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The Centre for Sustainable Design[®]

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Sustainable Innovation 2025

Mission: Planet - Harnessing Compound Interest and Token Economics to Fund Climate Action at Scale - Keiron Allen	4
The Design Compass®: Evaluating a New Tool for Senior Product Design with Students - Simon Andrews, Evy Dutheil, Rebecca Falcon, Stefan Knox	5
Sustainable Innovation: Past, Present and Future - Mike Barry	17
Climate Change, Net Zero and Product Decarbonisation - James Cameron	18
Ensuring Trust in Sustainability Claims: Standards, Compliance, and Industry Impacts under the European Green Deal- Raul Carlsson, Tatiana Nevzorova	19
Sustainable Innovation: An Overview - Martin Charter, Trevor Davis	29
Digital Decarbonisation in Fashion: A Case Study for Creative Industries' Climate Resilience - E Cox	37
Materials-First and Product-First Approaches to Creating Local, Circular & Bio-based Textiles in the HEREWEAR Project - Rebecca Earley, Guy Buyle, Lien Van der Schueren, Nona Dokuzova, Denitsa Nika, Laetitia Forst	44
Embedding Regenerative Design in Design Education: A Framework for Interdisciplinary Collaboration and Climate Conscious Innovation - S Fallouh, K Ryan, K Wilmot	48
Sustainable Design: Where Are We Now? - Jerme Faludi	63
Cross-Functional Approach Towards Product Sustainability Implementation in the Household Appliances Sector: an Italian Case Study. Drivers, Limitations and Insights from Field Research Interviews - Stefano Ferraresi, Barbara Del Curtoo	64
Influencing Motivations: Exploring how Social Media Influencers and Voucher Schemes may be Fuelling a Pre-owned Denim Revolution - Jules Findley, Martin Bouette, Claire Dawson	76
The Cultural Barriers to Sustainable Innovation within Organisations - Ari Hautaniemi	87
Co-Designing Transparency: Understanding Barriers and Opportunities in the Transition Toward a Transparent Shipbreaking Industry - Maria Marilyn Joseph, Alessio Franconi, Elise Hodson	95
One for One: Vodafone Germany & Closing the Loop's Customer-Centric and Pragmatic Circularity Leads to the Recovery of over 2.7 Million Scrap Phones - Joost de Kluijver	110
Antecedents, Moderators, Mediators, and Outcomes of Circular Business Models: A Systematic Literature Review - V.Litaudon, M. Altaf, M. Borsara	118
The Just Fashion Project: EU Policies Transforming the Fashion and Textile Sector - V Litaudon	119
The Maze of Circularity Standards Landscape - Pradeep Mahat, Susanna Kallio	120

Sustainable Innovation 2025

Design for Degrowth- Wardrobe Analysis to Inform a New Business Lease Model in Fashion and Clothing - Nicola Mansfield	136
Eco-Design as a Catalyst for Circular Innovation: A Knowledge-Based Framework to Sustainable Product Development - Enrica Monticelli, Francesco Zurlo	159
Post-manufacturing Production – a Key Circular Economy Concept Prolonged Product Lifetime - Tatiana Nevzorova, Raul Carlsson	169
A Practice-based Material Exploration of Chitosan Coatings for Sustainable Fashion - Mingsheng Ni.....	179
Thinking Global, Acting Local: Designing for Regenerative Solutions - Paula Nurminen, Noora Nylander, Mervi Koistinen, Aino Vepsäläinen.....	189
Challenges to the Adoption of Textile Biomaterials and the Potential Role of Digital Supply Chain Platforms - Josef Pacal, Gareth Loudon, Steve Evans, Sharon Baurley	198
Traceability 5.0: Why Digital Product Passports Will Reshape Consumer Trust and Business Models - Anand Rao, Abhijit Chatterjee.....	205
Designing Low-carbon Innovation: Slowing Design Loops for Sustainable Resource Usage and Products - Mohammad Idrees Rasouli.....	214
Integrating Circular Economy Principles into New Product Development: Challenges and Opportunities in the Household Appliance Sector - Benedetta Rotondo, Venanzio Arquilla....	231
Affecting and Affected: B Corp Representations of the Environment as a Stakeholder - Mark Ryan.....	249
Product Circularity, Strategies, Indicators and Challenges: Insights from Industry - Lilian Sanchez Moreno.....	251
Comparative Analysis of Decarbonisation Pathways of Electric and Fuel Powered Vehicles - Muhammad Shafique	252
Transparency in Care Labels: the Key Enabler for a Circular Fashion System - Beatrice Soncina	253
Developing a Circular PSS: Insights on the Adaptation of Regulations Through a Reusable Packaging Case Study at an Airport - E Tschavgova, S van Dam, C Bakker, J van Engelen, R Jonyer, A Rognan	261
Developing a Circular Design Approach: Towards Truly Sustainably Stronger Solutions - Aino Vepsäläinen, Noora Nylander	270
Sustainable Design as a Catalyst for Biodiversity Conservation and Circular Economy Innovation: with Reference to the Hospitality Sector in Asia Pacific - Mark Watson	277

