



D2.1 REQUIREMENTS OF INNOVATIVE CONSTRUCTION SOLUTIONS (V2.0)

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D2.1 REQUIREMENTS OF INNOVATIVE CONSTRUCTION SOLUTIONS

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Abstract	This report evaluates end-users' perspectives on innovative construction solutions, focusing on thermal insulation materials. It begins with a literature review identifying key specifications and barriers influencing adoption. A survey of 115 end-users from 12 European countries revealed that the most critical features are impact on human health, energy efficiency, durability, and thermal performance. Less importance was assigned to aesthetics, bio-based, and biodegradable materials. The study found that technical, economic, environmental, and social criteria influence decision-making, with expertise levels affecting priorities. Validation with manufacturers confirmed alignment with market needs but highlighted discrepancies, especially regarding cost and sustainability perceptions. The findings suggest that successful adoption of bio-based, circular insulation solutions requires demonstrating competitive performance, long-term



durability, and effective communication of benefits to diverse customer segments.

Keywords Insulation material, specification, requirement, end-user, perception, survey

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STATEMENT ON MAINSTREAMING GENDER

The SNUG consortium is committed to including gender and intersectionality as a transversal aspect in the project's activities. In line with EU guidelines and objectives, all partners – including the authors of this deliverable – recognize the importance of advancing gender analysis and sex-disaggregated data collection in the development of scientific research. Therefore, we commit to paying particular attention to including, monitoring, and periodically evaluating the participation of different genders in all activities developed within the project, including workshops, webinars and events but also surveys, interviews and research, in general. While applying a non-binary approach to data collection and promoting the participation of all genders in the activities, the partners will periodically reflect and inform about the limitations of their approach. Through an iterative learning process, they commit to plan and implement strategies that maximize the inclusion of more intersectional perspectives in their activities.

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ABBREVIATIONS

CE	Circular Economy
CO ₂	Carbon Dioxide
EN	Europäische Norm (European standard)
EPBD	Energy Performance of Buildings Directive
EPD	Environmental Product Declaration
ESG	Environmental, Social, and Governance
EU	European Union
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
NTA	Netherlands Technical Agreement (Nederlandse Technische Afspraak)
R&D	Research & Development
SDG	Sustainable Development Goal
Sig.	Significance
SPSS	Statistical Package for the Social Sciences
UK	United Kingdom
VOC	Volatile Organic Compounds

EXECUTIVE SUMMARY

This report presents the findings of Task 2.1, of the SNUG project, focusing on end-user requirements for innovative construction solutions, particularly thermal insulation materials. The study aims to inform the development of sustainable, high-performance insulation products aligned with market needs.

A comprehensive literature review established the theoretical framework, identifying key drivers and barriers influencing the adoption of insulation materials. Following this, an online survey was conducted to gather insights from 115 responses across 12 European countries, including a diverse range of end-users such as architects, building owners, occupants, and professionals. The survey assessed the importance of 35 different material specifications, revealing that end-users prioritize health impacts, energy efficiency, durability, and thermal performance. Specifications related to impact on human health, energy efficiency, and durability received the highest importance ratings. Conversely, attributes such as aesthetics, bio-based, biodegradable materials, and weight or density were perceived as less critical.

The decision-making process of end-users is predominantly driven by technical considerations, followed by economic, environmental, and social factors. Notably, there are significant differences based on the level of expertise among respondents. Those with higher knowledge of insulation materials tend to place greater emphasis on sustainability and technical performance, whereas less knowledgeable users tend to undervalue these aspects. This highlights the role of market education in shaping preferences and priorities.

Validation of the survey findings through direct feedback from manufacturers confirmed that the identified priorities generally align with market realities. Manufacturers emphasized that health, performance, and safety are central to customer demands. However, discrepancies were identified regarding the influence of cost and sustainability factors; manufacturers noted that cost and circular economy considerations often play a more prominent role in actual purchasing decisions than the survey rankings suggest. Challenges in effectively communicating complex sustainability metrics, such as environmental benefits and durability, were also highlighted as barriers to market acceptance.

The insights gained from this study have important implications for product development and market strategies. To succeed, SNUG's bio-based and circular insulation solutions must demonstrate competitive performance, long-term durability, and cost-effectiveness. Furthermore, targeted market education and tailored communication strategies are essential to bridge the gap between current customer priorities and the increasing importance of sustainability in the building sector. Overall, the market is pragmatic and performance-driven, with a growing appreciation for health and energy efficiency, which should guide the development and positioning of innovative, sustainable insulation products.

1 INTRODUCTION

The present report describes the work performed to evaluate end-users' vision with respect to the requirements of innovative construction solutions in terms of specifications such as sustainability, energy efficiency, performance, environmental footprint, finance, safety and security. To do so, end-users' attitudes and needs were examined, with a particular focus on the requirements of thermal insulation materials.

The first step of this work consisted of a desk study, i.e., a literature analysis of existing research and the development of a conceptual model representing the diverse aspects affecting end-users, including insulation materials' specifications and innovative materials' barriers and drivers. This work is presented in Section 2, "Theoretical Framework".

Following this, an interview protocol was prepared based on the conceptual model, focusing on insulation materials' specifications. In addition, the diverse types of relevant end-users were identified, and the interviews were planned, organized and implemented in collaboration with the project partners. The particular activities are described in Section 3, "Materials and Methods".

The next step, following the conduction of the interviews, was to create a dataset including all responses and perform the statistical analysis of the data. The analysis results are presented in Section 4, "Results".

Next, the findings of the end-users interviews were validated with building component manufacturers participating in the SNUG project consortium, through a structured questionnaire and a dedicated online workshop; this process is described in Section 5 "Validation of Results with Manufacturers".

The report continues with Section 6 "Discussion", and closes with Section 7, "Conclusions," and the study's references and annexes.

2 THEORETICAL FRAMEWORK

The first step of the present study was to perform a literature analysis on the work performed on end-users' perceptions of innovative construction materials' specifications, as well as market barriers and drivers, with a specific focus on innovative insulation materials. To do so, two groups of keywords were identified, the first covering the technical theme and the second covering the societal/ behavioral theme of the topic under investigation. A combination of keywords from each group was used to detect the relevant existing research. In specific, the keywords utilized were the following:

- Technical theme: insulation materials; building materials; building insulation materials; innovative insulation materials; circular economy construction.
- Societal/ behavioral theme: drivers; barriers; stakeholder perceptions; characteristics; attributes; perceptions.

In brief, the most interesting and relevant results to our work are the following, presented per study in ascending chronological order:

- Jelle [1], based on a literature review, investigated traditional, state-of-the-art and future thermal building insulation materials and solutions properties and requirements. Identified critical properties and requirements included building site adaptability and cuttability, climate aging durability, costs and environmental impact, fire protection, fume emission during a fire, mechanical strength, perforation vulnerability, resistance towards freezing/thawing cycles, robustness, thermal conductivity, and water resistance.
- McCoy et al. [2] examined the attributes affecting the diffusion of innovative green building products, specifically focusing on structural insulated panels. On this basis, a literature review was performed focusing on attributes relevant to diffusion and adoption, residential construction innovation, and green products. Moreover, interviews with certified green home builders from the United States were carried out, evaluating the significance of the identified attributes. According to the study's results, the factors with the most considerable effect on adopting structural insulated panels were supporting innovation, relative advantage, and risks.
- Ojanen et al. [3] worked on creating roadmaps for thermal insulation materials, products and solutions applicable to northern conditions. Focusing specifically on the case of Finland, and based on the results of a literature review and interviews and workshops with key stakeholders, the study concluded that the main barrier hindering the diffusion of such technologies was not technical, i.e., it was related to regulatory aspects. In parallel, the main drivers were building directives and regulations, sustainability targets, technology development and new materials, and shortness of energy and natural resources.
- Persson and Grönkvist [4] worked on identifying barriers and drivers for implementing energy-efficient houses in Sweden from the perspective of construction companies. According to the results of the performed interviews, identified drivers included personal commitment, increased awareness, life-cycle thinking, future EU building regulations and

technical assistance from banks and real estate agents. On the other hand, lack of information, adoption and hidden costs, split incentives, risk aversion, distortion in fuel prices, and lack of life cycle cost perspectives were seen as potential barriers.

- Markström et al. [5] examined the drivers and barriers related to the increased use of bio-based building materials in apartment buildings. In this respect, interviews with Swedish stakeholders (architects, contractors, developers) were performed, indicating the lack of robust drivers and the existence of barriers such as inadequate incentives, lack of knowledge and experience, bad examples, concerns regarding performance, and construction-related culture and habits. According to the study, future drivers could focus on green building certificates, environmental standards and regulations, durability, and educational support from local authorities.
- Schiavoni et al. [6] reviewed and analyzed the thermal insulation materials for the building sector. In this respect, a comparative analysis was performed, considering the primary commercialized insulation materials considering five attributes: thermal performance of insulation material, acoustic characterization/sound insulation, impact on the environment and human health, and water vapor resistance.
- Tsoka et al. [7] examined potential users' and professionals' attitudes and perceptions toward an innovative, energy-efficient façade refurbishment system in three Mediterranean countries: Greece, Italy and Spain. The potential users' questionnaire focused on socioeconomic and residence characteristics, awareness levels, perceptions towards the system's characteristics (including aesthetics, resistance to corrosion, fire resistance, thermal insulation efficiency, water and moisture penetration, noise reduction, improvement and control of indoor air quality, ease and speed of construction, energy efficiency, environmental impact, installation and acquisition costs, maintenance easiness and cost) and willingness to use the system. On the other hand, the building professionals' questionnaire focused on socioeconomic/professional characteristics, perceptions toward the potential implementation of the solution (based on the system's parameters mentioned previously), and previous experience with relevant systems. The study's results highlighted that the main constraints toward the technology diffusion included increased investment costs, maintenance issues, and low levels of professionals' knowledge.
- Wang et al. [8], based on a literature review, examined the challenges and barriers hindering the development and deployment of green construction materials, including wall materials and thermal insulation materials. According to their findings, the challenges and barriers could be classified into three groups, i.e., business-related barriers (e.g., investment cost, low market demand, consumption habits, and low synergy between products), technical-related barriers (e.g., quality of raw material, immature technology, lack of information disclosure) and policy-related barriers (e.g., lack of education, not in compliance with building regulations, lack of incentives).
- Harris et al. [9] examined stakeholders' (e.g., architects/designers, builders, regional authorities, homeowners) experience and attitudes toward using structurally insulated panels in New Zealand. In this regard, they implemented a survey focusing on stakeholders' awareness, experience, satisfaction (on aspects such as thermal performance and cost-

effectiveness), perceptions of drivers (i.e., proper training and clear design information, improvement of consent processes) and barriers (e.g., lack of familiarity) toward the adoption of the particular components.

- Balador [10] examined New Zealand's construction industry's stakeholder (i.e., architects, designers, builders, manufacturers, suppliers, environmentalists, regulators, and consumers) perceptions of using reused and recycled building materials, focusing on identifying challenges and opportunities. In this respect, the study examined several topics, including environmental-friendly building construction attitudes, the importance of using such materials, regulatory aspects, material specifications and stakeholders' roles.
- Camarasa et al. [11] studied the drivers and barriers of nine energy-efficient technologies relevant to the residential building context according to the stakeholders' perceptions (architects, construction companies, engineers, installers, and demand-side actors) from eight EU members. The drivers and barriers were classified into five categories (environmental, technical, economic, social, and legal). Based on the study results, technical and economic drivers had the highest potential to contribute toward implementing energy-efficient technologies irrespective of the country and the technology. On the other hand, economic barriers were seen as the main reason hindering the diffusion of the particular technologies.
- Díaz-López et al. [12] explored the drivers that can assist governments in enhancing sustainability in buildings, renovation, and dwellings. Their research was conducted through a multi-stakeholder survey in Spain. The results indicated that drivers could be grouped into three categories, namely -from the most to the least important- financial (e.g., grants, bonds, preferential financing), fiscal (e.g., tax-related), and government (e.g., design tools, technical support, public procurement programs) interventions.
- Guerra and Leite [13] investigated the practice of circular economy in the United States built environment based on interviews with architectural, engineering, and construction industry stakeholders. The study's results highlighted the level of applicability of the strategies, significant barriers (such as investment costs, project schedule, lack of awareness and regulations, current business model), as well as the most significant drivers (including education, cultural change, data availability, policies and governmental incentives) relevant to the implementation of circular economy practices in the construction sector.
- Zhang and He [14] examined the factors (drivers, motivations and barriers) affecting the implementation of green roofs based on a systematic literature review. According to their results, drivers consisted of policy, market pressure, innovation, and technological advancements. Moreover, barriers were categorized into lack of government policy, unsound technological level, unsound economic benefits assessment, and individual unwillingness. In addition, the most significant motivations were identified, including –among others- energy efficiency, air purification, water purification, sound insulation and noise reduction, biodiversity increase, and property value enhancement.
- GadAllah and Abounaga [15], based on a theoretical and analytical approach, examined the market drivers of thermal insulation materials globally and in developing countries while

focusing on the relationship between market drivers and SDGs. According to the study’s results, five drivers controlled the global market for thermal insulation materials, including building codes and regulations, construction of new buildings, population growth and urbanization, energy costs, and sustainability aspects.

- Gottlieb et al. [16] investigated the drivers and barriers affecting the market uptake of biogenic materials in the Danish construction industry through the conduction of interviews with stakeholders with in-depth knowledge of the topic (originating from higher education institutions, insurance companies, manufacturers of conventional and biogenic materials, industry associations, practitioners, and knowledge centers and standardization organizations). A plethora of barriers were grouped into seven categories: cultural, infrastructural, technological, market, political, techno-scientific, and industrial network. In addition, the identified drivers were grouped into the corresponding categories and classified based on their time-frame implementation into short, medium and long-term measures.

To summarize the findings of the literature review, a conceptual model was structured (Figure 1), presenting the drivers and barriers relevant to innovative materials’ utilization uptake and –in particular- the insulation materials’ specifications. The specifications of the insulation materials are examined within T2.1, while the drivers and barriers of innovative materials will be examined in the following steps of the SNUG project, particularly in T7.3.

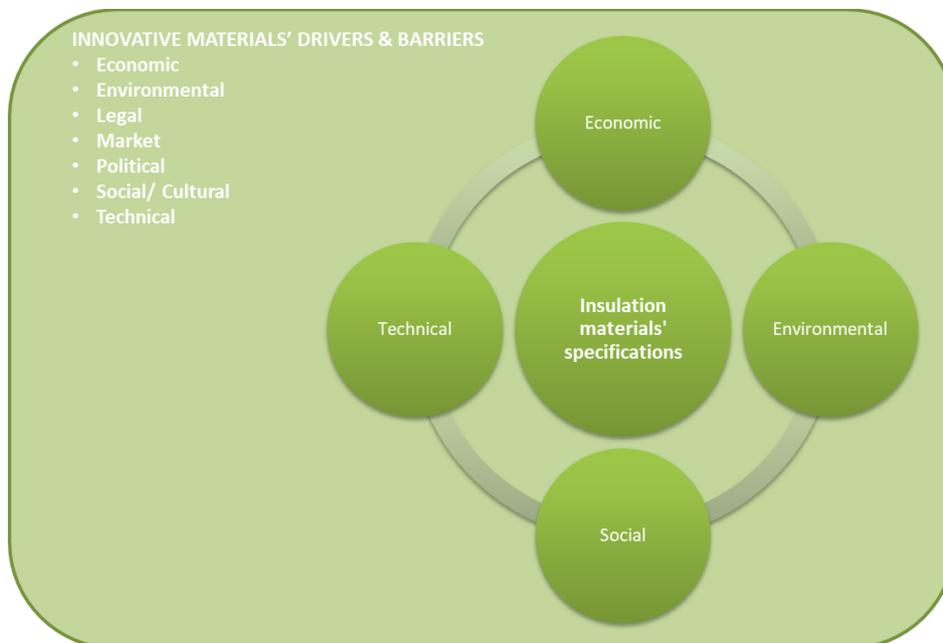


FIGURE 1: CONCEPTUAL MODEL BASED ON LITERATURE REVIEW FINDINGS

3 MATERIALS AND METHODS

A survey was planned, organized, and implemented to examine end-users' vision concerning the requirements of innovative construction solutions -with a particular focus on thermal insulation materials. The survey aimed to collect the perceptions and attitudes of end-users of diverse types and knowledge levels regarding innovative insulation materials.

The first step of this process was to identify the relevant end-user categories, which was done primarily through a dedicated online workshop with the participation of several SNUG project partners. The defined end-user categories were:

- Architect, planner, engineer
- Association of building component manufacturers
- Building and construction company
- Building occupant
- Building owner
- Certification provider/ energy auditor
- Energy consultant
- Facility manager
- Financing organization
- Professional organization for building and construction
- Property manager
- Public authority
- Real estate agent

Following that, the survey's specifications were defined. According to the project's KPIs, at least 100 interviews should be conducted. Hence, it was decided to collect responses through an online survey -with the collaboration of the SNUG partners- from EU countries and the UK, particularly in SNUG-participating countries. In this respect, for each of the 11 SNUG-participating countries, a partner responsible for collecting responses was specified. Next, each partner identified at least ten relevant stakeholders and contacted them to inform them about the project and invite them to participate in the survey. To do so, a specific communication template was created and used by all partners (Annex A).

In parallel, an interview protocol was created; the literature review findings (see Section 2) were used as a basis, along with additional feedback from selected SNUG partners. The questionnaire, entitled "Desired properties of buildings' thermal insulation", was created on the GoogleForms platform in English and included the following sections:

- Introduction
- Background information
- Insulation materials' specifications

The questionnaire can be found in Annex B, while also available online at: <https://forms.gle/hX31ekvnneT1agxQ7>

The collection of the interviews took place during March 2024. The responsible partners sent the survey link to the invited end-users. In some cases, reminder emails were sent after approximately two weeks to prompt the end-users to participate in the interview. Moreover, additional individuals were invited to collect the appropriate number of interviews. In addition, it should be mentioned that the survey link was also posted on the SNUG project's social media to enable end-users' further participation. Moreover, it is worth noticing that the interview protocol –created in English- was translated into German to enhance the collection of responses from Austria, Germany and Switzerland.

Overall, 115 responses were collected from 12 European countries. A dataset incorporating all responses was created; a print screen of the dataset is available in Annex C, while the dataset Excel file is available online, in the SNUG project SharePoint. The statistical analysis was performed using the SPSS 20 statistical package, while the corresponding figures were created using Microsoft Excel 2010 and SPSS 20. The results of the statistical analysis are presented in Section 4.

4 RESULTS

4.1 DESCRIPTIVE STATISTICS

The sample comprised 115 end-users from 12 European countries (Figure 2); the countries with the highest participation were Spain (20%), Austria (16%), Greece (13%) and Portugal (12%). The category “Other” (8%) included respondents from Norway, Germany, Italy and Denmark. Concerning the type of end-users questioned (Figure 3), the most common categories were architects, planners and engineers (28%), building occupants (15%) and private, single-building owners (11%). In total, 16 distinct end-user groups were represented. The count in the end-user type question was 157, as the participants could select more than one end-user category. The respondents were also asked about their knowledge of insulation materials (Figure 4). Overall, 40% of the respondents stated a higher than average level of knowledge (i.e., “Above Average” and “Very High”), 40% expressed an average knowledge, while 20% declared a lower than average level of knowledge on insulation materials (i.e., “Below Average” and “Very Low”).

Figures 5 to 39 present end-users’ perceptions in terms of the importance of each insulation material specification, ranked on a 1 to 5 scale (low importance – slightly important – moderately important – considerably important – very important); additionally, the “I do not know” option was available for the respondents. Overall, it could be noted that the specifications with the highest percentages for the “Very Important” ranking were impact on human health (70%), release of dangerous substances (68%), durability (67%), energy efficiency (67%), and thermal conductivity/ thermal insulation performance (63%). On the contrary, the specifications with the lowest percentages for the “Very Important” ranking were weight/density (15%), aesthetics (17%), bio-based material (18%), supply security (21%), biodegradable material (23%), and technology maturity (23%).

On the other side, the specifications with the highest percentages in the “Low Importance” ranking were aesthetics (13%), biodegradable material (12%), and weight/ density (8%). The specifications with the lowest rankings for the “Low Importance” ranking were cost efficiency/ payback period, dimensional stability, impact on human health, installation and acquisition costs, mechanical strength/ robustness, release of dangerous substances, resistance to corrosion/ fire/ fungi, sound insulation and noise reduction, thermal conductivity/ thermal insulation performance, water/water vapor resistance; all of them had a 0% score in the particular ranking. When examining the “I do not know” responses, it could be noted that the specifications with the highest percentages in the specific response were energy efficiency (8%), perforation vulnerability (8%), relevance and synergy with other materials (8%), cost efficiency/ payback period (7%), mechanical strength/ robustness (7%), technology maturity (7%), and weight/density (7%). The specifications with the lowest percentages for the specific response were aesthetics (2%), fume emission during a fire (2%), property value increase (3%), resistance to fungi (3%), and thermal comfort (3%).

