| Joint analysis of datasets (EU level) | ● | ● | ● | ● |
| Inform and include policymakers using dedicated section | | | ● | ● |
| Feasible business model | ● | | | ● |
| Training for stakeholders including policy and decision-makers | ● | | ● | ● |
| Data community building and exchange of data | | | ● | ● |
| Comparison of building stock datasets (national/regional/city) | ● | ● | ● | ● |
| Quantitative analysis and modelling for policy measures | ● | ● | | ● |
| Advance calculation of indicators and indices | | ● | | |
| Economic quantification for decision-makers | ● | ● | | |
| Added value of the platform | ● | | | ● |
| Verification and validation of datasets | ● | ● | ● | |
| Awareness on climate change using building stock analysis | | ● | | ● |
| Generate infographics, maps, and visualisations | | ● | ● | ● |
| Quality of data (control and comparison) | ● | ● | | |
| Author rights and permissions | | | ● | ● |
| Best practice information | ● | ● | | ● |
| Extrapolation solutions and support | | ● | ● | |
| Import and integrate data from other platforms | | ● | ● | ● |
| Environmental impacts quantification | ● | ● | | |
| Access to benchmarks and references for MS | ● | ● | ● | |
| Analysis for education and training | ● | ● | | |
| Lifecycle and circularity analysis (e.g., material, processes) | ● | ● | | |
| Future pathways, scenarios, and trends | ● | ● | | ● |
| Complimentary data from other sectors (e.g., manufacturing) | ● | ● | | |
| Cross-sector analysis | | | ● | |

| | | | | |
|---|---|---|---|---|
| Self-service tools and applications (e.g., calculators) | ● | | ● | ● |
| Contacts (industry players, administrators, and policymakers) | | | ● | ● |
| Common formatting guidelines/ data ontology | ● | ● | ● | |
| Open Application Programming Interface (API) | | | ● | |
| Setup alliances with universities, organisations, and agencies | | | | ● |
| Transparency and ethics (e.g., methods, assumptions) | ● | ● | ● | ● |
| Long-term engagement and continuous support | | | ● | ● |
| Accessible and easy to use platform and interface | ● | | ● | |
| Open access, open queries, and free downloads | ● | | ● | ● |
| Protection of data from commercial use | ● | | ● | ● |

In addition, the QFD analysis conducted with the project partners in Section 6 provided an exhaustive set of relevant technical requirements for the BuiltHub platform (see Table 4) that would be useful to address most of the identified needs of stakeholders (Table 3) effectively. These have been divided in five main categories:

(i) platform accessibility and sharing,
(ii) support to platform users,
(iii) calculations and analysis,
(iv) self-service tools, and
(v) platform data needs.

**Table 4: Overview of technical requirements for BuiltHub platform**

| **Platform accessibility and sharing** |
|---|
| Accredited expert database |
| Central and authoritative database on building stock |
| Open maps and plans for district heating and cooling |
| Integrated platform with regional statistics and data |
| Membership options (licensing, access) |
| Periodic data |
| Common exchange and data formats |
| Glossary of terms |
| Standards and ethics for data exchange |
| Version management and archiving routines |
| Download and upload protocols |
| **Support to platform users** |
| Community posts, exchange, and uploads |
| Sustainable hub model for all stakeholders |
| Community support in testing |
| Feedback, survey, and support |
| Author permissions and rights |
| Connection to direct channels use by policymakers |

