



Mapping Stakeholder Information Needs to Enhance Energy Efficiency, Circularity, and Sustainability in the Built Environment

Paolo Dell'Oro¹ , Marta Maria Sesana¹ , and Helena Gervasio² 

¹ Department of Civil Engineering, Architecture, Land and Environment, and Mathematics,
Università degli Studi di Brescia, Brescia 25121, Italy
paolo.delloro@unibs.it

² Department of Construction, Civil Engineering, University of Coimbra, Coimbra 3030-790,
Portugal

Abstract. Achieving more sustainable and circular practices in the construction sector requires a clear understanding of the information needs of the stakeholders involved throughout the building lifecycle. This study investigates the data requirements, roles, and decision-making needs of key actors in the European construction sector, including architects, engineers, contractors, energy consultants, regulators, facility managers, and material suppliers. The research adopts a mixed-method approach combining an online survey and targeted interviews. The survey, distributed across Europe through professional networks and social media channels, collected 101 responses from construction-sector stakeholders. In addition, 13 semi-structured interviews have been conducted to deepen the understanding of stakeholder perspectives and contextualize survey results. The collected data have been analyzed through data-mining techniques and visualized through graphical representations to identify patterns in information needs, preferred data formats, and decision-support requirements. The results highlight differences among stakeholder groups in terms of required information types, levels of technical detail, and preferred delivery formats. These findings support the development of structured information workflows that better align data provision with stakeholder responsibilities and decision-making processes. By clarifying stakeholder information requirements, the study contributes to improving data management practices and supporting the implementation of sustainable and circular strategies in the built environment.

Keywords: Energy resource efficiency · Sustainability · Circularity · Building life cycle · Digitalization

1 Introduction

The construction sector plays a central role in the transition towards a more sustainable and resource-efficient built environment. In the European Union (EU), buildings account for a significant share of energy consumption and greenhouse gas emissions, making the

sector a key focus of climate mitigation and circular economy strategies [1]. European policies such as the European Green Deal [2] emphasize the need to improve building performance, enhance resource efficiency, and lifecycle-based approaches to building management.

To support these objectives, the European Union is increasingly promoting the digitalization of the construction sector as a key enabler for more efficient data management and decision-making processes. Initiatives such as Digital Building Logbooks (DBLs) and Digital Product Passports (DPPs) aim to improve the availability, traceability, and interoperability of building-related information throughout the lifecycle of assets [3]. These digital approaches facilitate better monitoring of building performance, improved resource management, and the implementation of circular economy principles within the built environment [4].

Despite these developments, the effective management and exchange of information within the construction sector remain significant challenges. The sector is characterised by a high level of fragmentation, involving multiple actors operating across different project phases, organizations, and digital environments [5–7]. Architects, engineers, contractors, facility managers, regulators, material suppliers, and energy consultants all contribute to generating and managing building-related data, yet they often rely on different standards, tools, and workflows. As a result, information is frequently stored in isolated systems or exchanged through non-standardized formats, limiting its accessibility and usability for other stakeholders involved in the building lifecycle [8, 9].

In this context, understanding the information needs of stakeholders in relation to specific topics becomes a critical prerequisite for improving data management practices in the construction sector [10]. Identifying which data are required by different actors, how these data should be structured, and through which formats and exchange mechanisms they should be delivered can support the development of more effective and interoperable information frameworks. These are essential for enabling digital tools to provide practical value for industry professionals and for supporting the implementation of sustainability and lifecycle-oriented strategies [11, 12].

Within this context, the paper investigates the data and needs of key stakeholders involved in the construction sector in relation to four selected topics: energy efficiency, sustainability, circularity and resource efficiency. The study focuses on answering the following research questions: *RQ1) What are the data needs of stakeholders in the construction sector in relation to energy efficiency, sustainability, circularity, and resource efficiency?; RQ2) Which formats and delivery methods are most commonly used by stakeholders in the construction sector to share this information?*

The study is based on a mixed-method research approach combining an online survey and targeted interviews conducted among stakeholders of the European construction sector.