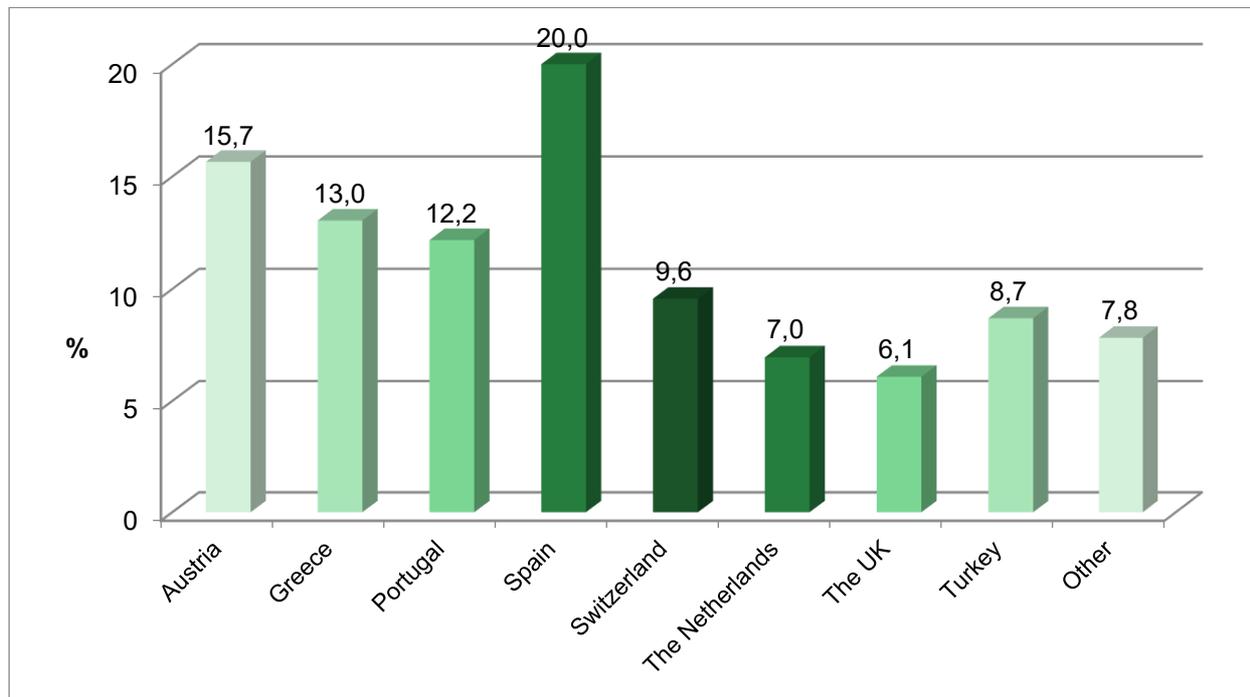


FIGURE 2: COUNTRY OF RESIDENCE

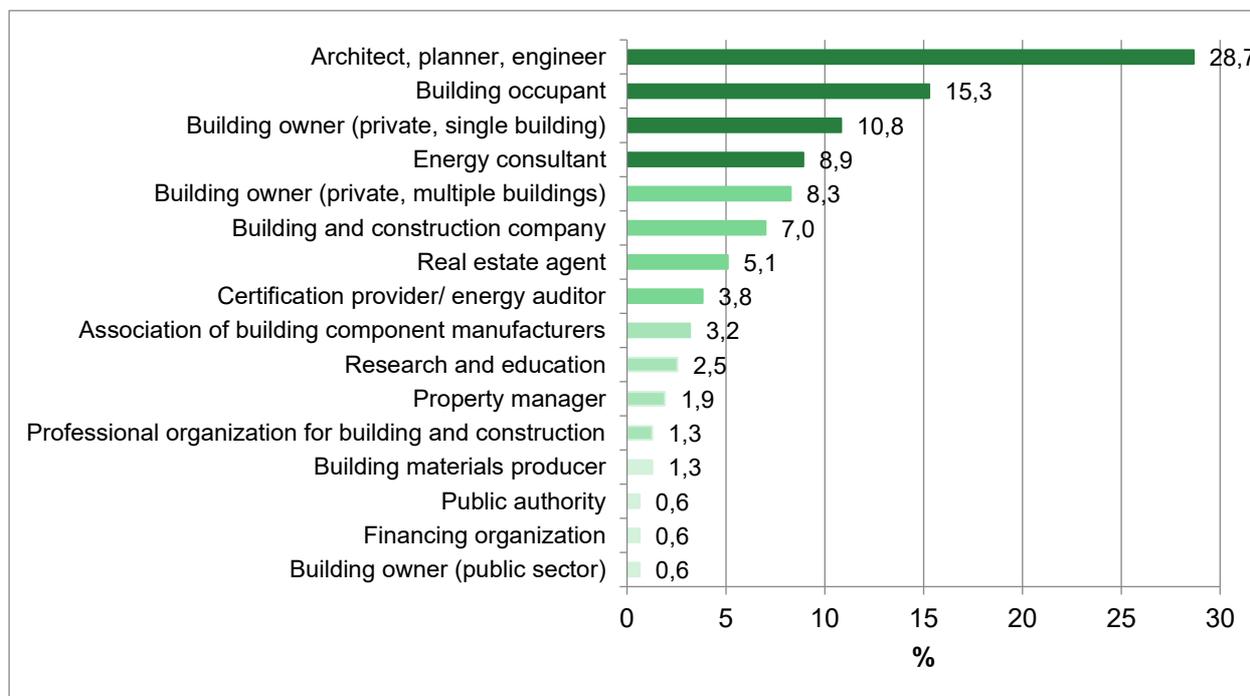


FIGURE 3: END-USER CATEGORIES

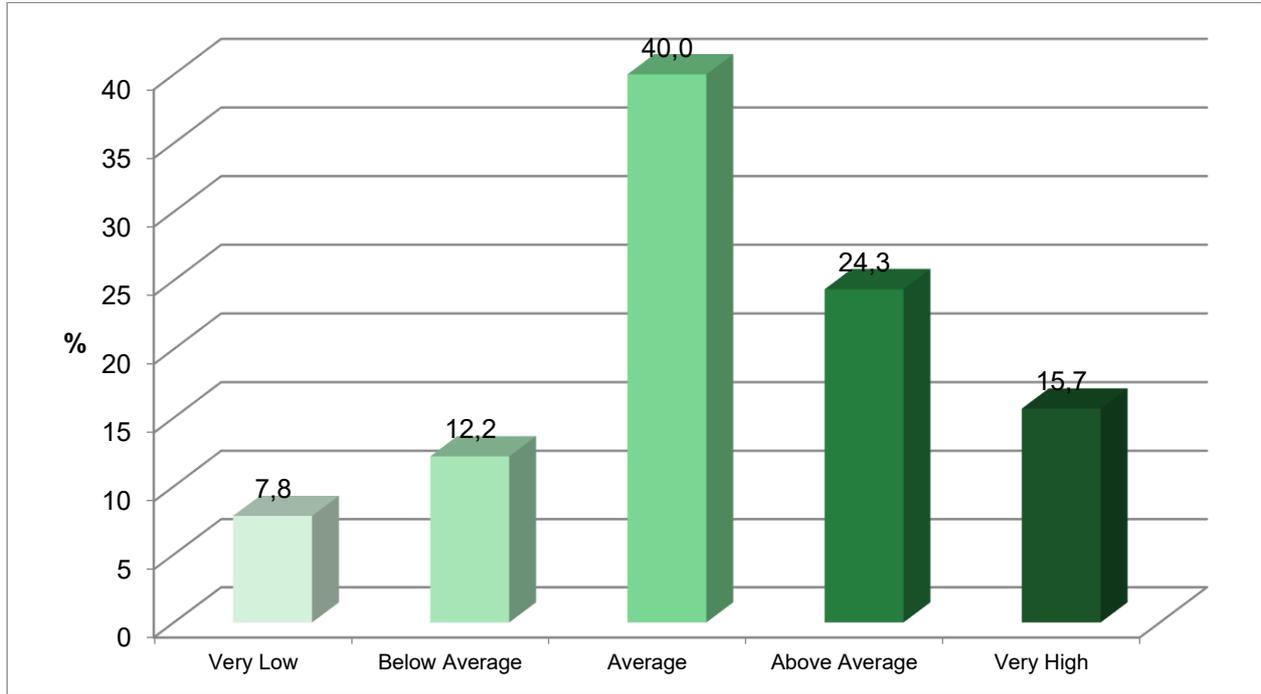


FIGURE 4: LEVEL OF KNOWLEDGE OF INSULATION MATERIALS

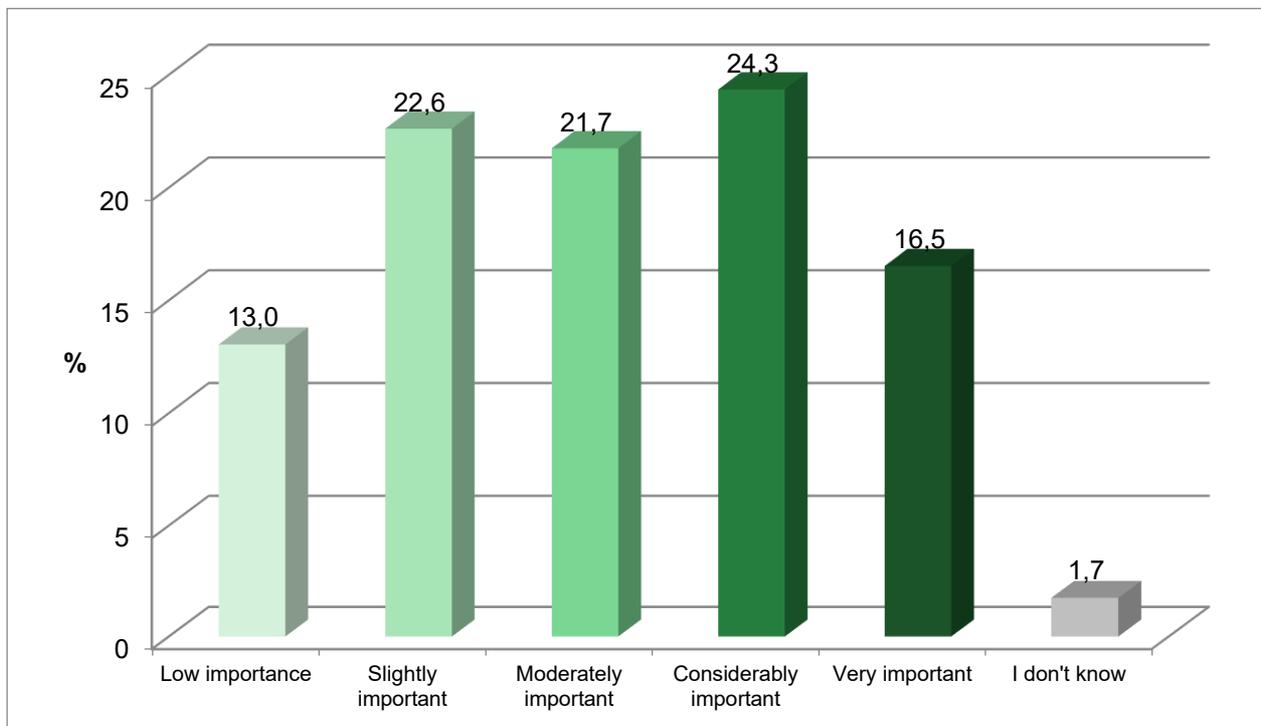


FIGURE 5: IMPORTANCE OF AESTHETICS AS A SPECIFICATION OF INSULATION MATERIALS

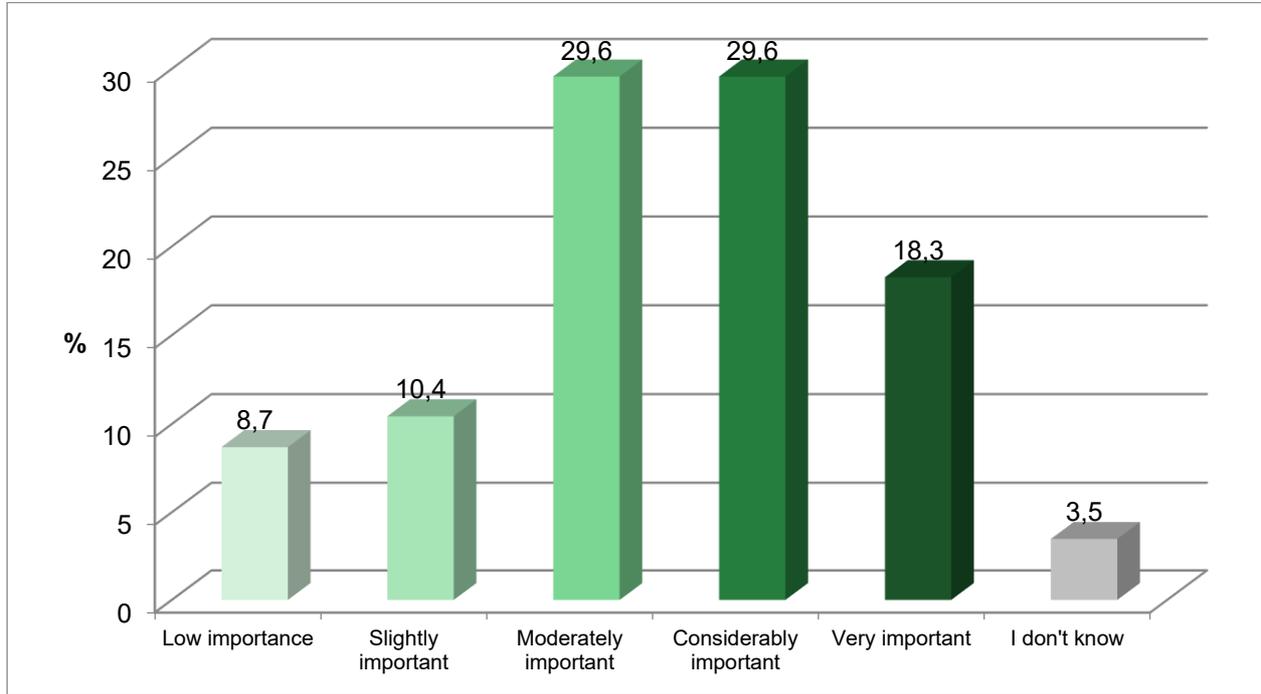


FIGURE 6: IMPORTANCE OF BIO-BASED MATERIALS AS A SPECIFICATION OF INSULATION MATERIALS

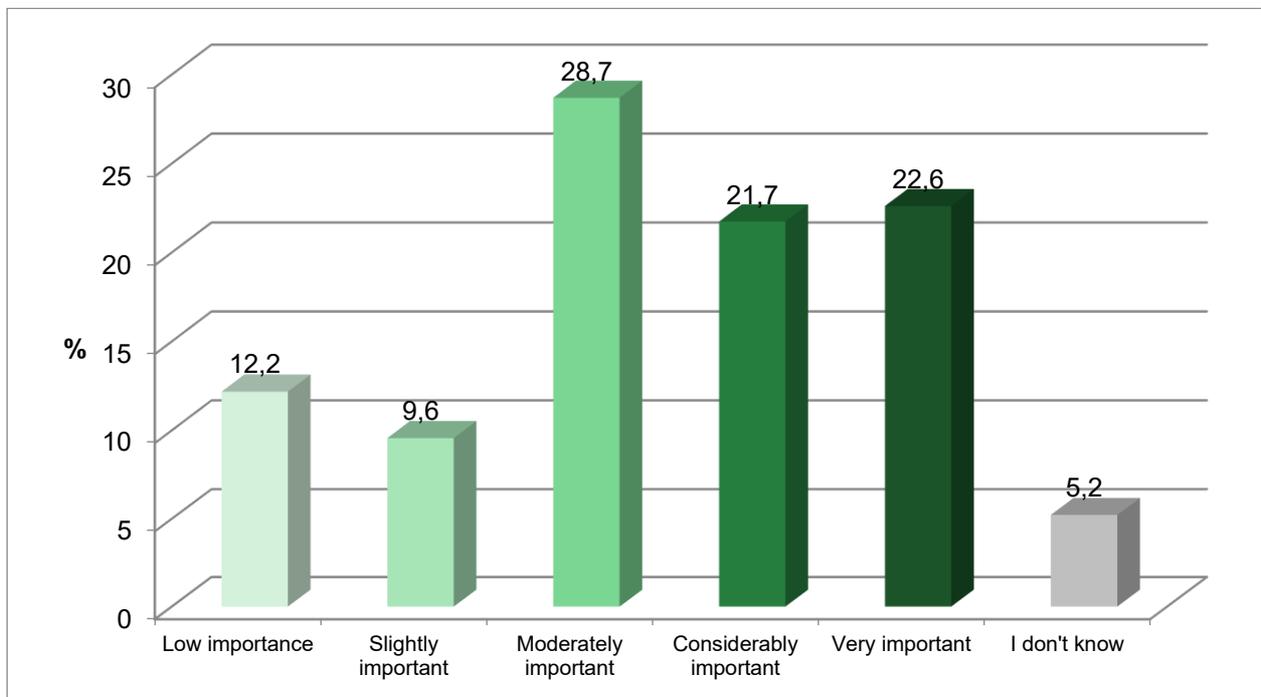


FIGURE 7: IMPORTANCE OF BIODEGRADABLE MATERIAL AS A SPECIFICATION OF INSULATION MATERIALS

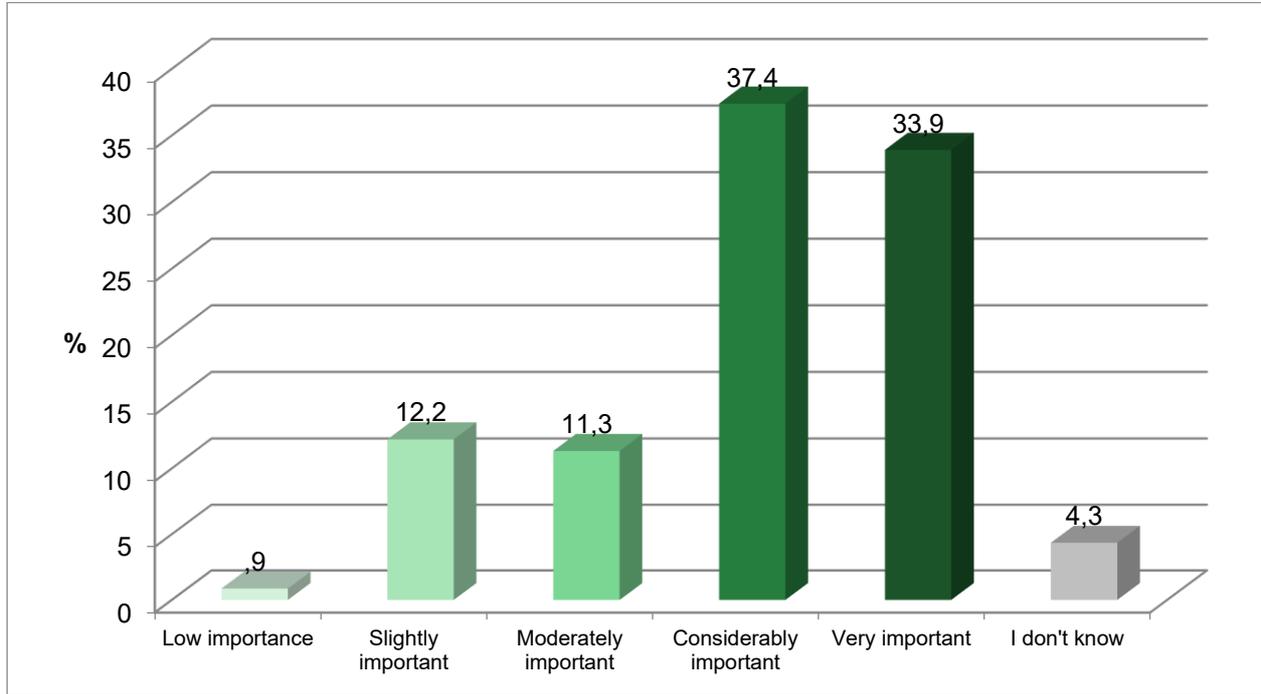


FIGURE 8: IMPORTANCE OF BUILDING SITE ADAPTABILITY AND CUTTABILITY AS A SPECIFICATION OF INSULATION MATERIALS

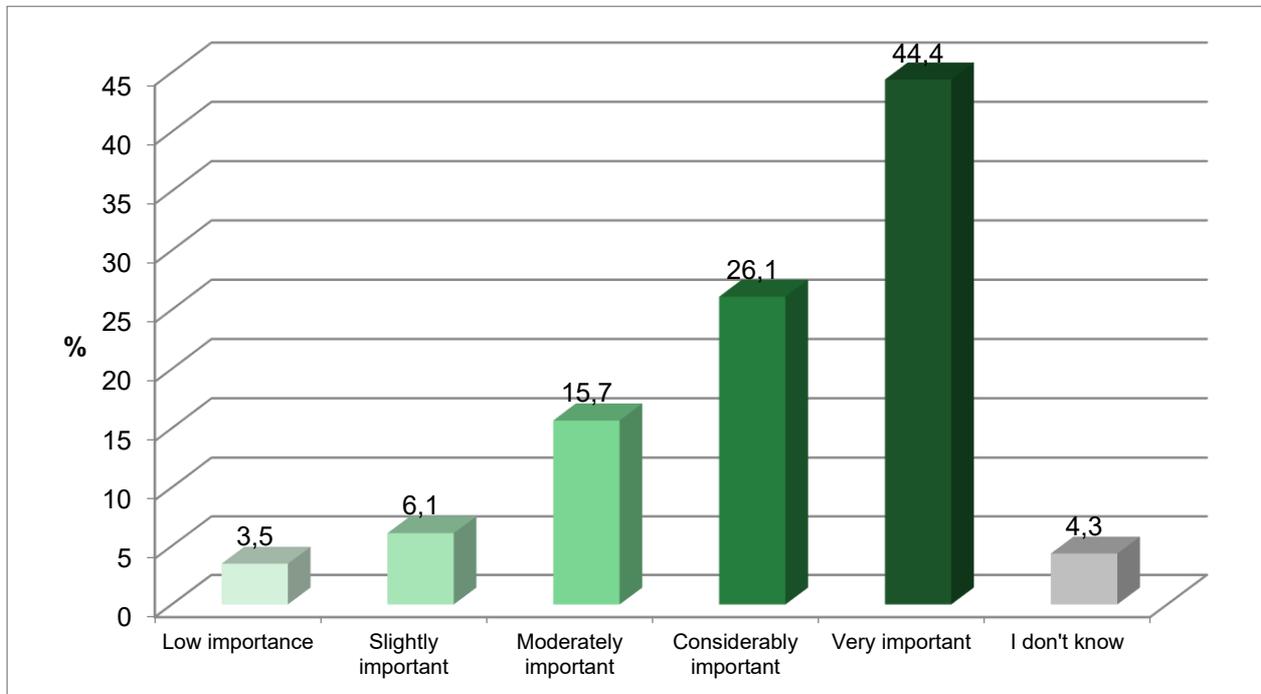


FIGURE 9: IMPORTANCE OF CONTRIBUTION TO CLIMATE CHANGE AS A SPECIFICATION OF INSULATION MATERIALS

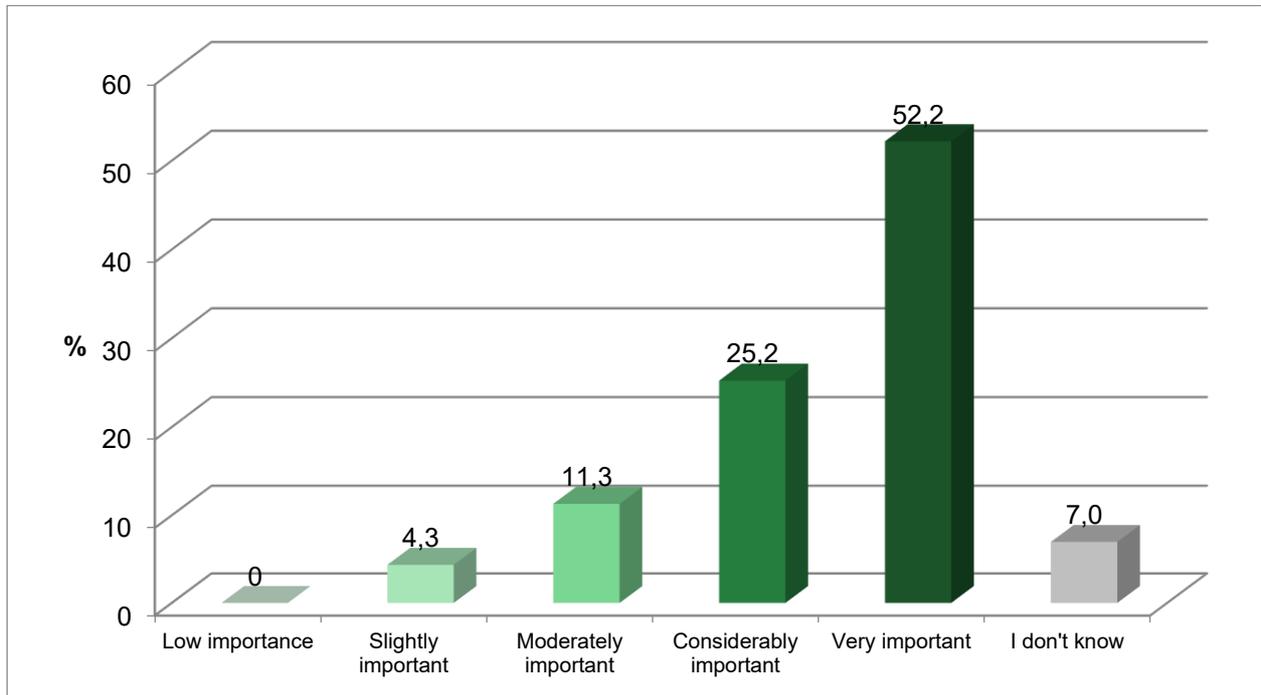


FIGURE 10: IMPORTANCE OF COST EFFICIENCY/ PAYBACK PERIOD AS A SPECIFICATION OF INSULATION MATERIALS

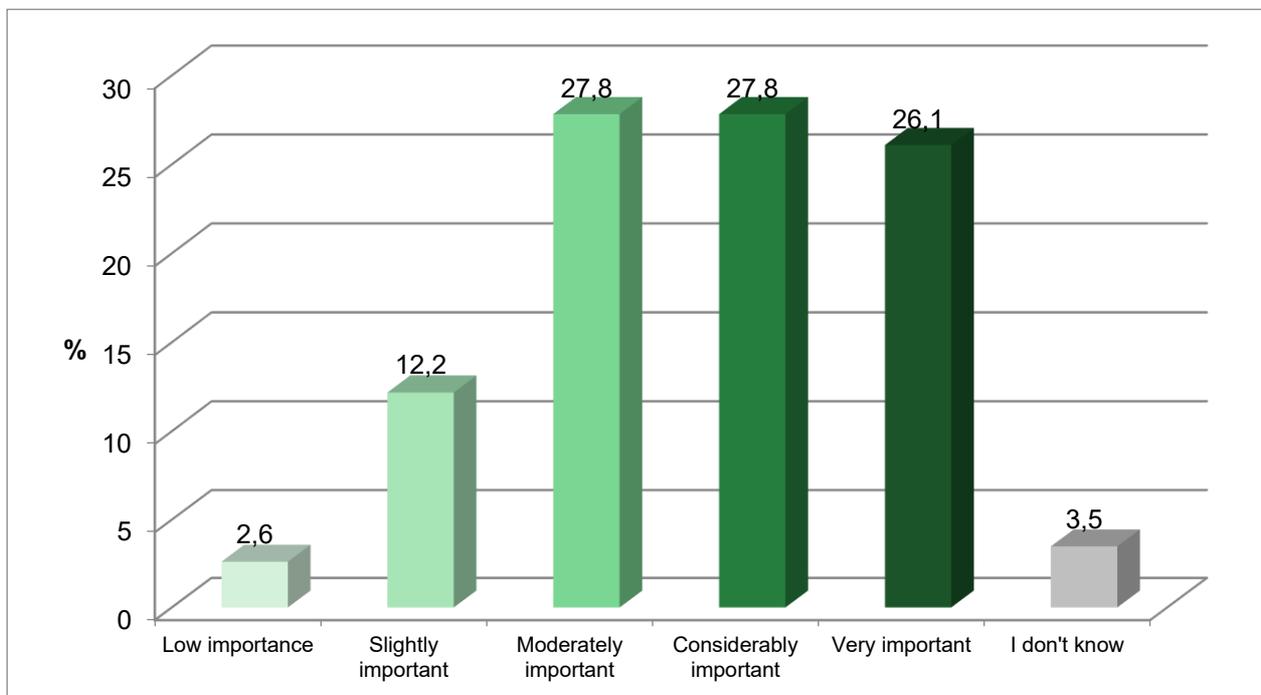


FIGURE 11: IMPORTANCE OF DELIVERY TIME AS A SPECIFICATION OF INSULATION MATERIALS

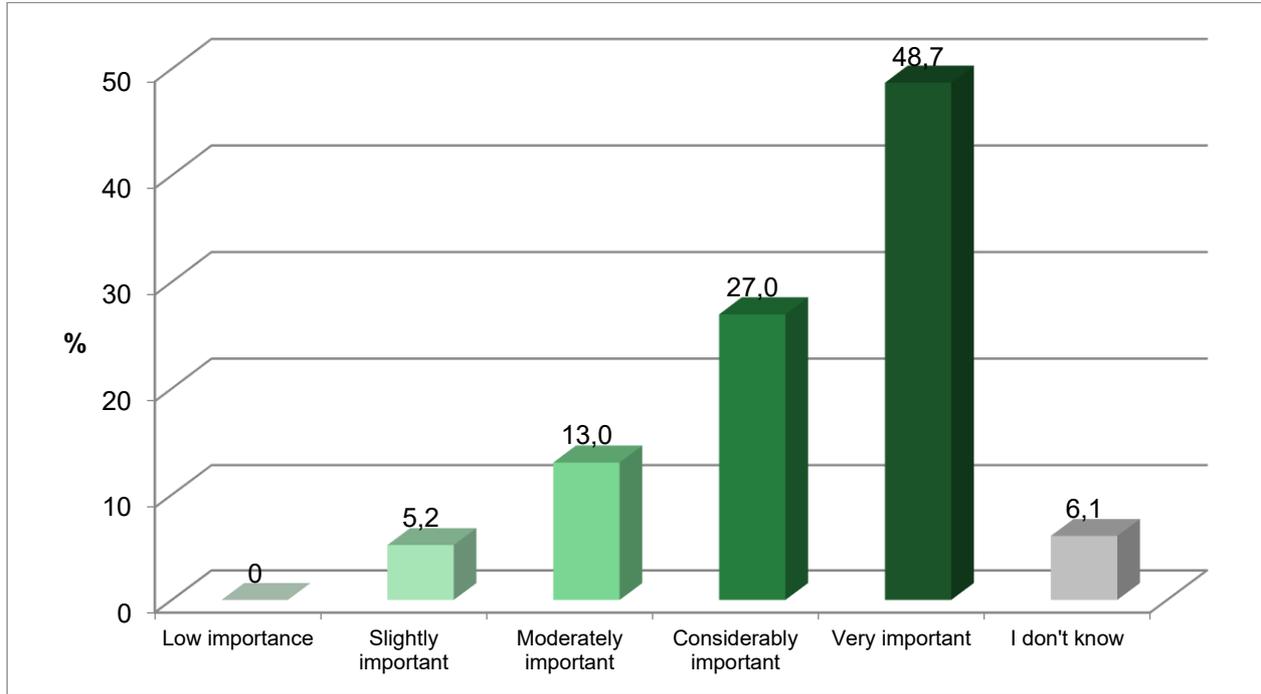


FIGURE 12: IMPORTANCE OF DIMENSIONAL STABILITY AS A SPECIFICATION OF INSULATION MATERIALS

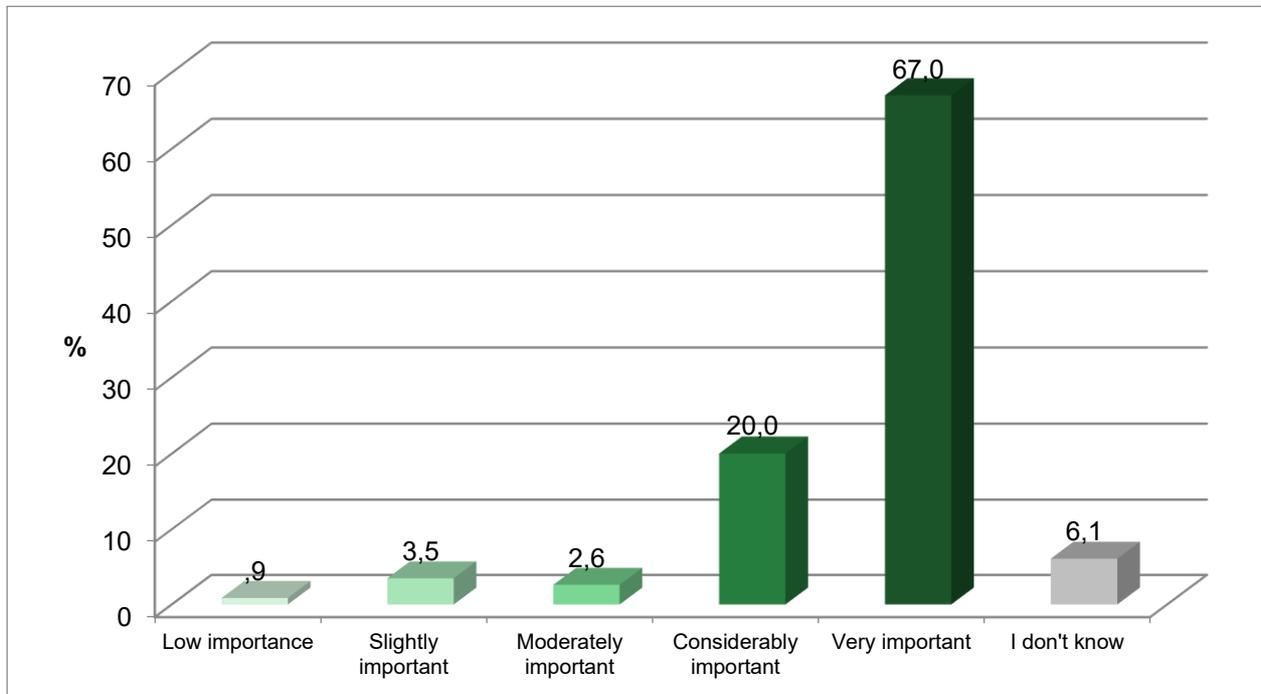


FIGURE 13: IMPORTANCE OF DURABILITY AS A SPECIFICATION OF INSULATION MATERIALS