| |
|---|
| Formatting guidelines and data ontology |
| Open-source access |
| **Calculations and analysis** |
| Comparative analytics NUTS (local, regional, country) |
| Metrics of performance |
| Advanced modelling support |
| KPIs for benchmarking |
| Common analysis framework |
| Comparison of efficiency and performance indicators |
| Data classification |
| Quality analysis of data |
| Statistical analysis |
| Extrapolation solutions |
| Uncertainty and accuracy analysis |
| **Self-service tools** |
| Centralised cloud storage and upload |
| Application programming interface |
| Centralised data exchange and logs |
| Visualisation, infographics dashboards |
| Artificial intelligence functions |
| Specific tools for general public, policymakers & technical use |
| User-friendly interface |
| Data clean up and validation |
| Permissions to set up links with other datahubs |
| Calculators |
| **Platform data needs** |
| Energy related data (consumption, embodied, etc.) |
| Environmental impact data (product, process, service) |
| Health and well-being related data (IEQ, morbidity etc.) |
| Emissions related data (CO2, GHG, embodied etc.) |
| Financing data (credit lines, incentives etc.) |
| Construction, demolition, renovation data |
| Certification's data (voluntary and mandatory) |
| Smart technologies and smart readiness data |
| Circular, re-use and re-cycling data |
| Material thermophysical properties data |
| Socio-economic data (energy poverty etc.) |
| Climatological data (HDD, CDD etc.) |
| Economic data (energy related investments etc.) |
| Building stock characteristics (age etc.) |
| Material consumption in buildings |

# 8. Conclusions

Data is needed to support the transformation of the building stock in Europe toward existing and future social, economic and environmental challenges such as emissions, resource consumption, health, energy poverty etc. European legislation underlines and outlines requirements under several articles such as the EPBD, RESD and EED that a significant amount of data is needed to achieve their objectives. These range into multiple themes but not limited to the detailed analysis of the building stock, impact of policies, climate, economic

welfare, energy efficiency, financial investments, renewable energy solutions, and cost-efficiency of measures to increase energy efficiency etc. A more harmonised approach to European data collection and analysis would definitely benefit compliance with the national goals set under the European directives and ease the burden on public authorities for policy making. This aspect was perceived very important by most of the participants in the survey and interviews.

An overwhelming interest was observed from the stakeholders to engage in a community to support the building stock transformation using data, thus establishing the need for a robust, continuous, and durable flow of reliable building data at the EU level. Services like data collection and storage, processing and analysis, benchmarking data, visualisation, data sharing, and exchange are of great value to most of the stakeholders included in this study. Comparative data and analysis are of strong interest to most of the stakeholders. Harmonisation of indicators and metrics for the building stock would be a crucial step in this direction.

Stakeholders expressed a strong need of building sock related data such as energy consumption, emissions, certifications, financing and investments, socio-economic data and performance of building envelope, systems, and technological solutions and decarbonisation pathways. Stakeholders are also interested in sharing the data with BuiltHub such as data on energy performance of buildings, case studies, buildings systems monitoring data, no. of permits issued, energy grant data, district level statistics (e.g. energy consumption, built-up area, renovation) among others. A key finding of this study is that many stakeholders are more willing to share information in exchange of getting access to more information, rather than being incentivised economically. Local stakeholders such as construction companies and utilities are identified as potential sources for data collection concerning regional building stock data. There is also hesitation to share data due to recognised inconsistencies in building stock data. Issues such as compliance with national laws and regulations, scientific agreements, security, and privacy are important for stakeholders concerning BuiltHub success.

Participation of policymakers in BuiltHub community is identified as one of the primary needs by the other stakeholders for it to be impactful. A clear need could be established from participants who were either policymaker/ government bodies requiring clear and uniform analysis for comparison at country, regional and local level supported by maps and visualisations. To drive informed policy and decision-making in Europe, the policymakers must be integrated as lead-users and into the process through targeted reach out, awareness and training. A common reliable format and framework for data exchange would enhance the impact of BuiltHub. Most importantly, the creation of a community that care, sharing data in international communities, collaboration with existing EU projects, supporting initiatives like New European Bauhaus, setting up alliances with universities, energy agencies and professional organisations are key to move forward.

Certain limitations were established during the investigation that may have influenced the outcome of this study. One of them was the limited participation of stakeholders such as real-estate sector, policy makers, public and private utilities and property owner associations. However, further stakeholder engagements planned during the project would strongly reflect on this aspect and would expand the interactions and participation with other stakeholders.