Cross-Functional Approach Towards Product Sustainability Implementation in the Household Appliances Sector: an Italian Case Study. Drivers, Limitations and Insights from Field Research Interviews

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Keywords

Ecodesign; Product sustainability; Material selection; Material innovation; Household Appliances; Corporate Sustainability; Organisational change; Sustainability culture; Sustainability drivers; Sustainable innovation approach; Case study research; Interviews; Participatory approach; Cross-functional collaboration

Abstract

A research project conducted in collaboration between Politecnico di Milano and a major Italian appliance manufacturer aims to define a cross-functional and participatory approach to advance product sustainability within this industrial sector. The paper outlines the overall research protocol and focuses on findings from preliminary interviews conducted during an extended field research period within the company. These interviews involved staff responsible for product-related decisions. Results include current materials and design choices' driver e.g., regulatory compliance and competitiveness. Perceived barriers to the implementation of sustainability-related actions are also presented, mainly related to operational and cultural aspects, such as the lack of a shared corporate sustainability background, ecotools, and structured processes. Accordingly, recommendations include fostering a sustainability culture, formalising internal guidelines, and defining clear objectives and KPIs. Methodological steps for subsequent validation and generalisation of the findings are described to ensure broader applicability of the approach. The study, still ongoing, confirms the potential of academia-industry collaboration for generating actionable insights, guiding organisational change, and supporting the integration of sustainability strategies in industrial contexts.

Premise

Delivering a sustainable transition within firms demands substantial commitment and cross-functional coordination underpinned by organisational capabilities and change processes (Amui et al. 2017; Castro-Lopez et al. 2023).

In the European context, the urgency of this transition for product manufacturers is underscored by a suite of legislative instruments acting across multiple phases of product development: material selection, product design, and information traceability under the Ecodesign for Sustainable Products Regulation (ESPR) (European Union 2024a) together with the Digital Product Passport (DPP), and the Critical Raw Materials Act (CRMA) (European Union 2024b); environmental claims and marketing

communications under the Greenwashing (European Union 2024c) and Green Claims (European Commission, 2023) initiatives; downstream activities following sale under the Right to Repair Directive (European Union 2024d) and national measures such as France's AGECE law (République Française 2020); and, more broadly, the promotion of Circular Economy principles implementation for industries through wider initiatives such as the Circular Economy Act (European Commission, Directorate-General for Environment 2025), currently under public negotiation.

In parallel, technical standards are defining requirements for tracking and exchanging information on product circularity along the value chain in an interoperable manner e.g. the Product Circularity Data Sheet (ISO 2025a), as well as methodological guidelines for integrating circularity into the product design and development process – focusing on material efficiency and trade-offs without compromising product functionality and safety – set out in EN 45560 (ISO 2025b), part of the EN 4555x-4556x family on durability, reparability, reusability, upgradability, remanufacturability, use of reused components, recyclability and recycled content; and communication on critical raw materials.

Consequently, for firms it becomes critical – within the continually evolving framework of corporate sustainability – to integrate specific objectives and strategies for product sustainability, alongside the capabilities required to measure it using standardised criteria and methodologies such as Life Cycle Assessment (ISO 2006a,b; Zampori et al. 2019).

Introduction & research aim

Along this sustainable transition pathway, collaboration with the research community can help to inform and steer the change process. Moreover, fostering sustained dialogue and partnership between academia and industry represents a valuable opportunity to generate fruitful synergies: scholars, as privileged observers of emerging research agendas, can offer innovative, scientifically robust and long-term methodological insights, while companies can, in turn, sharpen researchers' awareness of the real-world challenges faced by industry. As illustrated by Andriamanantena et al. (2025), external collaboration with industry networks, NGOs, and research institutions – including universities – is a critical determinant for the effective implementation of sustainability-oriented strategies in traditional enterprises. Furthermore, as stated by Hervas-Oliver et al. (2021), collaboration between academia and industry is a key driver of innovation across European regions, often exerting an even greater effect than internal R&D investment, particularly in intermediate-innovation contexts such as Italy.

Building on this premise, the Italian institutional initiative 'From Research to Business' (MUR 2023) – under which the Ministry of University and Research co-funds PhD research projects alongside Italian companies – aims to support sustainable innovation. One such project, co-financed by a large (European Commission, 2003) Italian household appliance enterprise and currently conducted by the authors, pursues the development of a novel holistic cross-functional approach to product sustainability that integrates sustainability-oriented material selection – to ensure a responsible and circular use of resources – with ecodesign – to reduce impacts along the product life cycle – tailored to the appliance sector.

