CHALMERS
UNIVERSITY OF TECHNOLOGY

The Hurdles of Corporate Sustainability Claims

A Case Study of Building Automation and Energy Savings

Master's thesis in Industrial Engineering and Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2026
www.chalmers.se

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Gothenburg, Sweden 2026

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Abstract

As the building sector contributes roughly 40% of global energy consumption, the twin transition of digitalization and green transformation has positioned building automation as a critical tool for decarbonization. However, hardware manufacturers face a significant challenge because current reporting standards, such as the GHG Protocol, fail to capture the potentially positive environmental impacts of "saved emissions" from the use of certain products. This creates a friction between the commercial need for organizational legitimacy in sustainability communication and the complex, non-linear reality of building physics, which can give rise to organized hypocrisy or greenwashing even where no deception is intended.

This study employs an abductive research strategy and a case study of Bemsiq Group AB to explore these challenges. We used interviews, focus group discussions and a novel "white paper simulation" to document the specific frictions that arise when translating technical performance data into sustainability claims.

The findings reveal that credible, aggregated sustainability disclosure has a hurdle in structural data gaps, such as the absence of standardized baselines and limited access to end-user operational data. Our "Friction Log" identifies conflicts between the frame of engineers prioritizing accuracy, and the business case frame of sales teams and management seeking cognitive clarity for customers.

While the frictions are numerous, double-counting and attribution dilemmas are the main hurdles. To navigate these, we propose a shift toward a bottom-up strategy centered on micro-level validation through specific customer cases. This approach allows companies to secure legitimacy with verifiable evidence while advancing more transparent communication standards for the industry.

Keywords: Building Automation Control Systems (BACS), Twin transition, Energy performance gap, Organizational legitimacy, Scope 4 (saved emissions), Sustainability communication, Sensemaking, Boundary objects, Mimetic isomorphism

Acknowledgements

We would like to extend our sincerest thanks to our supervisor and examiner Björn Sandén who supported us throughout this project. His guidance has helped us navigate how we approached and executed the thesis, with many wise words and perspectives about the slippery slopes we were traversing.

Another 'thank you' is given to Angelica and the participants from Bemsiq Group AB. We have met many an employee within the organization, both holding company and subsidiaries, and we are grateful for their transparency, their willingness to improve and the attitude in which they participated throughout meetings, interviews and other interactions.

For the team at HQ, we give special thanks for the many lunches in the basement, the confidence in letting us go to Finland and Germany to anchor the project within the organization and last but not least - "the Tombas Challenge" which spurred us to go the extra mile (quite literally).

Edvin Gustavsson & Knut Zetterling, Gothenburg, May 2026

List of Acronyms

Below is the list of acronyms that have been used in this thesis (alphabetical order):

AI	Artificial Intelligence
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BACS	Building Automation Control Systems
BAS	Building Automation Systems
BEMS	Building Energy Management Systems
BMS	Building Management Systems
BREEAM	Building Research Establishment Environmental Assessment Method
CAE	Customer Avoided Emissions
CO_2e	Carbon Dioxide Equivalent
DCV	Demand Controlled Ventilation
EEA	European Environment Agency
EPBD	Energy Performance of Buildings Directive
EPCs	Energy Performance Certificates
EPDs	Environmental Product Declarations
EPG	Energy Performance Gap
ESG	Environmental, Social and Governance
FGD	Focus Group Discussion
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IEA	International Energy Agency
IoT	Internet of Things
ISO	International Organization for Standardization
KAM	Key Account Manager
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
MEI	Mandatory Energy Improvement
SBM	Sustainable Business Model
SBTi	Science-Based Targets initiative
UNEP	United Nations Environment Programme
VOC	Volatile Organic Compound
WRI	World Resources Institute

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Introduction

1.1 Background

In an era defined by the urgent need for climate action, industries around the world are being encouraged to fundamentally redefine their business models. This global shift is no longer framed only as environmental protection. It is increasingly understood as the "twin transition", which is a strategic paradigm where the green transformation of the economy is linked to its digital transformation (Müller et al., 2024).

This concept means that the path to climate neutrality can be paved with digital solutions. Technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and advanced data analytics are the necessary enablers that allow industries to monitor, optimize, and reduce their resource consumption (Mignon and Bankel, 2023). Digitalization is therefore not just a tool for economic efficiency but a management imperative for sustainability.

Few industries feel the twin transition as tangibly as the building and construction sector. Globally, this sector is a massive consumer of resources, estimated to contribute 40% of total global energy consumption (United Nations Environment Programme, 2024). The vast majority of this energy is consumed during the operational phase of a building's lifecycle, specifically impacted by heating, ventilation, and air conditioning (HVAC) systems.

Despite decades of policy interventions, energy demand in this sector continues to rise, driven by increasing global floor area and demands for higher comfort levels (United Nations Environment Programme, 2024). To reverse this trajectory, regulatory frameworks have become increasingly stringent. The Energy Performance of Buildings Directive (EPBD) in Europe is just one example of a counteraction that has mandated a shift toward zero-emission buildings, already by 2030 (European Parliament and Council of the European Union, 2024). Crucially, the EPBD explicitly identifies "smart" technologies and devices as the cornerstone of this transition, effectively mandating the deployment of digital control systems to manage energy loads.

As regulatory pressure mounts, the ability to measure and report environmental impact has moved from a voluntary practice to a requirement for organizational legitimacy. This reporting is governed globally by the Greenhouse Gas (GHG) Protocol, which categorizes emissions into three distinct "scopes" to standardize corporate accountability (WRI and WBCSD, 2004).

- **Scope 1 (Direct Emissions)** Emissions from sources owned or controlled by the company (e.g. gas boilers or company vehicles).
- **Scope 2 (Indirect Emissions):** Emissions from the generation of purchased electricity, heating, and cooling consumed by the company.
- **Scope 3 (Value Chain Emissions):** All other indirect emissions that occur in a company's value chain, including upstream (e.g. the embodied carbon of purchased goods) and downstream (e.g. the use of sold products).

These three scopes provide a clear framework for the reporting of environmental footprints, which is suitable for a manufacturer to do. But while these scopes increase transparency and operational visibility they are designed to only measure negative impact, not positive contribution. Consequently, they fail to capture the systemic benefit of technologies specifically designed to reduce impact through operation.

To give an easy illustration of why this accounting gap is an issue: a company dedicated to reforestation would, under Scopes 1-3, report a net-negative environmental impact for fuel and resources consumed during its planting operations since the trees planted have no attributable benefit. Meanwhile, a smaller manufacturer of disposable plastic bags could appear less harmful simply by maintaining a lower operational footprint through the scale of their operations.

Connecting back to the building automation industry, the purpose is to reduce impact through operation, but the performance of building automation control systems (BACS) is dynamic and non-linear. Even without the bias in carbon disclosure that works against environmental supportive technologies, potential energy savings depend heavily on complex physical factors like thermal stratification and room inertia. This complexity makes the quantification of environmental benefits difficult to calculate with precision (World Resources Institute, 2019), creating a conflict between the rigid accounting of the GHG Protocol and the dynamic reality of building physics.

The built environment, represented through property owners and facility managers, are the primary stakeholders of sustainability claims from BACS manufacturers. As regulatory pressure increase, through e.g. the European mandate of building automation installations in non-residential buildings above 290 kW (European Parliament and Council of the European Union, 2024), these actors face a growing need to procure the technology and evaluate the environmental claims that accompany it. Yet no standardized framework exists for distinguishing credible disclosure from marketing narrative. The manufacturer's challenge documented in this thesis, which is how to construct a defensible sustainability claim, is therefore also the property owner's challenge but viewed from the opposite side of the same information asymmetry.

While BACS is marketed as a precision tool, a significant disconnect exists between the predicted energy savings of these technologies and their measured performance in reality. This phenomenon, known as the "Energy Performance Gap" (EPG), is a widespread issue where buildings often consume 10–20% more energy than calculated in design models (de Wilde, 2014).

Recent studies in the Swedish context confirm that this gap arises because BACS performance is heavily influenced by unpredictable occupant behavior and "soft" physical factors that standard models fail to capture (Bandak et al., 2025). For hardware manufacturers, this creates a profound challenge: they are selling a tool for precision in an environment defined by uncertainty, making the communication of verified savings exceptionally difficult.

1.2 Problem Discussion

While the regulatory and technological landscape suggests a clear path forward, the commercialization and communication of BACS are obstructed by deep-seated economic and organizational paradoxes. The following subsets identify current obstacles to market adoption of building automation technologies.

1.2.1 The Economic Dilemma

Despite the roll-out of BACS technologies, their commercialization is hindered by two fundamental market failures. First is the "double externality problem" (Rennings, 2000). Sustainable innovations produce innovation spillovers (knowledge benefits for competitors) and environmental spillovers (social benefits like cleaner air). Because the market price rarely captures the value of the environmental spillover, companies face a valuation gap where they carry the cost of implementation while others reap the benefit. Consequently, it is difficult to market sustainable innovations - both related to the approach and the amount of resources that should be allocated to it.

Second, and perhaps more damaging to the building sector, is the "principal-agent" or "split incentive" problem (Jaffe and Stavins, 1994). In many real estate contexts, the party paying for the energy efficiency upgrade (the landlord) is not the party paying the energy bill (the tenant). This misalignment reduces the demand for energy-efficient technologies in a broader sense, even when they are cost-effective on paper (Allcott and Greenstone, 2012).

The economic challenge is compounded by the twin transition referred to earlier, but in a paradoxical way. While digital technologies are the primary enablers of energy efficiency, academic literature warns of rebound effects (Lange et al., 2020). Efficiency gains derived from digital tools can lower the cost of energy services, leading to increased consumption that offsets the initial savings - a phenomenon known as "Jevons paradox" (Sorrell, 2007). The paradox can be translated to the principal-agent problem (Jaffe and Stavins, 1994), where savings instigated by the landlord might change behavior of tenants.

For a property owner, this introduces a critical ambiguity: does the installation of BACS result in a net absolute reduction in emissions over time, or is it a zero-sum game?

1.2.2 The Measurement Challenge

Adding to the ambiguity, one fundamental issue lies in how potential benefits are measured. The standard GHG Protocol (Scopes 1, 2, and 3) is designed to track the inventory of a company's carbon footprint. Scope 1 covers a company's direct emissions from sources they own, such as emissions from company vehicles. Scope 2 measures the indirect emissions that come from producing the energy resources consumed by the company. Lastly, Scope 3 emissions encompass all the emissions that occur up or downstream of the value chain - and these are often the largest portion of a company's footprint (WRI and WBCSD, 2004). However, neither of these scopes recognizes or accounts for the positive impact of a product that helps others (e.g. customers) reduce their emissions (World Resources Institute, 2019).

This missing metric is often referred to as "Scope 4", "Saved Emissions" or "Avoided Emissions". This thesis distinguishes between them by using Scope 4 to denote the formal accounting framework, while avoided and saved emissions will refer to the broader environmental outcome. Scope 4 aims to quantify the difference between the emissions in a business-as-usual scenario and the emissions in a scenario where the efficient solution is used. However, unlike mandatory Scopes 1-3 of the GHG protocol, Scope 4 is so far a voluntary metric that lacks a standardized reporting framework. The absence of a rigorous standard leaves manufacturers in a difficult position: they want to quantify the avoided emissions to justify their value, but it is a task that invites skepticism since it will be based on their own incentives and data.

1.2.3 The Legitimacy Gap

Additionally, in a volatile business environment, effective corporate communication becomes a quest for "organizational legitimacy" (Suchman, 1995). To secure their own operations and survival, sustainable companies must satisfy pragmatic legitimacy (providing utility), cognitive legitimacy (being understandable) and moral legitimacy (contributing to societal good) through the information they disclose and the actions they take.

However, the pressure to create legitimacy using the derivatives of Scope 4 creates a high risk of "greenwashing" - meaning to actively or passively mislead stakeholders in sustainability claims (Lyon and Montgomery, 2015). This disconnect is frequently analyzed through the lens of "organized hypocrisy" (Cho et al., 2015), where a company's corporate discourse diverges from its actual practice to satisfy conflicting stakeholder demands. If BACS manufacturers simplify complex Scope 4 data into marketing ploys to create cognitive legitimacy for property owners or other stakeholders, it might be easier for them to gain market acceptance. Pushed too far, they instead risk decoupling their claims from the complex physical reality of the building and become guilty of greenwashing.

1.3 Aim and Research Questions

This thesis examines the intersection between the business case for building automation and its sustainability claims. As the demand for BACS solutions accelerates, companies face the challenge of articulating their environmental value without engaging in organized hypocrisy or greenwashing. Taking a critical view inspired by the literature, the study examines the alignment between the current BACS business rationale, the corporate communication strategies of established actors, and the characteristics of the industry.

Beyond the theoretical exploration, this thesis has a practical objective: to generate transferable insights for navigating sustainability communication. Specifically, the project aims to conduct an assessment of a company's product portfolio to simulate a commercial sustainability white paper. This deliverable serves as a tool to uncover flaws, hurdles, and potential solutions in the communication process. By analyzing the creation of the white paper, the research seeks to distinguish between "feasibly marketed sustainability" and "actual sustainability", ultimately contributing to a more transparent communication standard for the industry.

Research Questions

- **RQ1, The Strategic Dilemma:** How do competing strategic drivers shape corporate decision-making when formulating communication strategies for sustainable technology innovations?

- **RQ2, The Negotiation of Legitimacy:** In what ways can BACS performance be translated into value propositions that satisfy stakeholder demands for clarity without compromising legitimacy or triggering organized hypocrisy?

- **RQ3, The Navigation of Hurdles:** How do methodological, organizational, and structural frictions constrain the development of credible sustainability-linked claims within the building automation sector?

1.4 Research Setting

This study is conducted as a case study within the building automation industry, specifically analyzing Bemsiq Group AB (Bemsiq). Headquartered in Gothenburg, Sweden, Bemsiq functions not as a single manufacturer but as a holding company and a "wholly-owned industrial operation" within Investment AB Latour - a major Swedish investment firm listed on the Nasdaq Stockholm Large Cap list. The group employs more than 500 individuals across 12 holdings, with 9 of these specializing exclusively in building automation hardware (Bemsiq AB, 2026).

So, Bemsiq manages a decentralized portfolio of international subsidiaries including industry brands such as Produal (Finland), S+S Regeltechnik (Germany), and Greystone Energy Systems (Canada). The organizational structure of Investment Latour allows Bemsiq to operate with a long-term investment horizon, acquiring and developing companies that specialize in niches of energy efficiency and building control on the international market.

The group's collective portfolio is reliant on the business case of energy savings, aligning well with the definition of sustainability innovation and business models (Mignon and Bankel, 2023; Boons and Lüdeke-Freund, 2013; Rennings, 2000). The subsidiaries primarily produce "smart devices", meaning small, modular, and connected units measuring variables such as temperature, CO2, pressure, and air quality. These then serve as the critical sensory inputs for the BACS. While each subsidiary operates independently to maintain agility and brand identity, Bemsiq serves as a central platform for growth, driving synergies in R&D and sustainability across the group (Bemsiq AB, 2026).