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# Annex I: Survey questionnaire

BuiltHub seeks to determine how a platform for a European-wide data exchange related to the building stock needs to be organized to propose value to all stakeholders and respect their conditions and needs. How do you see such a data exchange platform generating value for you or your organisation? And what do you or your organisation require to participate? This survey helps us to understand you as a stakeholder, with your needs and technical requirements, conditions, and limitations. Answering this survey should take 12- 15 minutes .Thank you very much in advance for completing this questionnaire.

BPIE is the lead partner of this survey conducted for BuiltHub, a project funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 957026.

By filling out this form you agree that we will process your data in line with our privacy policy.

If you have questions regarding the privacy policy please email our Data Protection Officer: caroline.milne@bpie.eu.
For general questions please contact: judit.kockat@bpie.eu.

* answer required

* 1. By clicking Yes, you agree to the above terms.

- ◯ Yes
- ◯ No

* 2. What is your professional experience level (in years)?

- ◯ under 1
- ◯ 1 - 5
- ◯ 6 - 10
- ◯ 11 - 20
- ◯ 21 - 30
- ◯ over 30

* 3. Are you...?

- ◯ Female
- ◯ Male
- ◯ Prefer not to say

* 4. What type of organisation you work for?

* 5. Which country are you based in?

* 6. What is the geographical coverage of your organisation's activity? Select all that apply.

- ☐ North Europe
- ☐ West Europe
- ☐ Central Europe
- ☐ East Europe
- ☐ South Europe
- ☐ South East Europe

* 7. With regard to the purpose of BuiltHub, which of the following statements you agree with? Select all that apply.

- [ ] There is a need for user-friendly platform to exchange buildings related data around Europe.
- [ ] I am interested to engage in a community to support building stock transformation using data.
- [ ] I am ready to pay fees if data services provide value for money.
- [ ] There should be a single hub where I can access buildings related data.
- [ ] Other (please specify)

* 8. What do you consider the ideal functions or benefits of a buildings related data sharing hub and community? Select all that apply.

- [ ] Data collection/ storage
- [ ] Data analysis/ processing
- [ ] Data community building/ exchange with community/ data sharing
- [ ] Access to more data
- [ ] Other (please specify)
- [ ] Exchange with data providers
- [ ] Jointly analyse datasets
- [ ] Generate infographics and visualisations

* 9. Which benefits do you consider important for your organisation?

| | Extremely important | Very important | Somewhat important | Not so important | Not at all important | I don't know |
|---|---|---|---|---|---|---|
| Access to more data | ○ | ○ | ○ | ○ | ○ | ○ |
| Access to comparable data for other countries/ cities/ municipalities | ○ | ○ | ○ | ○ | ○ | ○ |
| Access to complementary data from other sectors that interact with buildings (e.g. energy, manufacturing industry) | ○ | ○ | ○ | ○ | ○ | ○ |
| Access to cross sector analysis that the BuiltHub will provide based on the size of database | ○ | ○ | ○ | ○ | ○ | ○ |
| Access to comparison tools for your dataset with other datasets. | ○ | ○ | ○ | ○ | ○ | ○ |
| Access to validation tools for your dataset, for example across different time periods | ○ | ○ | ○ | ○ | ○ | ○ |
| Access to benchmarks, scenarios, plans and goals | ○ | ○ | ○ | ○ | ○ | ○ |
| Privileged access to a live data-sharing community | ○ | ○ | ○ | ○ | ○ | ○ |

* 10. What data-related services would be valuable for you or your organisation's dataset(s)?