To date, at least regarding scholarly knowledge, both material selection (Ashby 2022; Ashby 2012; Ashby & Johnson 2013) and sustainable and circular design (Bakker et al. 2014; Bhamra & Lofthouse 2016; Bocken et al. 2016; Clark et al. 2009; Vezzoli & Manzini 2008) are individually broadly explored fields and can count on major literature contributions. However, these theoretical approaches although potentially valid are sometimes not actually and efficiently implemented in real business contexts. This implementation gap affects the full exploitation of the competitive advantage and environmental benefits that such methodological strategies and processes could offer if introduced from the early product design and material selection phases. Instead, introducing these concepts would enable household appliance manufacturers to be prepared for if not anticipate the increasingly strict regulatory framework, thereby ensuring product compliance.

Accordingly, this novel approach aims to be guided by, and informed through, field research within a company case study and Participatory Action Research (PAR); and enable the systemic (Bistagnino 2011) diffusion of product sustainability within the company context, extending beyond sole designers and engineers to the cross-functional actors who shape and operationalise the integrated product strategy.

This contribution presents the overall research strategy of the project and discusses the preliminary findings from the interviews carried out during the field research conducted within the above-mentioned company.

Methods

PhD methodological approach

The PhD research, based on a mixed-methods approach, involved a 9-month field research period at the corporate headquarters in Italy. During this period, a two-phase research protocol composed of the strategies described hereafter has been followed.

- 1) To map the company context, understand the current ('As-Is') state of product sustainability-related practices and the main stakeholders, on-site observations as well as unstructured and semi-structured interviews were conducted, as described in detail in the following paragraph.
- 2) Based on the findings from on-site observations and interviews: (2.1) A briefing was convened involving nineteen top managers and directors from company functions identified as product-impacting (i.e. Procurement & Logistics, Mechanical Design Department, Electronic Department, Product Management, Marketing & Communications Department, Project Management, Product Compliance Office, Laboratories and R&D Department). During this session, key concepts relating to product sustainability – intended for integration within the company culture – were presented to highlight their strategic importance, along with a cross-functional activities plan aimed at transferring these concepts to relevant departmental staff. (2.2) Subsequently, in collaboration with the top managers and directors of functions who participated in the briefing, a total of eighty-three individuals from various functions and differing levels of seniority were identified. This group was then involved in training initiatives and participatory activities (workshops and focus groups) centred on product sustainability (e.g. Circular economy concept and principles, ESG criteria, corporate sustainability fundamentals, design for sustainability methods and tools, LCA and some insights on the EU legislative framework). The effectiveness of these activities was assessed using questionnaires administered before and after the process.

Semi-structured and unstructured interviews – Methodology and objectives

An in-depth case study research was conducted using the partner household appliance company as the analytic unit, during the aforementioned period of field research. To map the organisational context, semi-structured and unstructured interviews were carried out.

In collaboration with a corporate tutor, the researcher selected sixteen candidates at different working career stages (Chourasiya & Agrawal 2019; Super 1980) from departments whose decisions influence the product, ranging from product strategy definition, through design and testing, to final communication. The technical staff interviewed are involved in the design of major appliances. Additionally, two representatives from the Legal & CSR Department, responsible for CSR topics and the drafting of the Sustainability Report, were interviewed.

An overview of the company departments to which the interviewees belong, as well as their career stage, is provided in Table. 1.

Department	Working Career Stage (Super, D. E., 1980; Chourasiya, A., & Agrawal, V., 2019).
Project Management	Establishment
Product Management	Establishment
Product Compliance Office	Maintenance
Product Compliance Office	Establishment
Mechanical Design Department	Maintenance
Mechanical Design Department	Maintenance
Mechanical Design Department	Establishment
Mechanical Design Department	Establishment
Mechanical Design Department	Establishment
Electronic Department	Establishment
Laboratories and R&D Department	Establishment
Health, Safety & Environment (HSE) Department	Establishment
Marketing & Communications Department	Maintenance
Marketing & Communications Department	Establishment
Procurement & Logistics	Maintenance
Procurement & Logistics	Maintenance
Legal & CSR	Establishment
Legal & CSR	Establishment

Table 1 – Details of the interviewees.

The interviews were conducted in person, each lasting between 45 minutes and one hour. The topic guides were designed in accordance with qualitative research interviewing guidelines (Harvey 2011; Bryman 2016; Kvale & Brinkmann 2009; Kvale 2007).