A key characteristic of this research setting is the specific medium chosen to bridge the "valuation gap" caused by the double externality: the sustainability-linked commercial white paper. A white paper is at its core a mix between a marketing document and a technical specification, being plastic enough to serve both purposes depending on the design preferences and the purpose of its conception (Stelzner, 2006). Preliminary research indicates that while formal Life Cycle Assessments (LCAs) are well-established in academia and regulated reporting (Moutik et al., 2023), the use of white papers for entire portfolios to communicate saved emissions is an under-researched subject. This selection invites findings of corporate sustainability that would be hard to find on purely theoretical ground.

However, this process carries inherent risks. Because these documents are not governed by the standards of the GHG Protocol, or any official standard, they become a point of tension between organized hypocrisy (Cho et al., 2015) and transparent communication. Bemsiq's ambition to produce such a document provides a unique opportunity to investigate the tension in real-time.

1.5 Delimitations

To ensure the feasibility and rigor of the study, a set of boundaries have been applied.

1.5.1 GHG Scope 4

The study incorporates a Scope 4 assessment as part of its analytical scope. Unlike Scopes 1, 2, and 3, which are standardized inventories of a company's own emissions under the GHG Protocol, Scope 4 quantifies the benefit a product provides to its user or the broader environment. To manage the ambiguity of this metric, the study draws on the comparative emissions framework of World Resources Institute (2019).

Scope 4 is treated as a communicative value proposition tied to legitimacy, not as a compliance exercise. As such, it does not cover elements that would be included in isolated studies of the concept, like end-of-life treatment or recovery considerations. The theoretical rationale is developed in Chapter 2 and the methodological design in Chapter 4. A full worked example, using dummy data, is disclosed in Appendix C.

1.5.2 Exclusion of Technical Verification

The scope of this research is bound to management and communication theory rather than electrical engineering or building physics. No independent technical verification of the hardware's performance or operational efficiency is done. Technical performance data, energy meter readings, and hardware specifications provided by Bemsiq and its subsidiaries are accepted as valid secondary data. The analytical purpose is to translate, contextualize, and package this data into potential sustainability claims - not to verify its accuracy. The findings are therefore mostly dependent on the process of creating sustainability claims.

Lastly, the study acknowledges that reliance on averages or aggregation serves as a form of abstraction and a direct risk of reducing legitimacy of the project by itself, despite it being one of the main topics. However, the use of different heuristics is intentional and serves as an important point for the analysis of how companies sometimes must choose between specificity or cognitive legitimacy in their market communication.

2

Theoretical Framework

This chapter establishes the theoretical lens through which the commercialization of building automation sustainability is analyzed. It follows a "macro-to-micro" storyline: beginning with the global imperatives of the twin transition (2.1), moving to the organizational pursuit of legitimacy (2.2), and concluding with the specific analytical tools of boundary critique (2.3) and sensemaking (2.4) required to navigate the complexity of avoided emissions. Lastly, a theoretical synthesis (2.5) is provided.

2.1 The Strategic Driver

The primary enabler of Bemsiq's current business is the twin transition, a paradigm where green and digital transformations are viewed as inseparable (Müller et al., 2024). In the building sector, this transition positions digital control systems (BACS) as a useful tool for decarbonization. However, the combination of these two transitions creates a "green-digital paradox". As commented by Lange et al. (2020), the efficiency gains from digitalization often cause rebound effects where lower operational costs lead to increased usage, removing the potential carbon savings. For some hardware manufacturers, this creates a theoretical uncertainty: their product might be sold as an environmental benefit, but it may also function as an implicit driver of increased consumption.

Another issue is the double externality market failure introduced earlier (Rennings, 2000). BACS manufacturers, with or without the rebound effects, produce positive environmental spillovers that the market does not automatically price. Property owners might agree that it brings value, but there is no substantiated model for how much indoor air quality improvements represent in monetary terms. To capture this invisible value, companies must adopt sustainable business models (SBM) that actively internalize these externalities into a commercial value proposition (Bocken et al., 2014).

Building on SBM, Bocken et al. (2014) provide a framework of archetypes that allow companies to understand their path toward sustainability. For a manufacturer of sensory-layer hardware within the building automation industry, the archetype of "delivering functionality rather than ownership" is particularly relevant. This is because it shifts the focus from the physical unit to the precision and reliability of the data it provides. This shift lets the company partially internalize externalities the market price ignores. Theoretically, this positions the hardware not as standalone, but as an enabler within a broader technological system. This moves the organizational logic from "value-in-exchange" (the sale of the sensor) to "value-in-use" (the energy saved through the sensor's data). However, this transition also introduces an attribution paradox.

The attribution paradox, as the term is used throughout this thesis, refers to the mismatch between where a saving is produced and where it can be credibly claimed. A sensor-layer device is a necessary input for the energy-saving outcome a BACS system delivers, but the saving itself is produced together with the actuator that acts on the signal, the management layer that processes it, the system integrator that commissioned the installation, and the building operator who has chosen to have it installed. Each of these actors has a reason to claim a share of the saving, and no disclosure standard currently prescribes how the shares should be divided. The paradox, then, is not that sensors lack impact but that any attempt to convert that impact into an emissions claim requires a boundary judgment that the physics of the system does not supply. This construct surface in the friction log of Section 5.3, is developed analytically through boundary critique in Section 6.2.1, and quantified in Appendix C.

2.2 The Organizational Goal

If the twin transition provides the reasons behind some corporate strategies, organizational legitimacy provides the goal. Defined by Suchman (1995) as the perception that the actions of an entity are desirable, proper, or appropriate, legitimacy is a resource that firms must secure to commercialize sustainable technology. To successfully navigate the double externality, a company within the building automation sector must satisfy three distinct pillars of legitimacy through its communication:

- **Pragmatic Legitimacy:** Proving that BACS technology provides direct utility (e.g. financial return on investment) to the customer.
- **Moral Legitimacy:** Demonstrating that the technology contributes to societal welfare (decarbonization), independent of profit.
- **Cognitive Legitimacy:** Ensuring the complex data and benefits are understandable and "make sense" to stakeholders.

To satisfy these potentially conflicting demands, the industry relies on a specific communicative artifact: the commercial white paper. While academic literature views the white paper as a technical report, the marketing industry use it as a persuasive essay that combines facts and logic to promote a specific solution. According to Stelzner (2006), the ideal of a white paper is strictly separated from a "sales brochure". To be effective, it must lead with educational content rather than product features. This is to secure the reader's trust or understanding before a solution is ever proposed.

In the context of legitimacy theory, this format is strategic and is framed as being a "problem/solution" structure by Stelzner (2006). By adopting the structure where a high-level industry problem is established before the product is introduced, companies create cognitive legitimacy. The white paper should signal scientific objectivity, allowing the company to present its commercial interest (e.g. selling sensors) only as a necessary solution to a societal crisis (say, climate change). This idea is one subset of strategic actions to frame a sustainability narrative. As a follow up, the aggregation of sustainability white papers, or extrapolation of the results, is fed into what is often referred to as sustainability or impact reports (Honeywell International Inc., 2025; Schneider Electric SE, 2025; Siemens AG, 2025).

Figure 2.1 illustrates a generic structure of a problem/solution narrative in the BACS context. The progression from macro problem to impact claim follows the legitimacy logic described above: educational framing produces cognitive legitimacy at the top, boundary judgments determine what enters the product and evidence layer in the middle, and the company specific claims concentrates at the bottom.

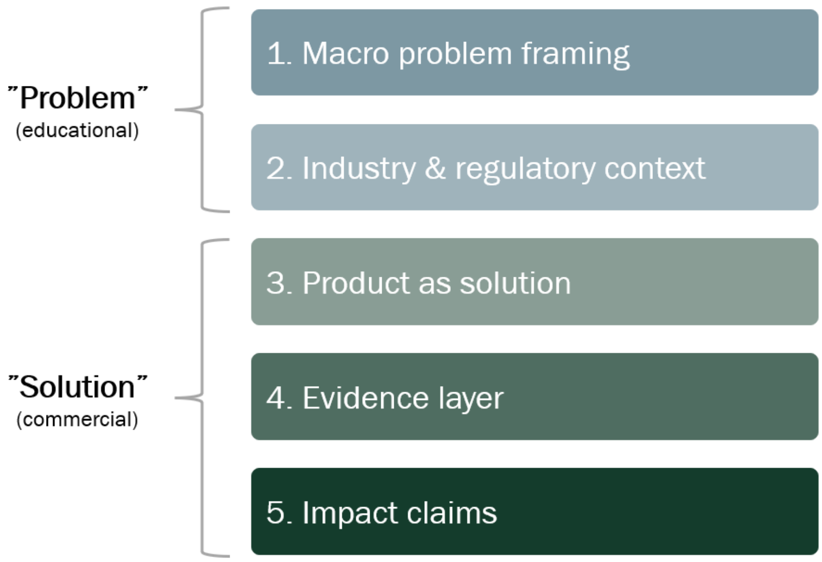

Figure 2.1: Typical configuration of a BACS sustainability white paper.
Left: Stelzner's (2006) problem/solution divide. This structure is observed across five benchmarked companies (Section 5.1.2).

The widespread adoption of this specific problem/solution format and the following use of methods to scale gains into portfolio wide successes is an example of "mimetic isomorphism" (DiMaggio and Powell, 1983). Facing high uncertainty regarding how to measure avoided emissions (Scope 4) or anything similar in terms of sustainability claims, companies copy the approach of industry leaders to signal their own competence.

However, this pursuit of legitimacy can lead to decoupling, which is a core concept in institutional theory where an organization's formal structures or "talk" diverge from its actual work (Meyer and Rowan, 1977). When the reality of BACS (or any other example of a non-linear and complex problem) is forced into the simplified problem/solution narrative required for a white paper, a state of organized hypocrisy can arise (Cho et al., 2015).

Organized hypocrisy is when corporate discourse comes ahead of verifiable practice, not necessarily through deliberate intent but as a response to conflicting stakeholder demands. This can be embodied in many ways, but becomes particularly present in communication where there is no underlying proof of statements or claims. For the typical configuration of the white paper, it would be embodied through a valid problem statement but weak evidence layer. While seemingly naive and unprofessional, it is not uncommon in corporate discourse (Lyon and Montgomery, 2015). To avoid this fallacy, the evidence layer must be developed so it can serve as the way of verification and the source of origin behind any claim. According to Power (1997), the need for verification tools is a result of political pressures on accountability and control. In the case of decoupling or organized hypocrisy, the white paper by default becomes the artifact that satisfies the market's need for legitimacy or understanding, showing that claims can be verified.

2.3 The Technical Filter

To move beyond the organizational risks of hypocrisy identified in Section 2.2, a framework for validating sustainability claims is required. While Section 1.2.2 introduced the ambiguity of avoided emissions, this subchapter uses systems thinking and boundary critique (Midgley, 2000; Ulrich, 1983) to explain why this ambiguity persists.

According to Ulrich (1983) no sustainability claim exists as a neutral fact. It is always the result of a boundary judgment. This concept means that any assessment of a system (such as a building) relies on a critical distinction between what is included and what is not. For a BACS manufacturer, this requires a choice between a narrow boundary, which focuses exclusively on the device's immediate operational benefit, or a broad boundary, which expands to include for instance rebound effects, grid interactions, and embodied carbon.

Critically, Ulrich argues that these boundary judgments are value-based. They determine whose interests are served by what is presented. If a white paper highlights the operational savings of a sensor while not including the environmental cost of its production, it is performing a selective boundary judgment. This theoretical lens explains greenwashing not necessarily as the falsification of data, but as the strategic management of system boundaries to maximize utility. It can however obscure the broader perspective and reality, since the complete absence of the actual environmental costs would go beyond the utility rationale of the intended communication and become naive.

This requires a theoretical shift from "attributional" to "consequential" thinking. As Ekvall and Weidema (2004) argue, claiming avoided emissions in a valid way requires a system expansion. The expansion should account for how the introduction of a new technology (the intervention/improvement) replaces something else in the existing system (the base-case). By applying boundary critique, the analysis in this thesis evaluates whether the applied selection of system boundaries is fair and reasonable or a commercially convenient solution.

2.4 The Internal Process

While boundary critique provides the framework for evaluating the validity of claims, sensemaking theory (Weick, 1995) explains the process by which these boundaries are negotiated. Sensemaking describes how organizations when faced with the ambiguity of the twin transition not only interpret what happens but also act on what they know or believe.

In the context of this thesis, the creation of a Scope 4 claim is not a neutral calculation but a negotiation between competing "cognitive frames" (Hahn et al., 2014). The technical part of the company operates within a "paradoxical frame". They are aware of and must acknowledge the trade-offs between physical and functional uncertainties of the hardware and resulting performance. Conversely, the commercial part operates within a "business case frame", which seeks to combine environmental issues or solutions with financial value. This difference is not unique for building automation companies, but even transfers across the industry vertical down to system integrators or construction companies - as well as in entirely different industries.

To resolve the disconnect between different parts, the white paper, or any similar product of communication, functions as a boundary object (Star and Griesemer, 1989). It exists in a gray zone between rigorous science (moral legitimacy) and persuasive marketing material (pragmatic or cognitive legitimacy). For a holding company like Bemsiq, that wants to aggregate diverse data from multiple subsidiaries into a coherent value proposition, the white paper merges these social worlds. It is plastic enough to allow marketers to simplify the narrative while robust enough for engineers to recognize as valid if done right.

However, as Basu and Palazzo (2008) argue, this process is filtered by the identity of the organization. If a company consider itself as a "green enabler", it is likely that it will filter out data that contradict this identity. One of those filtering tools being the boundary setting. The filtering process impacts anything that follows, meaning that friction or organizational sensemaking is already biased towards the established, or perceived, identity. Consequently, the friction later analyzed in Chapter 5 is not an error but a result of the idea that sensemaking is deep-rooted and must be scrutinized. Any organization likely selects the "business case" boundaries that make its identity fit the market, effectively trading back and forth between the frame of the engineers and the sales team depending on what is believed as needed.

2.5 Theoretical Synthesis

The theoretical perspectives form a single causal chain. The twin transition (Section 2.1) and the double externality together generate an environmental value that the market does not price, which pushes manufacturers toward legitimacy claims for commercial recognition. Making those claims is complicated by the sensemaking issue (Section 2.4) between the paradoxical frame of the technical core and the business case frame of the commercial side, a tension that in practice also maps onto the conflict between bottom-up evidence and top-down ambition.

Boundary judgments (Section 2.3) are the mechanism through which this tension is reconciled. Following Ulrich (1983) logic, the organization can draw the system wide enough to include beneficial operational effects (say, Scope 4) while leaving embodied emissions (Scope 3) outside the frame, turning the white paper into a boundary object that caters to competing demands. Because decision power is biased toward management, the choice of boundaries is rarely neutral, and a company without a cemented SBM risks settling on boundaries that are commercially convenient rather than defensible.

The consequence is that the risk of organized hypocrisy is not primarily a question of intent but a structural outcome of the sensemaking process described by Weick (1995). Driven by the need for cognitive legitimacy, companies tend to prioritize reasonability and feasibility over accuracy, communicating a simplified version of reality that "makes sense" to the customer, even if it requires decoupling the corporate narrative from the complex truth. If this framework holds, the frictions observed during the white paper simulation should cluster around boundary decisions rather than around data availability, a prediction the empirical chapters are designed to test.