The results provide insights into stakeholder data needs, preferred information formats, and current practices for information exchange. These findings contribute to supporting the development of more structured and interoperable information workflows capable of improving data accessibility and facilitating the implementation of sustainable practices in the built environment.

The work has been conducted within the EU research project “INTElligent digital tools for Green Renovation, Assessment, Transformation, Efficiency and Sustainability” (INTEGRATES), funded under the Horizon Europe programme. The INTEGRATES core goal is to develop a framework integrating Building Information Modelling (BIM), digital twins, and data services supported by neuro-symbolic AI, and in this context, the manuscript presents the first results of the activities aimed at identifying the key stakeholders involved across the building lifecycle (construction, renovation, operation, and end-of-life) and mapping their roles and responsibilities in relation to energy efficiency, sustainability, circularity, and resource efficiency objectives.

2 Methodology

The study has been structured using a mixed-method approach to answer the RQs, combining quantitative and qualitative data collection techniques.

The quantitative technique is based on an online survey, that aimed to collect structured information on stakeholder roles, data needs, and current information exchange practices within the construction sector. The qualitative technique, instead, consisted of targeted semi-structured interviews, conducted with selected stakeholders to further explore and contextualize the results obtained from the survey.

The collected data from both the survey and interviews have been analyzed using data mining techniques and subsequently represented through graphical visualizations to identify recurring patterns, differences among stakeholder groups, and key trends in information exchange practices.

2.1 Survey Structure

The survey has been structured into five sections: an introductory section and four thematic ones, each dedicated to one of the selected topics. The introductory section aimed to cluster the respondents according to their stakeholder profile and the EU countries in which they carry out their work.

The thematic sections follow the same structure, and they are divided into four subsections corresponding to four scenarios representing different stages of the building lifecycle: (i) new construction, (ii) renovation, (iii) district-scale development, and (iv) demolition. Each subsection includes the same set of questions to ensure consistency in the collected data and facilitate comparison across topics and scenarios. Table 1 presents the list of questions related to the energy efficiency topic and the new construction scenario, which are representative of the structure adopted for all topics and scenarios.

The survey has been translated into 9 languages to maximize participation and shared through mailing lists and professional networks of the INTEGRATES project partners, promoted via professional communication channels, and presented during events and meetings of the construction sector.

Table 1. List of survey questions for the “Energy Efficiency – New Construction” combination.

Section: Energy Efficiency – Subsection: New construction	
Q1	Do you usually work, or have you ever worked, on the construction of a new building?
Q2	Referring to the construction of a new building, which are the stakeholders among with you share data about the energy efficiency framework?
Q3	Which are your data needs about energy efficiency framework?
Q4	In which format do you share information with them? F1) Worksheet; F2) Document; F3) PDF file; F4) Images; F5) 2D model; F6) 3D model; F7) BIM format; F8) Simulation software; F9) Web application; F10) Dashboard
Q5	Which delivery methods do you use to share with them? M1) Physical media; M2) Email attachments; M3) Common Data Environment (CDE); M4) Company file servers; M5) Cloud storage; M6) Online dashboard; M7) Web application; M8) BIM server; M9) Digital twin platform

2.2 Interviews Structure

The interviews have been designed as a follow-up phase to the survey, maintaining a similar thematic structure while introducing additional questions (Table 2). An interview guide has been developed based on a preliminary analysis of the survey results and on the main uncertainties that emerged from the responses, to clarify ambiguous aspects and explore specific topics relevant to answering the RQs of the study.

Table 2. List of the additional questions asked during the interviews.

Additional questions	
Q1	How do you evaluate the integration and interoperability level of your information system? Where do you see opportunities for improvements?
Q2	How would you describe the construction/renovation/operation/demolition workflow in terms of 3–5 main steps from your perspective?
Q3	What are the best critical decision points in this workflow to optimize processes?