The interviews allowed researchers to map product-related decision-making processes, as well as the roles and interactions among departments responsible for product design and materials selection. They enabled the identification of current drivers for design and material choices, provided an understanding of the present ('As-Is') level of integration of product sustainability methods and tools, and, crucially, helped to pinpoint factors perceived as limiting the implementation of sustainability-related initiatives and to highlight potential areas for improvement to better steer the company towards sustainability, as indicated by the interviewees.

To extract information from the interviews, qualitative research analysis methods were applied (Belotto 2018). In particular, the interviews were transcribed and subjected to thematic analysis (Alhojailan & Ibrahim 2012).

Findings & Discussion

This section presents and discusses the main findings from the interview analysis. Specifically, it first addresses the investigation of current drivers for product design and material choices. Then, it examines employees' involvement in product sustainability-related projects and the integration of ecodesign and material selection tools into current practice. Finally, it highlights the critical factors that nowadays limit the implementation of sustainability-related actions, as well as the areas for improvement that could better guide the company towards sustainability.

Product design and materials choices 'drivers

Product design drivers

The interviews clearly indicate that when it comes to product design, the most cited drivers are economic competitiveness/costs (8 out of 16 respondents) and regulatory compliance (7/16). Notably, most interviewees also cited these drivers as the most important when asked to rank them in order of

Sustainable Innovation 2025

significance. Quality was another driver mentioned by the interviewees (4/16), which aligns with the company's objectives, as its Sustainability Report materiality matrix highlights quality as one of the most significant product-related aspects. Finally, feasibility and functionality (3/16), as well as design for assembly (4/16), are regarded as important by a significant minority. The technical feasibility and manufacturability of the product are especially relevant, given that many production and assembly lines are managed internally within the company.

Materials choices drivers

For material selection, regulatory compliance figures even more prominently (9/16), since appliances are subject to various regulations – often cited by interviewees – such as REACH, RoHS, and those relating to food contact. In this regard, three interviewees explicitly mentioned food contact and avoidance of hazardous materials. The second most cited driver is again economic competitiveness/costs (8/16). For material selection as well, important drivers are quality (4/16) and aesthetic properties (5/16), in line with the company's strategic approach and brand positioning towards quality and premium perception. Another important driver (3/16) relates to the technical properties of materials, and in particular to mechanical properties, thermal ones, and resistance to certain environments or chemicals. In material selection, suppliers also play a pivotal role: three interviewees stated that their proposals can be a driver of materials' innovation, and three of them emphasised that suppliers' proximity is a decisive factor. Nonetheless, material selection can also be influenced by considerations related to supply chain robustness and procurement.

Figure 1 shows an overview of all the drivers mentioned by the interviewees. This breakdown underlines how decision-making for both product design and material selection tends to be mainly led by economic factors and regulatory compliance, and this is consistent with the drivers identified in other similar studies conducted on household appliance companies (Piselli et al. 2016; Zhou et al. 2023).

However, the current lack of a structured approach towards sustainability is reflected in the absence of sustainability-oriented drivers reported in both domains.