To understand why this decoupling is convenient for companies, one must first understand a bit about the technical objects and the industry in its entirety. The following chapter details this industrial and technical context, and why the nature of building physics makes the energy performance gap (Aste et al., 2017; Bandak et al., 2025) a persistent problem for legitimacy.

3

Industrial & Technical Context

This chapter outlines the current state of Building Automation Control Systems (BACS), the regulatory pressure for "net zero" for property owners, and the persistent performance gap that makes accurate sustainability reporting and marketing so difficult. It must be said that while this thesis uses the definition BACS for simplicity and continuity, it can also be referred to as Building Automation Systems (BAS), Building Energy Management Systems (BEMS), Building Management Systems (BMS) or several other lesser known definitions or derivatives thereof with minor differences in between.

3.1 The Building Stock Transition

The building sector is currently undergoing a fundamental shift from static, reactive management to dynamic, predictive control. At the center of this transition is the BACS, which act as the brain of the modern building.

Historically, BACS were centralized systems designed primarily for operational safety rather than efficiency. However, the integration of Internet of Things (IoT) has revolutionized this. As noted by Sivasankari and Rathika (2025), modern IoT-driven BACS allow for real-time monitoring and data driven decision-making, shifting from simple "on/off" to adaptive actions that are triggered by, among other things, occupancy and environmental conditions.

3.1.1 The Industrial Backbone

In the commercial market, industry leaders like Siemens and Schneider Electric aggressively promote this change as the future of real estate (Schneider Electric, 2022; Siemens Smart Infrastructure, 2023). From the outside, this market comes with a rather static hierarchy:

1. **The Sensory Layer:** Devices that measure physical reality (e.g., temperature, CO2, and humidity).
2. **The Actuation Layer:** Devices that physically act on the building (e.g., valves, dampers, and actuators).
3. **The Management Layer:** The software that interprets data to optimize comfort and energy.

While the academic literature confirms that these systems are essential for green building strategies (Kolokotsa et al., 2011; Sivasankari and Rathika, 2025; Qiang et al., 2023; O'Grady et al., 2021), the market often simplifies this hierarchy into a singular promise of "smartness". However, the smartness of the management layer is entirely dependent on the accuracy of the sensory layer. It can become a 'garbage in, garbage out' relationship where hardware failure could make software optimization useless. Similarly, an extensive and advanced sensory layer does not make the BACS better if there is no actuation on the data input.

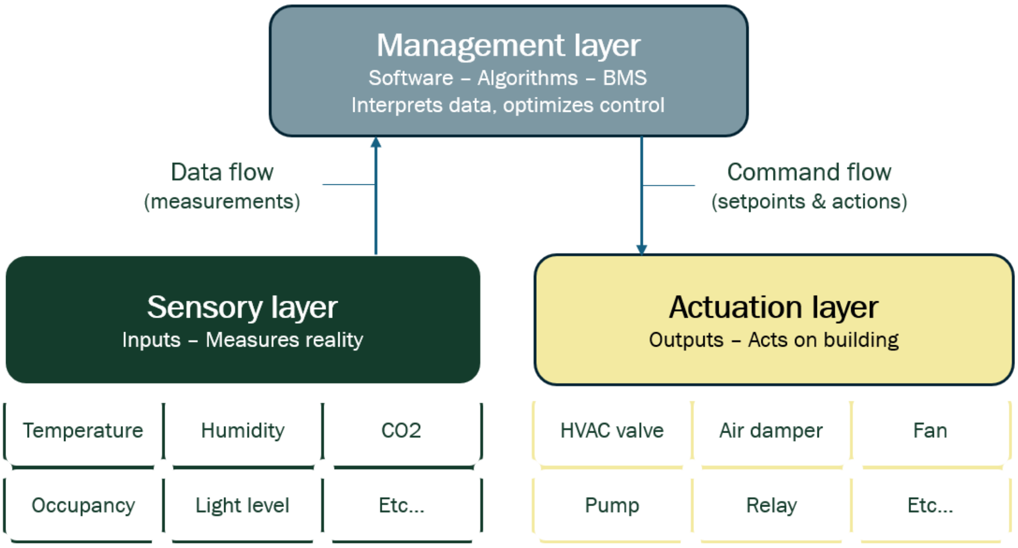

Figure 3.1: The BACS Architecture in one of its simplest forms. Sensory layer devices feeds variable input to the management layer, which enforce and control responses from actuation devices based on acquired data. Any new state will be subject to new measurements, re-triggering the information flow continuously.

3.1.2 The Bemsiq Hardware Portfolio

To ground the theoretical and industrial context in this study, it is useful to briefly introduce the hardware that defines Bemsiq's position in the BACS hierarchy. As described in Section 1.4, Bemsiq Group operates as a holding company managing a portfolio of international subsidiaries. Three product lines were selected for analysis in this study based on sales volume, sustainability-relevant features, or market novelty. Together, they illustrate the range of the sensory layer and the types of claims a manufacturer at this tier of the hierarchy might seek to make.

The Produal RTX series is a room transmitter designed to optimize building energy consumption while maximizing indoor comfort, shown in Figure 3.2. It monitors temperature, humidity, and CO_2 levels and transmits this data to the BACS for real-time adjustment of heating, cooling, and ventilation. Its key differentiator is a patented airflow-correction technology that maintains a temperature accuracy of ±0.3°C (at 20–25°C), compared to ±0.5°C for standard transmitters. Internal documentation suggests that this improvement can reduce total building HVAC energy consumption by 2–5%, depending on system sensitivity. The RTX series supports building certifications including LEED (ANSI/ASHRAE Standard 62.1-2022), BREEAM, WELL v2, and RESET grade B.

Figure 3.2: The Produal RTX series room transmitter featuring energy-efficient circuitry. Picture provided for visual aid to the product explanation.

The S+S Rymaskon series shown in Figure 3.3 is a room controller identified as a strong sustainability case within the group due to its integrated energy consumption tracking - the first product in the Bemsiq subsidiary's portfolio to have this capability. By allowing the device to monitor and report its own power usage, the Rymaskon provides granular data that bridges the legitimacy gap described in Section 3.3.2. It also reduces the complexity of Scope 3 data collection for embedded emissions.

Figure 3.3: S+S Rymaskon series with integrated energy tracking functionality. Picture provided for visual aid to the product explanation.

Lastly, Figure 3.4 show the Greystone IAQ series that offers a broad sensing capability, monitoring up to six indoor air quality parameters simultaneously: particulate matter (PM1.0, PM2.5, PM4.0, PM10), volatile organic compounds (VOCs), CO2, formaldehyde, humidity, and temperature. From a sustainability perspective, the IAQ series facilitates demand-controlled ventilation by providing high-accuracy CO_2 and VOC data via BACnet or Modbus signals, preventing overventilation and reducing unnecessary HVAC energy consumption. Its replaceable sensor modules contribute to circularity by extending device lifetime.

Figure 3.4: Greystone IAQ series with 6 sensors. Picture provided for visual aid to the product explanation.

All three product lines share support for standardized communication protocols (BACnet, Modbus), multi-parameter sensing, and elements of modularity. Each one also a strong candidate and example for the sensory layer within BACS.

Consequently, these products are the hardware around which the white paper simulation in Chapter 5 is constructed. Their specific sustainability claims, and the frictions encountered when attempting to substantiate those claims, are examined in the empirical findings.

3.2 The Push for Net Zero

Buying and installing these kinds of products, or BACS in general, is no longer strictly voluntary. In some places it has become a regulatory imperative. In Europe, the 2024 recast of the EPBD (European Union, 2024) pushes for zero-emission buildings, where e.g. France's Décret BACS (République Française, 2020) enforces automation for a certain threshold. Similarly, Singapore has introduced the Mandatory Energy Improvement (MEI) regime (Building and Construction Authority, 2025), and China has also enforced actions towards automation - being the emerging leader (Ministry of Housing and Urban-Rural Development of the PRC, 2021). These policy trends make data accessibility and transparency a legal requirement in construction and building markets. So, the concept of "net zero" buildings has moved from an idea to a common policy mandate.

Kaczmarczyk (2024) highlights that the accurate determination of a building's energy demand is the cornerstone of the European energy transition, pushing for BACS adoption in line with the EPBD. This general push from many actors is formalized in practice through Energy Performance Certificates (EPCs), which rate buildings on modeled rather than measured performance. Despite policy support none of these mandates and regulations addresses avoided emissions or net positive effects, thus leaving it in a vacuum. For property owners of non-residential buildings above the directive's threshold, this mandate transforms building automation from an optional efficiency measure into a procurement requirement, creating a new population of stakeholders who must evaluate sustainability claims from BACS suppliers without an established standard for doing so.

While that vacuum is one hurdle, the BACS market still appears to be healthy and trending positively through net zero targets. CBRE (2026) highlights in a recent European survey report that the building and property sector has strong investor sentiment. Particularly, they state that retrofits (modernizing and renovation of old buildings) and the increase of sustainability credentials among building stock will continue to be a strong lever for value creation. In both of these dimensions, BACS is a core contributor to the solution. Kolokotsa et al. (2011) align with this argument, stating that intelligent control is the most effective pathway to decarbonize the building stock. However, reliance on retrofitting to achieve climate goals brings us back to the unpredictable nature of design and performance, as well as the complexities of the physics of buildings.

3.3 The Energy Performance Gap (EPG)

Starting with the unpredictable nature of design: a technical tension in this thesis, and one of the root causes of the organized hypocrisy risk, is the Energy Performance Gap (EPG).

While BACS manufacturers want to market precision, the reality is one of high uncertainty. de Wilde (2014) categorizes the EPG into three distinct types of gaps. The first type of gap occurs between different predictions. This often shows as the discrepancy between a simplified model used for regulatory compliance and a more granular simulation used during the design phase. The second type is the most widely discussed in the industry: the gap between a specific building's predicted energy use and its actual, measured performance once it is occupied and operational. Finally, the third type shifts the perspective to a macro level, focusing on the gap between predicted and measured performance across an entire building stock. The last type is particularly relevant for evaluating the effectiveness of large-scale energy policies and renovation programs, and while beyond the scope of this thesis it is the type of gap that prompted the mandates for zero-emission buildings in the first place.

3.3.1 Difficulties of the "Standard Case" of Aggregation

To satisfy the policy mandates and large-scale stakeholders, industry white papers and impact reports often rely on static models to claim specific savings (e.g., "20% reduction") from the deployment of their products or software. However, recent empirical studies in the Swedish context by Bandak et al. (2025) demonstrate that such models frequently fail because they cannot account for dynamic factors, for instance (but not limited to):

- **Occupant Behavior:** The unexpected nature of how people act - e.g. opening windows, doors or overriding system configurations.
- **Thermal Inertia & Lag:** Aste et al. (2017) emphasize that the physical "heaviness" of a building means it does not react linearly to control signals.

- **Design Errors:** Discrepancies arising from poor sensor placement, lack of calibration, or data failure. All of which mislead the control system regarding the building's actual state.

This creates an issue. As Allcott and Greenstone (2012) argue, the technologies are not adopted due to lack of information and split incentives because of what they call the "energy efficiency gap" (mirroring the EPG). To increase customers and property owners willingness to invest, manufacturers promise and guarantee certain returns. Yet the evidence suggests that accurately predicting these returns for a "standard case" is flawed and what causes the EPG in the first place when the BACS are designed.

3.3.2 The Resulting "Legitimacy Gap"

When companies publish aggregated sustainability data, they are trying to smooth over this physical variance. They present a deterministic value in a world that Aste et al. (2017) describe as riddled with errors committed during all phases of the building life cycle. This disconnect between the market need for certainty and the physical reality of uncertainty is the communication challenge explored in this thesis.

This creates a paradox of compliance versus verification. While the EPBD in Europe explicitly mandates the adoption of BACS as a prerequisite for the 'net zero' transition, regulators have failed to establish a standard for verifying the resulting avoided emissions. Unlike the rigorous GHG Protocol that governs Scopes 1, 2, and 3, the quantification of these downstream benefits remains entirely voluntary and unregulated (World Resources Institute, 2019).

3.3.3 The Market Response

With the lack of standardized avoided emissions disclosure, the building automation industry has no objective way to prove its value within sustainability. This is simultaneous with regulators lacking feedback on the real-world effects of their mandates. Consequently, manufacturers bridge this legitimacy gap themselves. In the absence of a verified standard, the industry has universally adopted the use of white papers and impact reports as the primary vehicle for this purpose. These are by design self-authored artifacts that can provide technical information or evidence for claims to stakeholders.

A review of market leaders reveals a form of mimetic isomorphism explained by DiMaggio and Powell (1983), where diverse actors ranging from large-scale system integrators to component manufacturers use the same 'problem/solution' narrative to translate technical complexity into commercial utility. While these artifacts attempt to mitigate the uncertainty of the EPG, internalize externalities and increase legitimacy, they are deeply tied to the company's identity and business case.

4

Methodology

With the foundation of theory and industrial context completed, the methodology used to fulfill the research aim and answer the guiding questions must be outlined. These outlines are designed to support the exploration of the intersection between commercial sustainability communication and performance. The study adopts an abductive research strategy centered on an embedded case study of Bemsiq Group AB. The following sections detail the research approach, the case design and selection, and the multi-method data collection strategy.

4.1 Research Approach

Given the study's objective to uncover the mechanisms through which organized hypocrisy and legitimacy are produced in a technical and commercial field, a purely deductive or a purely inductive approach was deemed insufficient. A deductive approach would require hypotheses about Scope 4 communication that current theory cannot support. A purely inductive approach would risk producing a rich description of Bemsiq without enough theoretical grounding to generalize from it.

Instead, this thesis follows an abductive research approach as formulated by Dubois and Gadde (2002). Abduction operates through what they term "systematic combining", a continuous and iterative interplay between theoretical frameworks and emerging empirical realities. This makes it particularly suitable to phenomena where established management theory meets unexplored empirical conditions.

In practice, this meant the research process was iterative rather than linear. The initial theoretical understanding of the GHG Protocol, greenwashing, and legitimacy theory guided the early stages of data collection and the construction of the white paper simulation. However, the technical friction encountered when attempting to model avoided emissions forced a re-evaluation and pivot of the theoretical framing. What across the industry appeared to be instances of deliberate greenwashing were with increased knowledge re-framed as structural outcomes of sensemaking failure, driven by the absence of an industry standard rather than bad intent. This oscillation between theory and empirics continued across all phases of fieldwork, ensuring that the final analysis is not only a description of observed constraints but a theoretically grounded explanation of why those constraints are reproduced across the BACS industry (Figure 4.1).