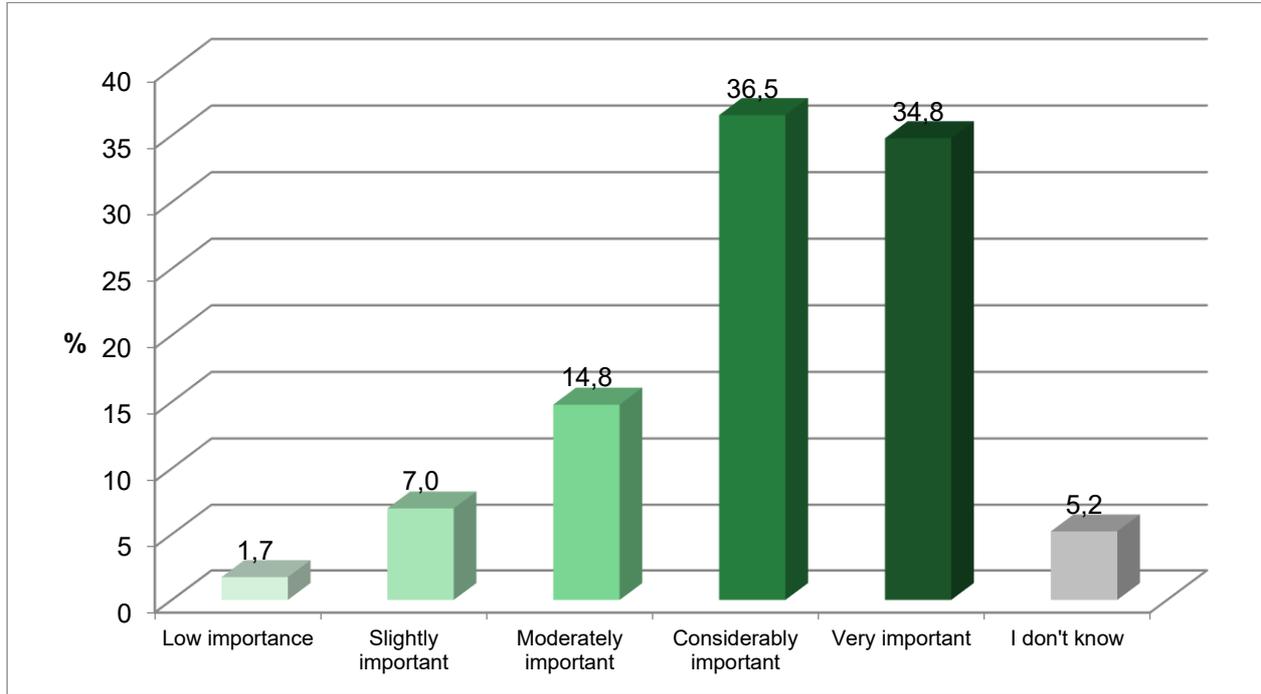


FIGURE 14: IMPORTANCE OF EASE AND SPEED OF INSTALLATION AS A SPECIFICATION OF INSULATION MATERIALS

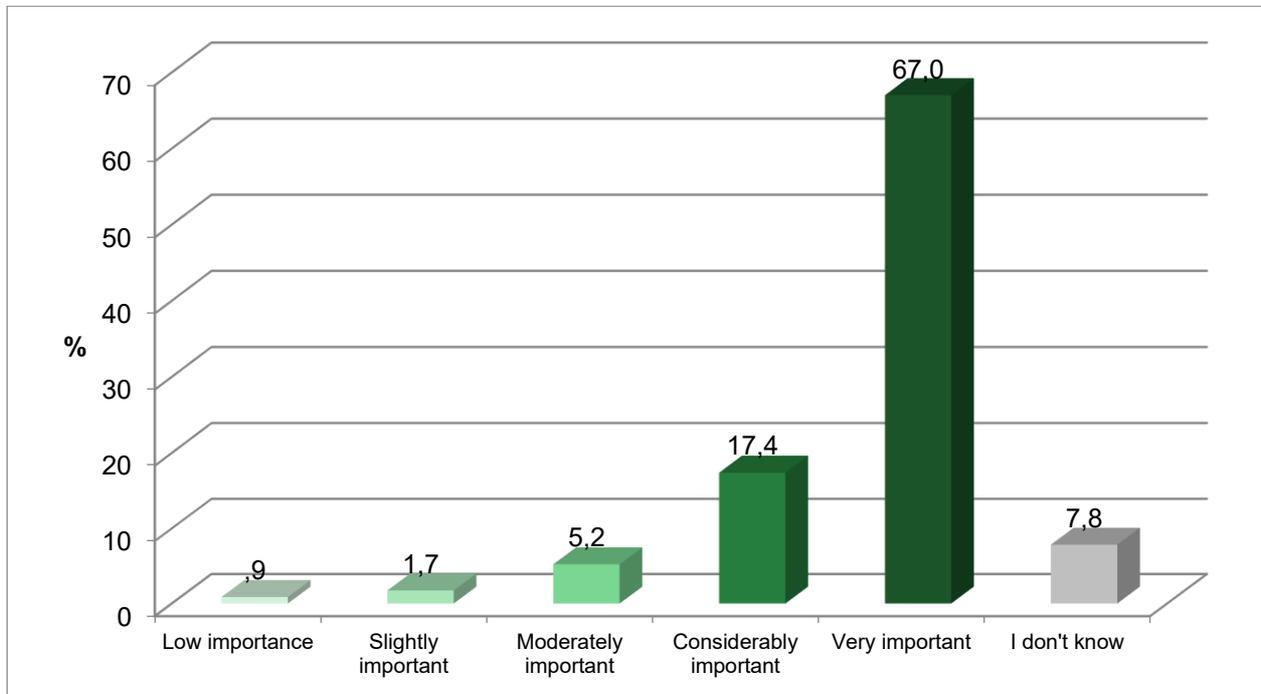


FIGURE 15: IMPORTANCE OF ENERGY EFFICIENCY AS A SPECIFICATION OF INSULATION MATERIALS

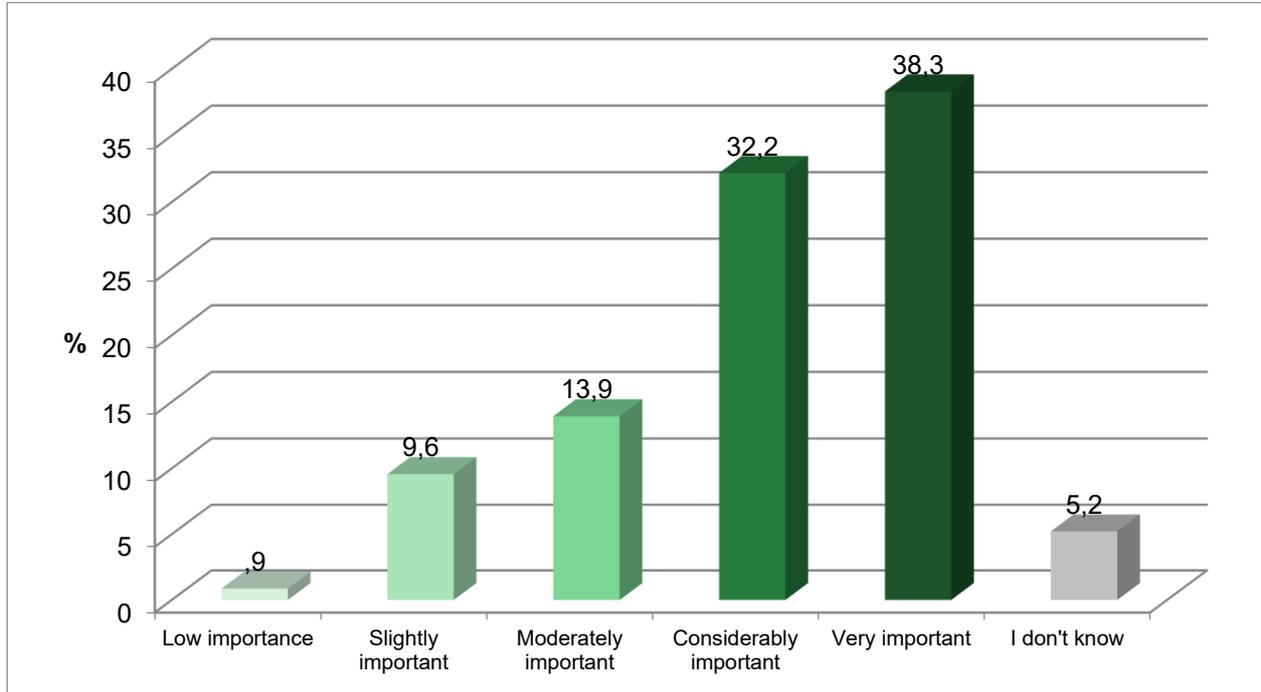


FIGURE 16: IMPORTANCE OF ENVIRONMENTAL IMPACT AS A SPECIFICATION OF INSULATION MATERIALS

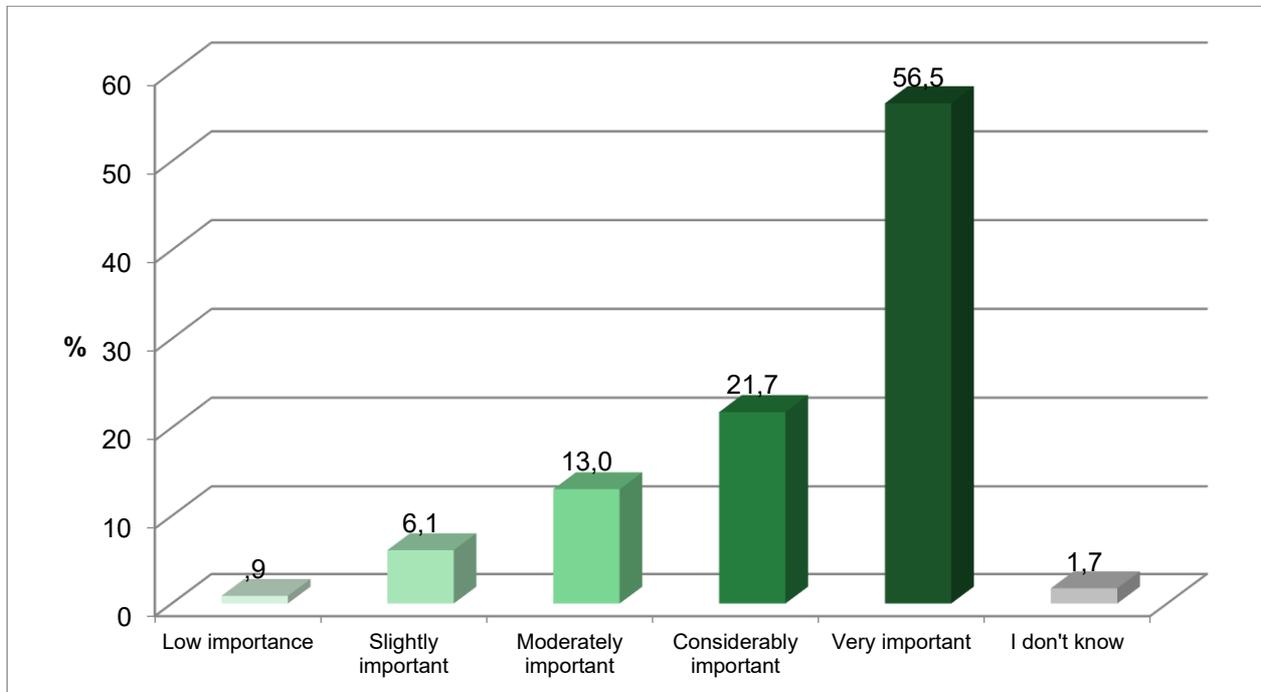


FIGURE 17: IMPORTANCE OF FUME EMISSION DURING FIRE AS A SPECIFICATION OF INSULATION MATERIALS

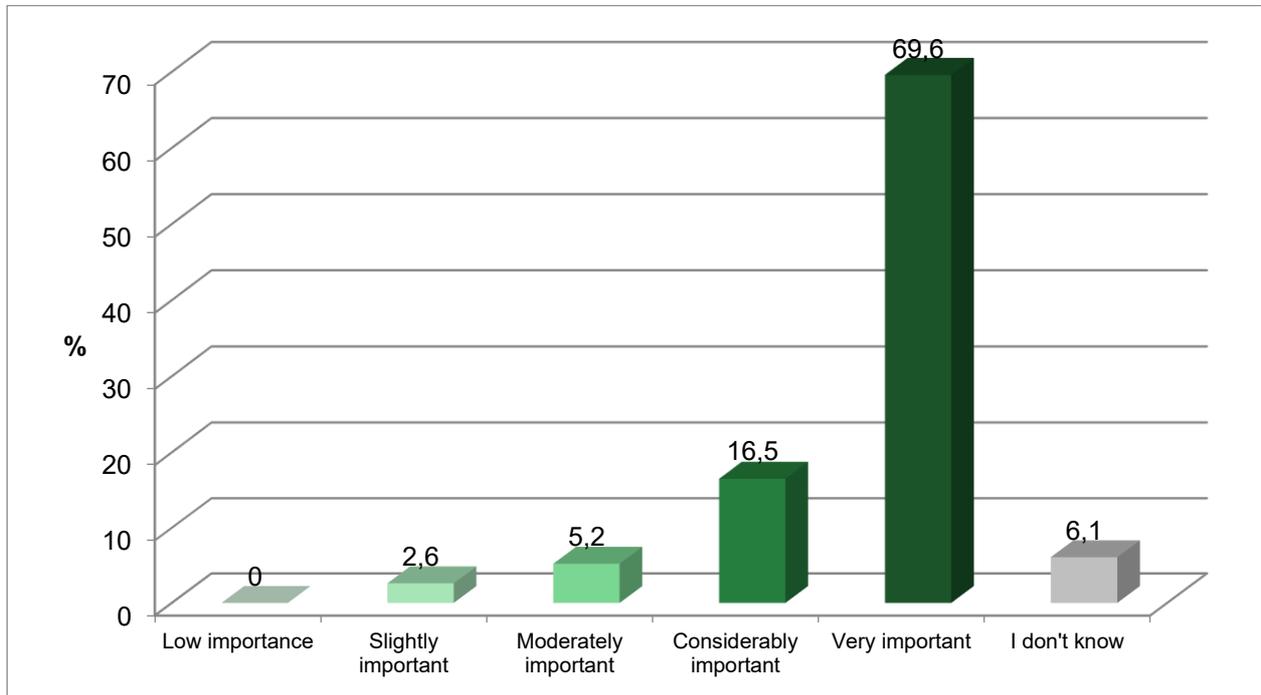


FIGURE 18: IMPORTANCE OF IMPACT ON HUMAN HEALTH AS A SPECIFICATION OF INSULATION MATERIALS

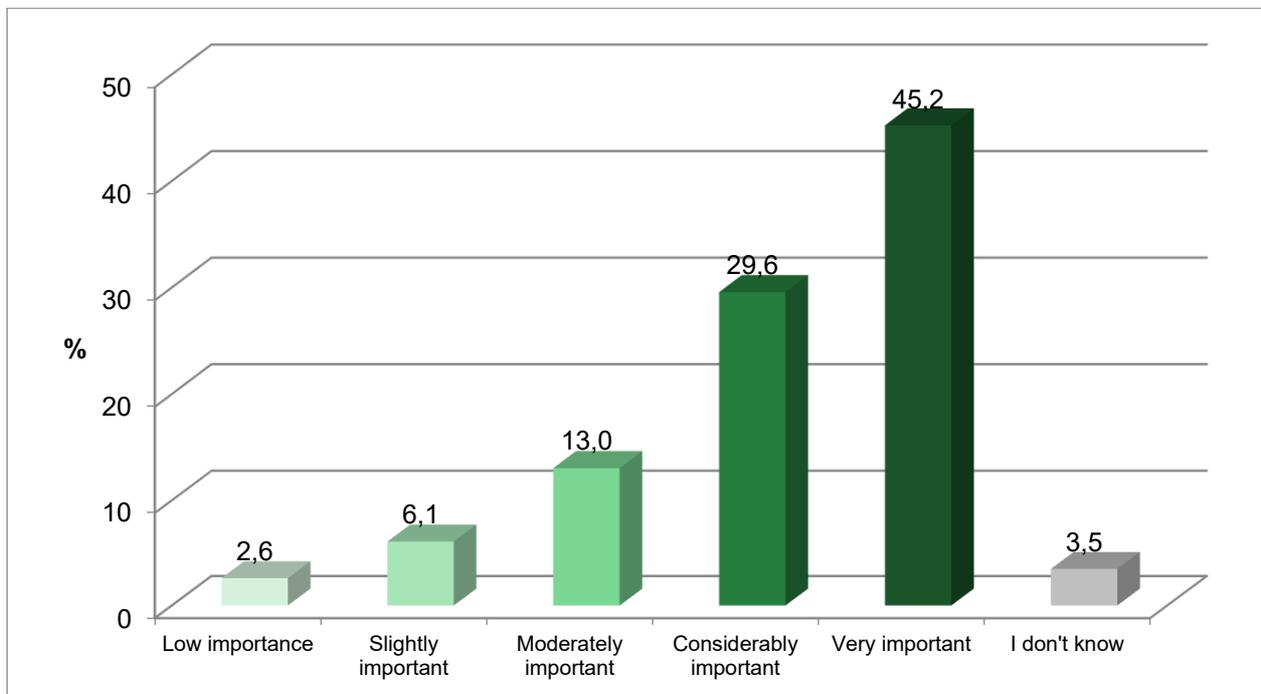


FIGURE 19: IMPORTANCE OF IMPROVEMENT AND CONTROL OF INDOOR AIR QUALITY AS A SPECIFICATION OF INSULATION MATERIALS

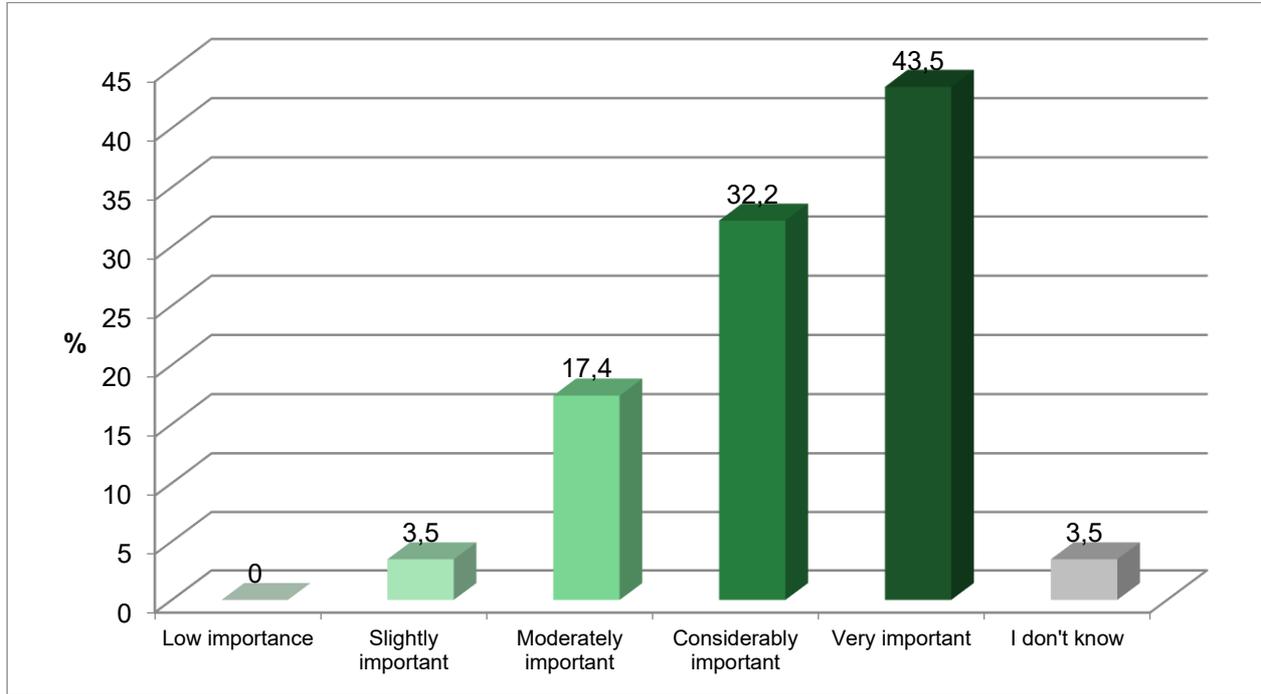


FIGURE 20: IMPORTANCE OF INSTALLATION AND ACQUISITION COSTS AS A SPECIFICATION OF INSULATION MATERIALS

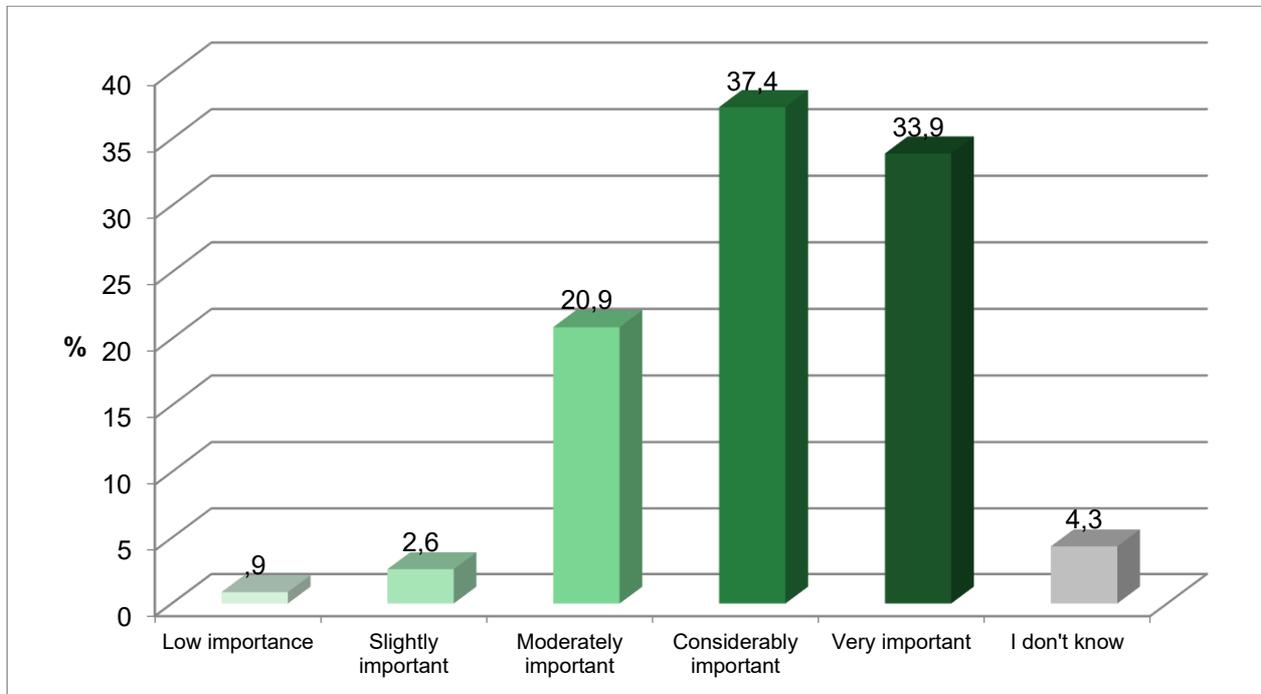


FIGURE 21: IMPORTANCE OF MAINTENANCE EASINESS AND COST AS A SPECIFICATION OF INSULATION MATERIALS

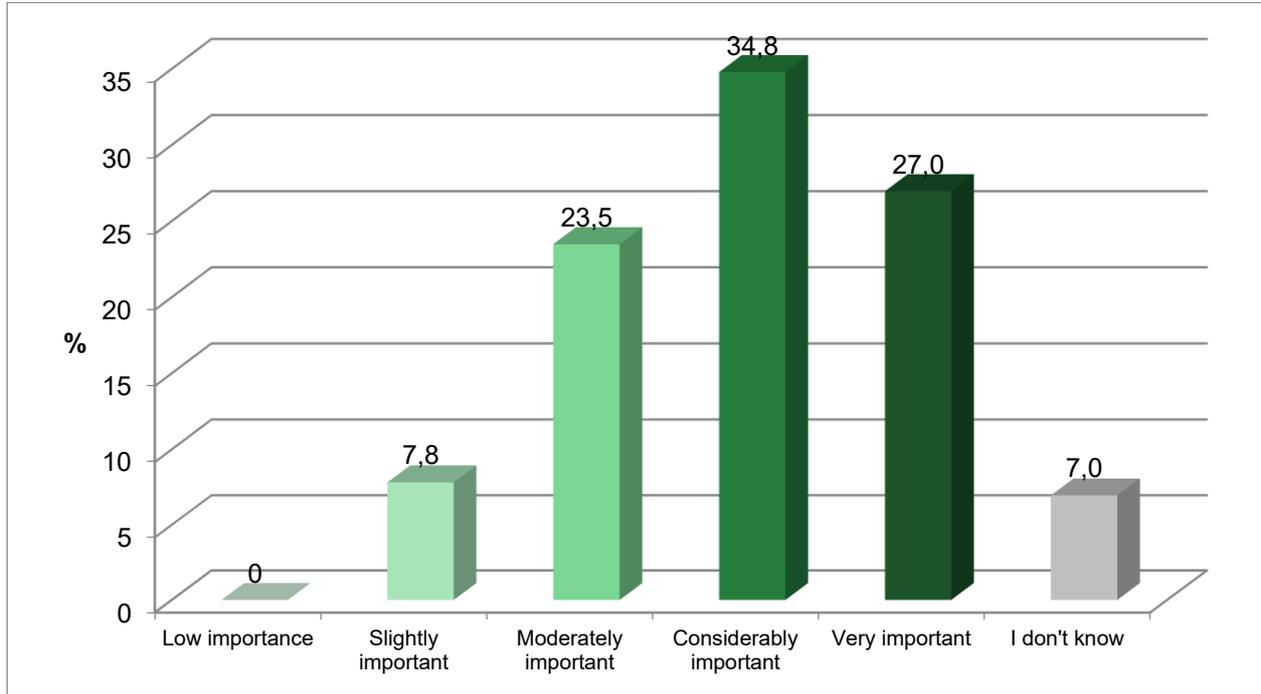


FIGURE 22: IMPORTANCE OF MECHANICAL STRENGTH/ ROBUSTNESS AS A SPECIFICATION OF INSULATION MATERIALS

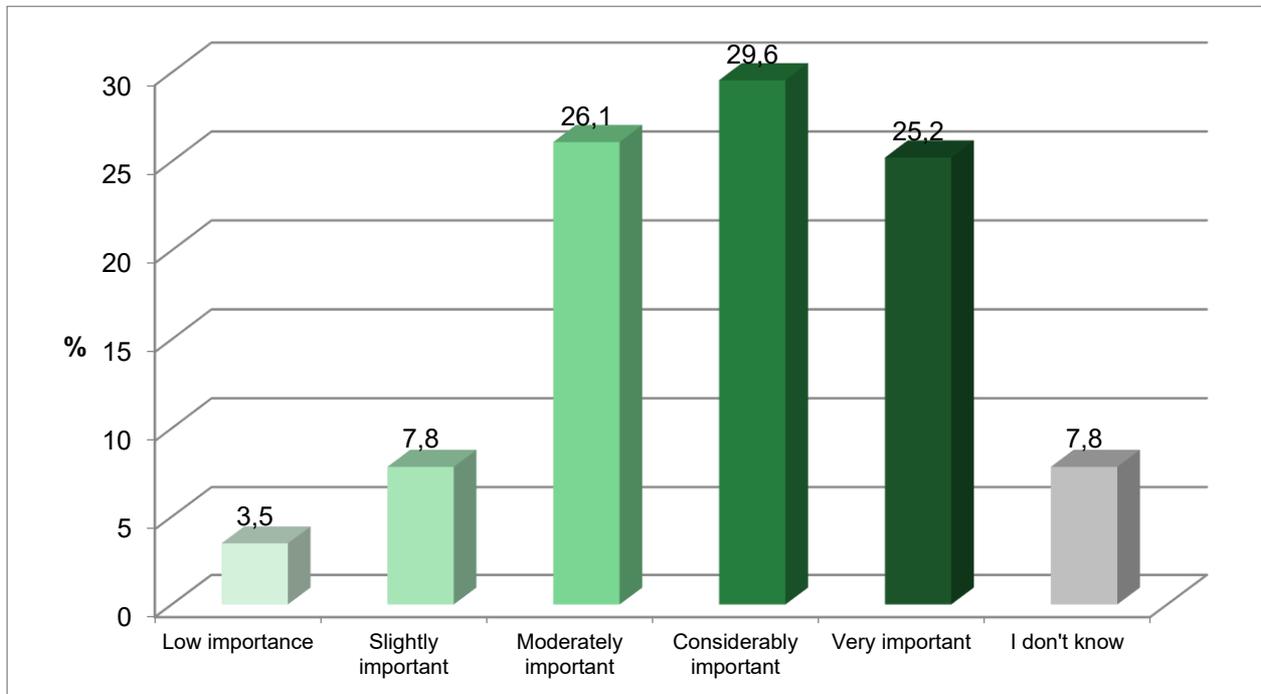


FIGURE 23: IMPORTANCE OF PERFORATION VULNERABILITY AS A SPECIFICATION OF INSULATION MATERIALS

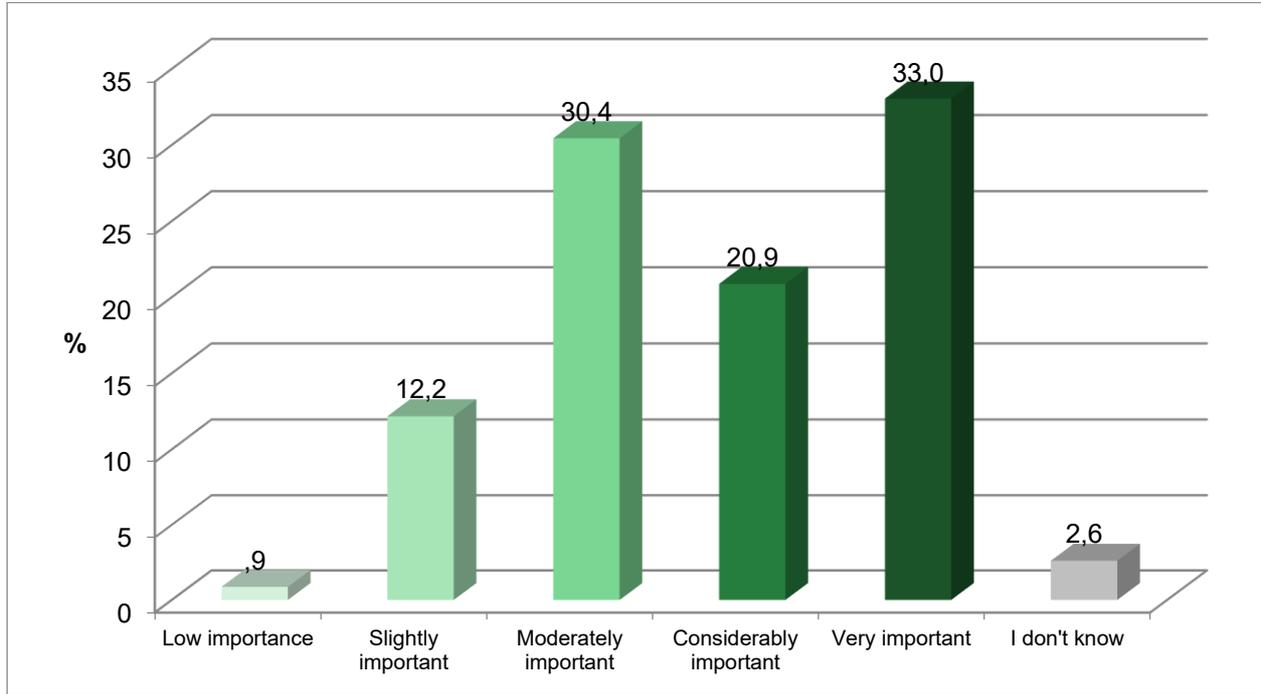