| | Extremely valuable | Very valuable | Somewhat valuable | Not so valuable | Not at all valuable | I don't know |
|---|---|---|---|---|---|---|
| Check/ clean/ validate my data | ○ | ○ | ○ | ○ | ○ | ○ |
| Compare my data against itself | ○ | ○ | ○ | ○ | ○ | ○ |
| Compare my data against other datasets | ○ | ○ | ○ | ○ | ○ | ○ |
| Visualise my data | ○ | ○ | ○ | ○ | ○ | ○ |
| Import/ integrate my data into other platforms | ○ | ○ | ○ | ○ | ○ | ○ |
| Complement or cross-reference my data with data from other sources | ○ | ○ | ○ | ○ | ○ | ○ |
| Benchmarking of all collected data | ○ | ○ | ○ | ○ | ○ | ○ |
| Quality analysis of my data | ○ | ○ | ○ | ○ | ○ | ○ |
| Stories (case studies, scenarios, plans) | ○ | ○ | ○ | ○ | ○ | ○ |

* 11. Which other dataset(s)/ data source(s) would you consider useful for BuiltHub to establish access with?

| | Extremely useful | Very useful | Somewhat useful | Not so useful | Not at all useful | I don't know |
|---|---|---|---|---|---|---|
| EU statistics | ○ | ○ | ○ | ○ | ○ | ○ |
| National statistics | ○ | ○ | ○ | ○ | ○ | ○ |
| Data on municipality/regional level | ○ | ○ | ○ | ○ | ○ | ○ |
| Data from Energy Performance Certificate registries | ○ | ○ | ○ | ○ | ○ | ○ |
| Data from industry | ○ | ○ | ○ | ○ | ○ | ○ |
| Consumption/production data from utility companies | ○ | ○ | ○ | ○ | ○ | ○ |
| Data from smart meters | ○ | ○ | ○ | ○ | ○ | ○ |
| Data collected in the Digital Building Logbooks, Renovation Passports/ Renovation Roadmaps | ○ | ○ | ○ | ○ | ○ | ○ |
| Post occupancy evaluations/ audits | ○ | ○ | ○ | ○ | ○ | ○ |

Other (please specify)

* 12. Which of the following thematic areas are the most relevant for you or your organisation?

| | Extremely relevant | Very relevant | Somewhat relevant | Not so relevant | Not at all relevant | I don't know |
|---|---|---|---|---|---|---|
| Nearly zero-energy buildings | ○ | ○ | ○ | ○ | ○ | ○ |
| Building stock characteristics | ○ | ○ | ○ | ○ | ○ | ○ |
| Building renovation | ○ | ○ | ○ | ○ | ○ | ○ |
| Energy poverty | ○ | ○ | ○ | ○ | ○ | ○ |
| Energy market | ○ | ○ | ○ | ○ | ○ | ○ |
| Certification | ○ | ○ | ○ | ○ | ○ | ○ |
| Financing | ○ | ○ | ○ | ○ | ○ | ○ |
| Indoor Environmental Quality (e.g. thermal comfort, indoor air quality, daylight, noise) | ○ | ○ | ○ | ○ | ○ | ○ |
| CO2 emission | ○ | ○ | ○ | ○ | ○ | ○ |
| Smart technologies | ○ | ○ | ○ | ○ | ○ | ○ |
| Electric vehicle readiness of buildings | ○ | ○ | ○ | ○ | ○ | ○ |

Other (please specify)

* 13. How would you like to use the data if you receive it from BuiltHub? Select all that apply.

- ☐ Training and education
- ☐ Research and analysis
- ☐ Benchmarking
- ☐ Analyse future pathways/ scenarios/ trends
- ☐ Evidence backing
- ☐ Design processes
- ☐ Measure impact of policies
- ☐ Calculation of advanced parameters
- ☐ Other (please specify)
- ☐ Product or services development
- ☐ Energy efficiency solutions
- ☐ Life-cycle assessment
- ☐ Health and well-being
- ☐ Economic decision-making
- ☐ Environmental decision-making
- ☐ Verification and validation

14. Which questions would you like datasets to answer? Or where is more quantitative evidence needed?

* 15. Do you search for information using external sources to develop or update an approach for environment protection or sustainability for your organisation such as a business strategy, local, regional or national government policy?

- ◯ Yes
- ◯ No
- ◯ I don't know

* 16. Please select the sources you most often use for this purpose.