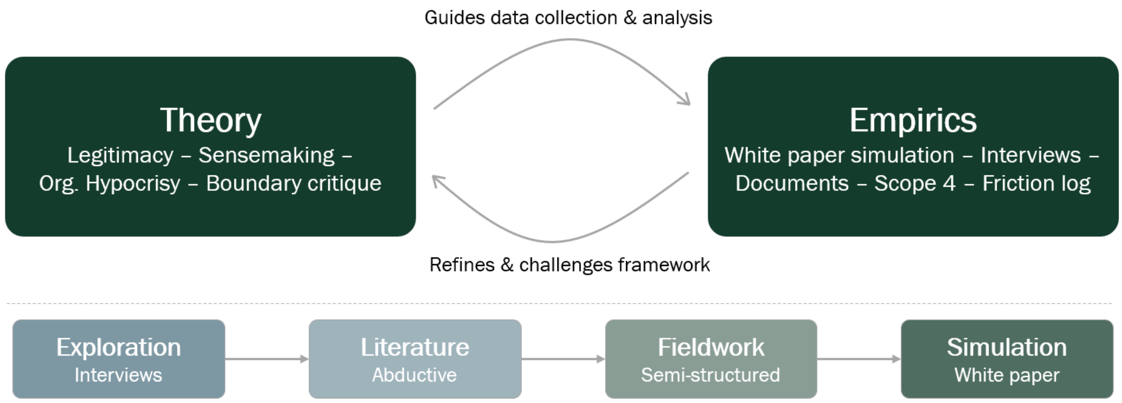

Figure 4.1: Abductive process followed in the study

4.2 Research Design

4.2.1 Case Study Strategy

The study employs a case study design centered on Bemsiq Group AB as the primary empirical setting. According to Yin (2018), case studies are the preferred research strategy when "how" or "why" questions are being asked and when the researcher has little control over the events under investigation, which are distinct conditions for this study. Complementing this, Bell et al. (2022) describe the case study as requiring a detailed and intensive analysis, with an emphasis on understanding the complexity and nature of the phenomenon or issue in question.

This design is especially well suited to the study, where the aim is not to generate statistical generalizations across a population of companies. Instead, it investigates the specific mechanisms by which a sensory-layer hardware manufacturer navigates the tension between technical uncertainty and the commercial need for credible sustainability communication. The case study further supports the multi-method data collection strategy employed here, combining different kinds of interviews, quantitative secondary data, and the white paper simulation without favoring any single source over another (Bell et al., 2022).

4.2.2 Case Selection

Bemsiq Group was selected based on the principle of intensity sampling (Patton, 2015), which suggests choosing a case that manifests the phenomenon of interest strongly, without being an extreme outlier. Bemsiq represents a strong and diverse case for three reasons.

First, its organizational structure as a holding company within Investment AB Latour requires it to aggregate diverse data from several independent subsidiaries including Produal (Finland), S+S Regeltechnik (Germany), and Greystone Energy Systems (Canada) - mirroring the industry challenge of standardizing sustainability disclosure but in this case across decentralized operations.

Second, the company's recent formal commitment to the Science-Based Targets initiative (SBTi) provides an environment in which sustainability data is actively being generated and scrutinized, making internal tensions visible in real time.

Third, Bemsiq represent the research problem precisely: it sells products positioned as enablers of decarbonization while simultaneously consuming resources in their manufacturing, placing it at the center of the green-digital paradox that defines the twin transition.

4.2.3 Unit of Analysis

The primary unit of analysis in this study is the sustainability communication artifact - specifically, the commercial white paper and the process of its construction. This definition follows Bell et al. (2022) argument that the unit of analysis should be aligned with the study's research questions rather than using the most accessible object of study, such as the company as a whole.

This choice is deliberate and analytically important. While Bemsiq Group provides the empirical context, the analytical focus is on a narrower object: the transformation of raw technical data into polished commercial claims. Concretely, this means tracing how energy performance measurements from Bemsiq's subsidiaries, pre- and post-installation data, and Scope 1–3 disclosures are negotiated within the organization. This negotiation might lead to simplification, but the process of how it ultimately ends up as a potential Scope 4 figure suitable for market communication is of interest.

By anchoring the analysis to the artifact and its construction process, the study gains the analytical opportunity to identify where, why and if scientific integrity is easily compromised for cognitive legitimacy. Each decision point such as which baseline to assume, which variable to exclude, and where to draw the system boundary becomes an observable data point recorded in the friction log described in Section 5.3.

4.3 Data Collection

Data collection was structured around five distinct but complementary sources: unstructured exploratory interviews, semi-structured interviews, focus group discussions, quantitative secondary data, and the white paper simulation. This combined approach ensures that conclusions about the constraints of sustainability disclosures are not dependent on any single source of evidence (Bell et al., 2022).

4.3.1 Unstructured Exploratory Interviews

Before the main fieldwork, a first round of unstructured interviews was conducted with executive leadership across Bemsiq's subsidiaries. Unlike the semi-structured interviews described in the following section, these conversations were deliberately open-ended with no predefined question guide. This format is appropriate in the early stages of abductive research, where the goal is not to test theoretical propositions but to map the empirical landscape and allow unanticipated themes to surface (Bell et al., 2022).

The respondents in this phase were the CEOs of Produal, S+S Regeltechnik, and Greystone Energy Systems, as well as senior representatives from Bemsiq, including CFO, Head of Business Development and Sustainability Manager. These individuals were selected for their strategic overview of the organization's sustainability ambitions and their proximity to the practical constraints of the white paper project. The conversations centered loosely on the feasibility of a group-wide Scope 4 claim, the organization's current data availability, and the risks of premature sustainability claims.

This phase complemented the abductive logic of the study. First, it generated the important empirical observation reported in Section 5. Namely, that a credible top-down white paper was not yet feasible, which in turn triggered the first theory-empirics action described in Section 4.1. Second, it fed into the design of the semi-structured interview guide used in the second phase, ensuring that the focus of the fieldwork reflected genuine organizational tensions rather than hypotheses.

4.3.2 Semi-Structured Interviews and Focus Group Discussions

To address the research questions about the strategy of sustainability communication and the negotiation processes behind it (RQ1 and RQ2), semi-structured interviews and focus group discussions served as the primary qualitative data source. Respondents were selected by purposive sampling, a non-probability approach in which participants are chosen strategically for their direct relevance to the research questions (Bell et al., 2022). To classify constraints, three distinct type of roles were targeted in the interviews:

- **The Technical Core:** Product managers and engineers with direct knowledge of the physical limitations and performance characteristics of the hardware.
- **The Strategic Layer:** Sustainability officers and senior management responsible for overarching sustainability commitments and decision-making.
- **The Commercial Front:** Key Account Managers (KAMs) who translate technical information into value proposition for customers.

A total of four semi-structured interviews were conducted across these layers (see Table 4.1). Each interview followed a guide, giving consistency while keeping the flexibility to explore emergent topics in depth. This approach is particularly appropriate for studying legitimacy and sensemaking, as it allows respondents to articulate the reasoning behind their choices rather than simply confirming or denying predetermined assumptions. Interviews were conducted both in-person and remotely depending on respondent availability

To encourage team engagement, the study conducted nine focus group discussions (FGD), separated into three each for Produal, S+S Regeltechnik and Greystone. For the former two companies, the sessions were conducted on site in Finland and Germany respectively. For Greystone, sessions were held online.

The FGDs intended to merge perspectives and frames with cross-layer participation on select topics. The idea was to find additional information through deliberate discussions. In pre-designed order the topics were "R&D", "sales" and "strategic", separated into 60 minute sessions each. A full list of how these were structured can be seen in Appendix B, but in short the execution of the discussions was guided by statements or open questions, upon which participants could voice their opinion based on their professional experience within their role. The different interviews showed individual perspectives from the layers, while the FGDs brought frictions to the surface.

Table 4.1: List of Interview Respondents. The table documents all primary data interactions conducted during the study, organised by data collection phase. Unstructured interviews were exploratory and used to scope the research problem. Semi-structured interviews followed a predefined guide while allowing follow-up questions. Focus Group Discussions (FGDs) were conducted per organizational layer using the session guides documented in Appendix B. Department classifications reflect the respondent's functional position within the Bemsiq Group: *Strategic* (holding company or subsidiary management), *Sales* (customer-facing commercial roles), and *Technical* (R&D, engineering, and product management). Time denotes approximate session duration per respondent; FGD participants sharing a session are listed individually.

#	Phase	Role	Company	Department	Time [min]
1	Unstructured	CEO	Produal	Strategic	30
2	Unstructured	CEO	S+S	Strategic	30
3	Unstructured	CEO	Greystone	Strategic	30
4	Unstructured	CFO	Bemsiq	Strategic	15
5	Semi-structured	Sust. Manager	Bemsiq	Strategic	60
6	Unstructured	Business Dev.	Bemsiq	Strategic	15
7	FGD	KAM 1	Produal	Sales	120
8	FGD	KAM 2	Produal	Sales	60
9	FGD	Sust. Officer	Produal	Strategic	180
10	FGD	Senior Engineer 1	Produal	Technical	60
11	FGD	Senior Engineer 2	Produal	Technical	60
12	FGD	CEO	Produal	Strategic	120
13	FGD	Sust. Manager	Bemsiq	Strategic	60
14	Semi-structured	Sust. Officer	S+S	Strategic	30
15	FGD	Sust. Officer	Greystone	Technical	30
16	FGD	Product Manager	Greystone	Technical	30
17	Semi-structured	Product Manager	Produal	Technical	30
18	FGD	Sust. Officer	S+S	Technical	60
19	FGD	Product Manager	S+S	Technical	60
20	FGD	CEO	S+S	Technical	60
21	Semi-structured	KAM	S+S	Sales	30
22	FGD	CEO	S+S	Strategic	60
23	FGD	Product Manager	Greystone	Technical	30
24	FGD	Product Manager	Greystone	Technical	30

4.3.3 Quantitative Secondary Data

The study draws on quantitative secondary data in a supporting rather than a central role. The material is meant to illustrate methodological choices and to ground the technical descriptions from Chapter 3. Three categories of input data are used.

The first is technical product documentation for the three product series analyzed - the Produal RTX, the S+S Rymaskon, and the Greystone IAQ - covering material inputs, energy consumption characteristics, and manufacturer-stated performance claims. This material leads to the portfolio description in Section 3.1.2 and the product-level claims examined in Section 5.2.2.

The second is reference and emission data used in the simulation in Appendix C. This includes BACS efficiency classes defined in ISO 52120-1:2021 (International Organization for Standardization, 2021), addressable building-stock and energy-demand figures from the IEA (International Energy Agency, 2023), fuel-specific CO_2e conversion factors from COWI A/S (2023), and a Defra-derived embodied emissions proxy for generic electronics (UK Department for Environment, Food and Rural Affairs, 2021).

The third is Bemsiq portfolio figures, including market share, installed base, and aggregated embodied emissions drawn from the Scope 1-3 disclosure prepared for the SBTi commitment (Bemsiq Group AB, 2023). For commercial confidentiality these figures are represented by dummy values throughout Appendix C. The numerical outputs are therefore illustrative of the method rather than claims about Bemsiq's actual performance.

4.3.4 The White Paper Simulation and Friction Log

A distinctive component of this study is the use of a white paper simulation as a data generation method. Rather than producing a finalized commercial document, we embedded ourselves in the process to expose the constraints on sustainability disclosures. This approach is consistent with Bell et al. (2022) emphasis on qualitative methods as tools for showing processes from within an organizational context, and it is well aligned with the abductive logic of the study.

The method works as follows. Based on interview data and quantitative secondary data, we constructed a multi-page commercial presentation folder structured around the "problem/solution" format used among industry leaders, shown conceptually in Section 5.1.3. At each stage where a methodological decision had to be made - which baseline to assume, which system boundary to apply, which attribution logic to use, which variable to include or exclude - the issue was recorded as an entry in a structured friction log.

The friction log is an inventory of the tensions encountered during the white paper construction process. Each entry is assigned four properties: a unique identifier (e.g. F1, F2), a descriptive label of the friction, a category, and a severity rating. The categories correspond to three clusters that emerged during the analysis. These being:

- **Methodological & Data:** Covering challenges related to baselines, data access, and analytical assumptions.
- **Organizational & Professional:** Capturing tensions between different layers and professional roles within the company.
- **Strategic & Structural:** Addressing systemic conflicts such as double-counting, scalability, and the absence of process standards.

In Chapter 5, each cluster is presented with a summary table followed by a discussion of the individual entries.

The severity rating reflects the degree to which each friction impacts the potential of a credible sustainability claim. A high severity indicates that the friction blocks credible disclosure, meaning that no defensible claim can be made while it remains. A medium severity means the friction introduces uncertainty or forces an assumption that weakens the claim but does not make it impossible to formulate. A low severity means a notable tension that is worth documenting for completeness and future consideration, but does not prevent a reasoned claim from being made at this stage. These classifications were assigned by the researchers based on the combined evidence from interviews, FGDs, and the simulation process itself, with particular weight given to whether the friction was obvious across multiple sources.

Each entry further documents the friction's analytical implications which are traced through the analysis in Chapter 6. The friction log is thus a record of the work process behind the white paper, making the mechanisms visible for how scientific precision is negotiated against commercial clarity.

This approach was chosen because it generates a form of evidence that is different from what interviews alone can provide. Respondents can describe their awareness of constraints but the simulation makes them visible in practice. The friction points documented in Chapter 5 are therefore not self-reported ideas about difficulties but empirical examples of where the available evidence was insufficient to support the commercial claim the narrative required or wanted.

4.4 Data Analysis

All interviews were transcribed in full, and transcripts were reviewed after each session to ensure the findings were logged. Interview findings and friction log entries were subsequently analyzed as a combined body of qualitative data, as part of the abductive logic of the study.

The analysis began with reading across all material to identify patterns in how respondents across the technical, strategic, and commercial layers of Bemsiq reasoned about the organizational constraints. Systematic coding was then applied, focused on instances of friction. Initial codes were grouped into broader themes developed through iteration between the empirical material and the theoretical concepts of legitimacy, sensemaking, and boundary critique. Themes were refined and tested against the data continuously, with some collapsed and others discarded where empirical grounding was insufficient.

This cross-layer perspective is deliberate. A central interest of the study is precisely where and why the technical, strategic, and commercial layers diverge in their opinions of the same problem, and what structural conditions lead to that divergence. The resulting themes form the backbone of Chapter 6, where they are used to explain not only what constraints exist for Bemsiq, but why those constraints are reproduced across the BACS industry.

4.5 Research Quality

Research quality depends on whether the findings of a study are repeatable (Bell et al., 2022). In qualitative case research, exact replication is not expected or the goal, given that the embeddedness in a specific context is part of what produces the insight. To address reliability, the analytical process was kept transparent and traceable. Interview guides, friction log entries, and other decisions made are documented in the thesis, enabling external readers to scrutinize the reasoning behind the conclusions drawn.

Internal validity was improved through triangulation across the data sources. No conclusion about the structural constraints of Scope 4 reporting is made from any source alone. Each finding is a deduction from at least two of the three. The iterative abductive process further strengthens internal validity, as preliminary conclusions were repeatedly tested against new empirical material and revised accordingly. While researcher embeddedness in the white paper simulation comes with potential confirmation bias, the interviews and FGDs were open-ended by design and thus led the findings in the directions of the respondents, not the researchers. By actively logging frictions as they appeared the risk of misrepresenting opinions was mitigated, especially since the categories themselves were emergent and not pre-specified.

Ecological validity is a particular strength of this study. By having the research directly within Bemsiq's operational reality and using the white paper simulation as a live test, the findings reflect the conditions companies actually face rather than a theorized model of them. While companies do not always act as the best champions for the environment, they collectively become an important group and their reality affects their impact.