Interviewees have been identified both through the project consortium partners and among survey respondents who indicated their availability to be contacted for a follow-up interview. A subset of participants has been then selected to ensure a reasonable representation of different stakeholder profiles. Interview transcripts and notes have been qualitatively analyzed through thematic coding. The analysis focused on identifying recurring themes related to interoperability challenges, information continuity, data duplication, and digital workflow integration.

3 Results and Discussion

This section presents the main findings of the study regarding stakeholder information needs and current practices for data exchange within the construction sector. Firstly, the results obtained from the online survey are presented, and secondly, the main insights emerging from the stakeholder interviews are discussed.

The dissemination of the survey through different platforms and communication channels enabled the collection of 101 responses from stakeholders operating within the EU construction sector. Respondents represent a wide range of professional roles involved across different phases of the building lifecycle, with engineers that constitute the largest group of participants (33 respondents), followed by architects (14), contractors or construction companies (14), and material suppliers or industrial companies (14). Additional respondents include facility managers (11), energy consultants (9), and regulators (6). This distribution highlights the presence of actors engaged along the entire value chain (design, construction, operation, and regulatory activities), providing more holistic results of the survey. Considering the geographical distribution, most respondents operate in Italy (35%), followed by Belgium (11%), Greece (9%), Bulgaria and Germany (8% each). The remaining responses are distributed across other European countries, confirming the international scale of the survey.

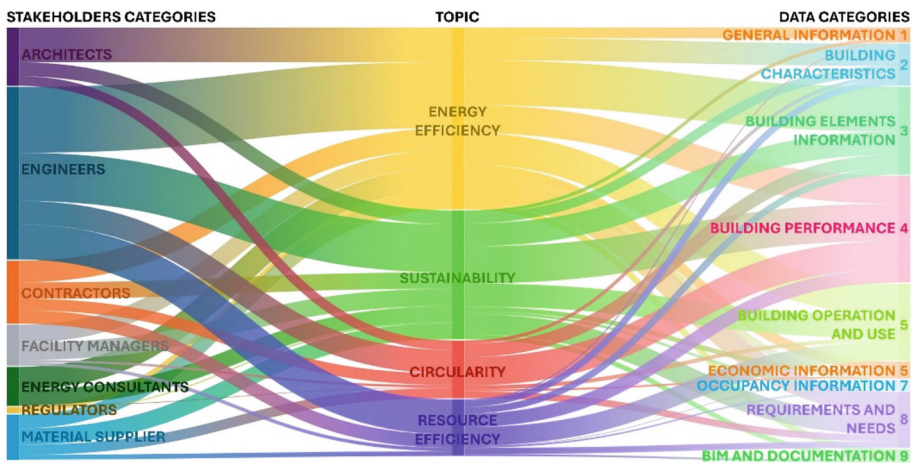


Fig. 1. Sankey diagram illustrating the relationships between stakeholder categories, thematic topics, and the corresponding data categories identified in the survey.

Figure 1 presents the results of Q3 of the survey and contributes to addressing the RQ1 of the study, which investigates the types of data required by stakeholders in the construction sector. The data has been categorized using the information groups commonly included in DBLs and DPPs, ensuring consistency with existing frameworks and practices already adopted in the sector.

The results highlight that all four topics are strongly connected to several data categories, particularly “Building performance”, “Building elements information”, and

“Building operation and use”. Each of these categories contributes at least 17% of the responses for all four topics, highlighting that stakeholders require both performance indicators and detailed technical information about building components. Another relevant category is “Requirements and needs”, which represents between 11% and 16% of the responses. This highlights the importance for stakeholders of accessing information capable of supporting decision-making processes, regulatory compliance, and the identification of performance targets throughout the building lifecycle.