FIGURE 24: IMPORTANCE OF PROPERTY VALUE INCREASE AS A SPECIFICATION OF INSULATION MATERIALS

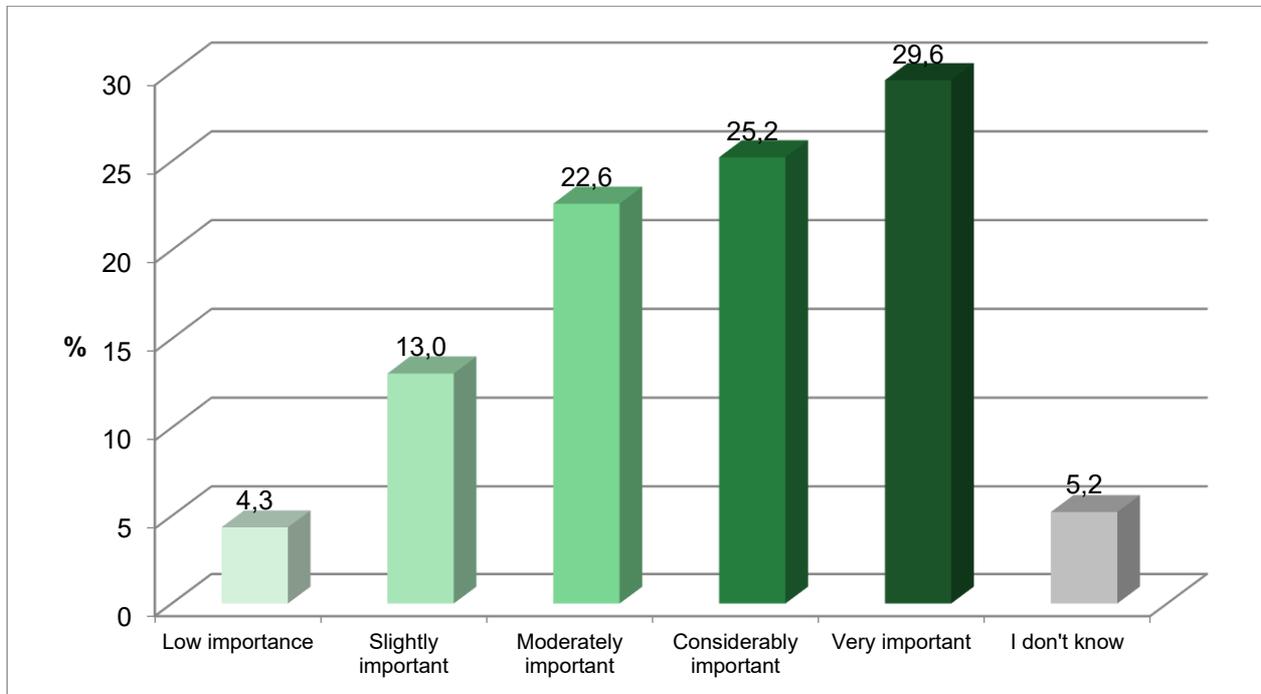


FIGURE 25: IMPORTANCE OF RECYCLABILITY AND REUSABILITY AS A SPECIFICATION OF INSULATION MATERIALS

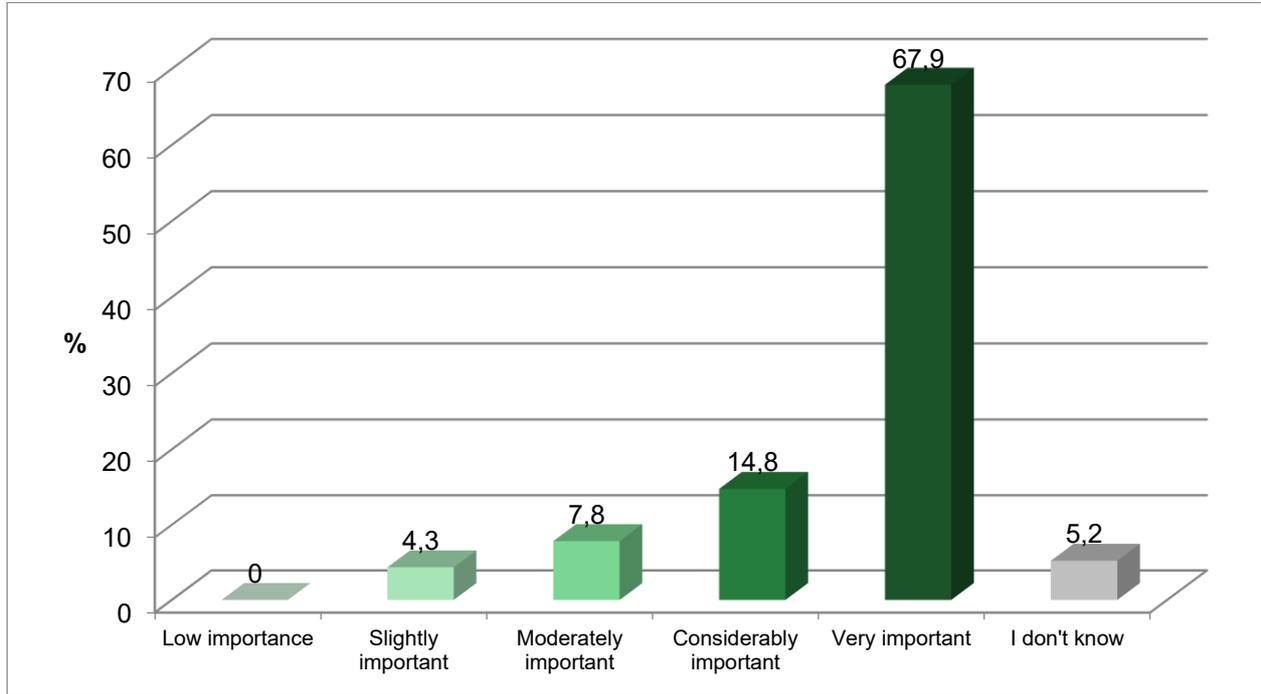


FIGURE 26: IMPORTANCE OF RELEASE OF DANGEROUS SUBSTANCES AS A SPECIFICATION OF INSULATION MATERIALS

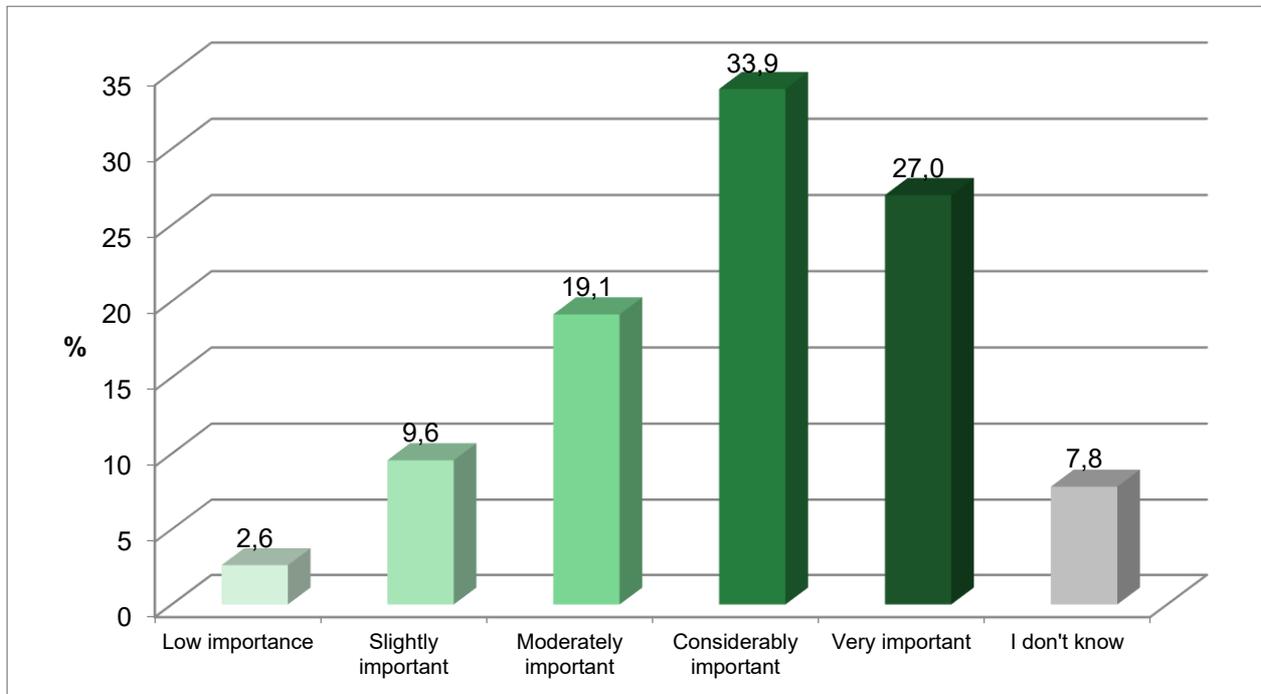


FIGURE 27: IMPORTANCE OF RELEVANCE AND SYNERGY WITH OTHER MATERIALS AS A SPECIFICATION OF INSULATION MATERIALS

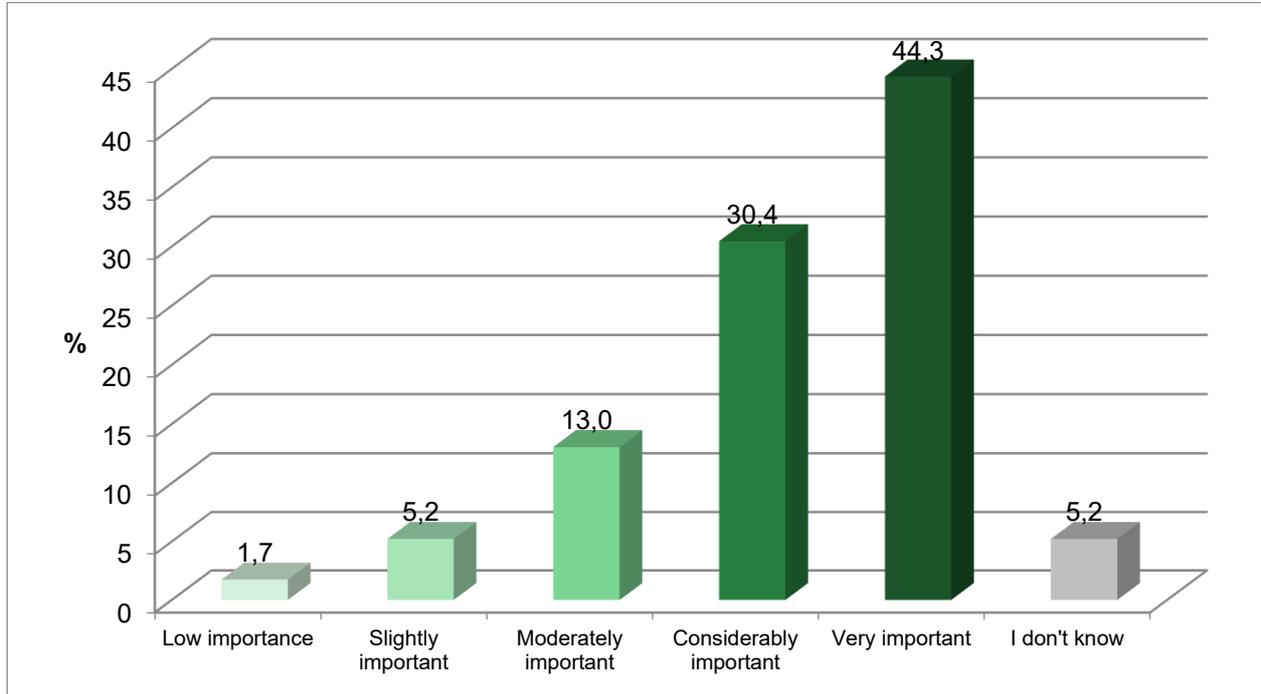


FIGURE 28: IMPORTANCE OF RESISTANCE TO CORROSION AS A SPECIFICATION OF INSULATION MATERIALS

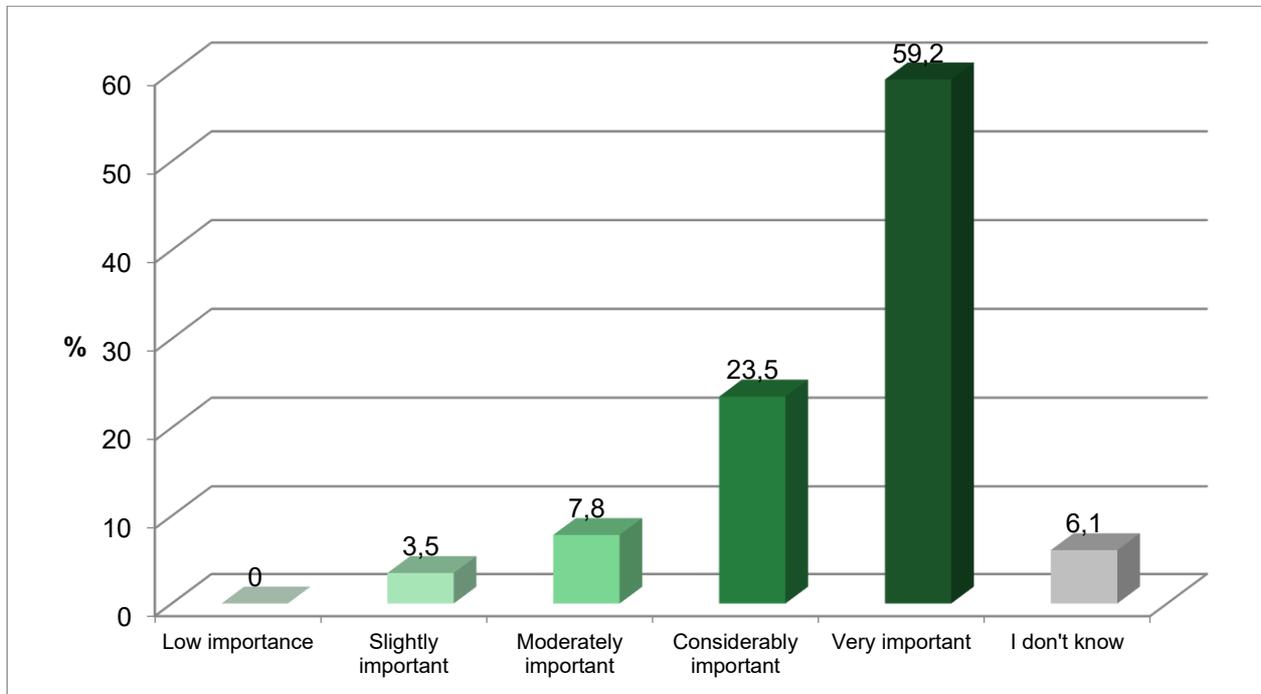


FIGURE 29: IMPORTANCE OF RESISTANCE TO FIRE AS A SPECIFICATION OF INSULATION MATERIALS

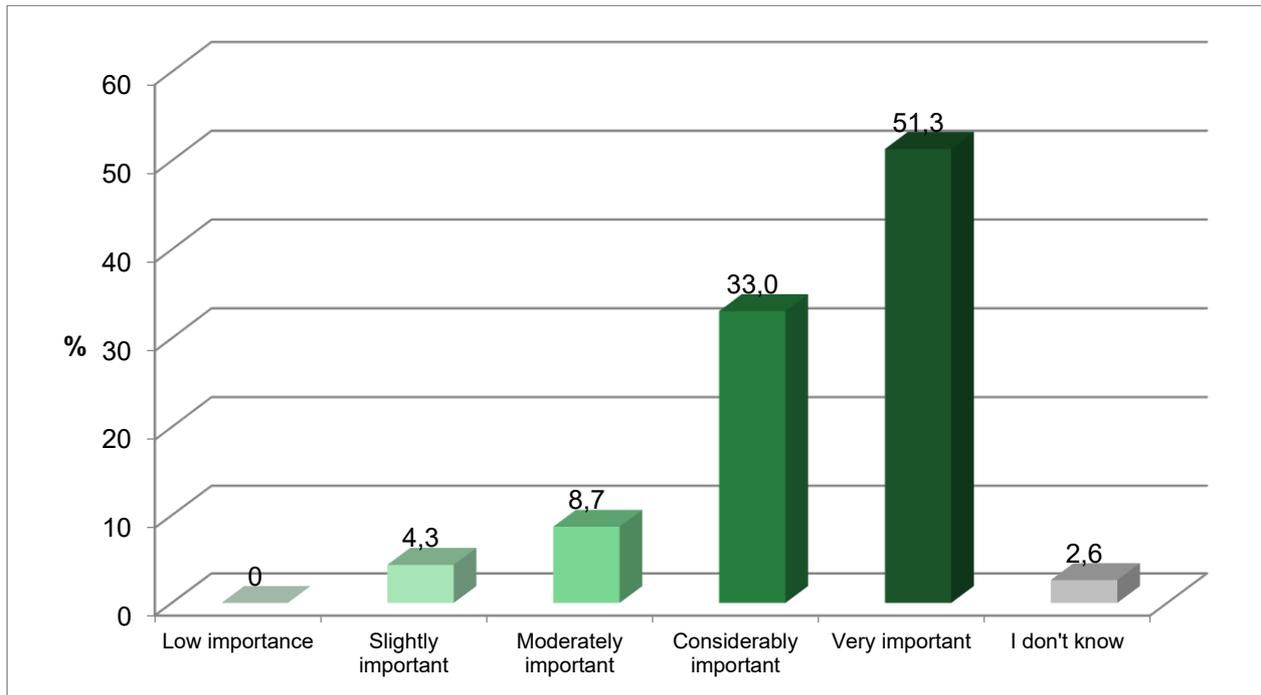


FIGURE 30: IMPORTANCE OF RESISTANCE TO FUNGI AS A SPECIFICATION OF INSULATION MATERIALS

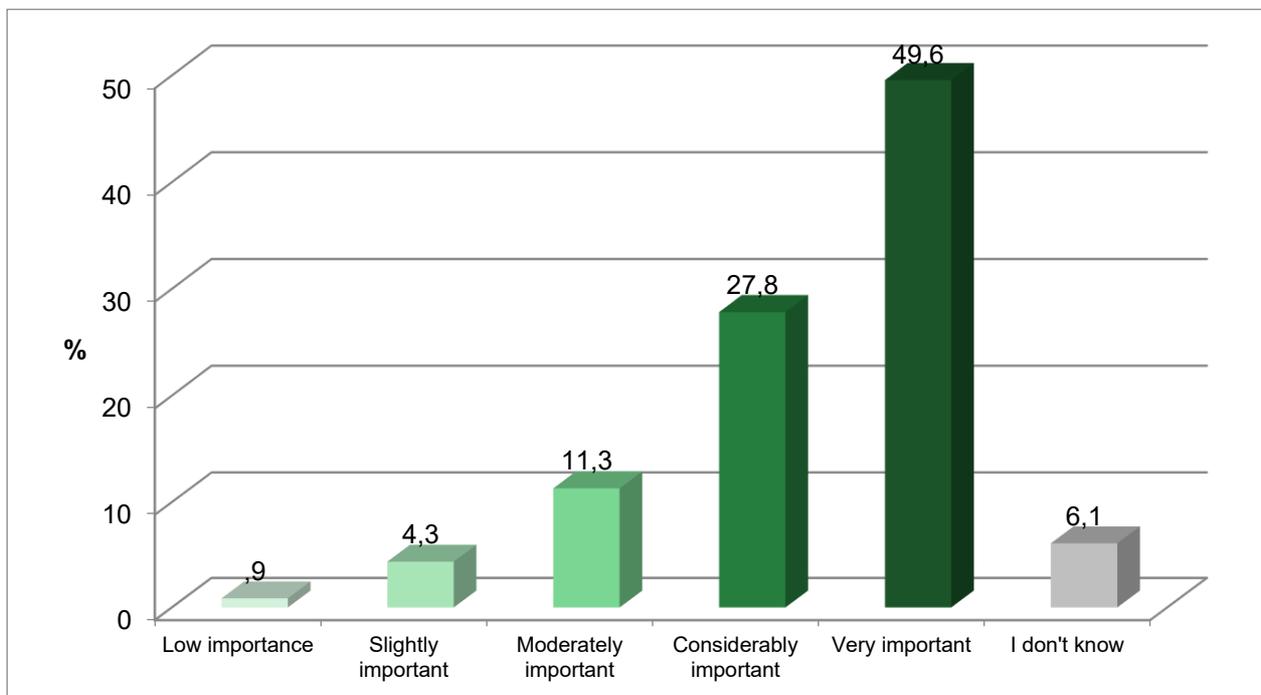


FIGURE 31: IMPORTANCE OF RESISTANCE TO WEATHER CHANGES AS A SPECIFICATION OF INSULATION MATERIALS

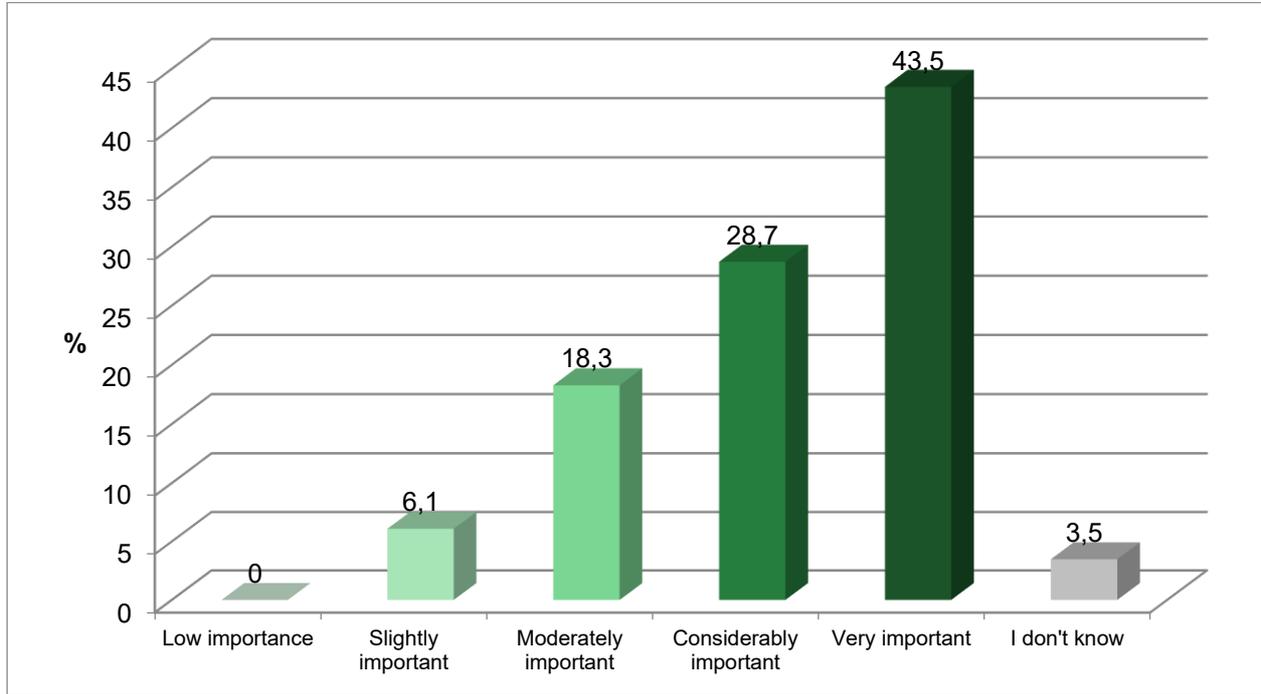


FIGURE 32: IMPORTANCE OF SOUND INSULATION AND NOISE REDUCTION AS A SPECIFICATION OF INSULATION MATERIALS

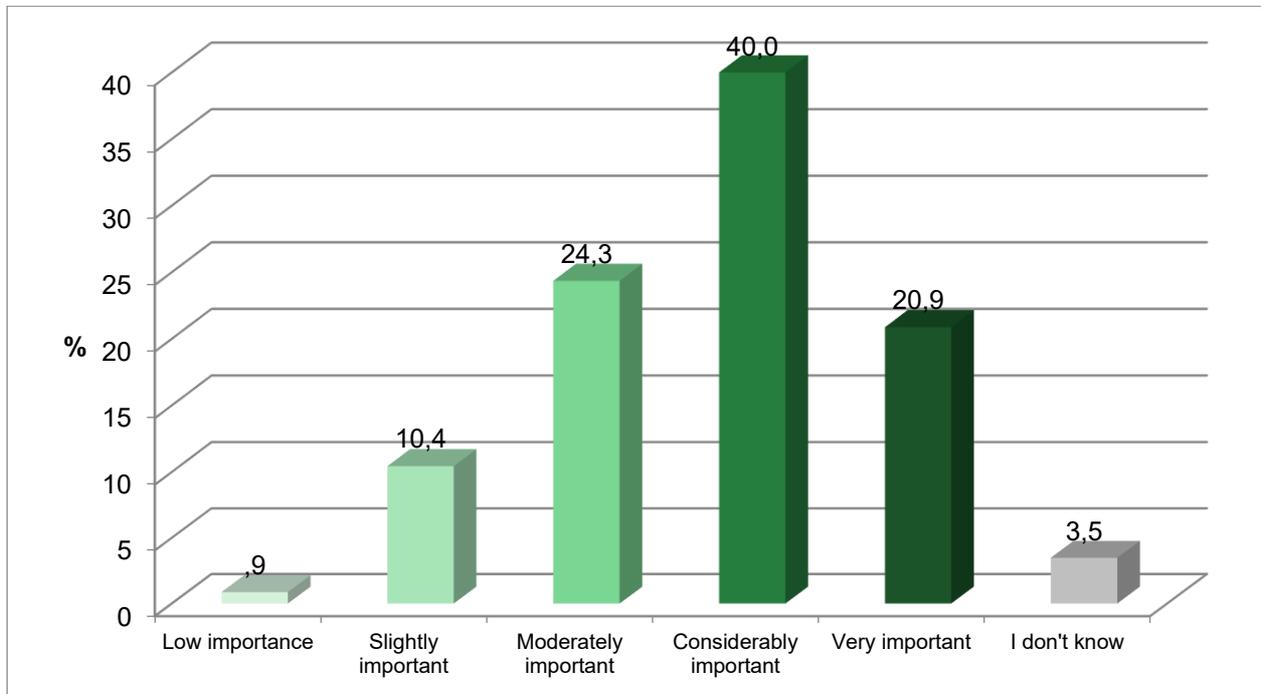


FIGURE 33: IMPORTANCE OF SUPPLY SECURITY (AVAILABILITY) AS A SPECIFICATION OF INSULATION MATERIALS

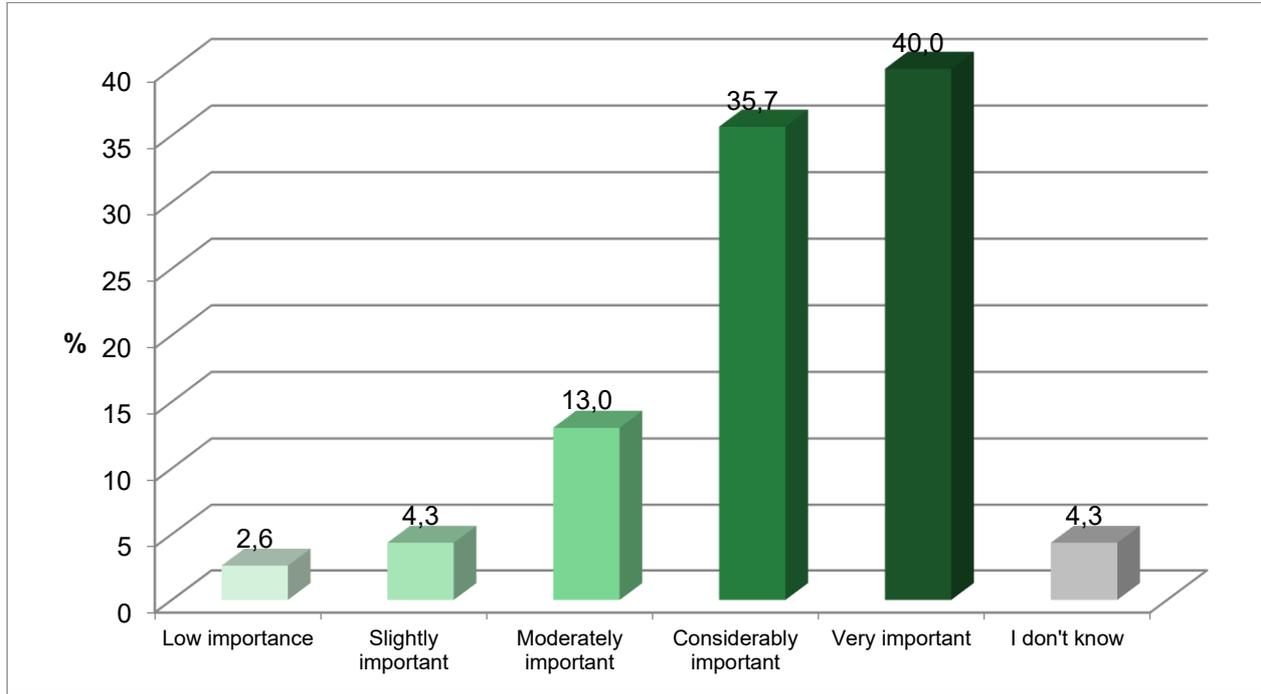


FIGURE 34: IMPORTANCE OF SUSTAINABILITY AS A SPECIFICATION OF INSULATION MATERIALS