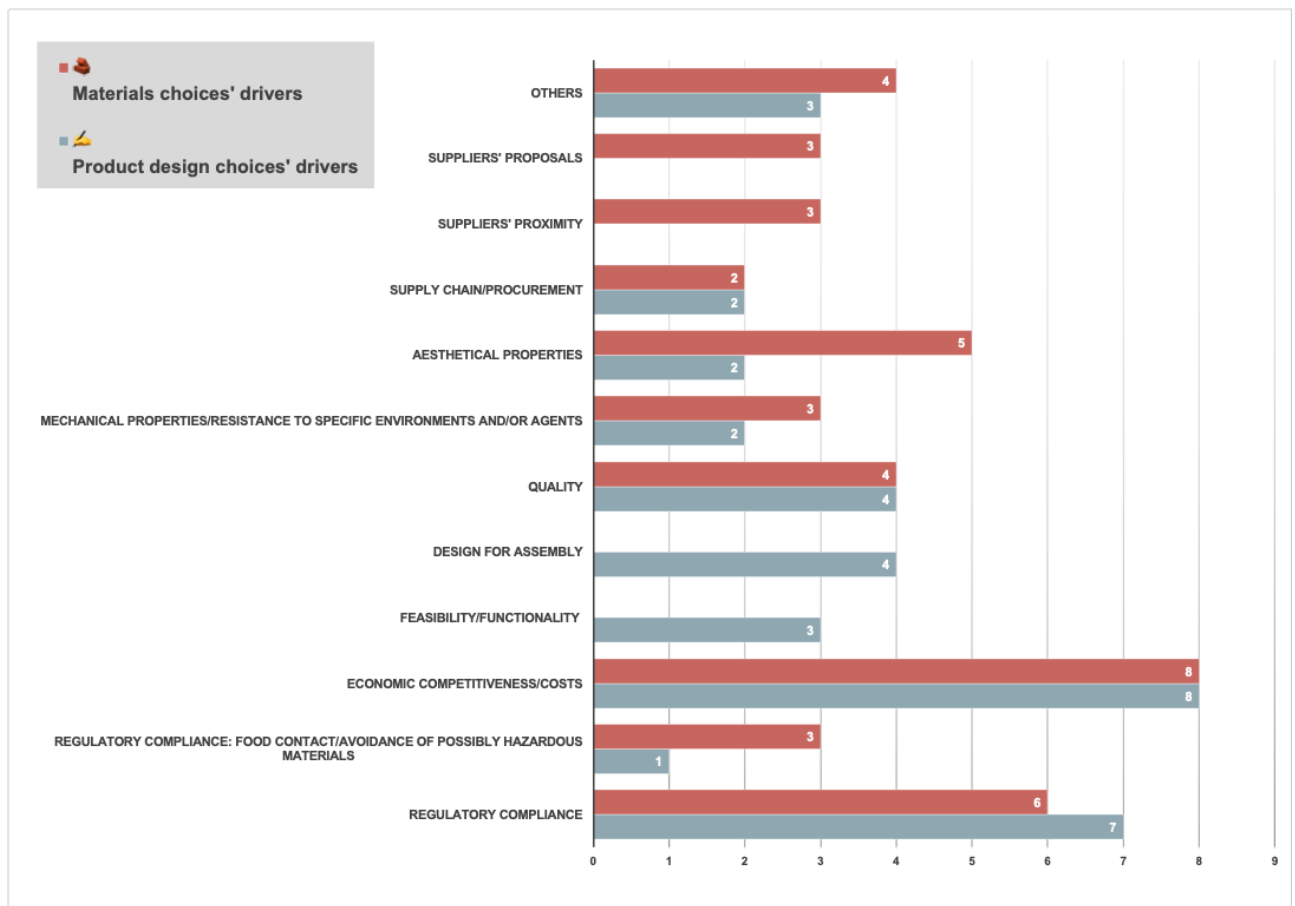


Figure 1 – Product design and materials choices' drivers reported by interviewees

Current product sustainability-related projects, practices and tools

Projects and actions

When asked to name product sustainability-related projects or actions they had directly participated in within the company, or of which they were aware, interviewees mentioned two main initiatives: a major project to progressively eliminate EPS from packaging in favour of paper-based solutions (mentioned by 9 out of 16 respondents); and a pilot product LCA project (5/16) involving multiple departments for the collection of primary data. Among other individual actions, two respondents reported the avoidance of materials containing PFAS, while another two cited the implementation of secondary materials, such as recycled paper for instruction manuals or a recycled copolyester grade for certain product components.

This shows that some punctual actions, which can affect the environmental impact of products and packaging, have been implemented; however, the primary driver behind such actions is typically not the sole sustainability, but rather regulatory compliance (e.g., upcoming national ban on the use of EPS), which in fact is among the main drivers mentioned for design and material choices. Thus, at present, the results suggest that the company's prevailing approach is compliance-oriented.

Tools

With respect to the use of tools supporting sustainability-oriented design (ecotools) and material selection, 10 out of 16 interviewees stated that currently these are not applied, except for some limited pilot actions. Two respondents indicated that, at times, knowledge-based guidelines are followed to improve product durability and reparability. One interviewee stated that although ecotools are not yet applied on a large scale, this is a goal to be pursued and one that the company is working towards, requiring considerable effort to be effectively and seamlessly integrated; furthermore, some respondents indicated that the use of filing templates and material selection tools could support sustainability-oriented design practices.

This demonstrates that there is both space and willingness to move forward with the integration of such supports, and the main factor causing this implementation gap is related to the complexity of integrating these tools into operational practice.

Factors limiting sustainability-related actions implementation and areas for improvement

Limiting factors

The main limitations to sustainability-related actions implementation reported by interviewees are visualised in (Fig. 2). The most frequently cited barriers (mentioned by 8 out of 16 respondents) are related to increased lead times (such as additional product design steps, extended time-to-market, etc.) or higher costs (e.g. the price of alternative materials, etc.). Half of the respondents also perceive the lack of training or shared sustainability culture as a barrier, and five the lack of dedicated personnel. Respondents (5/16) also highlighted as a limiting factor the lack of tools (e.g. ecotools), the difficulty in retrieval or unavailability of certain data, and the complexity of identifying effective metrics to measure sustainability actions. The lack of structured approaches and explicit prioritisation of sustainability – expressed as the absence of specific goals or KPIs – was noted by three respondents respectively. Limited communication and collaboration among departments, as well as the perceived effort required for the transition, were reported less frequently (2/16 responses apiece). Finally, among the individually mentioned barriers – grouped under 'others' – respondents highlighted the complexity associated with the breadth of the product portfolio, as well as issues related to controlling the end-of-life of environmentally critical components, such as electronic components.