- [ ] Open data platforms
- [ ] Digital libraries
- [ ] Legislation websites
- [ ] Scientific publications
- [ ] Other (please specify)

* 17. Do you or your organisation actively use/ provide/ rely on building stock related data?

*Building stock related data may include but not limited to meteorological and socio-economic data, building characteristics (typology, thermophysical etc.), technical services and systems, smart readiness (building's e-mobility etc.), renewables technologies, audits, indoor environmental quality, energy consumption, investments for operation, maintenance, and renovation, financing schemes and subsidies, energy market, and emissions.*

- ◯ Yes
- ◯ No
- ◯ I don't know

* 18. For what purposes do you or your organisation use/ provide/ rely on building stock related data? Select all that apply.

- [ ] Research or analysis
- [ ] Decision-making
- [ ] Prediction or forecasting
- [ ] Measure performance
- [ ] Track or analyse trends
- [ ] Benchmarking
- [ ] Calculation of scenario/ pathways
- [ ] Risk assessment
- [ ] Develop applications/ platforms/ tools/ services
- [ ] Visualisation
- [ ] Other (please specify)

* 19. Are you or your organisation currently a member of any data sharing community or data hub?

- ◯ Yes
- ◯ No
- ◯ I don't know

* 20. Which existing data community or hub is your organisation interested or involved in?

* 21. Did you or your organisation provided, shared, used, purchased, collected, or generated buildings related data in the past 5 years? Select all that apply.

- [ ] Provided/ shared/ used data
- [ ] Purchased data
- [ ] Collected data
- [ ] Generated data
- [ ] None of the above

* 22. You replied that you or your organisation provided/ shared/ used/ purchased/ collected/ generated buildings related-data in the last 5 years. What type of data it was? Select all that apply.

- [ ] Climatological (e.g. HDD,CDD etc.)
- [ ] Socio-economic (e.g. number of persons living per dwelling)
- [ ] Building stock characteristics (e.g. age by stock)
- [ ] Building envelope performance
- [ ] Building systems (e.g. type of heating, cooling etc. systems)
- [ ] Building stock energy consumption
- [ ] Building stock transformation (renovation rate, depth)
- [ ] Certifications (e.g. Building energy performance certificates)
- [ ] Economics (e.g. energy related investment)
- [ ] Financing (e.g. credit lines, incentives)
- [ ] Energy market (e.g. electricity prices)
- [ ] Environment related (e.g. emissions, renewable energy)
- [ ] Health and well-being related
- [ ] Electric vehicle-ready buildings
- [ ] Smart and grid-ready buildings
- [ ] Other (please specify)

* 23. Do you or your organisation currently plan to provide, share, use, purchase, collect, or generate buildings related data in the next 2 years? Select all that apply.

- [ ] Planning to provide/ share/ use data
- [ ] Planning to purchase data
- [ ] Planning to collect data
- [ ] Planning generate data
- [ ] None of the above

* 24. You replied that you or your organisation is planning to provide/ share/ use/ purchase/ collect/ generate buildings-related data. What type of data it will be? Select all that apply.

- [ ] Climatological (e.g. HDD,CDD etc.)
- [ ] Socio-economic (e.g. number of persons living per dwelling)
- [ ] Building stock characteristics (e.g. age by stock)
- [ ] Building envelope performance
- [ ] Building systems (e.g. type of heating, cooling etc. systems)
- [ ] Building stock energy consumption
- [ ] Building stock transformation (renovation rate, depth)
- [ ] Certifications (e.g. Building energy performance certificates)
- [ ] Economics (e.g. energy related investment)
- [ ] Financing (e.g. credit lines, incentives)
- [ ] Energy market (e.g. electricity prices)
- [ ] Environment related (e.g. emissions, renewable energy)
- [ ] Health and well-being related
- [ ] Electric vehicle-ready buildings
- [ ] Smart and grid-ready buildings
- [ ] Other (please specify)

* 25. Would you or your organisation be willing to share the data with BuiltHub?