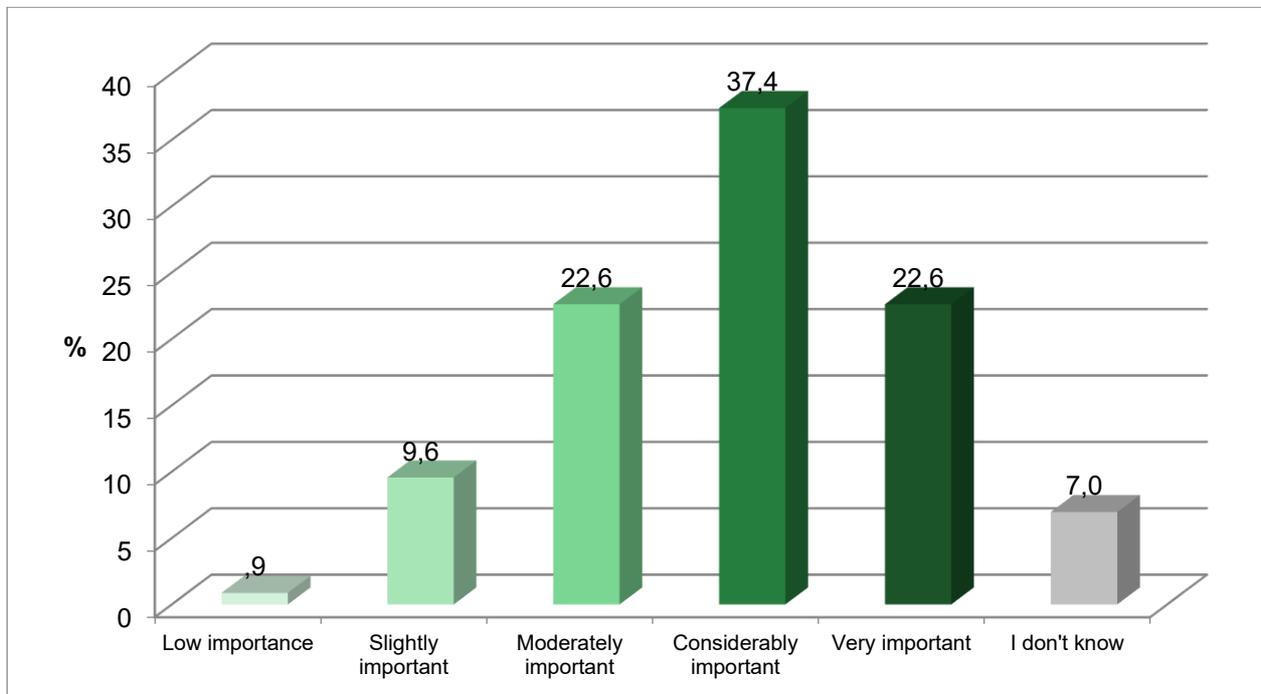


FIGURE 35: IMPORTANCE OF TECHNOLOGY MATURITY AS A SPECIFICATION OF INSULATION MATERIALS

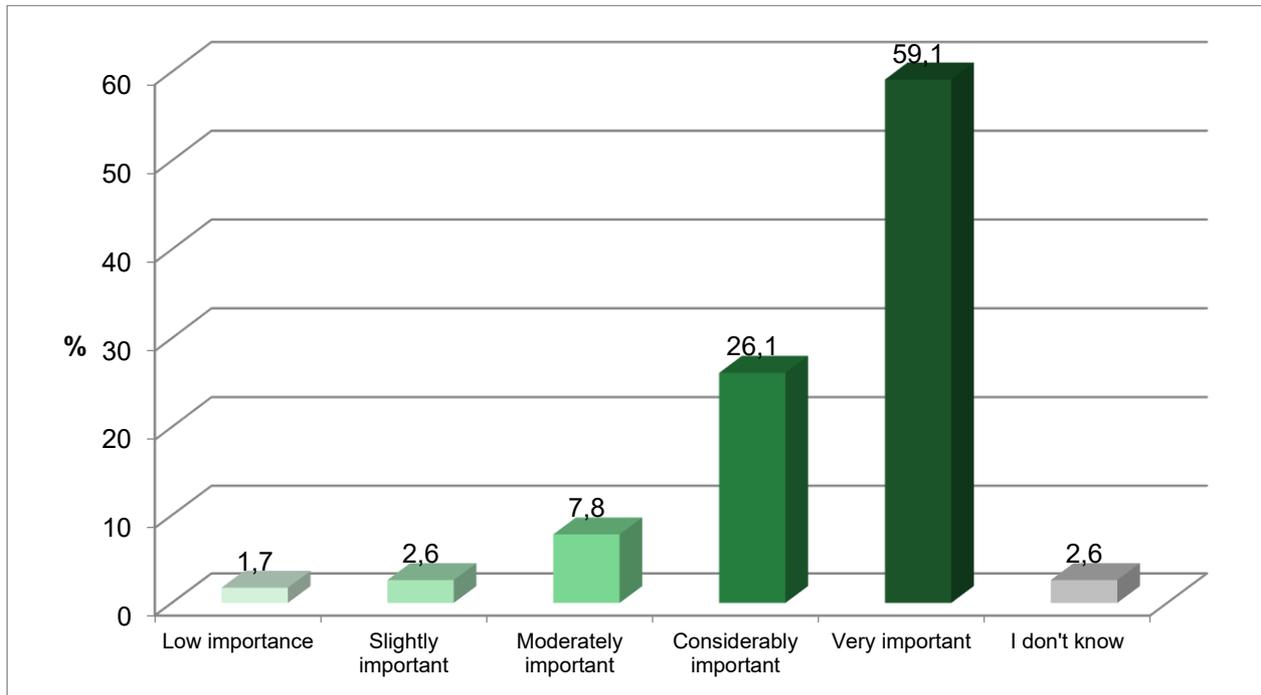


FIGURE 36: IMPORTANCE OF THERMAL COMFORT AS A SPECIFICATION OF INSULATION MATERIALS

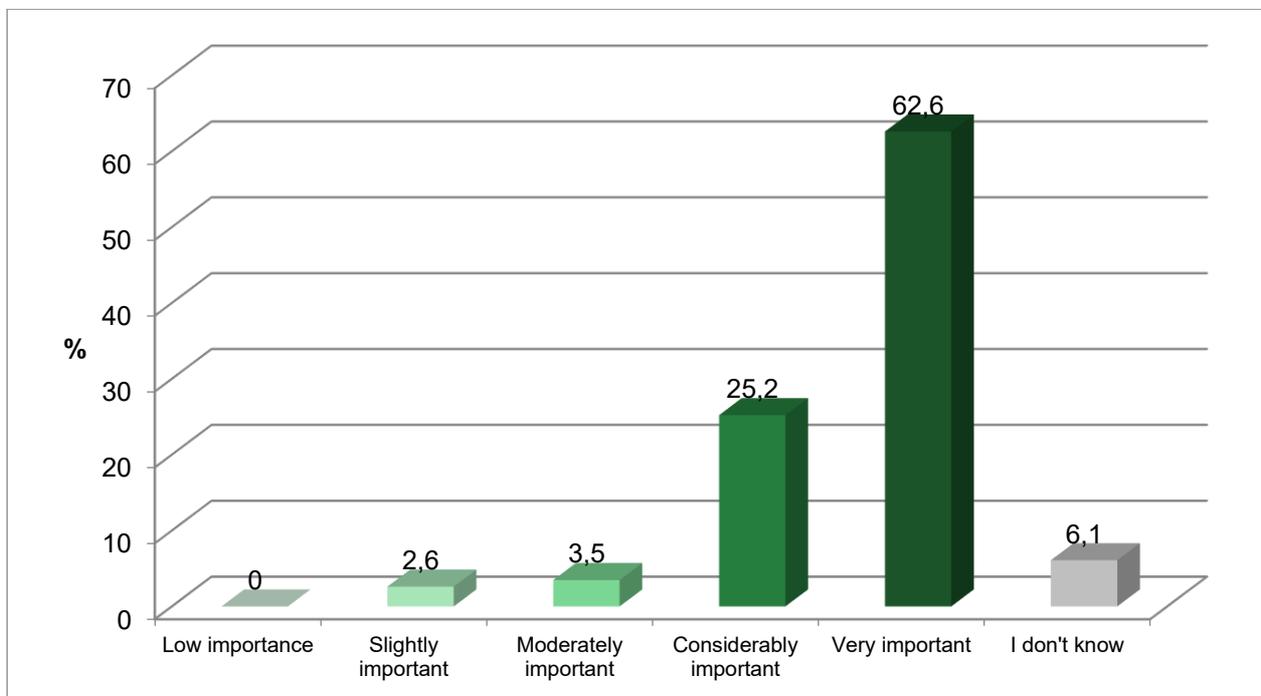


FIGURE 37: IMPORTANCE OF THERMAL CONDUCTIVITY/ THERMAL INSULATION PERFORMANCE AS A SPECIFICATION OF INSULATION MATERIALS

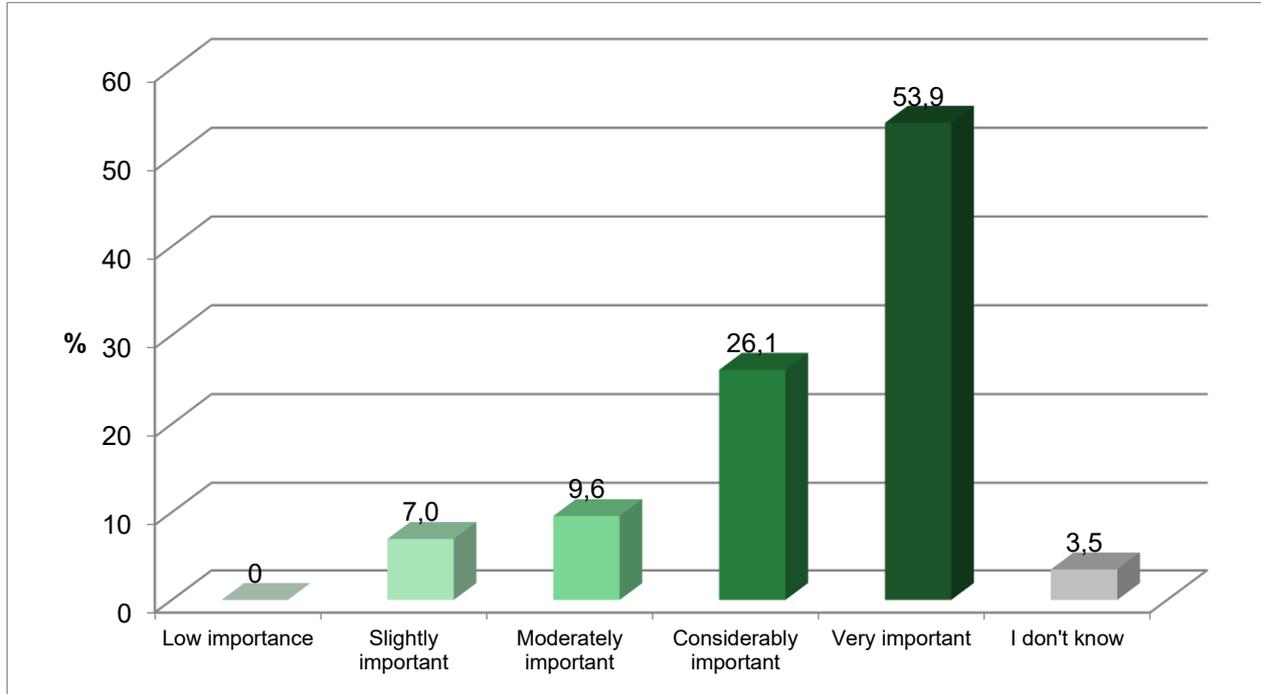


FIGURE 38: IMPORTANCE OF WATER/ WATER VAPOR RESISTANCE AS A SPECIFICATION OF INSULATION MATERIALS

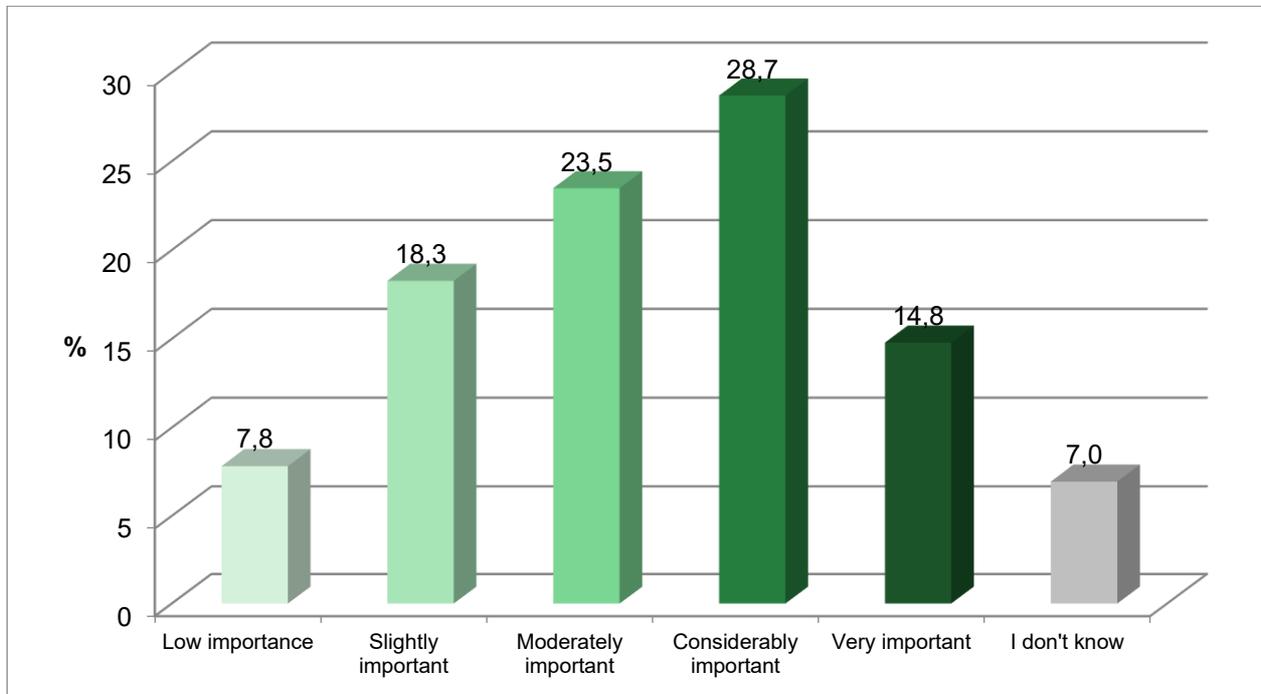


FIGURE 39: IMPORTANCE OF WEIGHT/ DENSITY AS A SPECIFICATION OF INSULATION MATERIALS

The following step was to estimate the mean value of the responses for each specification and use it to directly compare the perceived importance assigned by the respondents. The “I do not know” responses were excluded per specification case to calculate the mean values. The results (Figure 40) indicate that, according to the estimated mean values, the specifications of insulation materials perceived as most important were impact on human health, energy efficiency, durability, thermal conductivity/ thermal insulation performance, and release of dangerous substances. On the other end, aesthetics, weight/ density, biodegradable material, and bio-based material were perceived as the least important specifications.