These findings indicate that both operational and cultural factors hinder a more effective and widespread implementation of sustainability initiatives within the company.

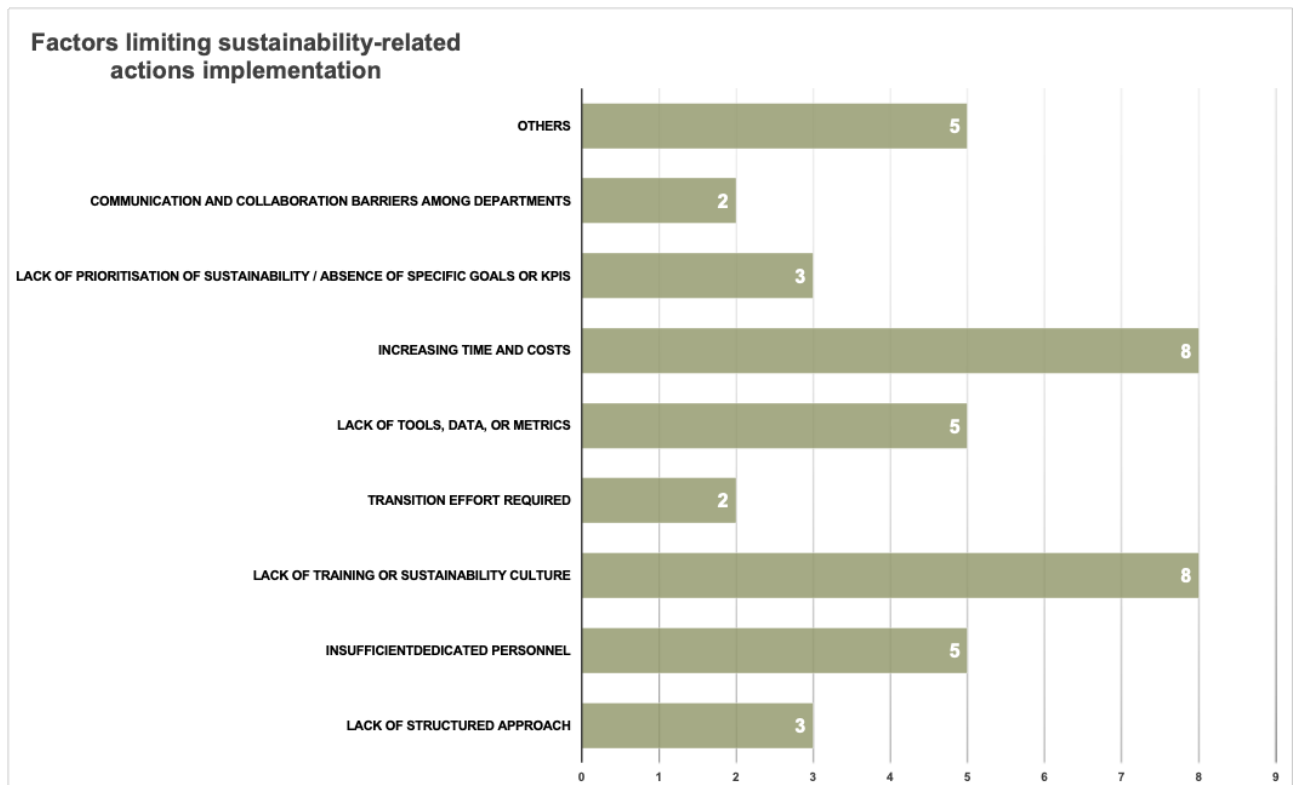


Figure 2 – Factors limiting sustainability-related actions implementation reported by interviewees

Areas for improvement

Possible areas for improvement to better steer the company towards sustainability, reported by interviewees, are visualised in (Fig. 3). The most frequently suggested intervention is the definition of structured approaches (both at the organisational level and at an operational scale) and the statement of clear internal guidelines (7/16), underscoring the need for formalised processes. Provision of training activities on sustainability is recommended by 5/16 respondents, recognising the staff awareness and competence as a key enabler. Setting clear sustainability goals is put forward by 4/16, while defining criteria for materials and finishes selection is cited by 3/16 as an action to support an eco-informed decision-making. Increasing interdepartmental communication and enhancing the provision of proper tools to support sustainability integration were considered enablers by two respondents, respectively. Three respondents suggest that developing an effective sustainability communication strategy towards customers and stakeholders is crucial, a process which is currently underway within the company.

These recommendations indicate a consensus towards structured organisational change, targeted training, and improved clarity in sustainability processes and objectives.