- ◯ Yes, completely
- ◯ Yes, partially
- ◯ No
- ◯ I don't know

* 26. Under what conditions would you be willing to share data? Select all that apply.

- [ ] Receiving data from other (not yet available) sources
- [ ] Connect to other data providers and data users that are part of the community
- [ ] Privileged access to a live community of data providers
- [ ] Visibility for my organisation’s contribution
- [ ] Agreement
- [ ] Protection of intellectual property
- [ ] Provision of services (data processing, visualisation, support, data backup etc.)
- [ ] Insurance against data breach
- [ ] Compliance with national law (security, privacy etc.)
- [ ] Monetary incentive, fees, or cost compensation
- [ ] We would only share if it were a legal requirement
- [ ] Other (please specify)

_____

* 27. What restricts you or your organisation from sharing the data? Select all that apply.

- [ ] Legal aspects
- [ ] Organisational regulations/rule
- [ ] National guidelines
- [ ] Pressure from organizations we work with
- [ ] Time constrains
- [ ] Economic reasons (e.g. high costs, competition)
- [ ] Other (please specify)
- [ ] Personal data protection issues
- [ ] Lack of structured and standardised repository
- [ ] Lack of data sharing framework
- [ ] Misuse of data without giving due credit
- [ ] Quality of data
- [ ] Condition as raw data

* 28. Would you like to answer more questions on the technical aspects of sharing and the platform?

*These will take less than 2 minutes.*

- ◯ Yes
- ◯ No

* 29. Which file format is most preferable for use in your organisation?

| | Extremely useful | Very useful | Somewhat useful | Not so useful | Not at all useful |
|---|---|---|---|---|---|
| Machine-readable format (such as RDF, XML, JSON) | ○ | ○ | ○ | ○ | ○ |
| Tabular data format (csv/ tsv) | ○ | ○ | ○ | ○ | ○ |
| Excel format (xlsx) | ○ | ○ | ○ | ○ | ○ |
| Document format (pdf) | ○ | ○ | ○ | ○ | ○ |
| Web format (html) | ○ | ○ | ○ | ○ | ○ |
| Statistics format (spss) | ○ | ○ | ○ | ○ | ○ |
| Plain text format (txt) | ○ | ○ | ○ | ○ | ○ |

Other (please specify)

* 30. How would you prefer to utilise the BuiltHub platform?

- ☐ Receiving the data through a RESTful API
- ☐ I don’t know
- ☐ Through the browser on the BuiltHub’s web dashboard
- ☐ Other (please specify)

* 31. Do you handle or administer a building and/or energy efficiency- related database?

- Yes
- No

32. Which database is that?

* 33. What do you generally use to organise or share data in your organisation?

- [ ] Data management platform (e.g. Lotame, Cloudera)
- [ ] Via email
- [ ] Analytical tools (e.g. Power BI)
- [ ] Cloud services (e.g. MS Sharepoint)
- [ ] Files (e.g. excel, csv)
- [ ] Local storage (e.g. USB sticks, hard disks)
- [ ] Other (please specify)

* 34. Which geographic granularity would you or your organisation be most interested in to get data from the BuiltHub platform?

- [ ] NUTS-0: Country level
- [ ] NUTS-1: major socio-economic regions (e.g. Group of States, Regions)
- [ ] NUTS-2: basic regions for the application of regional policies (e.g. States, Regions, Provinces)
- [ ] NUTS-3: small regions for specific diagnoses (e.g. Counties, Cantons, Districts)
- [ ] LAU-2 (e.g. Municipalities, Communes, Settlements)
- [ ] I don't know
- [ ] Other (please specify)

* 35. At which level of geographical granularity do you or your organisation would like to provide or share data with BuiltHUB platform?