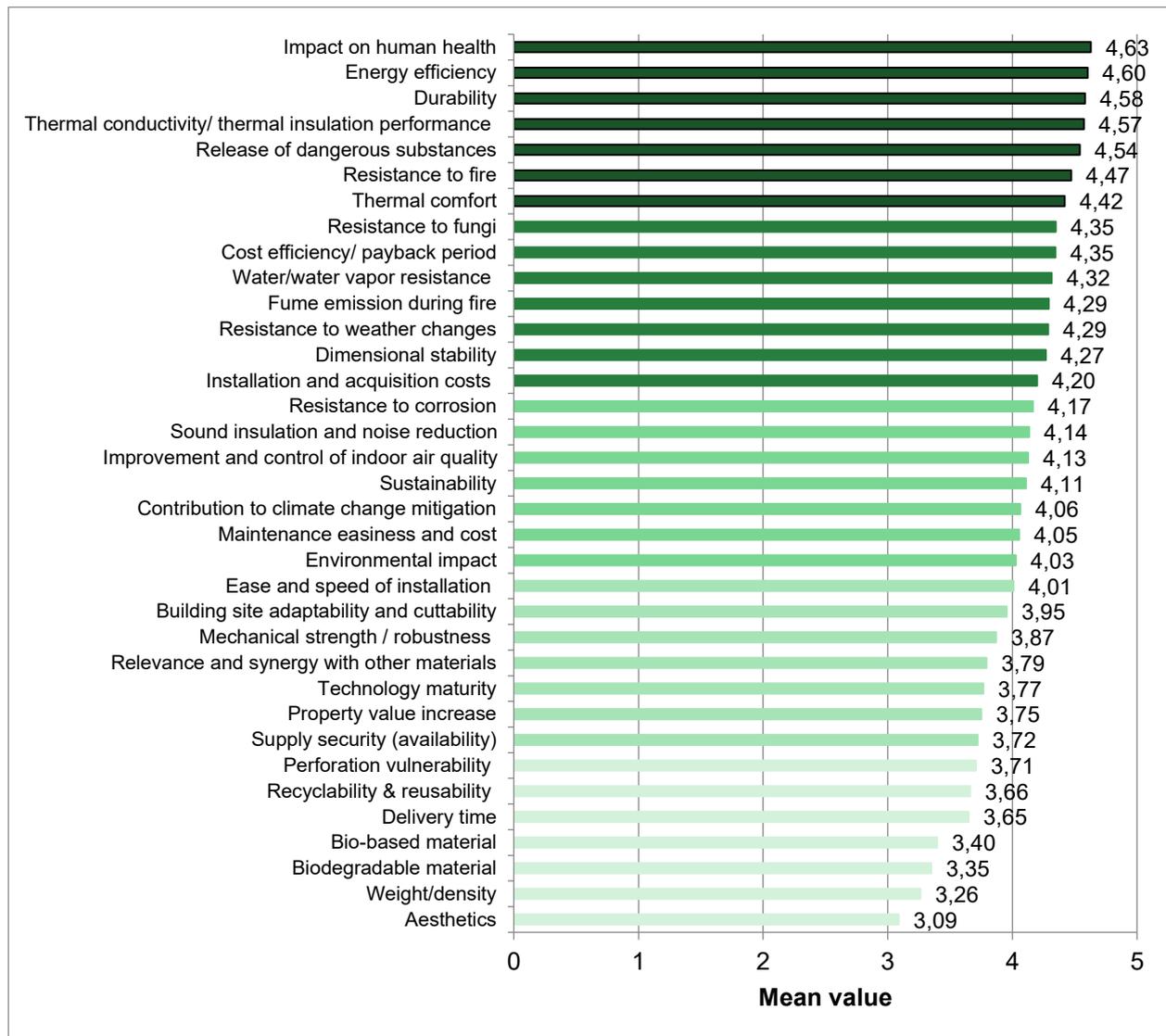


FIGURE 40: MEAN VALUES OF THE PERCEIVED IMPORTANCE OF INSULATION MATERIALS' SPECIFICATIONS

The questionnaire also prompted the respondents to select the three most important specifications based on the provided list (i.e., the specifications included in Figure 40). On this basis, 331 responses were selected from 111 participants; four did not respond to the question, while two only

noted their two most important specifications. Hence, Figure 41 illustrates participants' preferences regarding the top-3 most significant specifications. The specifications selected most extensively were cost efficiency/ payback period (11,5% of total responses), energy efficiency (11%), thermal conductivity/ thermal insulation performance (9,5%), durability (9,5%), and impact on human health (8%). These specifications also ranked high in terms of the mean value of importance (see Figure 40), except for the cost efficiency/ payback period, which ranked 1st when asking the respondents to choose their top-3 specifications and ranked 9th in terms of the mean value of perceived importance. In addition, it should be noted that all specifications were selected at least once in terms of top-3 importance, except for the perforation vulnerability requirement.

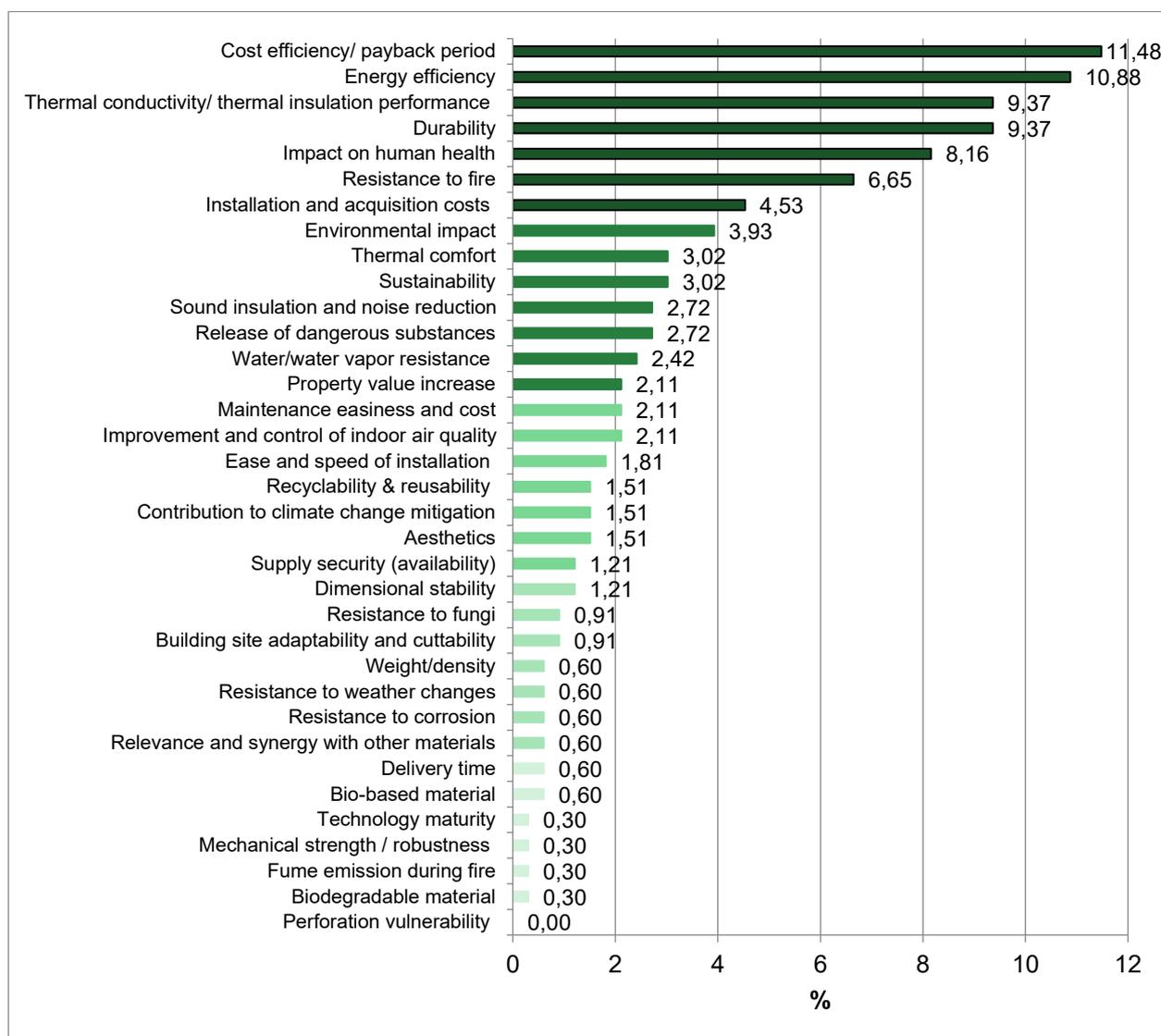


FIGURE 41: SPECIFICATIONS PERCEIVED AS OF TOP-3 IN TERMS OF IMPORTANCE (% EXPRESSES THE SHARE OF EACH SPECIFICATION IN RELATION TO THE TOTAL ANSWERS PROVIDED)

The final interview question asked the respondents to rank four criteria (economic, environmental, social, and technical) regarding their importance in selecting insulation materials. As illustrated in

Figure 42, the criterion ranked as most important was the Technical, as it was selected by 46% of the respondents as the most important, by 29% as the 2nd most important, and by 27% as the 3rd most important criterion. Accordingly, the Economic criterion was evaluated as the 2nd most important (ranked 1st by 32% of the respondents; 2nd by 34%; 3rd by 22%), the Environmental criterion as the 3rd most important (ranked 1st by 17% of the respondents; 2nd by 29%; 3rd by 39%), while the Social criterion was rated as the least important, with 59% of the participants ranking it 4th in terms of importance, and 27% ranking it 3rd.

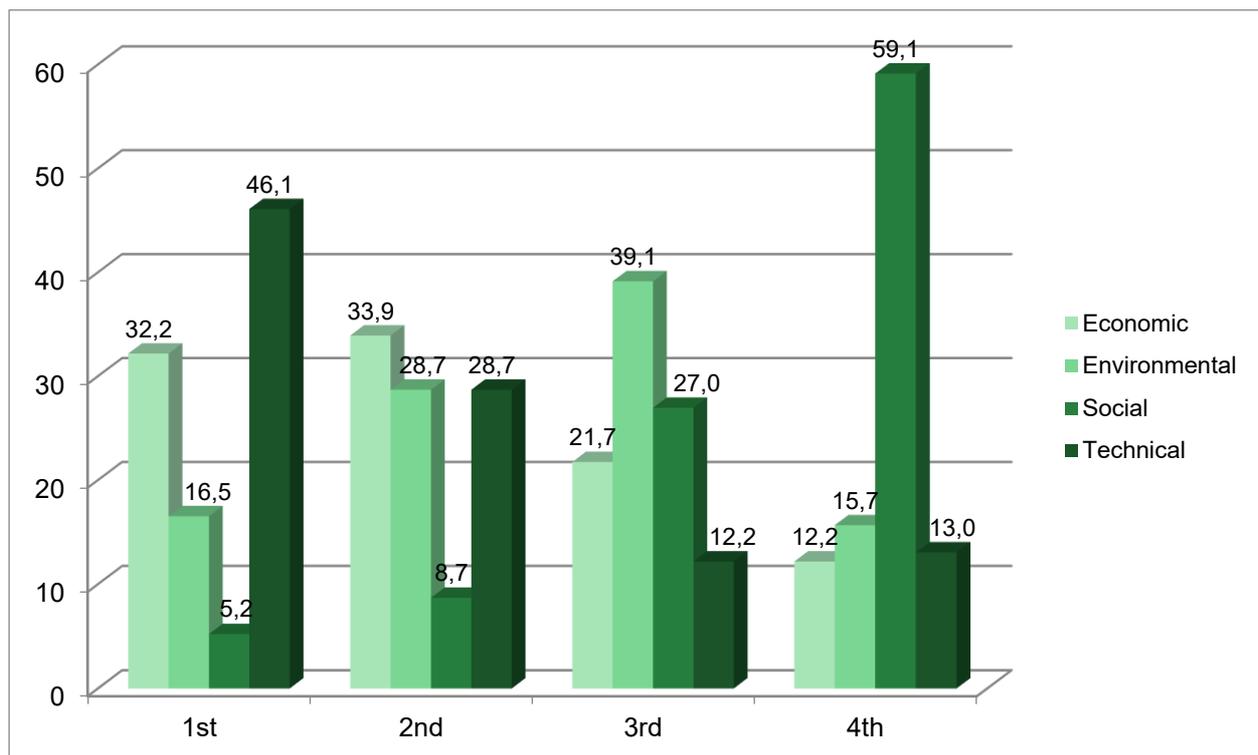


FIGURE 42: RANK OF CRITERIA IN TERMS OF THEIR IMPORTANCE FOR SELECTING INSULATION MATERIAL

4.2 COMPARISONS BETWEEN DIFFERENT KNOWLEDGE LEVELS

Following the overall descriptive statistics, an analysis was performed to determine potential significant differences between the participants regarding their knowledge of insulation materials (i.e., low, average and high levels of knowledge). In this regard, the mean value of the responses for each specification was estimated. The “I do not know” responses were excluded per specification case to calculate the mean values. The results for each knowledge level group are presented in Figures 43 to 45. The results indicate that when examining the highest and lowest-ranked specifications, there were similarities between the three knowledge groups.

Regarding the specification rated as most important (top-4 mean values), energy efficiency and impact on human health were common for all three groups. At the same time, thermal conductivity/

thermal insulation performance was also common for the high and average groups. On the contrary, when examining the lowest rated specifications (bottom-4 mean values), weight/ density and bio-based material were common for all three groups, and aesthetics was common for the average and high-level groups. In contrast, biodegradable material was common for the low and high-level knowledge groups.

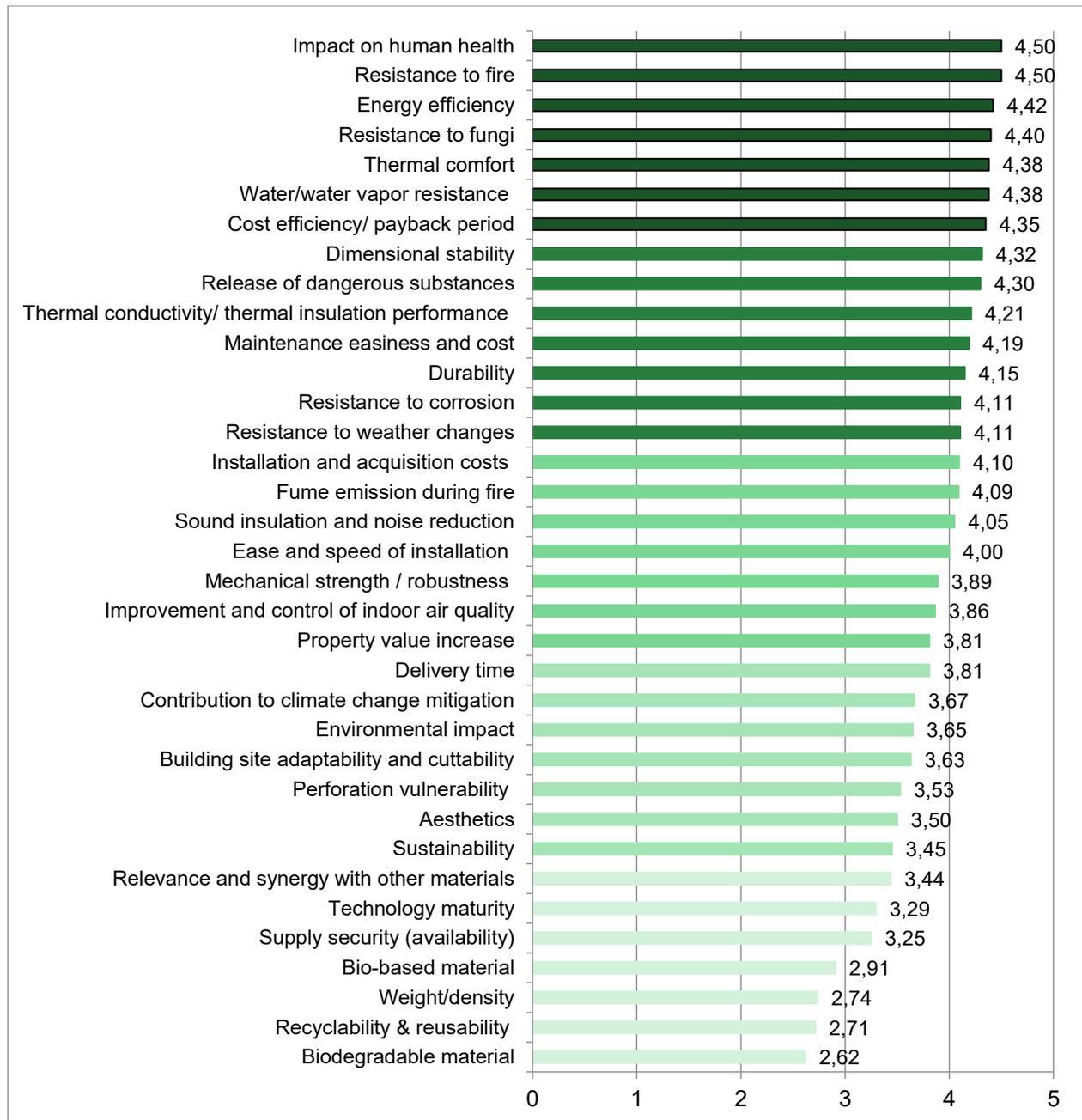


FIGURE 43: LOW-KNOWLEDGE PARTICIPANTS: MEAN VALUES OF THE PERCEIVED IMPORTANCE OF INSULATION MATERIALS' SPECIFICATIONS

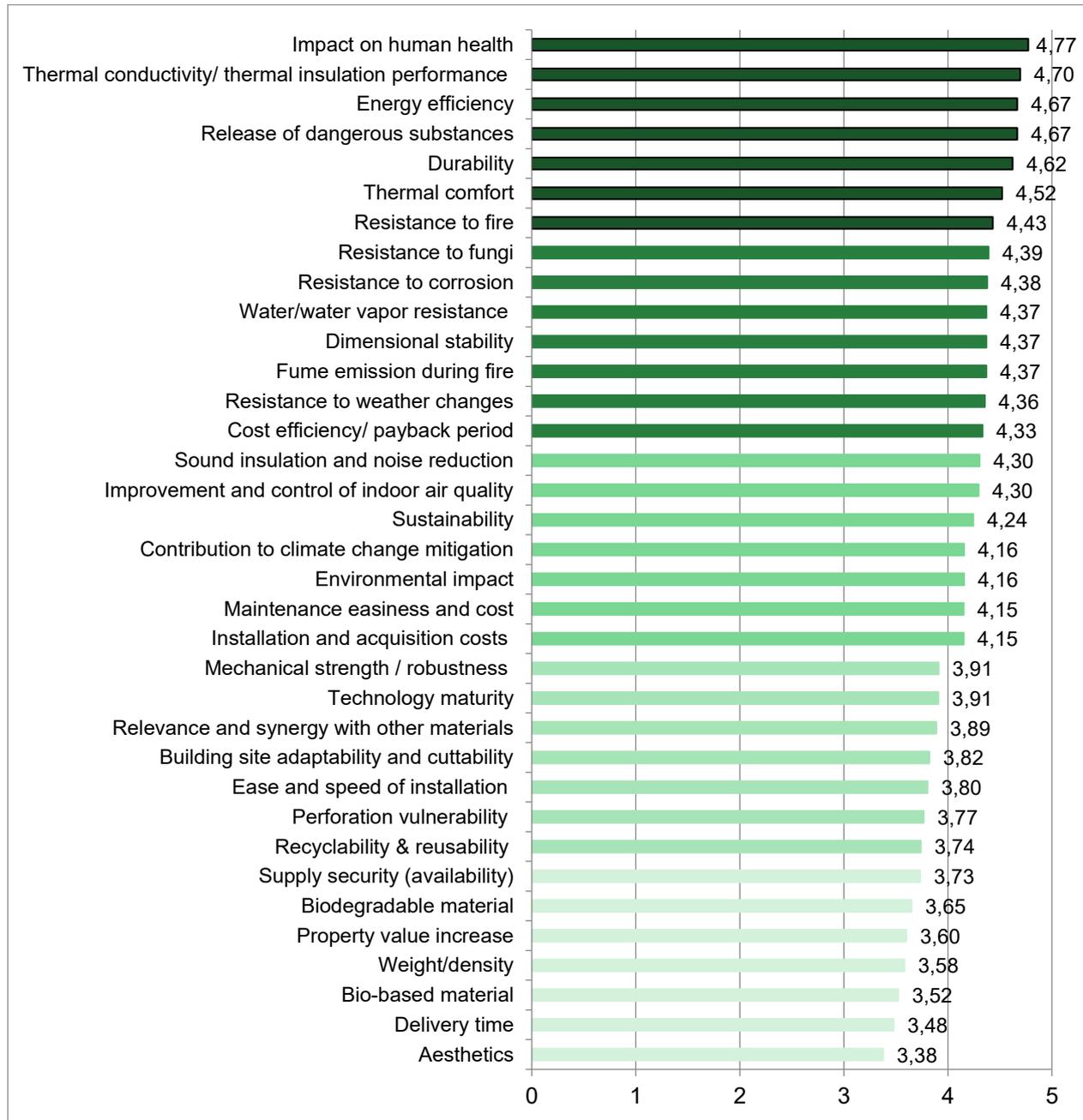


FIGURE 44: AVERAGE-KNOWLEDGE PARTICIPANTS: MEAN VALUES OF THE PERCEIVED IMPORTANCE OF INSULATION MATERIALS' SPECIFICATIONS

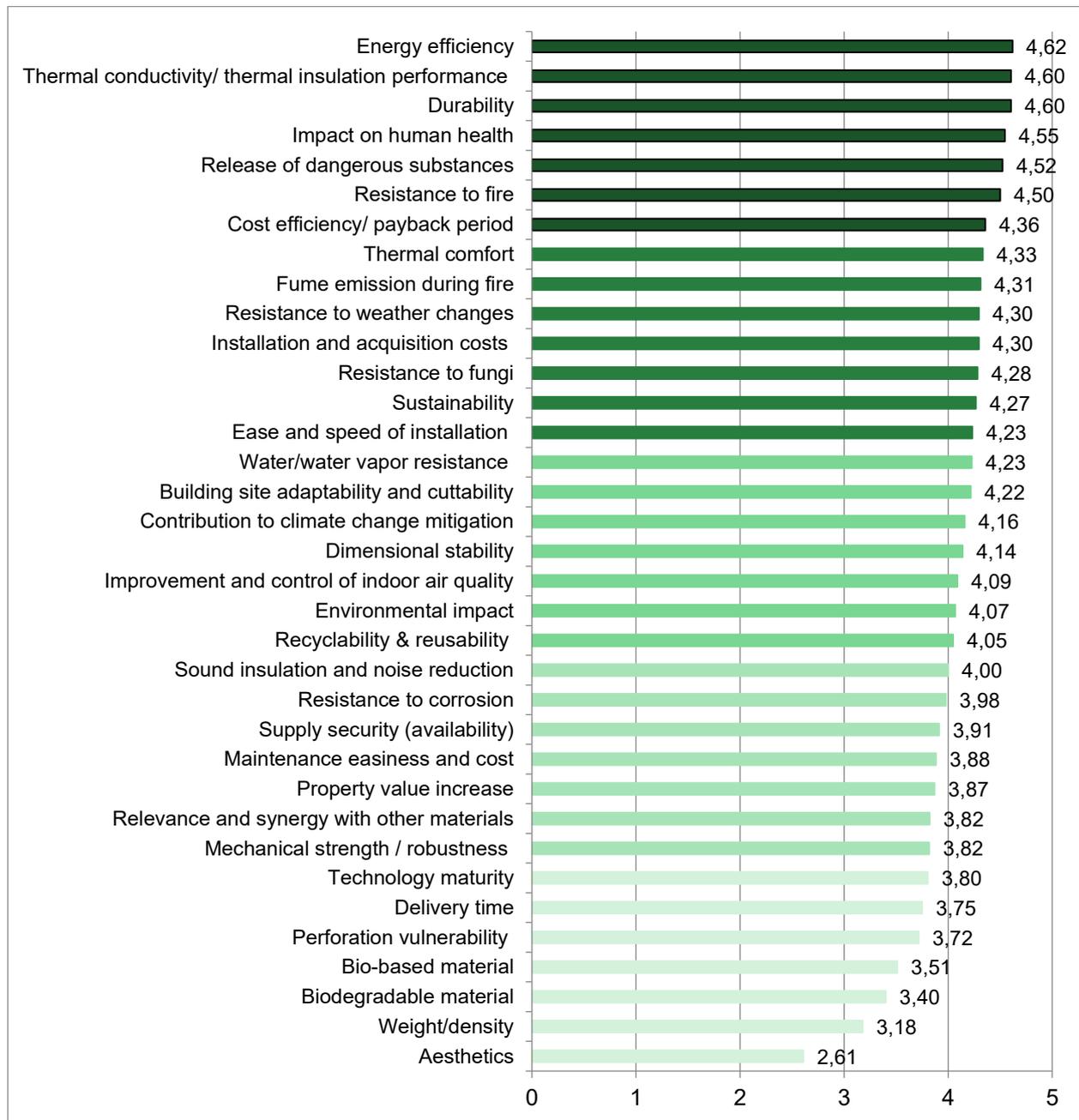


FIGURE 45: HIGH-KNOWLEDGE PARTICIPANTS: MEAN VALUES OF THE PERCEIVED IMPORTANCE OF INSULATION MATERIALS' SPECIFICATIONS

Furthermore, statistically significant differences between the responses of the three knowledge groups were identified using Kruskal-Wallis H non-parametric tests (appropriate for ordinal categorical variables). Kruskal-Wallis post-hoc tests were conducted to determine the specific statistically significant differences between the pairs. Table 1 illustrates the results of tests for each insulation material specification. A significance level (Sig.) lower than 0,05 indicates a statistically significant difference for the particular specification between at least one pair of the three knowledge groups. Hence, according to the test results, statistically significant differences within

the three groups were present in the aesthetics, biodegradable material, recyclability and reusability, supply security (availability), sustainability, and thermal conductivity/ thermal insulation performance specifications (marked with green color in Table 1).

Specification	Sig.
Aesthetics	0,004
Bio-based material	0,179
Biodegradable material	0,026
Building site adaptability and cuttability	0,063
Contribution to climate change mitigation	0,500
Cost efficiency/ payback period	0,919
Delivery time	0,307
Dimensional stability	0,290
Durability	0,766
Ease and speed of installation	0,148
Energy efficiency	0,460
Environmental impact	0,334
Fume emission during a fire	0,282
Impact on human health	0,281
Improvement and control of indoor air quality	0,293
Installation and acquisition costs	0,862
Maintenance easiness and cost	0,230
Mechanical strength/robustness	0,927
Perforation vulnerability	0,779
Property value increase	0,418
Recyclability & reusability	0,000
Release of dangerous substances	0,605
Relevance and synergy with other materials	0,473
Resistance to corrosion	0,321
Resistance to fire	0,808
Resistance to fungi	0,703
Resistance to weather changes	0,814
Sound insulation and noise reduction	0,258
Supply security (availability)	0,031
Sustainability	0,028
Technology maturity	0,267
Thermal comfort	0,817
Thermal conductivity/ thermal insulation performance	0,031
Water/water vapor resistance	0,966
Weight/density	0,061

TABLE 1: COMPARISONS OF RESPONSES BETWEEN KNOWLEDGE GROUPS: RESULTS OF KRUSKAL-WALLIS TESTS

According to the results presented in Table 1, Kruskal-Wallis post-hoc tests were carried out to identify the particular statistically significant differences between the three groups for each of the six specifications. The results of the pairwise comparisons are illustrated in Figures 46 to 51. According to the results, the following differences occur on a statistically significant level:

- The high-level knowledge group perceived aesthetics as less important in comparison to the other two groups (Figure 46);
- Biodegradable material was perceived as more important by the high-level knowledge group in comparison to the low-level knowledge group (Figure 47);
- The low-level knowledge group perceived recyclability and reusability as less important compared to the other two groups (Figure 48);
- The high-level group perceived supply security (availability) as more important in comparison to the low-level knowledge group (Figure 49);
- The low-level group perceived sustainability as less important compared to the other two groups (Figure 50);
- The average-level knowledge group perceived thermal conductivity/ thermal insulation performance as more important than the low-level knowledge group (Figure 51).