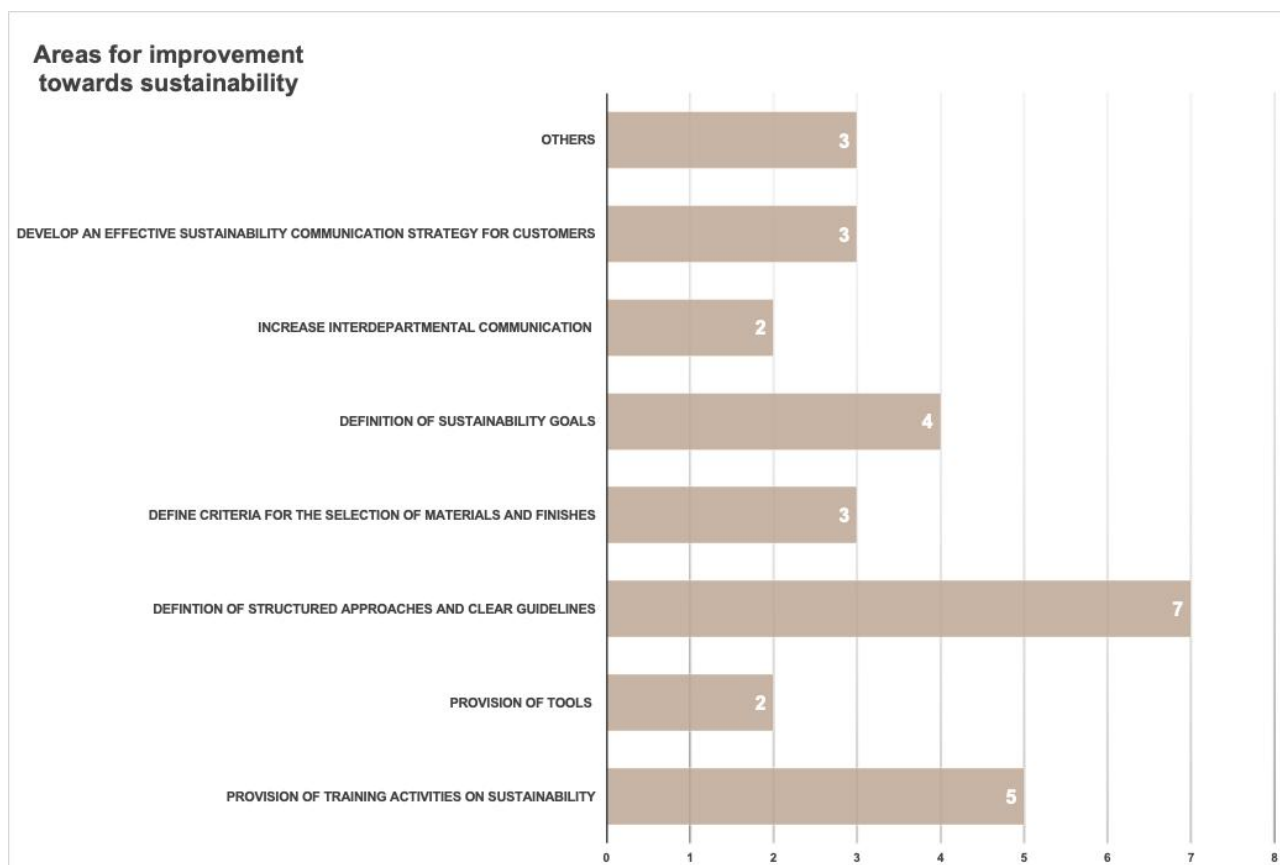


Figure 3 – Areas for improvement to better steer the company towards sustainability reported by interviewees

The analysis reveals a strong alignment between the main barriers hindering sustainability practices and the improvement areas proposed by interviewees. Notably, the lack of structured approaches, clear internal goals, and explicit prioritisation of sustainability – cited as significant limitations – are directly addressed by the most frequently suggested improvement: developing formal processes and clear organisational guidance. Similarly, the absence of a shared sustainability corporate culture and insufficient training, both considered major obstacles, find a direct counterpart in the recommendation to implement targeted training activities to enhance staff awareness and competence.

Operational challenges, such as the lack of adequate tools (e.g. LCA software applied at scale), difficulties in collecting data and defining proper metrics, are mirrored in the suggested provision and enhancement of tools and supporting infrastructures. The issue of limited interdepartmental communication and collaboration, though less frequently reported as a barrier, is echoed in the proposals for increasing internal communication channels and cross-functional integration.

Additional recommendations, such as setting clear sustainability guidelines and criteria for materials selection, reflect an effort to overcome the current lack of explicit targets and support more informed eco-oriented decision-making. The ongoing process of developing an external sustainability communication strategy is also shaped in response to the need for clarity, both internally and in stakeholder engagement.