- [ ] NUTS-0: Country level
- [ ] NUTS-1: major socio-economic regions (e.g. Group of States, Regions)
- [ ] NUTS-2: basic regions for the application of regional policies (e.g. States, Regions, Provinces)
- [ ] NUTS-3: small regions for specific diagnoses (e.g. Counties, Cantons, Districts)
- [ ] LAU-2 (e.g. Municipalities, Communes, Settlements)
- [ ] I don't know
- [ ] Other (please specify)

* 36. Which time-period data related to buildings would your organisation be most interested to get or share?

- [ ] We have historic time-series or trends
- [ ] We need historic time-series
- [ ] We have single historic data points before 2018
- [ ] We need single data points
- [ ] We have recent data (2018 or later)
- [ ] We need most recent data
- [ ] I don't know
- [ ] Other (please specify)

* 37. How often would you or your organisation like to get or share such BuiltHub data?

*To support the Renovation Wave, for example, renovation activity in the building stock would be tracked, which is currently a challenge. The frequency of recording and reporting renovation activity will determine the reaction time and enable timely adjustment of measures.*

- [ ] Monthly
- [ ] Semi-annually
- [ ] Quarterly
- [ ] Annually
- [ ] Other (please specify)

* 38. Are you interested to become or continue to be a member of the BuiltHub community?

*We ask for your consent to have your contact details in BuiltHub's stakeholder database and to be contacted by members of the consortium for engagement actions. Your contact details will be kept in the database until the end of the project's lifetime and will be strictly confidential. Participation is free and there are no mandatory requirements. Involvement is entirely up to you, and you have the right to deny participating at any time without justification.*

- ◯ I am already a member
- ◯ Yes
- ◯ No
- ◯ I don't know

* 39. Would you be interested in testing the beta version of the platform by being involved in the BuiltHub pioneer user group?

- ◯ Yes
- ◯ No

* 40. Please provide your contact details:

| | |
|---|---|
| **Name** | |
| **Email Address** | |

41. Any general comments?

# Annex II: Interview questionnaire

# Discussing more specific needs of stakeholders for the BuiltHub platform

## Interview outline

*The overall aim of the BuiltHub project is to define a roadmap and vision for a durable (FAIR - Findable, Accessible, Interoperable, Reusable) dataflow and collection enabling to characterise the EU building stock. The project aims to do so by developing a robust and resilient web-based IT Infrastructure (platform) that allows for collecting and extracting building performance and characteristics related data. BuiltHub will support transforming the data into information and knowledge by offering dedicated uses and services for platform users and beneficiaries, such as policy makers (EU, national and local authorities).*

This interview aims at identifying key areas of action that can be the most relevant, suitable and promising for implementing BuiltHub platform in relation to the building stock data.

| Topic | Questions |
|---|---|
| **1) Expected support to/ from BuiltHub** | • What do you consider the benefits of a data-sharing platform and community?<br>• What would be your organization's conditions to share data with BuiltHub?<br>  o What (type of) data (if any) would you like to share with BuiltHub? |
| **2) Key data/ metadata for effective building stock transformation** | • Which kind of data analysis you think BuiltHub should deliver?<br>  o E.g. BuiltHub could take over part of the work an organization currently has to do, so that they can focus on other activities<br>• How do you think BuiltHub can establish links with other data communities? |
| **3) Collection of data easily, reliably and responsibly** | • With regard to the benefits, do you have quality requirements for the data or analysis that you receive?<br>• Do you consider transparency and accessibility in a data-sharing community as beneficial?<br>  o What measures could be taken to establish these in the data-sharing community? |
| **4) Filling the gaps** | • What datasets/ indicators/ data-related services would be valuable for your organization?<br>• Where is more quantitative evidence needed in the building sector? |
| **5) Concluding remarks** | • What would be the single key area that would have the greatest impact on moving the implementation of the BuiltHub platform forward?<br>  o E.g. self-service (analytics, visualization and AI services), community support, third-party monetization, democratizing data, capability to provide services, open API, user privacy control, agility<br>• Do you see interaction of BuiltHub with any of your projects? or other projects or initiatives? |

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