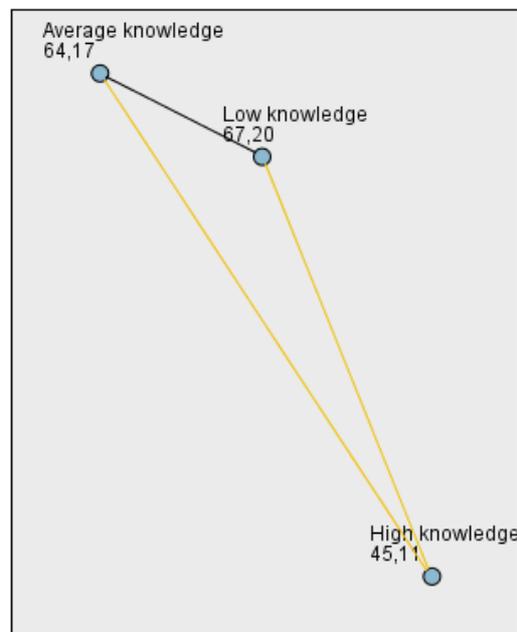


FIGURE 46: RESULTS OF THE PAIRWISE COMPARISON OF THE IMPORTANCE OF AESTHETICS AS A SPECIFICATION OF INSULATION MATERIALS BETWEEN THE DIFFERENT KNOWLEDGE LEVELS OF END-USERS

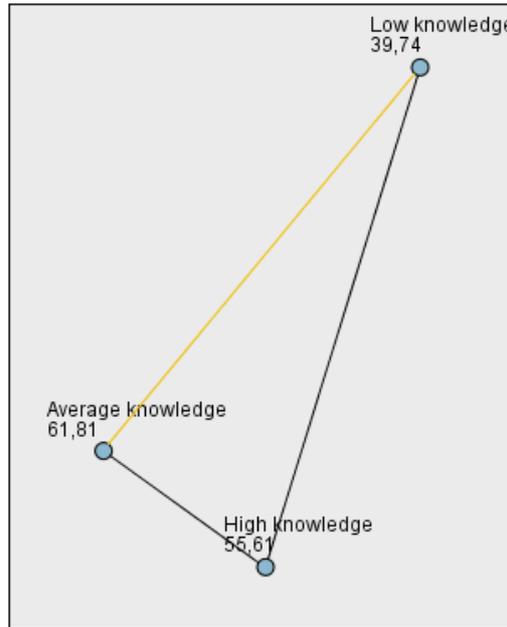


FIGURE 47: RESULTS OF THE PAIRWISE COMPARISON OF THE IMPORTANCE OF BIODEGRADABLE MATERIAL AS A SPECIFICATION OF INSULATION MATERIALS BETWEEN THE DIFFERENT KNOWLEDGE LEVELS OF END-USERS

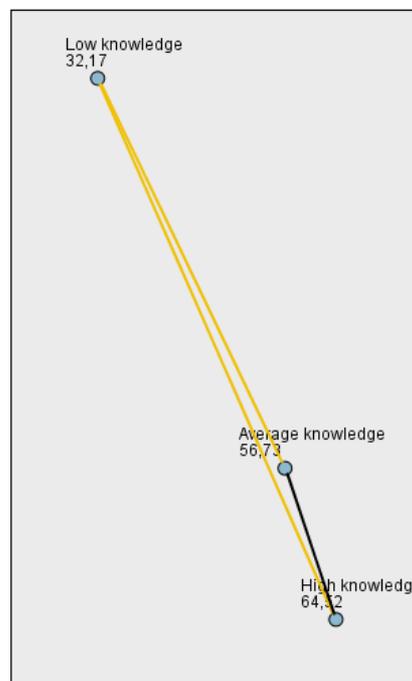


FIGURE 48: RESULTS OF THE PAIRWISE COMPARISON OF THE IMPORTANCE OF RECYCLABILITY AND REUSABILITY AS A SPECIFICATION OF INSULATION MATERIALS BETWEEN THE DIFFERENT KNOWLEDGE LEVELS OF END-USERS

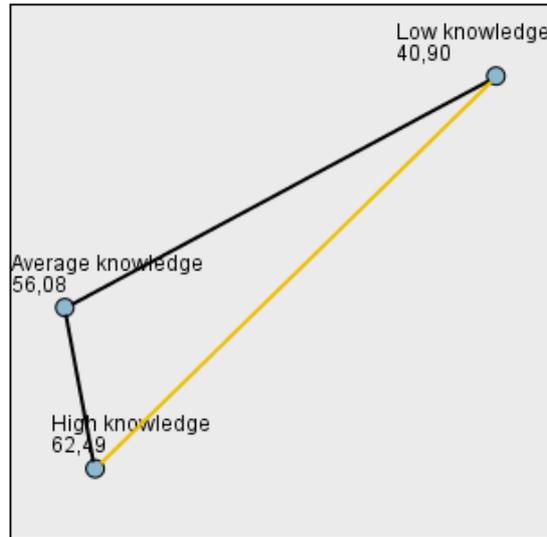


FIGURE 49: RESULTS OF THE PAIRWISE COMPARISON OF THE IMPORTANCE OF SUPPLY SECURITY (AVAILABILITY) AS A SPECIFICATION OF INSULATION MATERIALS BETWEEN THE DIFFERENT KNOWLEDGE LEVELS OF END-USERS

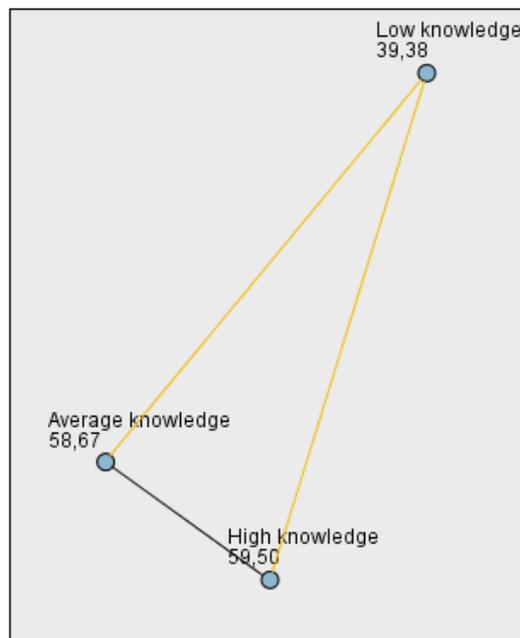


FIGURE 50: RESULTS OF THE PAIRWISE COMPARISON OF THE IMPORTANCE OF SUSTAINABILITY AS A SPECIFICATION OF INSULATION MATERIALS BETWEEN THE DIFFERENT KNOWLEDGE LEVELS OF END-USERS

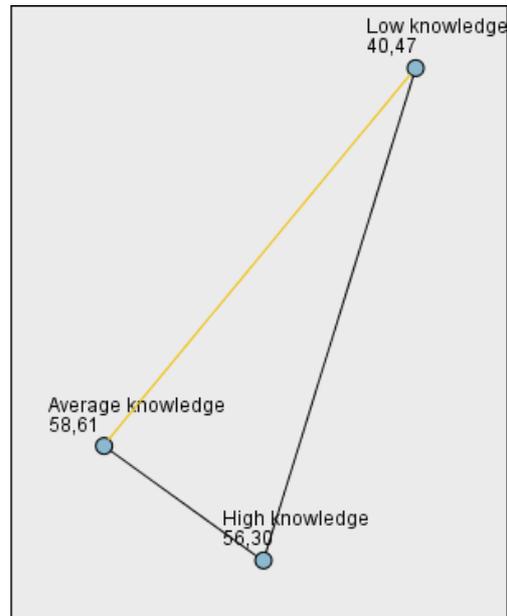


FIGURE 51: RESULTS OF THE PAIRWISE COMPARISON OF THE IMPORTANCE OF THERMAL CONDUCTIVITY/ THERMAL INSULATION PERFORMANCE AS A SPECIFICATION OF INSULATION MATERIALS BETWEEN THE DIFFERENT KNOWLEDGE LEVELS OF END-USERS

4.3 KEY TAKEAWAYS

The survey was carried out to examine end-users' attitudes and perceptions regarding the requirements of innovative insulation materials. The survey targeted a wide range of end-users of insulation materials from the EU and the UK, focusing on the countries participating in the SNUG project. An online questionnaire collected 115 responses from 12 countries during March 2024. The countries with the most participants in the survey were Spain, Austria, Greece and Portugal. The end-users mainly represented were a) architects, planners and engineers, b) building occupants, and c) private, single-building owners, while most of the participants stated having either a high or average knowledge of insulation materials.

According to the survey results, the most important specifications of insulation materials were cost efficiency/ payback period, durability, energy efficiency, impact on human health, release of dangerous substances, and thermal conductivity/ thermal insulation performance. On the contrary, the specifications perceived as least important were aesthetics, bio-based material, biodegradable material and weight/density. Moreover, based on the survey responses, the overall criteria for selecting insulation materials can be ranked in order of importance as technical, economic, environmental and social.

Furthermore, an analysis was performed to determine differences between the participants regarding their knowledge of insulation materials (i.e., low, average and high levels of knowledge). In this respect, energy efficiency and impact on human health were rated among the most important specifications (i.e., among the top-4), while weight/ density and bio-based material were rated among the least significant (i.e., among the bottom-4) specifications by all three knowledge groups. In addition, statistically significant differences between the responses of the three knowledge groups were identified. Based on the results, on a statistically significant level, the low-level knowledge group perceived biodegradable material, recyclability and reusability, supply security (availability), sustainability, and thermal conductivity/ thermal insulation performance as less important in comparison to the other two groups (either both of them or just one of them, depending on the case), while the high-level knowledge group perceived aesthetics as less important, in comparison to the other two groups.

5 VALIDATION OF RESULTS WITH MANUFACTURERS

5.1 INTRODUCTION

To validate the findings from the end-user survey on thermal insulation material requirements (presented in the previous sections of this deliverable), a comprehensive validation exercise was conducted with building component manufacturers participating in the SNUG project consortium. This validation process served dual purposes: first, to verify whether the survey findings align with manufacturers' direct market experience, and second, to understand how these research insights can support their commercial objectives and product development strategies.

The validation methodology consisted of:

- The creation of a structured questionnaire (see Annex D) distributed to the manufacturer partners of the SNUG project; five responses were collected during September – October 2025 (partners: AGITEC, CHIMAR, CRH, KEAS, and TAKKENKAMP).
- Organization and implementation of a dedicated online workshop (see Annex E for agenda) where the questionnaire responses –as well as additional issues- were discussed in depth; the workshop took place on the 8th of October 2025, including six participants from four SNUG partners.

This section presents the synthesis of manufacturer feedback across key thematic areas, highlighting both confirmations and discrepancies between end-user priorities and market realities. Following, for reasons of anonymization, the partners will be referred to as “Partner #1”, “Partner #2”, etc.

5.2 MARKET VALIDATION OF SURVEY FINDINGS

Alignment with Customer Priorities

The manufacturer feedback revealed strong overall alignment between the survey findings and their direct market experience. All participating manufacturers confirmed that the top-ranked specifications—impact on human health, energy efficiency, durability, thermal conductivity, and fire resistance—accurately reflect customer priorities they encounter in practice.

Partner #1 emphasized that their experience in panel manufacturing directly supports these priorities, noting that customers consistently focus on health, durability, thermal insulation, and fire safety. This alignment extends to their characterization testing protocols, which specifically address VOC emissions, fire reaction, and thermal conductivity. Similarly, Partner #2 confirmed that customers consistently prioritize health and safety aspects, particularly the absence of harmful

emissions, alongside energy efficiency and durability. They noted that thermal performance, typically measured by λ -value, occupies a central position in customer decision-making.

Partner #3 provided insight into the practical hierarchy of customer concerns, explaining that customers primarily evaluate three fundamental aspects: health and fire safety, genuine energy retention capabilities, and long-term durability without moisture or mold issues. They noted that certifications such as CE marking and fire classifications serve as crucial proof points for these attributes, with price and payback period becoming relevant only after these baseline requirements are satisfied.

Contradictions and Surprising Findings

Despite the overall alignment, manufacturers identified several significant discrepancies between the survey results and their market observations, particularly regarding cost considerations and sustainability factors.

The positioning of cost efficiency and payback period emerged as a primary point of contention. Partner #4 expressed surprise that cost efficiency ranked relatively low in the survey's list of most important specifications, noting that in the wood-composites industry, cost consistently ranks among the top three specifications. Partner #2 concurred, suggesting that while cost efficiency appeared underweighted in the summary rankings, it was actually rated as number one when survey participants selected their top three specifications. Partner #5 similarly indicated that, based on their knowledge of the Belgian market, price represents an important decision parameter that should rank higher on the importance scale.

The low ranking of sustainability factors—particularly recyclability and reusability—emerged as another surprising finding. Partner #1 highlighted that in their development of bio-based boards, they observe increasing demand for circularity and bio-based solutions, with recyclability and low embodied carbon being especially important in public projects. Partner #3 noted that while sustainability and reuse scored low in the survey, larger professional projects increasingly incorporate circularity and CO₂ impact as part of decision-making criteria.

Partner #2 provided additional context regarding sustainability specifications, noting that while the low ranking among less knowledgeable users was expected, in today's EU markets with mounting ESG pressures, these factors will likely rise in importance in the near future. This observation suggests a potential gap between current stated preferences and emerging market requirements.

Partner #5 expressed particular surprise regarding the low importance assigned to recyclability and reusability, noting that during their customer polling at events, customers demonstrated enthusiasm for these concepts. This discrepancy suggests a possible distinction between stated priorities in survey contexts and actual interest when sustainability concepts are presented tangibly.

Another specification that revealed contradictory findings was delivery time. Partner #3 observed that while lead time appeared of little importance in the survey, supply reliability proves often

decisive in actual construction and renovation projects. This highlights a potential disconnect between abstract priority rankings and practical project constraints.

Communication Challenges

Manufacturers identified particular specifications that present communication challenges with customers, revealing insights into the practical difficulties of translating technical advantages into customer understanding.

Partner #1 identified embedded carbon and environmental benefits of bio-based boards as particularly challenging to communicate, as these advantages are not directly perceptible in everyday use. They emphasized that convincing customers regarding durability and cost compared to conventional products requires strong technical evidence.

Partner #2 highlighted several technically complex areas that prove difficult for non-specialists to grasp: long-term durability metrics including aging and moisture resistance, sustainability indicators such as EPDs and embodied carbon, and fire safety classifications according to Euro class EN 13501-1. These communication challenges suggest that even when specifications are important to customers, technical complexity can create barriers to informed decision-making.

Partner #4 identified thermal comfort, energy efficiency, and recyclability/reusability as challenging to communicate, while Partner #5 specifically mentioned impact on human health as a difficult concept to convey effectively to customers.

5.3 IMPLICATIONS FOR PRODUCT DEVELOPMENT AND STRATEGY

Influence on Product Development Priorities

The survey findings provided manufacturers with confirmation and refinement of their product development directions. Partner #1 indicated that the results confirm their focus on boards produced with low-VOC and non-toxic binders, specifically referencing their bio-based board development activities. Partner #2 outlined a comprehensive development strategy influenced by the findings: focusing on achieving low λ -values, ensuring durability and health safety, securing strong certifications regarding the absence of hazardous substances, testing for moisture and fungal resistance, and continuing development of recyclable and circular solutions to anticipate future regulations and demand.

Partner #3 highlighted how the findings strengthen their product positioning, specifically mentioning Airofill's formaldehyde-free and low-emission characteristics as aligning with the emphasis on health impacts. They noted that this translates into customer benefits of clean indoor air and safe installation—currently a prominent topic in the industry.

Partner #4 stated their intention to adapt specifications for new product development based on the survey findings, indicating direct integration of the research results into their innovation pipeline.

Customer Education Strategies

Given that sustainability factors ranked lower among less knowledgeable users, manufacturers were asked to describe their current approaches to customer education about these benefits. The responses revealed varied levels of engagement with sustainability communication.

Partner #1 described an approach tailored to less knowledgeable users, presenting bio-based board advantages through practical, everyday benefits rather than technical details. These include healthier indoor air, reduced chemical emissions, eco-friendly production, and ease of installation due to lightweight properties. This strategy demonstrates an understanding that technical sustainability metrics must be translated into tangible user benefits.

Partner #2 takes a more formal approach through publishing Environmental Product Declarations (EPDs), providing standardized sustainability information for those customers seeking it. Partner #4 engages in field conference presentations that emphasize sustainability factors and regulations, targeting education at the professional level.

Partner #3 employs a consultative approach, discussing pros and cons with customers in conversation, sharing information sheets, and explaining example cases. This personalized method allows for addressing specific customer concerns and knowledge levels.

Partner #5 revealed that their customers generally lack understanding of what green building entails in practical detail. They provide presentations on request to inspire customers but acknowledged that as a company they are not yet positioned to speak openly and extensively about sustainability, suggesting varying levels of organizational readiness for sustainability communication across manufacturers.

Market Segmentation Approaches

Manufacturers revealed diverse approaches to segmenting their marketing based on customer knowledge levels. Partner #1 confirmed that their customer portfolio spans from technically knowledgeable professional buyers to less informed end users, necessitating segmented marketing approaches. They utilize field conference presentations to reach professional audiences with sustainability and regulatory information.

Partner #2 described a sophisticated three-tier segmentation strategy: for high-knowledge professionals such as architects and auditors, they provide detailed datasheets, test reports, LCAs, and EPDs; for average-knowledge installers and builders, they focus on installation ease, warranties, and costs; and for low-knowledge end users, they emphasize comfort, health, safety, and payback with visual communication tools.

In contrast, Partner #4 indicated they do not currently segment their marketing approaches based on customer knowledge levels, suggesting a more uniform communication strategy. Partner #3 focuses exclusively on the business-to-business market, targeting other businesses and

organizations including producers, resellers, governments, and institutions, which inherently segments their approach toward more knowledgeable audiences.

Partner #5 noted that their market approach is currently still under formulation, indicating ongoing strategic development in this area.

During the workshop discussion, Partner #2 and Partner #4 agreed on the significance of emphasizing health, safety, and energy efficiency in product positioning. They noted that customer education strategies should be tailored to the audience's knowledge level, with Partner #2 sharing specific practices regarding their aerogel products as examples of effective knowledge-based segmentation.

5.4 COMMERCIAL APPLICATION OF FINDINGS

The survey findings offer multiple pathways for commercial application across product positioning, marketing communications, and research investment decisions.

Partner #1 identified that the prioritization of human health, energy efficiency, durability, and fire resistance most directly impacts all three commercial dimensions—product positioning strategies, sales and marketing messages, and R&D investment decisions. These findings guide their emphasis on performance, safety, and sustainable innovation across the commercial spectrum.

Partner #2 provided detailed implementation perspectives for each commercial dimension. For product positioning, they plan to emphasize health, durability, and thermal performance while presenting sustainability as added value rather than a primary feature. For sales and marketing messages, they intend to translate technical results into user-friendly benefits, such as quantified heating cost savings percentages and performance longevity measured in decades. Regarding R&D investment decisions, they will prioritize thermal performance, fire safety, moisture resistance, and durability, while also investing in recycling systems despite currently low demand, anticipating future EU requirements.

Partner #4 indicated that the findings would most directly impact their R&D investment decisions, while Partner #3 identified product positioning strategies as the primary area of commercial application. During the workshop discussion, both Partner #2 and Partner #4 confirmed agreement on these commercial applications.

5.5 SNUG PROJECT ALIGNMENT

Alignment with Project Objectives

Manufacturers expressed strong confidence that the end-user priorities identified in the survey align well with the innovative materials being developed within the SNUG project. Partner #1

confirmed that SNUG materials, particularly bio-based boards, address the key requirements identified: health, energy efficiency, durability, fire safety, and sustainability. Partner #2 characterized the alignment as "very well," noting that SNUG's emphasis on energy efficiency, durability, circularity, and health safety directly corresponds with the survey's top-ranked needs.

Partner #4 stated unequivocally that the SNUG-developed products fully align with the survey findings, while Partner #3 confirmed alignment, noting that the main priority points are covered by the project's materials development.

Identified Gaps and Challenges

Despite strong overall alignment, manufacturers identified several potential gaps between end-user requirements and what sustainable or circular economy materials can currently deliver.

Partner #1 highlighted two primary challenges: first, some bio-based or recycled materials may have limitations in moisture resistance or durability; second, achieving short-term cost competitiveness remains challenging for sustainable alternatives. These concerns reflect fundamental tensions in sustainable material development—balancing environmental benefits with performance parity and economic viability.

Partner #2 identified cost competitiveness as a significant gap, alongside the challenge of demonstrating proven long-term durability, noting that new circular materials lack decades of field validation that conventional materials possess. This temporal gap in performance data represents a structural challenge for market acceptance of innovative materials.

Partner #4 suggested that water and water vapor resistance specifications might represent potential gap areas for sustainable materials. This aligns with Partner #1 concerns about moisture resistance limitations in bio-based and recycled materials.

Partner #3 highlighted supply chain maturity as a potential gap, noting that circular and bio-based supply chains remain relatively young, making the assurance of volume and consistency crucial for market viability.

During the workshop discussion, Partner #2 pointed out that while durability and fire safety are critical to market success, sustainability may not be the foremost concern for end users—a finding that creates tension for a project focused on sustainable innovation. Partner #4 added that moisture resistance represents a common weak point for bio-based materials, confirming this as an area requiring continued technical development.

Additional Valuable Specifications

Manufacturers identified several additional insulation material specifications that would enhance the project's commercial success potential.

Partner #1 emphasized the importance of long-term durability, sufficient mechanical performance, and desired acoustic performance of bio-based boards. These specifications extend beyond the core thermal insulation function to address broader building performance requirements.

Partner #2 provided a comprehensive list of additional valuable specifications: acoustic insulation, which is particularly important in urban renovations; ease of dismantling and reuse aligned with Design for Disassembly principles; compatibility with prefabrication and modular construction systems; and carbon footprint per square meter insulated, to align with EU climate and building targets. This list reflects emerging trends in building design and regulatory frameworks.

Partner #4 highlighted a more fundamental requirement, i.e., that feedstocks for insulation products must be readily available at affordable prices. This emphasizes the importance of supply chain viability and raw material economics for commercial success.

Partner #3 identified compatibility with common vapor barriers and finishes, and specific impact on the NTA 8800 calculation method—the Dutch national standard for calculating building energy performance that implements EU EPBD rules and is used for building permits and energy labels. This highlights the importance of integration with existing regulatory frameworks and building systems.

5.6 ADDRESSING KEY REQUIREMENTS

Coverage of Key Requirements

The validation exercise specifically addressed whether the stakeholder input adequately covered all aspects required by the SNUG project grant agreement: sustainability, energy efficiency, performance, environmental footprint, finance, and safety and security.

An important discussion emerged regarding the relative importance of these aspects. Partner #2 emphasized that sustainability is not considered as important among their customers and that energy efficiency and performance should be prioritized over sustainability, as they are often considered more critical factors by customers. Partner #4 agreed, suggesting that energy efficiency should be the primary consideration when selecting insulation products.

This perspective aligns with the survey findings, where 67% of respondents rated energy efficiency as very important and 63% rated thermal performance as very important, while only 40% rated sustainability as very important. However, both Partner #4 and Partner #2 noted that people often confuse sustainability with environmental footprint and performance with energy efficiency, suggesting that the corresponding survey results should be interpreted as indicative rather than definitive.

Partner #4 mentioned that they expected financing indicators to score higher values in terms of importance than the survey indicated, echoing the earlier concerns about cost considerations being underweighted in the results.

The survey results regarding the high importance of fire safety and lower importance of security parameters (strength and robustness) were confirmed as being in alignment with market observations. Partner #2 mentioned that the importance customers assign to robustness depends on the specific product and its intended use, suggesting context-dependent variation in security parameter importance.

Support for Commercial Objectives

Manufacturers were asked to assess how the survey findings support their commercial objectives. Partner #4 mentioned that with the exception of cost aspects, the survey findings were as expected and serve as verification of Partner's #4 objectives. This confirmation function provides valuable external validation of their strategic direction.

Partner #2 similarly indicated that the findings align with their market perspectives and verify their commercial strategy. This validation from independent research strengthens manufacturers' confidence in their current market positioning and development priorities.

Criteria Ranking Validation

Both Partner #4 and Partner #2 explicitly confirmed that customer preferences, in terms of order of importance, follow the hierarchy identified in the survey: technical criteria ranked highest, followed by economic, environmental, and finally social criteria. This confirmation validates the survey methodology's ability to capture relative priority structures that match manufacturers' market experience.

Validation Methodology Formalization

The validation methodology itself was discussed and formalized during the workshop. Participants agreed to formalize the workshop as an official validation phase of the research, with documentation consisting of manufacturer feedback questionnaires from Partner #1, Partner #2, Partner #3, Partner #4, and Partner #5, along with minutes from the validation workshop.

These validation materials have been integrated into the revised version of deliverable D2.1 through this section, documenting the manufacturer validation process and findings. All participants agreed with this validation methodology, providing formal endorsement of the approach.

5.7 FUTURE MANUFACTURER ENGAGEMENT

The validation workshop concluded with discussion of future collaboration opportunities within Work Package 7 of the SNUG project. Planned engagement activities were confirmed, including a) a workshop among project partners and key stakeholders to jointly analyze and validate outcomes from interviews, the quantitative survey, and the two-phase survey results targeting demo site users, and b) a meeting with manufacturers focused on the co-creation process for technologies under development.

These activities are planned to be conducted online. Participants confirmed their commitment to these planned engagement tasks, with the project coordinator highlighting the critical importance of continued manufacturer engagement for project success.

5.8 KEY TAKEAWAYS

The manufacturer validation exercise confirmed strong overall alignment between end-user priorities identified in the survey and manufacturers' direct market experience. The top-ranked specifications—health impact, energy efficiency, durability, thermal performance, and fire resistance—accurately reflect customer priorities across diverse market contexts and product categories.

However, the validation process also revealed important nuances and contradictions. Cost considerations appear underweighted in the survey results relative to their actual importance in purchasing decisions, particularly in certain industry sectors and market segments. Similarly, sustainability factors, while ranking low among current customer priorities, show signs of increasing importance, particularly in professional and public procurement contexts, suggesting an evolving market landscape.

The validation identified several communication challenges that manufacturers face in conveying technical specifications to customers, particularly regarding sustainability benefits, long-term durability metrics, and fire safety classifications. These findings suggest opportunities for developing more effective communication tools and customer education materials.

Manufacturers confirmed that the SNUG project's innovative materials align well with identified end-user priorities, while also acknowledging potential gaps in cost competitiveness, proven long-term performance data, moisture resistance, and supply chain maturity. These gaps represent areas requiring continued technical development and market strategy attention.

The validation methodology employed—combining a structured questionnaire with a collaborative workshop discussion—proved effective in capturing both individual manufacturer perspectives and collective insights. This approach successfully formalized manufacturer input as an integral component of the end-user requirements research, enhancing the robustness and practical relevance of the findings for guiding project development and commercialization strategies.