On the topic of 'collectively' - generalization across companies, industries, or sectors cannot be made from one single-case study (Bell et al., 2022). The authors make no claim that Bemsiq's specific constraints are always representative for the broader BACS industry. However, the case was selected precisely because it represent the research problem well and the mechanisms uncovered are based on industry-wide conditions, including the universal absence of a standardized Scope 4 framework and the existence of mimetic isomorphism across market actors. The findings are therefore analytically generalizable to comparable companies navigating the same regulatory and communicative context, consistent with comments by Yin (2018) of analytical rather than statistical generalization.

4.6 Ethical Considerations

Researching corporate sustainability practices from an embedded position requires navigation of both sensitive internal data and potential conflicts of interest. The primary ethical challenge in this study was the dual role of the researchers. Namely to simultaneously act as analysts with access to proprietary commercial and technical data, while maintaining the academic independence necessary to critically assess Bemsiq's sustainability communication, including its risks of greenwashing and organized hypocrisy.

To mitigate this tension, a clear agreement was established prior to fieldwork. The researchers retained full academic freedom to document and critique any constraints, failures, or greenwashing risks uncovered during the study, irrespective of the commercial implications for the company. All respondents were informed that the purpose of the research was process analysis rather than the production of a commercial deliverable. For the sake of publication, the individual respondents were anonymized.

A further ethical consideration concerns the use of proprietary data. Technical specifications and internal performance data are used here strictly for analytical purposes. No commercially sensitive data are disclosed beyond what is necessary to make the analytical claims of the thesis, and all quantitative figures are presented at an aggregated or illustrative level.

4.7 Artificial intelligence usage and considerations

Given the growing applicability and usefulness of artificial intelligence (AI), several tools have been used during the course of this thesis. Their use is documented here for transparency.

First, the image-generation tool Nano Banana by Gemini was used to produce the cover image, prompted to capture the exterior of a sustainable building together with the "hidden complexity of the systems behind it". Gemini was also used to write the LaTeX code for tables, figures, and BibTeX references, reducing both time spent on formatting and improving its consistency.

Second, Claude AI was used to draft figures for the typical configuration of a white paper, the theoretical synthesis, the BACS architecture, and the abductive research process, based on our own input and outline. Each draft was adjusted to match the framing and design preferences of the thesis. Claude also actively supported the formulas, graphs, and tables in Appendix C, similar to how Gemini was used for the other parts of the thesis.

Lastly, the Overleaf built-in AI tool "Writefull" was used for grammatical and spelling corrections throughout all chapters of the thesis.

5

Empirical Findings

This chapter presents the empirical findings of the study, structured in three parts.

First, Section 5.1 identifies an approach to sustainability disclosure for Bemsiq, including the benchmarking of industry leaders and the strategic pivot toward customer cases.

Second, Section 5.2 documents the simulated white paper artifact, with its narrative, the boundary judgments embedded in its claims, and the points where commercial ambition and available evidence visibly collide.

Third, Section 5.3 presents the Friction Log: a structured inventory of the specific tensions between technical uncertainty and the need for commercial clarity that surfaced during the simulation process. The hardware portfolio used as the basis for the white paper has been introduced in Section 3.1.2, and a theorized Scope 4 calculation that was developed to make the assumptions behind a portfolio-wide claim explicit is provided in full in Appendix C.

5.1 Sustainability Approach

The aim of this study - and of Bemsiq's leadership - was to pave the way for how to properly work with sustainability discourse and communication. It is a slippery slope, and many companies are facing difficulties in navigating these environments without backlash. For Bemsiq, a key priority was to find something that summarizes the sustainability performances of their young organization while avoiding fallacies.

To address that priority, a white paper simulation was conceived. The simulation captures everything that surfaced during the project of creating a white paper, thus generating empirical evidence of any hurdles or issues throughout the process. Executing on this simulation, one point of investigation was the potential synthesis of a Scope 4 calculation that could be turned into a comprehensive, top-down summary.

First stage interviews with the executive leadership across Bemsiq's subsidiaries revealed a critical disconnect between the theoretical ideal of carbon accounting and the operational reality of the BACS market for device manufacturers. Respondents agreed: the organization cannot immediately produce a credible, holistic white paper because the data needed for such claims does not exist yet. At least within the subsidiaries, the idea of an aggregated white paper is supported, but not if it is lacking in legitimacy for the intended use-cases.

5.1.1 Premature Claims and the Risk of Hypocrisy

To author a white paper without empirical grounding is to risk slipping directly into greenwashing according to respondents. The executives recognized and unanimously agreed that relying only on theoretical formulas - with values of generic grid intensities or assumed energy efficiency coefficients - is not enough to resonate with the market and individuals interested in the white paper. Especially since the needed system boundaries to introduce variables for those calculations are a far leap from any technical quality or performance of the small devices themselves.

As discussed in Chapter 3, but now also confirmed by the executives, the barriers inherent to claims (e.g. the absence of knowledge through historical data) are tangible. By the executives' arguments, a perfect Scope 4 calculation is practically impossible. Respondent 3 could not see how such a value could be modeled without too many assumptions. Therefore, publishing a generalized normative document right now would lack the proof that the technology yields measurable financial and environmental benefits in the real world. To follow that up, one of the main issues for the respondents was that even if there were data, they would not feel confident in claiming any gain since the devices are only a part of the solution, and there is no way of attributing percentages in a systematic and fair way.

With that comes the first methodological discovery, but before leaping into definitive conclusions, focus will be turned back to re-connect with the notion of 'institutional isomorphism' and see what industry leaders do and how they have reasoned.

5.1.2 Benchmarking of Industry Leaders

To contextualize the industry-wide characteristics, established actors and their actions can be examined. This benchmarking exercise reveals that the pursuit of organizational legitimacy is not a standardized process, but a back-and-forth narrative constructed through varying methodological assumptions. While the assumptions and narrative differ, the end-products communicated often end up similar to each other. This is because the end-products, say a white paper or impact report, is the standard boundary-spanning artifact for translating technical complexity into commercial utility. Notably, the larger the company, the greater the chances that they will use more than one method or end-product. For the following examples, a selected few companies are represented with a specific paper that adds perspective to the 'how' of corporate sustainability disclosure. Note that these examples are only a select few out of many documents published by each company, so the takeaways are illustrative and not definitive.

The five benchmarked companies are Schneider Electric, Siemens, Honeywell, Belimo and Johnson Controls. They collectively reveal three dimensions where sustainability disclosure strategies diverge, despite converging on the format upon which they communicate.

Object of focus

The most apparent difference between claims and focus is where in the BACS hierarchy each company resides and anchors its claims. Schneider Electric and Siemens operate across all three layers and report portfolio-wide "saved and avoided" emissions against Business-as-Usual baselines (Schneider Electric, 2022, 2025; Siemens Smart Infrastructure, 2023). Honeywell and Johnson Controls focus claims at the management layer, framing sustainability as an outcome of platform-level optimization rather than individual device performance (Honeywell Building Technologies, 2022; Johnson Controls, 2021). Belimo is the exception here: as a hardware-focused manufacturer it builds claims from device-level, attributing savings to specific field devices such as the Energy Valve (Belimo Automation AG, 2020, 2023). While similar in operation but entirely different entities, they argue in favor of their own relevance and contribution.

Verification strategies
Schneider's and Belimo's publications explicitly states that data is retrieved from trusted internal sources (like case studies), even though the values are confidential. They mitigate the confidentiality issue with external verification - Schneider use PwC as an external auditor and Belimo relies on a professor from Lucerne University of Applied Sciences and Arts (HSLU) to guarantee reasonable calculations (Schneider Electric, 2025; HSLU, 2022). Siemens mitigates risk by explicitly excluding product categories where decarbonization contributions cannot yet be reliably calculated, instead focusing on those that can. Honeywell and JCI examples rely on the storytelling of their narratives. These being outcome-based "healthy buildings" and a "7-step roadmap" respectively. While those are persuasive and intuitive, they are communicated without third-party validation of the underlying emissions models.

Legitimacy
While the approaches differ in content, each can be read as prioritizing a specific legitimacy pillar in the sense of Suchman (1995). Schneider and Siemens pursue moral legitimacy through methodological transparency and independent verification (Schneider Electric, 2022; Siemens Smart Infrastructure, 2023). Honeywell prioritizes cognitive legitimacy, offering accessible technical guides aimed at non-engineering stakeholders (Honeywell Building Technologies, 2022). Johnson Controls emphasizes pragmatic legitimacy, centering its communication on financial ROI from digital retrofits (Johnson Controls, 2021). The classification is interpretive rather than categorical. However, the broader point holds regardless of how any single publication is labeled: each publication is intended to generate legitimacy.

Together, these cases show that institutional isomorphism exist to some extent (DiMaggio and Powell, 1983): all five actors use the problem/solution white paper as their boundary-spanning artifact, yet the assumptions regarding baselines, attribution, and data access remain different. Each company shown has a broader portfolio of white papers targeting different verticals or topics. The examples above are selected to illustrate the range of methodological choices available to a company in Bemsiq's position. A comparative summary is provided in Table 5.1.

Table 5.1: Comparative Summary of Industry Sustainability Methodologies

Company	Primary Value Proposition	Reporting Focus	Dominant Assumption
Belimo	Precision Hardware Efficiency	Device-specific	Accuracy of internal savings models verified by external academic review.
Honeywell	Healthy & Sustainable Buildings	Regulatory Navigation	High system-integration effects and occupant response.
JCI	High-Efficiency Performance	ROI & Decarbonization Roadmap	Effectiveness of strategic platform optimization (OpenBlue).
Schneider	Net-Zero Building Path	Saved & Avoided CO_2	Use of "most-likely" Business-as-Usual (BAU) baselines.
Siemens	Digital Transformation	Customer Avoided Emissions (CAE)	Impact generated through electrification and efficiency.

5.1.3 The Anatomy of a Credible White Paper

The benchmarking exercise above demonstrates that the five industry actors converge on the same communicative format while diverging on the methodological substance behind it. By extracting the strongest elements from each, and grounding them in the theoretical requirements established in Chapter 2 and the comparative emissions framework of the World Resources Institute (2019), it is possible to compose what a credible sustainability white paper for a BACS manufacturer would ideally have. This composite is not observed in full in any single benchmarked document, but each element is shown by at least one of the five actors. Together, they represent the standard against which the Bemsiq simulation and its resulting frictions should be read.

The ideal white paper rests on seven requirements, organized across three categories: methodological foundations, evidence and verification, and communicative design.

Methodological Foundations

The first requirement is a *defined and defensible baseline.* The comparative emissions framework of the World Resources Institute (2019) specifies that avoided emissions must be calculated against an established reference scenario. In practice, this means metered energy data from the building in question prior to installation. Schneider Electric does this through “most-likely” Business-as-Usual baselines (Schneider Electric, 2022, 2025), while the ISO 52120-1 standard provides generic BACS efficiency classes that can serve as a secondary reference when building-specific data is unavailable (International Organization for Standardization, 2021). As shown in Appendix C, the theorized Scope 4 calculation for Bemsiq relied entirely on the latter, because building-specific metered data does not yet exist for any installation in the portfolio.

The second requirement is an *explicit attribution method*. Where the product is only one contributor within a multi-layered system, the white paper must state clearly how much of the total saving is attributed to the manufacturer's own hardware, and why. The benchmarking reveals that this requirement is handled differently depending on where the company sits in the BACS hierarchy. Belimo use device-level causality: the Energy Valve produces a binary physical state change (open/closed) that allows a direct before-and-after comparison at the unit level (Belimo Automation AG, 2020, 2024).

Schneider Electric and Siemens on the other hand, operating across all three BACS layers, absorb the full system-level saving into their portfolio claims (Schneider Electric, 2025; Siemens Smart Infrastructure, 2023). Neither approach is neutral, both reflect a boundary judgment in the sense of Ulrich (1983) but both are also stated explicitly, which allows external readers to evaluate the claim on its own terms.

The third requirement is *geographic and contextual differentiation*. A kilowatt-hour saved in Sweden does not carry the same CO_2e value as a kilowatt-hour saved in Poland, because the grid emission factors differ. The WRI framework (World Resources Institute, 2019) requires that avoided emissions be calculated using location-specific conversion factors. Any white paper claiming avoided emissions without accounting for this variance overstates impact in low-carbon grids and understates it in carbon-intensive ones.

Evidence and Verification

The fourth requirement is *verified case evidence*. The ideal white paper contains at least one - and ideally multiple - documented installations where pre- and post-installation performance has been measured, not modeled. Without it, a white paper can only present illustrative calculations, which satisfy cognitive legitimacy (Suchman, 1995) but leave moral legitimacy undefended.

The fifth requirement is *independent third-party review*. The benchmarking shows two distinct models with either corporate audit or academic support. Siemens takes a different route by self-imposing a scope restriction, explicitly excluding product categories where decarbonization contributions cannot yet be reliably calculated (Siemens Smart Infrastructure, 2023). While not third-party, they share a mechanism for accountability that protects the publisher against accusations of organized hypocrisy (Cho et al., 2015). Without such a mechanism, it is difficult to claim the white paper as credible.

The sixth requirement is *net impact disclosure*. A complete white paper accounts not only for the emissions avoided through the product's operational contribution but also for the emissions generated during manufacturing, transport, and end-of-life. Without the net figure, a white paper risks promoting gross savings while concealing the carbon cost of producing the hardware that enables them. While subject to boundary critique, a white paper should ideally cover net effects for trustworthiness.

Communicative Design

The seventh requirement is an *educational narrative before product claims*. Stelzner (2006) defines the ideal white paper as strictly separated from a sales brochure: it must lead with the industry problem and build the reader's understanding before introducing the a solution. The benchmarking confirms that all five actors follow this convention. Schneider Electric opens with the global building energy challenge, Honeywell with healthy-buildings regulation, JCI with the decarbonization roadmap. However, the format alone does not guarantee credibility. It is the substance behind the problem/solution narrative that determines whether the document is as a genuine boundary object (Star and Griesemer, 1989), or just a cover for claims that the evidence cannot support.

Summary

Taken together, these seven requirements form the composite standard of an ideal sustainability white paper in the BACS sector. While they are formulated from the manufacturer's perspective, they function equally as a due-diligence checklist for any stakeholder evaluating a BACS sustainability white paper - including property owners, system integrators, and certification bodies. Table 5.2 summarizes the requirements and maps each to the benchmarked company or companies where the practice is most clearly observed.

Table 5.2: Composite requirements for a credible BACS sustainability white paper

#	Requirement	Source / Rationale	Observed Examples
1	Defined BAU baseline from metered data	WRI comparative emissions framework; ISO 52120-1	Schneider, Belimo
2	Explicit attribution method	Boundary critique (Ulrich, 1983)	Belimo (device); Schneider/Siemens (system)
3	Geographic and contextual differentiation	WRI framework; grid emission factors	Schneider (PwC-verified)
4	Verified case evidence (measured, not modelled)	Legitimacy theory (Suchman, 1995)	Belimo, JCI
5	Independent third-party review	Organised hypocrisy avoidance (Cho et al., 2015)	Schneider (PwC); Belimo (HSLU)
6	Net impact disclosure (avoided minus embodied)	LCA completeness; boundary critique	Belimo (EPDs); Schneider (portfolio)
7	Educational problem/-solution narrative	Stelzner (2006); mimetic isomorphism	All five companies

The following section documents the executive consensus that led Bemsiq to adopt a bottom-up strategy centered on customer cases - a decision that is, in effect, a recognition of the distance between the organisation's current capacity and the requirements outlined above.