Figure 2 presents the results of Q4 and Q5 of the survey and contributes to addressing RQ2 of the study, which aims to identify the most common formats and delivery methods used for information exchange among stakeholders in the construction sector. The results show that document-based formats remain the dominant approach for information exchange. In particular, PDF files (F3) represent the most widely used format across all stakeholder categories, accounting for 88% of the responses. This is followed by worksheets (F1) and documents (F2), which account for 62% and 58% of responses, respectively. These formats are consistently adopted across most stakeholder categories, suggesting that information exchange in the sector still relies heavily on traditional document-based practices. In contrast, more advanced digital formats such as simulation software (F8), web applications (F9), and dashboards (F10) show significantly lower usage levels, below 20% of responses. This suggests that, although digital and model-based approaches are increasingly promoted within the construction sector, their adoption for daily information exchange is still relatively limited.

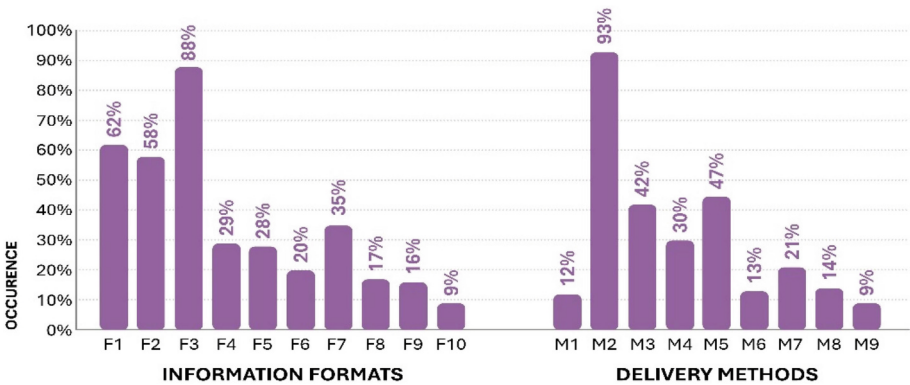


Fig. 2. Distribution of information formats (F1–F10) and delivery methods (M1–M9) used by stakeholders of the construction sector for sharing information.

A similar pattern emerges when analysing the delivery methods used to share information. The results clearly show the predominance of email attachments (M2), which are used by 93% of respondents, making them by far the most common delivery method across all stakeholder categories. Other digital infrastructures, such as cloud storage services (M5) and common data environments (M3), show moderate levels of adoption (47% and 42% respectively), indicating that shared digital environments are increasingly used to support collaboration and data exchange.

Other delivery methods appear to play a more complementary role. Company file servers (M4) and online dashboards (M6) are used by 29% and 13% of respondents, respectively, while more advanced solutions such as web applications (M7), BIM server (M8), and digital twin platforms (M9) show limited adoption across the surveyed stakeholders. Traditional approaches such as physical media (M1) also appear marginal, accounting for only 12% of responses.

The interviews have been conducted with stakeholders representing different roles within the construction sector, to manage a deeper interpretation of the survey results and provide additional context regarding current practices and challenges related to information management and exchange across the building lifecycle. A total of 13 interviews have been performed for the study.

A recurring theme emerging from the interviews concerns the fragmentation of information workflows and the limited interoperability between software environments used by different stakeholders. Several participants highlighted that information exchange often relies on manual transfers or static document formats, even when digital modelling tools are internally adopted.

Another frequent issue concerns the discontinuity of information across lifecycle phases. Interviewees reported that information generated during early project stages is frequently not transferred in a structured way to facility managers or demolition stakeholders, limiting the possibility of reusing data for maintenance, renovation, or circularity-related assessments.

Interestingly, several interviewees reported that advanced digital tools such as BIM platforms or simulation environments are increasingly adopted within specific organizational workflows, while information exchange between organizations still predominantly occurs through static and non-interoperable formats. This suggests that the gap is not only technological but also organizational and procedural.