6 DISCUSSION

This study provides comprehensive insights into end-users' attitudes, behavior, and needs regarding innovative construction solutions, with a particular focus on thermal insulation materials. The findings reveal a complex landscape of priorities that reflects both practical building performance requirements and emerging sustainability concerns.

6.1 END-USER ATTITUDES TOWARD INNOVATIVE CONSTRUCTION SOLUTIONS

The survey results demonstrate that end-users maintain a pragmatic approach to insulation material selection, prioritizing specifications that deliver tangible, measurable benefits. The prominence of health and safety considerations—with impact on human health (70% rating it as "very important") and release of dangerous substances (68%)—signals a fundamental shift in market consciousness. This heightened awareness aligns with broader trends in building science emphasizing indoor environmental quality and occupant wellbeing.

The strong emphasis on durability (67% very important) and energy efficiency (67% very important) reflects end-users' desire for long-term value rather than short-term cost minimization. This finding suggests a maturing market perspective that considers lifecycle performance alongside initial investment, though the manufacturer validation revealed that cost considerations may still carry more weight in actual purchasing decisions than the survey rankings initially suggested.

Interestingly, the relatively low importance assigned to aesthetics (17% very important) and weight/density (15% very important) indicates that end-users view insulation primarily through a functional rather than aesthetic or handling convenience lens. This perspective may reflect the hidden nature of most insulation applications, where visual appeal matters less than performance characteristics.

6.2 BEHAVIOURAL PATTERNS IN MATERIAL SELECTION

The ranking of selection criteria—with technical factors rated most important, followed by economic, environmental, and social considerations—reveals the decision-making hierarchy that guides end-user behavior. This technical-first approach suggests that innovative construction solutions must first demonstrate functional excellence before other attributes become decisive factors.

The discrepancy between stated preferences and manufacturer observations regarding cost efficiency warrants particular attention. While cost efficiency/payback period ranked ninth in mean importance values, it emerged as the most frequently selected top-3 specification (11.5% of responses). This apparent contradiction suggests that cost operates differently in decision-making:

it may not be perceived as the most important specification in isolation, but functions as a critical threshold criterion that can override other considerations when not satisfied.

The knowledge-level analysis revealed significant behavioral differences among end-user groups. High-knowledge respondents demonstrated greater appreciation for technical specifications like thermal conductivity/thermal insulation performance and showed less concern for aesthetics, while low-knowledge respondents undervalued sustainability-related specifications including recyclability, reusability, and biodegradability. This pattern suggests that education and expertise influence not only what end-users know about insulation materials but also what they prioritize, with technical knowledge correlating to greater emphasis on performance metrics and environmental considerations.

6.3 NEEDS ASSESSMENT ACROSS KEY REQUIREMENTS

Sustainability

The survey revealed a complex relationship between stated sustainability priorities and market reality. Sustainability as an overall concept received moderate importance (40% very important), while specific sustainability-related specifications showed varied reception. Recyclability and reusability (30% very important), bio-based materials (18% very important), and biodegradable materials (23% very important) ranked among the least important specifications overall.

However, the manufacturer validation provided crucial context: while current customer priorities may not emphasize sustainability, regulatory trends and professional procurement requirements increasingly incorporate circular economy principles and embodied carbon considerations. This suggests a gap between present stated preferences and emerging market requirements, indicating that innovative solutions addressing sustainability must be positioned strategically, emphasizing co-benefits such as health, performance, and long-term cost-effectiveness rather than environmental attributes alone.

The knowledge-level analysis revealed that higher expertise correlates with greater appreciation for sustainability specifications. This pattern suggests that as market knowledge deepens—through education, experience, or regulatory requirements—sustainability considerations will likely gain prominence in decision-making.

Energy Efficiency

Energy efficiency emerged as a universally recognized priority, rated very important by 67% of respondents and ranking second in mean importance values. This specification demonstrated remarkable consistency across all knowledge levels, indicating broad market consensus on its value. The prominence of energy efficiency reflects both economic rationality (lower operating costs) and alignment with regulatory frameworks increasingly focused on building energy performance.

The related specification of thermal conductivity/thermal insulation performance (63% very important) similarly ranked high, confirming that end-users recognize the direct link between material properties and building energy consumption. Thermal comfort (60% very important) received somewhat lower but still substantial importance ratings, suggesting end-users distinguish between energy metrics and occupant experience, valuing both but prioritizing the former.

Performance

Performance-related specifications dominated the highest importance rankings. Durability (67% very important) and dimensional stability (49% very important) received substantial recognition. This emphasis reflects end-users' need for reliable, long-lasting solutions that maintain their properties throughout the building lifecycle.

Notably, water/water vapor resistance (54% very important) and resistance to weather changes (50% very important) were also highly valued, indicating awareness that insulation performance depends not only on initial properties but also on resilience under varying environmental conditions. The manufacturer validation confirmed these as critical specifications, with particular emphasis on moisture resistance as a common challenge for bio-based materials.

The survey also revealed gaps in performance-related needs that current sustainable materials may struggle to address. Manufacturers highlighted that bio-based and recycled materials sometimes face limitations in moisture resistance and durability, while also lacking decades of field validation that conventional materials possess. These gaps represent critical development priorities for innovative construction solutions.

Environmental Footprint

Environmental impact as a specification received moderate importance (38% very important), positioning it in the middle range of priorities. Contribution to climate change mitigation (44% very important) received similar recognition. These findings suggest that while environmental considerations have entered end-user consciousness, they do not yet drive decision-making to the same extent as direct performance and health factors.

The manufacturer validation highlighted an important nuance: end-users often conflate environmental impact with sustainability or performance, suggesting confusion in terminology that may affect how environmental specifications are perceived and evaluated. This finding indicates a need for clearer communication frameworks that distinguish between operational environmental impacts (such as energy consumption during building use) and embodied environmental impacts (such as manufacturing emissions and resource depletion).

Finance

Financial considerations manifested in multiple specifications: cost efficiency/payback period (52% very important), installation and acquisition costs (44% very important), and maintenance easiness and cost (34% very important). While none individually topped the importance rankings, their

collective presence throughout the survey and their prominence in the top-3 selection (cost efficiency/payback period at 11.5%) confirms their fundamental role in decision-making.

The manufacturer validation emphasized this aspect forcefully, with multiple manufacturers noting that cost represents a more decisive factor in actual market transactions than survey rankings suggest. This discrepancy may reflect social desirability bias in surveys, where respondents are reluctant to emphasize cost over environmental or health considerations, or it may indicate that cost functions as a qualifying criterion rather than a differentiating one—materials must be cost-competitive to be considered, after which other factors determine selection.

Property value increase (33% very important) received lower importance ratings, suggesting that end-users focus more on direct costs than on potential resale benefits. This finding may reflect either uncertainty about quantifying property value impacts or a primary concern with immediate financial implications rather than long-term investment returns.

Safety: Fire Resistance

Fire safety received strong recognition across multiple related specifications. Resistance to fire (59% very important), fume emission during fire (57% very important), and the broader safety implications captured in impact on human health all ranked highly. This pattern indicates that end-users view fire safety comprehensively, considering not only the material's resistance to ignition and flame spread but also its behavior during fire events, particularly toxic emissions.

The manufacturer validation confirmed these priorities align with market experience and regulatory requirements. Fire safety classifications (such as Euro class EN 13501-1) serve as critical proof points in market communication, though manufacturers noted that conveying the nuances of fire safety ratings to less knowledgeable end-users remains challenging.

The relatively high importance assigned to fire safety specifications across all knowledge levels suggests that safety concerns transcend expertise, representing fundamental anxieties that all building occupants and owners share regardless of technical understanding.

Security: Robust Strength

Security-related specifications, interpreted as mechanical strength/robustness (27% very important) and perforation vulnerability (25% very important) received moderate importance ratings. Attributes such as resistance to corrosion (44% very important) and resistance to fungi (51% very important) received higher recognition.

The manufacturer validation provided important context: the importance of robustness specifications depends heavily on application context. Materials used in exposed applications or subject to mechanical stress require higher strength than those used in protected cavity applications. This context-dependency may explain the moderate average importance ratings—different end-users weight these specifications differently based on their specific use cases.

The lower emphasis on security compared to safety (fire) specifications may reflect a perception that structural failures and mechanical damage represent less catastrophic risks than fire events, or it may indicate that end-users rely on building design and other systems to provide structural security rather than expecting insulation materials themselves to serve load-bearing or protective functions.

6.4 IMPLICATIONS FOR INNOVATIVE CONSTRUCTION SOLUTIONS

The comprehensive needs assessment reveals that successful innovative construction solutions must achieve a multi-dimensional value proposition. Materials cannot succeed on environmental credentials alone but must deliver competitive performance on the technical specifications that end-users prioritize: health and safety, thermal performance, durability, and moisture resistance. Cost competitiveness, while sometimes understated in surveys, remains a fundamental market requirement.

The knowledge-level analysis suggests opportunities for market development through education. As end-users gain expertise, they demonstrate greater appreciation for technical performance nuances and environmental considerations. This finding implies that market transformation toward innovative sustainable solutions requires parallel efforts in product development and market education.

The manufacturer validation identified several critical development needs for innovative materials: achieving proven long-term durability, ensuring moisture resistance comparable to conventional materials, developing cost-competitive production and supply chains, and effectively communicating complex technical benefits to varied audiences. These challenges represent the frontier where material innovation must meet market requirements to enable widespread adoption of sustainable construction solutions.

7 CONCLUSIONS

This study has comprehensively evaluated end-users' attitudes, behavior, and needs regarding innovative construction solutions, specifically thermal insulation materials, across the critical dimensions of sustainability, energy efficiency, performance, environmental footprint, finance, safety, and security. The research integrates findings from a systematic literature review, a survey of 115 end-users from 12 European countries, and a validation exercise with five building component manufacturers from the SNUG project consortium.

7.1 KEY FINDINGS ON END-USER REQUIREMENTS

Sustainability: End-users currently assign moderate priority to sustainability considerations, with specific sustainability-related specifications—particularly bio-based materials (18% very important), biodegradable materials (23% very important), and recyclability/reusability (30% very important)—ranking among the least important overall. However, the knowledge-level analysis revealed that higher expertise correlates with greater appreciation for sustainability attributes, suggesting that market education and increasing regulatory requirements will elevate these considerations over time. The manufacturer validation confirmed that professional procurement and public projects increasingly incorporate circular economy criteria despite relatively low current customer emphasis.

Energy Efficiency: Energy efficiency emerged as a universal priority, rated very important by 67% of respondents and demonstrating remarkable consistency across all knowledge levels. This specification represents one of the strongest areas of market consensus, reflecting both economic rationality and alignment with regulatory frameworks. The related attribute of thermal conductivity/thermal insulation performance (63% very important) similarly ranked high, confirming that end-users recognize the direct connection between material properties and building energy consumption.

Performance: Performance specifications dominated the highest importance rankings, with durability (67% very important), thermal conductivity/thermal insulation performance (63% very important), water/water vapor resistance (54% very important), and dimensional stability (49% very important) all receiving strong recognition. This emphasis reflects end-users' fundamental need for reliable, long-lasting solutions that maintain their properties throughout the building lifecycle. The manufacturer validation identified moisture resistance and proven long-term durability as critical challenges for innovative bio-based and recycled materials seeking market acceptance.

Environmental Footprint: Environmental impact (39% very important) and contribution to climate change mitigation (44% very important) received moderate importance ratings, positioning environmental considerations in the middle range of priorities. The manufacturer validation revealed that end-users often conflate environmental impact with sustainability or operational performance, suggesting terminology confusion that affects how environmental specifications are perceived. This finding indicates that environmental benefits of innovative materials may be most effectively

communicated through tangible co-benefits such as improved indoor air quality or reduced operating costs.

Finance: Financial considerations manifested across multiple specifications, with cost efficiency/payback period (52% very important), installation and acquisition costs (44% very important), and maintenance easiness and cost (34% very important) all receiving substantial attention. Notably, cost efficiency/payback period was selected most frequently (11.5% of responses) when participants identified their top-3 specifications, despite ranking ninth in overall mean importance. The manufacturer validation emphasized this discrepancy, confirming that cost represents a more decisive factor in actual market transactions than survey rankings suggest. This pattern indicates that cost functions as a critical threshold criterion—materials must be cost-competitive to be considered, after which other factors determine final selection.

Safety (Fire Resistance): Fire safety received strong recognition across multiple related specifications, with resistance to fire (59% very important), fume emission during fire (57% very important), and impact on human health (70% very important) all ranking highly. This comprehensive view of fire safety—encompassing both resistance to ignition and toxic emissions during fire events—indicates sophisticated end-user understanding of fire risks. The high importance assigned to fire safety across all knowledge levels suggests that safety concerns transcend expertise, representing fundamental priorities for all building stakeholders.

Security (Robust Strength): Security-related specifications, interpreted as mechanical strength/robustness (27% very important) and perforation vulnerability (25% very important) received moderate importance ratings. Attributes including resistance to corrosion (44% very important) and resistance to fungi (51% very important), showed higher recognition. The manufacturer validation provided critical context: robustness importance varies significantly by application, with exposed or mechanically stressed installations requiring higher strength than protected cavity applications. This context-dependency explains the moderate average ratings, as different end-users weight these specifications according to their specific use cases.

7.2 BEHAVIOURAL PATTERNS AND MARKET SEGMENTATION

The ranking of overall selection criteria—technical factors first, followed by economic, environmental, and social considerations—reveals the decision-making hierarchy guiding end-user behavior. This technical-first approach establishes that innovative construction solutions must demonstrate functional excellence before other attributes become decisive factors.

The knowledge-level analysis revealed significant behavioral differences among end-user segments. High-knowledge respondents (40% of the sample) demonstrated significantly greater appreciation for technical performance specifications and sustainability considerations, while rating aesthetics as less important. Low-knowledge respondents (20% of the sample) assigned significantly lower importance to biodegradable materials, recyclability and reusability, supply security, sustainability, and thermal conductivity/thermal insulation performance. These statistically

significant differences ($p < 0.05$) indicate that education and expertise fundamentally shape what end-users prioritize, with technical knowledge correlating to greater emphasis on performance metrics and environmental considerations.

This segmentation has important implications for market development: as average market knowledge increases through education, experience, and regulatory requirements, demand for technically superior and environmentally responsible solutions will strengthen. Manufacturers must therefore tailor communication strategies to audience knowledge levels, providing detailed technical specifications and lifecycle assessments for professional specifiers while emphasizing tangible benefits such as comfort, health, and cost savings for less knowledgeable end-users.

7.3 STRATEGIC IMPLICATIONS FOR THE SNUG PROJECT

The findings provide clear guidance for developing innovative SNUG products that align with market requirements while advancing sustainability objectives:

1. **Prioritize health and safety specifications:** Impact on human health, release of dangerous substances, and fire safety must be demonstrably superior or equal to conventional materials. These non-negotiable requirements represent the foundation of market acceptance.
2. **Ensure competitive thermal performance:** Energy efficiency and thermal conductivity/thermal insulation performance rank among the top priorities across all end-user segments. Innovative materials must deliver thermal performance that meets or exceeds conventional alternatives.
3. **Demonstrate proven durability and moisture resistance:** The manufacturer validation identified these as critical challenges for bio-based materials. SNUG products must provide robust evidence of long-term performance under realistic building conditions, including moisture exposure.
4. **Achieve cost competitiveness:** Despite moderate survey rankings, financial considerations—particularly cost efficiency and payback period—function as qualifying criteria in actual purchasing decisions. SNUG products must offer compelling economic value propositions to enable market penetration.
5. **Position sustainability strategically:** Rather than emphasizing environmental attributes in isolation, SNUG products should integrate sustainability into a comprehensive value proposition that highlights health benefits, operational energy savings, and long-term durability. This approach acknowledges current market priorities while building demand for circular economy solutions.
6. **Address communication challenges:** The manufacturer validation identified significant challenges in communicating complex technical specifications to diverse audiences. SNUG

project dissemination should develop clear, audience-appropriate communication frameworks that translate technical innovations into tangible benefits for different end-user segments.

7.4 CONTRIBUTION TO KNOWLEDGE

This research makes several important contributions to understanding market requirements for innovative construction solutions. First, it provides quantitative evidence of end-user priorities across a comprehensive range of insulation material specifications, revealing the relative importance of different performance attributes. Second, the knowledge-level segmentation demonstrates how expertise shapes priorities, with important implications for market education strategies. Third, the manufacturer validation bridges the gap between stated survey preferences and actual market behavior, revealing critical discrepancies particularly regarding cost considerations and providing practical insights into commercialization challenges.

The study confirms that successful market transformation toward sustainable construction solutions requires simultaneous advances in multiple dimensions: technical performance must match or exceed conventional materials, cost structures must achieve competitiveness, communication strategies must effectively convey benefits to varied audiences, and regulatory frameworks must increasingly recognize and reward environmental performance. The SNUG project, through its focus on innovative bio-based and circular economy insulation materials, operates at this critical intersection of technical innovation and market requirements.

The findings ultimately demonstrate that end-users maintain pragmatic, multi-dimensional perspectives on insulation materials, prioritizing health, safety, and performance while showing increasing but still developing awareness of sustainability considerations. Innovative construction solutions that deliver superior performance across these interconnected requirements—while effectively communicating their benefits to market segments at varying knowledge levels—are positioned to transform the building materials sector toward greater sustainability and energy efficiency.

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9 ANNEX A: LETTER TO STAKEHOLDERS

<your letterhead>

<date>

To:

Subject: Interviews of stakeholders on desired properties of biobased thermal insulation panels

Dear Sir/Madam,

One key objective of the EU project SNUG “*Innovative methodology based in circular economy and artificial intelligence to foster the transition to Sustainable and very high eNergy performance bUildinGs at a cost optimal level*” is to **develop new thermal insulation and lightweight prefab solutions**, made of local renewable materials and bio-based components, addressing sustainability and environmental impact of buildings.

In this matter, and as we consider you as a key market actor, we seek your opinion on which are the most desired properties of these new thermal insulation prefab solutions that we plan to develop. Please let us know by 23 February if you will assist us in our task by completing the interview protocol (document), which will be sent to you in the beginning of March 2024.

Your response will be treated with utmost confidence and the information you provide will be anonymised when processed further and solely used for the purpose of the SNUG project.

Please respond at the email: <your email>

Sincerely,

<name> <signature>

Attachment: SNUG_project overview.pdf

10 ANNEX B: QUESTIONNAIRE

Questionnaire: Desired properties of buildings' thermal insulation

Introduction

Thank you for volunteering to participate in this interview regarding the desired properties of buildings' thermal insulation. This interview aims to understand what the market needs for building insulation are. This study is part of the SNUG European project (<https://snugproject.eu/>). Participating in this interview is voluntary and you can withdraw at any time.

This research is anonymous. This means nobody, including the researchers, will be aware of your identity. By answering it, you consent to use your responses in this research. Your answers will remain completely anonymous and unidentifiable. Once you submit the survey, it will be impossible to retract your answer. Please do not include any personal identifiable information in your responses. The collected information will be aggregated and presented in the SNUG project Deliverable 2.1 and relevant dissemination activities.

If you have any questions, either now or in the future, please feel free to contact Dr. Spyridon Karytsas, spkary@cres.gr, Center for Renewable Energy Sources & Saving (CRES), Athens, Greece.

A. Background information

A0. Please select your country of residence.

- Austria
- France
- Germany
- Greece
- Ireland
- Norway
- Portugal
- Spain
- Switzerland
- The Netherlands
- The UK
- Turkey
- Other [*please define*]

A1. Which of the following descriptions fit you?

Please check all that apply.

- Architect, planner, engineer
- Association of building component manufacturers
- Building and construction company
- Building occupant
- Building owner (private, multiple buildings)
- Building owner (private, single building)
- Building owner (public sector)
- Certification provider/ energy auditor
- Energy consultant
- Facility manager
- Financing organization
- Professional organization for building and construction
- Property manager
- Public authority
- Real estate agent
- Other [*please define*]

A2. How deep is your knowledge on insulation materials?

- Very Low
- Below Average
- Average
- Above Average
- Very High

B. Insulation materials specifications

B1. How do you evaluate the importance of the following specifications of insulation materials?

	Low importance	Slightly important	Moderately important	Considerably important	Very important	<i>I do not know</i>
1. Aesthetics	0	0	0	0	0	0
2. Bio-based material	0	0	0	0	0	0
3. Biodegradable material	0	0	0	0	0	0
4. Building site adaptability and cuttability	0	0	0	0	0	0
5. Contribution to climate change mitigation	0	0	0	0	0	0
6. Cost efficiency/ payback period	0	0	0	0	0	0
7. Delivery time	0	0	0	0	0	0
8. Dimensional stability (ability to maintain shape and size over time and under different conditions)	0	0	0	0	0	0
9. Durability (proof of quality over time)	0	0	0	0	0	0
10. Ease and speed of installation	0	0	0	0	0	0
11. Energy efficiency (less energy consumption in the building)	0	0	0	0	0	0
12. Environmental impact (including energy and materials used in production)	0	0	0	0	0	0
13. Fume emission during a fire	0	0	0	0	0	0
14. Impact on human health	0	0	0	0	0	0
15. Improvement and control of indoor air quality	0	0	0	0	0	0
16. Installation and acquisition costs	0	0	0	0	0	0
17. Maintenance easiness and cost	0	0	0	0	0	0
18. Mechanical strength/robustness	0	0	0	0	0	0
19. Perforation vulnerability	0	0	0	0	0	0
20. Property value increase	0	0	0	0	0	0
21. Recyclability & reusability	0	0	0	0	0	0
22. Release of dangerous substances	0	0	0	0	0	0
23. Relevance and synergy with other materials	0	0	0	0	0	0
24. Resistance to corrosion	0	0	0	0	0	0
25. Resistance to fire	0	0	0	0	0	0
26. Resistance to fungi	0	0	0	0	0	0
27. Resistance to weather changes	0	0	0	0	0	0
28. Sound insulation and noise reduction	0	0	0	0	0	0
29. Supply security (availability)	0	0	0	0	0	0
30. Sustainability	0	0	0	0	0	0
31. Technology maturity	0	0	0	0	0	0
32. Thermal comfort	0	0	0	0	0	0
33. Thermal conductivity/ thermal insulation performance	0	0	0	0	0	0
34. Water/water vapor resistance	0	0	0	0	0	0
35. Weight/density	0	0	0	0	0	0

B2. Please define the three (3) most important specifications of insulation materials from the list mentioned above:
[Open Question]

B3. If you think there are other significant specifications of insulation materials that are not mentioned above, please specify them here in your own words.
[Open Question]

B4. How do you rank the following criteria for selecting insulation materials in terms of their importance?

	Economic	Environmental	Social	Technical
1. First choice in terms of importance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Second choice in terms of importance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Third choice in terms of importance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Fourth choice in terms of importance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

12 ANNEX D: QUESTIONNAIRE FOR MANUFACTURERS FEEDBACK

Expert Feedback on End-User Requirements for Thermal Insulation Materials

As part of the SNUG project's efforts to develop innovative sustainable thermal insulation materials, we have completed a comprehensive study on end-user perceptions and requirements for insulation materials (D2.1). We would greatly value your expert feedback as building component manufacturers to validate our findings and better understand how this research can support your commercial objectives. Our study surveyed 115 end-users across 12 EU countries and identified the following priority rankings for insulation material specifications (among 35 examined specifications):

Most Important Specifications:

1. Impact on human health
2. Energy efficiency
3. Durability
4. Thermal conductivity/thermal insulation performance
5. Release of dangerous substances
6. Resistance to fire
7. Thermal comfort
8. Resistance to fungi
9. Cost efficiency/payback period
10. Water/ water vapor resistance

Least Important Specifications:

1. Recyclability & reusability
2. Delivery time
3. Bio-based material
4. Biodegradable material
5. Weight/density
6. Aesthetics

Overall Criteria Ranking:

1. Technical
2. Economic
3. Environmental
4. Social

We also found significant differences based on end-user knowledge levels, with less knowledgeable users undervaluing sustainability factors (such as biodegradable material, recyclability and reusability, and sustainability)

1. Market Validation

1.1 Do these findings align with your experience of customer priorities and market demands?

--

1.2 Are there any surprising results that contradict your market observations?

--

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1.3. Which specifications do you find most challenging to communicate to customers?

--

2. Product Development & Strategy

2.1 How could these insights influence your product development priorities for sustainable insulation materials?

--

2.2 Given that sustainability factors ranked lower for less knowledgeable users, how do you currently educate customers about these benefits?

--

2.3 Do you segment your marketing approaches based on customer knowledge levels, and if so, how?

--

3. Commercial Application

3.1 Which of these findings could most directly impact your:

- Product positioning strategies?
- Sales and marketing messages?
- R&D investment decisions?

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4. SNUG Project Alignment

4.1 How well do these end-user priorities align with the innovative materials being developed in the SNUG project?

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4.2 Are there any potential gaps between what end-users want and what sustainable/circular economy materials can deliver?

--

4.3 What additional insulation material specifications would be most valuable for the project's success?

--

Thank you for your participation!

13 ANNEX E: AGENDA OF DEDICATED ONLINE WORKSHOP

SNUG Project Workshop: Validation of Deliverable 2.1

Duration: 1 hour | Format: Online

Objective

Validate D2.1 findings with thermal insulation manufacturers and address European Commission review queries

Agenda

1. Welcome & Context (5 min)

- Workshop purpose and EC review queries
- Participant introductions

2. D2.1 Key Findings Recap (10 min)

- Top 10 priority specifications (health, energy efficiency, durability, thermal performance)
- Overall criteria ranking: Technical > Economic > Environmental > Social
- Knowledge-level differences on sustainability

3. Manufacturer Validation Feedback (25 min)

3.1 Market Alignment (8 min)

- Confirmation of findings vs. contradictions
- Cost efficiency positioning discussion
- Sustainability factors: current vs. anticipated demand

3.2 Practical Implications (10 min)

- Communication challenges (durability metrics, EPDs, fire classifications)
- Product development priorities
- Marketing segmentation by customer knowledge levels

3.3 Gaps & Additional Needs (7 min)

- Cost competitiveness of sustainable materials
- Long-term durability validation
- Missing specifications: acoustic performance, dismantling, carbon footprint, feedstock availability

4. Addressing EC Queries (15 min)

Q1: DoA coverage completeness

- Validation of stakeholder input on all required aspects

Q2: Assistance to manufacturers

- Discussion: How can findings better support commercial objectives?

Q3: Criteria ranking methodology

- Manufacturer perspective on technical > economic > environmental > social

Q4: Validation methodology

- Formalizing this workshop as validation phase
- Next steps for manufacturer engagement

5. Next Steps & Close (5 min)

- Documentation of validation feedback
- Integration into D2.1 revision
- Future collaboration opportunities

Pre-Workshop Materials

- D2.1 Executive Summary
- Manufacturer feedback questionnaires (AGITEC, CHIMAR, KEAS, TAKKENKAMP)