5.1.4 The Pivot to Customer Cases

Faced with the issue of not having the instantaneous resources to provide a full impact report, coupled with the difficult nature of building physics and the lack of standardized baseline data, the earlier communicated executive consensus pointed toward a necessary pivot.

Before a macro-level impact report can function as a boundary object, the company needs micro-level validation. As such, the idea of an aggregated result is postponed to the future, and an immediate switch towards specific customer cases had to be done. The executive consensus effectively acknowledged that Bemsiq cannot satisfy Requirements 1, 4, and 6 - a defined baseline, verified case evidence, and net impact disclosure - at the portfolio level. The pivot to customer cases is therefore not a retreat from the ideal but a matter of sequence.

These real-world pilot projects serve a dual purpose:

1. **Data Gathering:** They provide the actual data required to see which variables can be tracked and which must be discarded, as well as the actual per-

formance of the devices
2. **Narrative Building:** They offer verifiable instances of success that build trust with future customers for the entire Bemsiq Group

In essence, you cannot build the facts without first running the experiments. To illustrate why a portfolio-wide claim is premature, a theorized Scope 4 calculation was developed as part of this study. That exercise - documented in full in Appendix C - walks through the steps of establishing a baseline, stating assumptions, calculating the intervention effect, and extracting avoided emissions across attribution scenarios using dummy data. Its value lies in making each assumption explicit. It demonstrates that every step from baseline selection to geographic weighting to attribution percentage requires a judgment call that introduces uncertainty. The exercise confirmed the executive consensus: a credible top-down claim is not feasible at this stage.

With the limitations of the top-down approach now established, the remainder of this chapter turns to the bottom-up approach.

5.2 The "White Paper" Artifact

The simulated white paper takes the form of a multi-page commercial presentation folder structured around the 'problem/solution' format identified in the benchmarking exercise of Section 5.1.2. The three product lines introduced in Section 3.1.2 serve as the primary content of the folder, and the theorized Scope 4 calculation documented in Appendix C provided the guidelines against which product-level claims were formulated.

5.2.1 Narrative

The deck opens with a macro-level problem framing that is similar to the mimetic isomorphism observed from industry leaders and that has already been introduced in this thesis, namely the building and construction sector impact and how vital actions to decarbonize are.

The second narrative layer puts Bemsiq as the "nervous system" of a building. Their units provide the granular, room-level data without which no management or control layer can function. The document makes an explicit comment on the BACS hierarchy introduced in Chapter 3: field devices provide empirical truth to a BACS that would otherwise operate on assumptions. This framing assigns Bemsiq's sensors an important role in the system without need to quantify the precise contribution of any individual unit. Phrases used, like *"without sensors, the BACS operates on assumptions; with Bemsiq's hardware, it operates on reality"*, is a clear push of pragmatic legitimacy over scientific precision. It is persuasive and comprehensible, and it side-steps the attribution problem documented as F12 in the friction log.

In this same layer, tangible benefits are introduced. From focus group discussions during development stage, certifications and classifications like BREEAM, ASHRAE 62.1, WELL v2 were communicated as the enabling criteria for property owners to make financial gains through granted subsidies or chargeable premiums. Since these are valuable for customers, they are highly visible. The problem/solution format and the educational framing satisfy Requirement 7 from 5.1.3. This is the one requirement the Bemsiq white paper meets without additional data or external review. The substance behind the narrative, however, is where the remaining six requirements come into play.

The third layer introduces Scope 4 avoided emissions as the commercial value proposition. The document defines avoided emissions as the CO_2e that *"would have been emitted if a building continued operating without automation"*. A simplified calculation explains the concept as follows:

$$\text{Avoided Emissions} = (E_{\text{baseline}} - E_{\text{post-installation}}) \times \text{Grid Emission Factor} \tag{5.1}$$

The baseline is to be established from 12 months of pre-installation metered data, with post-installation figures drawn from the same meters. This aligns with the approach communicated by Schneider Electric (2025) and the comparative emissions framework (World Resources Institute, 2019). It is the methodologically defensible version of the calculation, which also would control for the variables in Section 3.3.1 of e.g. occupant behavior. However, as documented in F2 and F3, this baseline does not yet exist for any Bemsiq project in the portfolio. The 12-month pre-installation metered data is what they are intending to use when this process is more established within the organization. The white paper therefore presents the method credibly while the application of that method remains to be completed, which is a fair step in early stage sustainability pursuits. As one of the respondents for the exploratory interviews put it:

"I would rather say: 'We are not sustainable today but we have a roadmap on how we will be', instead of making false claims".

5.2.2 Product-Level Claims and Evidence

The simulation's purpose at the product level is to specify what each product's page should contain and to identify what evidence remains to be generated before it can be published with full defensibility. The specifications are summarized here.

The Produal RTX series had the most pre-existing material about sustainability impact. Its patented airflow-correction technology has a tested ±0.3°C temperature accuracy in the 20-25°C range, arguably better than the usual ±0.5°C tolerance of comparable transmitters. This accuracy differential is the mechanism behind the 2-5% HVAC energy reduction estimated in internal documentation. The logic follows that a transmitter that over- or under-reads by half a degree causes a control loop to heat or cool unnecessarily. The consensus through FGDs is that the RTX page should lead with the accuracy advantage, how that advantage boils down into an energy savings perspective, and illustrate the magnitude with a contextualized scenario. The case suggested is a typical hotel customer, with a 5,000 m^2 facility consuming 1.5-1.65 GWh annually. A conservative 2% reduction (which is the lower end of internal calculations) translates to roughly 0.033 GWh and 9 tonnes CO_2e avoided per year with the Bemsiq data on the specific hotels grid mix.

The S+S Rymaskon series should anchor the novelty of functionality. It is the first Bemsiq-group device to integrate unit-level energy tracking, which begins to resolve the last-mile data problem that constrains the industry (F3). The simulation specifies that information about the Rymaskon product should lead with this capability. Another feature unique to the Rymaskon is that they have attached the sensor "outside" of the central casing, meaning that the protrusion seen in Figure 3.3 is a tactical design choice. With distance from the rest of the device, the sensors are less disturbed by internal heating and gives better readings. Internal testing suggest that this practical design feature also makes the Rymaskon capable of a ±0.3°C temperature accuracy, but through a different solution compared to the RTX series.

The Greystone IAQ series has a unique upside in the certification-and-compliance case. Its broad sensing scope (PM1.0-PM10, VOCs, CO_2, formaldehyde, humidity, temperature) and replaceable sensor modules position it well around the certifications property owners appear to value. A quote from the FGDs with Produal was *"Customers does not really ask for energy savings, but they do inquiry for certifications regularly"*. The simulation specifies a page led by ASHRAE 62.1, WELL v2, and RESET grade B compliance, framed around how these translate into property-owner value for those readers that does not immediately recognize the upside of it. Given the product's recent release, a quantified performance claim is not really attainable yet.

Together, the three product series define a good start towards a portfolio white paper, but there will be work to be completed within the Bemsiq organization to gather adequate case data.

5.2.3 Headlines and the Precision-Narrative Trade-off

At the organizational level, the simulation specifies two headline metrics, a 13-30% typical energy reduction from A-class BACS relative to a C-level baseline and a 4.7-year CO_2 payback period, plus a theorized 2:1 avoided-to-embodied carbon ratio grounded in Belimo Automation AG (2023) and Appendix C methodologies (with the 5% attribution assumption, derived and explained in Appendix C).

The A-to-C baseline, rather than the A-to-D comparison used in Appendix C, is intentional. From discussions with executives it was made clear that Bemsiq's average customer already understands the use-case for BACS and is more often than not evaluating the marginal return on high-performance devices. So, the comparison against already-automated buildings is more relevant than against non-automated ones.

Both ranges are externally inspired rather than proprietary. The 13-30% figure is drawn from International Organization for Standardization (2021), consistent with the ranges cited by Honeywell Building Technologies (2022) and Johnson Controls (2021). The 2:1 ratio is inspired by Belimo's methodology and might require refinement - but the principle is that a claim anchored in verified external work is more defensible at this stage than one constructed from internal data alone. To really fulfill the composite requirements in both cases, Bemsiq should over time test the 13-30% range against their own installed base. They should also re-visit the 2:1 ratio recalculated using the derived data from the tests together with embedded emissions. The transition from externally-sourced to internally-verified figures is a step towards legitimacy. Similar to how Schneider historically adjusted, and improved, their CO2 methodology, Bemsiq will likely have to iterate.

5.2.4 Structural Choices as Boundary Judgments

Discussions within the group throughout the process pointed towards a building-level system boundary, with avoided emissions attributed to the sensing layer where Bemsiq's products operate. Extending the boundary to the actuation and management layers would require the document to account for technologies Bemsiq does not manufacture, introducing speculation into a document whose purpose is to communicate what Bemsiq contributes. Returning to the phrasing "attributed" - it is a topic of concern for the entire industry. A preliminary solution in the white paper is to weigh contribution in monetary value. If an end-user installs a BACS for 1 million of any currency, and the hardware for the same projects amount to 50 thousand, it is a reasonable assumption that the value contribution is 5%. Internal analysis (while limited) points towards 3-9%, which makes the low-to-mid scenarios of Appendix C valid.

Embodied carbon, geographic grid variance, and end-of-life characteristics are not explicitly shown in the white paper. Suggestions arose about mentioning them, while keeping their primary disclosure forum in other documents. A commercial white paper and a Scope 1-3 inventory answer different questions, so it makes more sense to keep them both polished. The benchmarked leaders follow the same idea, where for instance Belimo publishes EPDs separately from its commercial white papers (Belimo Automation AG, 2024).

These specifications mean that Requirements 3 and 6 of the composite standard (Table 5.2) are addressed at the organizational rather than the document level. If this is sufficient or not can be argued, since it definitely is a question within the boundary critique concept.

5.3 The Friction Log

The white paper artifact documented above is not evaluated as a finished commercial product. It is a simulation, and its value lies precisely in being incomplete. The suggestions of actions, the hedges in statements, and the incomplete impact calculations reveal visible traces of frictions where the available evidence was insufficient to support a credible claim.

This section documents those frictions systematically. Each friction represents a specific point where Bemsiq's available evidence, organizational capacity, or structural position in the BACS hierarchy prevented the simulated white paper from satisfying one or more of the seven requirements. They are organized into three clusters:

- **Methodological & Data:** Challenges related to establishing baselines, accessing end-user data, and accounting for variables.
- **Organizational & Professional:** Tensions between different layers of the company (e.g. strategic vs technical) and professional roles.
- **Strategic & Structural:** Conflicts regarding the scalability or reliability of data, the paradox of double-counting in systems, and vacuum of process standards.

Each cluster is introduced with a summary table, followed by a discussion of the related points.

5.3.1 Methodological & Data Friction

The first cluster consists of the methodological and data frictions, comprised of seven frictions.

Table 5.3: Friction Log – Methodological & Data Friction

ID	Friction Point	Category	Severity
F1	Absence of standardized framework	Methodological	High
	Any methodological choice feels wrong; technical and sustainability staff cannot claim anything with confidence.		
F2	Missing Business-as-Usual (BAU) baseline	Data	High
	Technical teams cannot reliably claim CO_2e saving figures without historical comparison data.		
F3	"Last mile" data access	Data	High
	Customers or end-users unwilling, or unbothered, to share operational data; limits findings to "potential" rather than "verified" impact.		
F4	Geographical differences in grid intensity	Methodological	Medium
	A 2% saving in Sweden (low-carbon grid) carries a different CO_2e impact than the same saving in Poland (coal-heavy grid).		
F5	Aggregation vs granularity trade-off	Methodological	Medium
	Country-level allocation based on revenue is less accurate than unit-level tracking; introduces assumptions but reduces administrative burden.		
F6	Linear scaling risk	Methodological	Medium
	Extrapolating gains from a product case to the entire portfolio introduces assumptions; Any translation might be inaccurate.		
F7	Embedded vs operational carbon trade-off	Data	Low
	No net calculations available; Improved products achieve efficiency gains, but Scope 3 data is not detailed enough to tell differences		

The methodological and data frictions documented in this cluster correspond primarily to Requirements 1, 3, and 6 of the composite standard (Table 5.2): the defined baseline, geographic differentiation, and net impact disclosure. Together, they explain why the white paper cannot yet make claims as confidently as the WRI framework and industry best practice suggest.

The three high-severity frictions (F1-F3) are interconnected and reinforcing. The absence of a standard for avoided emissions (F1) is not only an inconvenience. It basically produces a state of paralysis. Both technical and sustainability staff confirmed that *"there is no framework on how to do it"*, meaning that any metric chosen risks appearing arbitrary, which in turn discourages any choice at all. This directly feeds F2: without an industry-agreed baseline, there is no business-as-usual to compare or measure savings. Because no two building projects within the Bemsiq portfolio are alike - and because the primary customer is the system integrator rather than the building owner - establishing a standardized historical reference is difficult in the short term. F3 combines both, because even where performance data exists in principle, Bemsiq lacks the access to retrieve it easily. Customers will buy their hardware, but do not automatically share the operational information that would allow them to verify what that hardware actually achieved.

The medium-severity frictions is a second layer of difficulty that remain even if the high-severity barriers were resolved. F4 and F5 describe a fundamental tension between accuracy and scalability in a geographic perspective. A kWh saved in Sweden and a kWh saved in Poland means different CO_2e outcomes, yet unit-level geographic tracking introduces significant administrative overhead. By the same logic, a kWh saved in one electricity district in Sweden will differ for a kWh saved in another district. The logic deduces that the most accurate measure to attribute the saved emission is dependent on the marginal energy produced. However, this is beyond the granularity of the report and shifts the focus outside the boundaries of the study. The easiest alternative was suggested during the FGDs - weighing savings by country-level revenue distribution or using proxies like the energy use within regions. While a decent proxy, it sacrifices precision for practicality, since company revenue geography and product geography do not align perfectly. Neither does energy use perfectly proxy building automation activity, but there is a correlation.

F6 extends this into temporal aggregation: any case-based result could in theory be scaled across other markets. However, connecting the geographic variables with projections, an estimated lifetime of 10+ years also means that the grid intensity must be modeled for potential changes, since a lot can happen during that time. Finally, F7 lifts the "double-materiality" problem: any new hardware can have an efficiency gain, but whether the Scope 3 carbon of manufacturing that hardware is outweighed by the operational savings over the product lifetime must be calculated. Sometimes, it is a net positive effect due to minor differences in embodied emissions with a tangible effect on operational emissions - but without this net figure, any Scope 4 claim is incomplete.

5.3.2 Organizational & Professional Friction

The second cluster is less numerous, and only contain three frictions. However, these are important to recognize.

Table 5.4: Friction Log – Organizational & Professional Friction

ID	Friction Point	Category	Severity
F8	Share attribution dispute	Organizational	Medium
	Strategic layer seeks reasonable claims; technical core fears arbitrary allocation percentages that lack scientific validity.		
F9	Professional credibility (technical core)	Professional	High
	Engineers resist providing "ballpark" estimates since their work is reliant on precision; they fear reputational damage from third-party audits (reflecting paradoxical frame by Hahn et al. (2014)).		
F10	Investor relations paradox (CSO level)	Professional	High
	The CSO wants group-wide impact but receives fragmented subsidiary data.		