In synthesis, the areas for improvement identified by stakeholders closely correspond to the array of cultural, organisational, and operational barriers encountered, suggesting a certain degree of awareness within the company regarding the pathways needed to advance its sustainability agenda. The alignment also indicates that progress will largely depend on the systematic translation of these recommendations into concrete, coordinated actions across the organisation.

Additional insights from Legal & CSR Department

To complete the picture of the 'As-Is' state of product sustainability within the company, the perspective of the candidates directly responsible for product-related decisions was supplemented by interviews with two representatives from the Legal & CSR Department, who are responsible for one of the main sustainability-related corporate activities: drafting the Sustainability Report.

With regard to the European regulatory framework on product sustainability, the interviewees emphasised that appliance companies will soon be required to comply with the prescriptions defined for each product category by the delegated acts of the ESPR framework Regulation. In addition, the drafting of the sustainability report will need to align with the new standards set by the CSRD Directive. As a result, one of the main drivers prompting companies to take action on sustainability will primarily be regulatory compliance. Other increasingly decisive drivers include growing consumer (B2C) and customer (B2B) sensitivity toward sustainable products, as well as heightened scrutiny by banking partners of corporate sustainability policies and ESG criteria.

The interviewees also pointed out that the company's sustainability report, published voluntarily for several years, has been useful in measuring the organisation's impacts (i.e. carbon footprint). Among the key future improvement areas identified was the need to move beyond impact measurement alone, progressing towards the definition of targets and actions for impact reduction, along with the creation of a comprehensive sustainability strategy that spans the various business units across the corporate structure. For product-specific challenges, one of the most critical future tasks will be the large-scale implementation of Life Cycle Assessment.

Project perspectives and next steps

Some of the critical issues and limitations highlighted in the interviews have already been subsequently addressed through the training initiatives and participatory activities mentioned in section (2.2) of the Methods. These activities have provided a shared grounding in product sustainability culture, giving the necessary theoretical and methodological foundations. Furthermore, the main ecodesign and material selection tools were presented and discussed with those in operational roles related to the product, to begin spreading awareness and to evaluate the advantages and disadvantages of the available options.

Cross-functional workshops and focus groups also allowed for mapping the as-is state of product development and for initiating discussions to identify ideas and pathways for improvement. Not least, these activities have been occasions for collective exchange and dialogue among different functions within the company.

On a methodological level, the project's strategy involves two additional steps. Firstly, another 3 months of field research within the company is planned, during which further product-focused workshops will be conducted for the technical functions. In parallel, through Participatory Action Research, to validate a robust and practically implementable strategy, directions and guidelines to steer change will be proposed, discussed and refined together with management to assess their feasibility. This will serve as one of the metrics for evaluating the successful transfer of concepts from academia to industry (Cook et al. 2006). Secondly, for the purposes of generalising the approach, a cross-sectoral validation is planned to be carried out through interviews with experts (e.g. sustainability consultants) and professionals from other corporate contexts.

Conclusions and limitations

This study has demonstrated the necessity of organisational commitment and cross-functional coordination for advancing product sustainability within the studied appliance company, especially as regulatory, market and societal pressures intensify. The findings clearly indicate that, while compliance and competitiveness remain primary drivers of material and design choices, progress towards sustainability is frequently hindered by operational barriers, cultural inertia, and the lack of structured approaches and dedicated tools. Crucially, the results highlight how awareness of these challenges is growing within the organisation and suggest that targeted interventions – such as the provision of sustainability training, formalisation of internal guidelines, and the establishment of clear goals and key performance indicators – are essential to overcome progress barriers.

In this context, the cross-functional and participatory research approach has provided valuable insights into both the limitations encountered and the pathways for improvement. Collaborative research, systemic thinking, and continued dialogue between academia and industry are shown to be critical in driving the cultural and organisational change required to embed sustainability in product development practices. Future work will focus on validating the proposed strategies within the company and also on ensuring the generalisability of the findings by engaging with external experts.

This last step addresses the main potential limitations of the project, namely its focus on the company case study, which may restrict the direct applicability of the findings to other organisational contexts or sectors. Further limitations are connected to the data gathered through interviews and participatory workshops, which reflect subjective perspectives that could be influenced by individual backgrounds and organisational dynamics. Methodological constraints, such as the limited sample size and the challenge of capturing long-term effects in a short research timeframe, may also affect the comprehensiveness of the insights generated.

As concluding remarks, collaboration between industry and academia is proving to be effective in addressing the corporate gaps around product sustainability and in building a long-term vision grounded in research insights and capable of supporting the definition of specific objectives and KPIs, which are essential for real progress and to measure it.

Finally, one-to-one interviews and the researcher's presence within the firm have been crucial in building staff trust and credibility, enabling active participation and support for ongoing project activities.

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