The findings suggest that the main barrier to digital information exchange in the construction sector is not necessarily the absence of digital tools, but rather the lack of shared and interoperable workflows connecting stakeholders across lifecycle phases. While BIM-based and platform-oriented approaches are increasingly available, their use for inter-organizational information exchange remains limited. This indicates that the transition toward lifecycle-oriented digital ecosystems, such as DBLs and DPPs, requires not only technological adoption but also clearer information governance structures and standardized data exchange practices.

4 Conclusion

This study explored the information needs and data exchange practices of stakeholders operating within the European construction sector in relation to four key topics: energy efficiency, sustainability, circularity, and resource efficiency. The study shows that the construction sector is currently positioned in a transitional phase between traditional document-based information exchange practices and more integrated digital workflows. Although digital tools are increasingly available within organizations, information exchange across stakeholders and lifecycle phases still largely depends on static formats and fragmented delivery methods. By systematically mapping stakeholder information

needs in relation to the four topics, the study contributes to identifying the information gaps and interoperability challenges that may hinder the implementation of lifecycle-oriented digital frameworks. The results highlight the importance of developing shared data structures, interoperable exchange mechanisms, and governance approaches capable of ensuring information continuity throughout the building lifecycle. These aspects appear particularly relevant for supporting circular economy strategies, renovation processes, and long-term building performance monitoring. Future research should further investigate how stakeholder-specific information requirements can be translated into standardized digital data models and operational workflows supporting cross-phase collaboration in the built environment.

References

1. Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)
2. European Commission: The European Green Deal, Brussels (2019)
3. Çetin, S., Mêda, P., Farghaly, K., Hwang, S.A.: Linking digital product passports and digital building logbooks: socio-technical challenges and a pathways for integration. *Dev. Built Environ.* **25**, 100877 (2026)
4. Sesana, M.M., Dell'Oro, P., Salvalai, G., Gervasio, H.: Building life cycle assessment and digital technologies: a bibliometric and systematic literature review and recent advances on their integration to boost the decarbonization of the construction sector. *Energ. Buildings.* **352**, 116833 (2025)
5. Adekunle, P., Aigbavboa, C., Akinradewo, O., Oke, A., Aghimien, D.: Construction information management: benefits to the construction industry. *Sustainability.* **14**(18), 11366 (2022)
6. Ayodele TO, Kajimo-Shakantu, K.: Challenges and drivers to data sharing among stakeholders in the south African construction industry. *J. Eng. Des. Technol.* **20**(6), 1698–1715 (2022)
7. Sesana, M.M., Salvalai, G., Dell'Oro, P., Gupta, A.: Digital information and data flow management for building envelope solutions: the MEZeroE BIM dataset tool as an open innovation service. *Energ. Buildings.* **358**, 117252 (2026)
8. Bello, A.O. et al.: Exploring stakeholder communication strategies to promote circular economy in the Nigerian construction industry: north-central focus. *Int. J. Build. Pathol. Adapt.* (2025)
9. Zhang, R., Tang, Y., Zhang, Y., Wang, Z.: Collaborative relationship discovery in green building technology innovation: evidence from patents in China's construction industry. *J. Clean. Prod.* **391**, 136041 (2023)
10. Oluleye, B.I., Chan, D.W., Olawumi TO, Saka, A.B.: Assessment of symmetries and asymmetries on barriers to circular economy adoption in the construction industry towards zero waste: a survey of international experts. *Build. Environ.* **228**, 109885 (2023)
11. Giorgi, S., Lavagna, M., Wang, K., Osmani, M., Liu, G., Campioli, A.: Drivers and barriers towards circular economy in the building sector: stakeholder interviews and analysis of five European countries policies and practices. *J. Clean. Prod.* **336**, 130395 (2022)
12. Çetin, S., Raghu, D., Honic, M., Straub, A., Gruis, V.: Data requirements and availabilities for material passports: a digitally enabled framework for improving the circularity of existing buildings. *Sustainable Prod. Consumption.* **40**, 422–437 (2023)

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits any noncommercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if you modified the licensed material. You do not have permission under this license to share adapted material derived from this chapter or parts of it.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