Before an external reviewer can assess or verify a claim, the organization must first decide on what that claim is or should be. The frictions below show why that consensus does not yet exist, which mostly connects to Requirement 5 (the independent third-party review).

While the methodological frictions were mostly technical, the organizational frictions are personal and relational. They show the human role of sustainability disclosure inside a big organization. F8 describes the surface-level tension. The strategic layer wants a "reasonable" attribution percentage to publish, but engineers at the technical core believes any such percentage to be arbitrary. F9 and F10 reveal why this is so difficult to resolve through negotiation alone since both sides have valid arguments for their opinions within their own profession.

For the hardware engineers involved in this study, asking for a deterministic energy saving percentage is tough. It is "too vague a task" and outside of their traditional work-assignments. A career spent working on improving sensor accuracy of $\pm 0.1\%$ does not translate comfortably into guesstimates for a marketing document. One respondent had a really sharp take on why that is. According to him, signing off on a number can be contradicted and cause reputational damage, but saying nothing preserves credibility without downside for them personally. Consequently, it is better not to make those claims if they do not have an answer.

The CSO faces another problem. Positioned between wishes for aggregated group-wide metrics and subsidiaries generating different and fragmented data. A comment raised in discussions described the role as oscillating between visionary and realist. Seeing what could be done across the organization yet largely unable to execute due to inertia.

Together, the organizational and professional friction highlights the competing frames and how they are part of the internal sensemaking of organizations.

5.3.3 Strategic, Structural & Commercial Friction

Lastly, the remaining frictions is shown in this third cluster.

Table 5.5: Friction Log – Strategic, Structural & Commercial Friction

ID	Friction Point	Category	Severity
F11	Scalability vs specificity paradox Doubts about both top-down deterministic values and bottom-up aggregation; creates tension between corporate narrative and ground-level reality.	Strategic	Medium
F12	Double-counting allocation paradox Devices are only part of the solution; no systemic method exists to avoid several actors claiming the same savings.	Structural	High
F13	Belimo exception: actuation layer attribution Actuation devices (valves) enable a binary pre/post comparison; passive sensors cannot replicate this attribution factor.	Structural	High
F14	Damping effects Advanced devices is significantly worse-performing when not installed properly or in a building with other tangible weaknesses.	Structural	Medium
F15	"Anecdote vs aggregate" conflict Sales teams can provide selective success-stories; But opinions arise that single cases are insignificant without a lot of context.	Strategic	Medium
F16	Commercial timing vs environmental relevance (Greystone IAQ) One of the more sustainable products in the portfolio but due to recent release lacks the success stories needed for a white paper with strong claims.	Commercial	Low
F17	Unit density variation "Installation per m^2" is exceptionally difficult to standardize; Scope 4 calculations become building layout dependent rather than device dependent.	Structural	Medium

The strategic and structural frictions in this final cluster gravitates toward Requirement 2 (the explicit attribution method) and tradeoffs for legitimacy.

F12 has the most consequences of these. Even where a device like the Rymaskon directly tracks its own energy use, the double-counting paradox persists. The sensory layer enables the actuation layer and both are governed by the management layer. Consequently, each actor in that chain could in theory claim the same savings. Experience from the sales team indicated that the system integrators (actors that combine and deliver all three layers in one package toward property owners) actively claimed the entire savings-quota. For manufacturers of devices, respondents referenced Belimo as an interesting case. Because some of Belimo's field devices produce a binary physical state change (say flow on or off), the before and after effect of those devices is directly attributable. For passive sensory devices, this logic does not transfer directly. However, sensors unquestionably contribute to the saving since the actuators cannot function without information. But what they lack is observability. A valve's state change can be measured directly at the device, while a sensor's contribution is only a part of system-level performance. A room transmitter does not act on the building, it only informs the system that does, and no measurement method Bemsiq has access to can find what fraction of the eventual saving belongs to them. This is a property of the current industry configuration and hierarchy and better data cannot solve this.

F11 captures the resulting consequence from both directions. A top-down portfolio value cannot be created without validated bottom-up cases, yet those with most credibility to produce such cases are skeptical that isolated results can be aggregated usefully. F14 adds a further complication. Even though individual devices should perform and contribute, their impact can be mitigated by the way they are installed or which environment they are placed within. A RTX-series unit capable of high-resolution energy tracking is not useful if the surrounding BACS cannot process that data - meaning that the gap between marketed potential and realized performance sometimes lies in the hands of others that the manufacturer.

F15-F17 close the log by lifting the commercial dimension of these constraints. A sales team preference for compelling individual case studies (F15) conflicts with the objective mindset that cherry-picked cases can be misleading. F16 and F17 together illustrate this tension most visibly through the Greystone IAQ series. The product has strong sustainability potential but has low total sales due to being new to market. Low sales in turn impact any kind of systemic analysis of actual impact, how system integrators install the device, and how it is used in practice once employed.

These last friction points completes the issues within corporate sustainability efforts for the manufacturers of building automation devices. They complement the earlier noted concepts of sensemaking, conflicting frames, EPG, and boundary critique with the equally important persistence of institutional isomorphism and attribution problems.

Taken together, these three clusters of friction reveal that the challenge of Scope 4 reporting is mostly due to the passive nature of sensory hardware, lack of industrial guidance and information silos both between different actors but also within organizations.

6
Analysis & Discussion

6.1 The Twin Transition and the Valuation Gap

The commercialization of building automation within the Bemsiq Group sits right at the nexus of the twin transition. The business case is intimately connected to the green transformations and, by properties of the devices, the digitalization.

The Bemsiq products allow heating, ventilation, and air conditioning systems to monitor and optimize resource consumption in real-time. However, this study identifies a significant valuation gap caused by the double externality problem in sustainable innovations. Bemsiq's modular units produce substantial positive environmental spillovers such as the 2–5% building-wide energy savings compared to similar units enabled by either the RTX's patented airflow correction or Rymaskon's practical design. Despite such benefits, the market price rarely directly internalizes the value of these avoided emissions. It does to some extent lead to arguments for premium pricing, but the FGDs held within the company showed that customers' inclination to pay a premium is not due to the saved emissions, but rather the belief that measuring accuracy is better in these products and they associate a better product with less flaws and longevity. The customers allegedly showed little interest to decide on units to purchase based on deterministic percentages.

What surfaced instead, was that building classifications and certifications like LEED, BREEAM and others were highly desired. The underlying conditions of those certifications are numerous and many of the devices within the Bemsiq Group cater to several of these certifications. The common denominator for any certification is that they by extension allow the property owner or leaser to become more compliant themselves, but also make deductions on rental costs or charge premiums. Thus being a financial incentive rather than a sustainability driven one. Luckily, the certifications are primarily based on sustainability measures (with different levels or tiers of sustainability) and create a sustainability pull, but from the findings of this thesis BACS companies would prefer if this pull was even stronger. This is a concern for regulators, and outside the scope of what Bemsiq can hope to influence themselves. The industry at large might encourage even better policies if unified, but no single actor has that level of influence. So, by fulfilling the requirements of these certifications Bemsiq's hardware transforms from an abstract environmental solution into a concrete financial asset. This shift partially resolves the valuation gap introduced in Chapter 2 since it internalizes the environmental spillover into a recognized market value.

However, this also complicates the sustainability narrative as the sustainability pull is solved through financial incentives rather than a commitment to carbon reduction. For Bemsiq, this suggests that the most effective way to bridge the valuation gap is not to sell carbon savings, but to position their high-precision sensors as the essentials to unlock the highest tiers of building standards. To put it simply, customers care more about certifications than emission savings percentages, so pragmatic legitimacy is better than moral from a business point of view. Ironically, saved emissions percentages has a direct financial value in terms of energy cost, so what the sales representatives within Bemsiq claimed to be a lack of customer interest towards the topic is a market failure in itself.

Returning back to the lack of internalized ecological value for customers, this market failure encourages the development of sustainable business models that use well designed communicative artifacts to illuminate the positive externalities of their products. For instance, a white paper that can illustrate what certifications their products achieve, how it effects both the energy usage and saved emissions, and reap the rewards from either selling additional sensors, or pricing premiums. This holds independent of the policy strength or benefit from redeeming certifications for the property owners.

6.2 The White Paper as a Boundary Object

The composite standard developed in Section 5.1.3 gives operational meaning to the conflict between being plastic or robust raised in Chapter 2. Requirements 1 through 6 define what "robust" means: verified baselines, explicit attribution, geographic differentiation, case evidence, third-party review, and net impact disclosure. Requirement 7 defines what "plastic" means: an accessible problem/solution narrative that creates cognitive legitimacy. The concern with boundary objects is satisfying requirements that pull in opposite directions.

6.2.1 Boundary Critique

Through the lens of boundary critique (Ulrich, 1983), Bemsiq's sustainability claims will be the result of subjective boundary judgments rather than neutral facts. There is no way of avoiding that. Comparison between Schneider reports reveals that each released version has increased amount of detail behind variables and factors for the CO_2 methodology, leading to the analysis that robustness can be increased over time with maturity (Schneider Electric, 2025). The benchmarking in Section 5.1.2 shows that the companies which include 'robust' elements are also those whose claims carry the strongest external credibility, also partly due to having worked with these issues the longest time.

What the friction log adds beyond Section 5.2 is that there is a lot of underlying work to be completed before broad boundaries can be investigated deeply. The Bemsiq subsidiaries have appointed sustainability roles, but these have not worked with group wide claims or aggregation before. The CSO at Bemsiq oversees a cross-subsidiary Sustainability Group but receives fragmented data in incompatible formats (F10), while facing upward pressure from the Latour stakeholder group for aggregated results. In this situation, the question of which stakeholder should decide the appropriate system boundary is complicated and it requires the alignment discussed in Section 6.3.

6.2.2 Mimetic and Institutional Isomorphism

Raising the last theoretical topic, the building automation industry is showing clear signs of mimetic isomorphism (DiMaggio and Powell, 1983). Diverse actors like Siemens, Schneider Electric, and Honeywell all use similar "problem/solution" white paper narratives to signal their competence or usefulness. These industry leaders frequently rely on "most-likely" baselines and make bold commercial claims, such as 10–20% energy savings. However, the persistent EPG suggests that such deterministic claims are flawed. One problem is that disproving such claims is difficult, and is no one's responsibility. Notably, neither benchmarked company accounted for anything resembling rebound effects in their modeling.

The lack of rebound effects or other factors that gives the feel of 'incompleteness' is worth addressing precisely. The mimetic isomorphism documented in the benchmarking it mostly at the Requirement 7 level (Table 5.2). All actors adopt the problem/solution format regardless of their methodological robustness. At the level of Requirements 1 through 6, there is much less similarities. Instead, each company makes different assumptions, uses different baselines, and applies different attribution logic. The isomorphism is therefore only partial. For Bemsiq, this means that copying the format of industry leaders, which the simulated white paper does successfully, provides cognitive legitimacy but does not automatically lead to any methodological or evidentiary credibility that the remaining six requirements demand (Lange et al., 2020; Sorrell, 2007). So, while inspiration can be drawn, the work to develop cases, gather data and establish a procedure within the group must be completed internally.

6.3 The Practical Implications for Bemsiq

The empirical findings of this study provides Bemsiq with a path forward. They clarify what that path must look like and why shortcuts will undermine the legitimacy the organization is trying to build. The friction log, the white paper simulation, the group discussions and the interviews converge on a single insight: credible sustainability communication for a sensory-layer manufacturer takes time, effort and cannot only be constructed top-down. It must be earned bottom-up, incrementally, and with patience for a process that the industry's largest players took years to establish. Despite those years, much can still be said about the legitimacy of some claims. After all, there is a reason why Lyon and Montgomery (2015) has found that a majority of large companies make themselves guilty of greenwashing. The friction log implies that sustainability disclosures are stuck at compliance level because the technical, commercial, and strategic layers operate separately in these questions. Turning sustainability disclosure into value creation, so that sustainability becomes an asset rather than an obligation, requires management to bridge these frames. Consequently, the recommendations that follow are sequenced with this in mind, organized across three time horizons.

Each time horizon corresponds to one stage of satisfying the standard for a credible white paper identified in Section 5.1.3. The short-term actions target Requirements 1 and 4 (establishing baselines and generating verified case evidence). The medium-term actions target Requirements 3 and 6 (building geographic granularity and enabling net impact calculations). The long-term actions target Requirements 2 and 5 (formalizing the attribution method and subjecting it to independent review). Requirement 7 is already satisfied and does not require further action. Collectively, achieving them can lead to value creation.

6.3.1 Short Term

The most immediate and defensible action available to Bemsiq is to start gather verified case data from customers or end-users of their products. As the executive interviews confirmed and as F2 and F3 document in detail, no agreed upon baseline exists for a typical Bemsiq installation, and customers have not yet been systematically asked to share the operational data that would make such a baseline possible. Reaching out to them and start the process of retrieving knowledge about outcomes is a low-hanging fruit. Attempting to publish aggregated claims without this knowledge would place the organization in the risk of organized hypocrisy. Not because the intent is misleading or actually wrong, but because the corporate discourse would outpace the available and detailed evidence. If the subsidiaries were to be engaged and collectively worked on this issue, they could resolve it rather quickly.

These cases should initially be kept as standalone case studies, explicitly labeled as such. The distinction matters. An isolated case study makes no claim to be representative of a portfolio, it just shows one instance of outcomes. Starting with case studies protects the organization from the aggregation and linear scaling risks identified in F5 and F6, while still generating the narrative material that the commercial front requires. However, the combination of many of these cases allow for a solid Bemsiq white paper on the condition that claims remain case-specific.

6.3.2 Medium Term

Once the first verified cases exist, the medium-term priority is to make their "creation" repeatable and scalable. This requires Bemsiq to develop a standardized data collection process across its subsidiaries. Ideally a shared framework specifying which variables must be tracked, over what time period, and in what format, for any installation that is intended to contribute to a future sustainability claim. It is much easier to do this continuously than retrospectively. By establishing a continuous process with clear roles and responsibilities, the information silos between professional frames is also likely overcome through cooperation.

In parallel, the organization must address F4 (the geographic grid intensity problem) at the infrastructure level rather than the calculation level. This means that sales data and installation records should begin tracking geographic deployment at the country level as a standard practice, not as a retrospective exercise. But as previously mentioned, country-level grid emission factors change over time and vary across Bemsiq's markets. Even within countries the marginal effect of energy use is different depending on where and when. Building geographic granularity into operation now means that future saved emissions or Scope 4 calculations, if it changes from voluntary into enforced, will not need to rely on revenue-weighted approximations or other solutions. However, it will require further investigation into which detail level is sufficient enough.

6.3.3 Long Term

The long-term ambition of a credible, portfolio-wide Scope 4 claim remains a valid goal, but it is a conclusion rather than a starting point. The benchmarking exercise in Section 5.1.2 shows that even Schneider Electric, with significantly greater corporate resources, went through multiple iterations of its methodology before arriving at the current version. It is likely not the last one either. Belimo's path is more instructive for Bemsiq specifically because they built their avoided emissions methodology from the device level upward. The example of consulting a university professor from HSLU in Switzerland for an independent academic review, and earning a "fair and credible estimation" assessment before publishing is one way to go. While not flawless, it was certainly better for Belimo to have that solution than the alternative of having no third-party audit.

Bemsiq should pursue the same sequence. Once a body of verified customer cases exists across at least two subsidiaries and two geographies, the organization should engage an independent academic or professional reviewer to assess the methodology used to produce those cases.

This is a form of what Power (1997) calls "rituals of verification". This review does not need to be a full third-party audit in the PwC sense for Schneider. An academic partnership, potentially with Chalmers or another technical university, would serve the same legitimacy function at a scale appropriate to Bemsiq's current size and operations. The output of that review, combined with the accumulated case evidence, would then provide the foundation for a white paper that can withstand the scrutiny that F1 (the absence of a standardized framework) currently makes impossible to avoid.

This process will take time, but it is the only way to avoid the risk of organized hypocrisy that the friction log documents so clearly. So, the goal is to communicate sustainability in the same pace as the evidence is created. As a consequence the communication will become honest by default.

6.3.4 Implications for Stakeholders

Leaving the Bemsiq sphere and addressing the other parties of interest, the friction log reveals that no manufacturer in the benchmarking satisfies all seven requirements simultaneously. For someone evaluating a BACS supplier's sustainability claims, the composite standard provides a ready-made framework: does the white paper include a defined baseline (Requirement 1)? Explicit attribution (Requirement 2)? Third-party review (Requirement 5)? A property owner or other stakeholder who asks these questions can separate substance from mimetic isomorphism or greenwashing.

As global forces push for BACS installations, for instance the EPBD mandates across the European non-residential stock, the volume of sustainability white papers entering the market will increase. The frictions documented in this thesis, particularly F1 (no standardised framework), F3 (last-mile data access), and F12 (double-counting) are not unique to Bemsiq. They are structural features of the sensory layer's position in the BACS hierarchy. Stakeholders should therefore expect and be aware that these same frictions will likely appear in claims from any sensor-layer manufacturer. Expectations should be adjusted accordingly.

6.4 The Limitations

Any conclusions made from this study must be put against a set of constraints of what the findings can and cannot claim.

The most fundamental limitation is the single-case design. Bemsiq was selected because it represents the research problem in a concentrated form. It has a holding company structure, a fresh SBTi commitment, and a product portfolio positioned precisely at the sensor layer where the attribution problem is most critical.

These properties make it a good case for analytical generalization (Yin, 2018), but they also make it an unusual one. The configuration of frictions documented here, with the relative weight of organizational barriers versus methodological ones, is not necessarily the same for other actors. Particularly, the dynamics introduced with a decentralized holding company structure, and the properties of passive sensory hardware, might cause conditions that other manufacturers may share to some degree but not in full. The three-cluster frictions offered in this thesis were intended as a transferable framework and future research involving other cases would be needed before stronger claims about industry patterns could be made with absolute confidence.

A second limitation is the researcher involvement. The researchers had a dual role throughout the study: simultaneously simulating the white paper artifact and analyzing the constraints that made its construction difficult. This proximity to the material is what gives the friction log its analytical value. Constraints were observed in practice rather than reported retrospectively, but it also introduces the risk that the interpretation of friction points was shaped by the same dynamics it was meant to examine. Real-time logging and iterative cross-checking against interview data were used to mitigate this, but the limitation cannot be fully eliminated and should be kept in mind when reading the friction log entries.

Third, several empirical sections of the proposed Bemsiq white paper remain to be completed considering the thesis process only uncovered what should be done. The customer case studies for the subsidiaries are necessary to fulfill requirement 4 from Chapter 5.1.3 - to verify the claims. Connected to that, the Appendix C calculation is presented using dummy inputs because disclosing Bemsiq's true sales data, market share and LCA data would breach the confidentiality agreement. However, the purpose of the appendix is methodological transparency, not quantitative conclusion. This is left to be assessed and completed by Bemsiq.

Fourth, the study accepted all technical performance data provided by Bemsiq and its subsidiaries as valid secondary data without further verification. The 2–5% energy saving attributed to the Produal RTX's airflow correction technology, for instance, is drawn from internal documentation and has not been independently tested by the researchers. The analysis addresses the communication and legitimacy dimensions of such claims rather than their accuracy, and this boundary should not be overlooked when interpreting empirical findings.

Finally, the "saved emissions" thinking applied throughout the thesis is preliminary and focuses on the operational phase of the hardware lifecycle. End-of-life impacts, electronic waste, and the circularity characteristics of the devices are not incorporated explicitly. As regulatory attention to these dimensions increases, this exclusion will become harder to justify in future iterations of the methodology that Bemsiq might adopt, so this is something they will have to consider.

7

Conclusion

This thesis set out to examine the intersection of building automation and sustainability discourse, with particular focus on the struggle for actors to communicate their environmental value and what that struggle looks like in practice for a sensor-layer hardware manufacturer.

7.1 Responses to the Research Questions

RQ1 - how competing strategic drivers shape corporate decision-making when formulating communication strategies for sustainable technology innovations

Bemsiq's communication decisions are shaped by pressures that pull in opposing directions. From above, the SBTi commitment and Investment Latour's ESG expectations create a top-down pull for portfolio-level sustainability impact. From below, subsidiaries do not have the same pull from their customers. So despite having the customer relationships and proximity to the solution, they do not share the urgency of claims unless it brings direct value, like increased sales. They are also subject to the differences between professional frames, where engineers within the organization hesitated about deterministic claims that would satisfy the top-down pressure (F9). The suggestions on that end is to only claim what can be absolutely proven. Returning to the sales perspective, customers appear to respond to building certification credentials rather than emissions figures, aligning purchasing decisions with pragmatic legitimacy (Suchman, 1995) rather than moral. So while sustainability pull comes from both above and below, it is embodied differently.

The benchmarking confirms that these pressures are not unique to Bemsiq: all five industry leaders navigate the same tension and all have converged on the problem/solution white paper as their response, regardless of whether the underlying methodology is robust. However, the composite standard reveals that these larger actors at least partially satisfy Requirements 1 through 5, which gives their claims a methodological foundation Bemsiq currently lacks but quickly can attain. The strategic dilemma is therefore not only about managing competing drivers (like sales, good-will or moral high ground) but about how Bemsiq should get the same state of capabilities like the industry leaders. One crucial finding from the FGDs was that bridging this gap requires deliberate cross-layer collaboration: without alignment between the technical, commercial, and strategic layers, the sustainability pursuit remains disconnected from organizational identity and the white paper lacks internal buy-in.

RQ2 - in what ways BACS performance can be effectively translated into value propositions that satisfy stakeholder demands for clarity without compromising legitimacy or triggering organised hypocrisy

The Scope 4 simulation, interviews and FGDs all show that a strategy of specificity is the best path forward. Every attempt to translate sensory-layer performance into a portfolio-level claim required a boundary judgment - on grid factors (F4), on attribution between BACS layers (F12), on baseline construction (F2) and several others. All of these improve cognitive clarity at the cost of accuracy and scientific defensibility. The Belimo precedent shows that the two demands can be met, but only in sequence. Device-level claims built from verified case evidence first, independent review and assessment second, portfolio-level communication last. Attempting to satisfy them simultaneously is not a viable option.

RQ3 - how methodological, organizational, and structural frictions constrain the development of credible sustainability-linked claims within the building automation sector

The friction log provides a systematic answer across all three dimensions. Methodologically, the absence of a standardized framework (F1), missing baselines (F2), and inaccessible customer data (F3) means that the input required does not exist within the organization's current data infrastructure. These are the inputs needed to follow the calculations that industry peers publish. Organizationally, the competing professional identities of the technical core and the strategic layer (F9, F10) hinder the internal consensus. While some cross-layer collaboration and workshops might solve this obstacle, it will not cease to exist until actively resolved. Structurally, the double-counting paradox (F12) is the most consequential constraint because it is not resolvable through better data or stronger alignment. It is simply a direct consequence of where passive sensory devices sit in the BACS hierarchy, and approximations with transparency are the best work-around.

Together, these clusters demonstrate that the barriers are tangible and not due to a lack of motivation. Compared against the composite standard, the methodological frictions obstruct Requirements 1, 3, and 6; the organizational frictions block the preconditions for Requirement 5; and the structural frictions make Requirement 2 unattainable for passive sensory devices under the current status quo. Addressing them requires changes at the level of product design, data infrastructure, and eventually industry-wide standardization. Bemsiq's communication strategy cannot solve this alone.

7.2 Contributions

7.2.1 Theoretical

This thesis makes three contributions to the theoretical literature on corporate sustainability communication.

First, it applies boundary critique - as formulated by Ulrich (1983); Ekvall and Weidema (2004) - to the specific attribution problem facing manufacturers in the BACS hierarchy. Previous applications of boundary critique in sustainability research have focused primarily on lifecycle assessment and system-level carbon accounting. This study demonstrates that the same framework explains a structural problem in commercial communication, where the choice of system boundary is not only a methodological decision, but also one that has consequences for legitimacy and commercial outcome. The finding that Bemsiq's attribution problem is not a failure of their own but a consequence of where passive devices sit in the BACS hierarchy makes boundary critique particularly relevant.

Second, the use of a white paper simulation as a primary data generation method is a methodological contribution in its own right. Rather than asking respondents to describe the constraints of Scope 4 reporting, the simulation allowed those constraints to be observed in practice. The friction log captures actual instances where available evidence was not enough to support the commercial claim the narrative required or wished for. So while opinions of course surfaced, the takeaways are more empirically grounded by design. Importantly, grouping the observed frictions into three clusters also offers future research a usable taxonomy for sustainability disclosure.

Third, the study extends the concept of organized hypocrisy beyond deliberate decoupling. The friction log gives evidence that the gap between corporate sustainability discourse and verifiable practice (Lyon and Montgomery, 2015; Cho et al., 2015) is, in the BACS context, an outcome of both the sensemaking process and structural difficulties. Pressed for cognitive legitimacy, organizations show a simplified version of their strengths that the market understands. Not because they choose to deceive, but because sometimes there are no standards on how to disclose certain information, professional frames might diverge, and last-mile data could be inaccessible.

7.2.2 Practical

For Bemsiq Group AB, the practical contribution is a sequenced roadmap for building sustainability credibility. In the short term, the organization should pursue two to three verified customer case studies and publish them as standalone case studies and outcomes, thereby avoiding the aggregation and representativeness difficulties. In the medium term, Bemsiq should cascade the knowledge gained and processes developed in-house across all subsidiaries and begin capturing geographic installation data at the country level. In the long term, once there are verified cases across multiple subsidiaries and geographies, they should seek independent academic or professional review of the avoided emissions methodology before publishing any portfolio-level claim.

The seven-requirement framework is applicable as both an internal quality standard for manufacturers (like Bemsiq) and a procurement and evaluation tool for property owners, facility managers and others assessing BACS sustainability claims.

7.3 Future Research

Four directions for future research come directly from the findings of this study. The first is to track and follow up on whether the bottom-up case-building strategy recommended in Section 6.3 succeeded with its purpose. It could be to assess where it stands with regard to number of cases, geographic diversity, and methodology maturity. Such a study would also be well positioned to examine whether the process has a measurable effect on customer trust or purchasing behavior.

The second direction is a comparative study across several sensory-layer manufacturers. That study could include direct competitors and peers in adjacent hardware categories. Well executed, it would test whether the friction log documented in this thesis is reproducible across the sector or if it only reflects issues specific to Bemsiq. If the structure is reproducible, the implication is that the industry requires a collective rather than company-level response. This could be in the form of a sector-specific standard for Scope 4 attribution that neither the GHG Protocol nor current voluntary frameworks adequately provide.

The third direction concerns end-of-life and circularity impacts. This thesis focuses almost entirely on the operational phase of BACS hardware while the environmental cost of manufacturing and disposing of increasingly complex electronic devices remains largely undocumented. As regulators in Europe and elsewhere turn their attention to electronic waste and extended producer responsibility, this gap is likely to attract some scrutiny before manufacturers address it internally.

Lastly, future research could examine how property owners and facility managers currently evaluate sustainability claims from BACS suppliers, and whether the composite standard developed in this thesis improves their ability to distinguish credible from non-credible disclosure. After all, the credibility stamp is based on market perception, so the customers are the most impacted stakeholder. Similar to how this thesis suggests combination of the different frames within a company, an approach to combine the sustainability pursuit across the industry vertical can be fruitful.

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A

Appendix A

Table A.1: Mapping of theoretical concepts and empirical findings to thesis structure. The section reference under each concept name marks where it is first introduced. Cross-references use § for section numbers, F# for friction-log entries (Tables 5.3-5.5), and R1-R3 for interview respondents (Table 4.1).

Concept	Empirics	Evidence	Analysed in
Twin Transition Paradox *§1.2.1*	BACS is a decarbonization tool but rebound effects and split incentives remain unaddressed in the commercial narrative.	§5.2.1; R1, R3	§6.1
Sustainable Business Model *§2.1*	Value proposition depends on translating invisible environmental spillovers into commercial utility; the white paper is one solution.	§2.1; §5.2; R1-R3	§6.1
Double Externality *§2.1*	BACS produce societal benefits not captured by market price; premium pricing reflects performance perception rather than emissions value.	R1-R3; §5.1.1	§6.1
Organized Hypocrisy *§2.2*	Portfolio-level savings claimed without verified baseline data; narrative comes before available evidence.	F2, F9; §5.2.3	§6.2
Mimetic Isomorphism *§2.2*	Problem/solution white paper format replicated across benchmarked companies.	§5.1.2; Table 5.1	§6.2.2
Decoupling *§2.2*	Sustainability narrative takes another route than operational practice and reality.	F2, F9; §5.2.3	§6.2
Pragmatic Legitimacy *§2.2*	Customer decisions driven by LEED and BREEAM certification incentives rather than by Scope 4 savings claims.	R1–R3; §5.2.1	§6.1
Cognitive Legitimacy *§2.2*	Simplified formulas and illustrative case design used to simplify the avoided emissions concept.	§5.2.2; §5.2.3	§6.2

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Table A.1 – continued from previous page

Concept	Empirics	Evidence	Analysed in
Moral Legitimacy *§2.2*	Absence (or presence) of verified baseline data and third-party review leaves the scientific accuracy of portfolio-level claims undefended (or defended). The difference in-between constitute levels of morality behind claims.	F1, F2; §5.1.2	§6.2; §7
Boundary Judgment *§2.3*	Sensory-layer savings claimed without accounting for actuation or management-layer contributions; end-of-life excluded from the Scope 4 narrative.	F7, F12; R1, R3	§6.2.1
Sensemaking - Paradoxical Frame *§2.4*	Engineers do not want to assign attribution percentages to sensors; they consider deterministic savings claims to be arbitrary.	F9; R1, R3	§6.2
Sensemaking - Business Case Frame *§2.4*	Strategic and commercial layers seek simple, scalable propositions to satisfy investor relations and customer-facing sales.	F10, F15; R2, R3	§6.2
Boundary Object *§2.4*	The white paper functions as an artifact bridging the paradoxical frame and business case frame.	§5.2; §5.3	§6.2
Energy Performance Gap *§3.3*	Static savings models used in industry white papers fail to account for occupant behavior, thermal inertia, and design errors.	§3.3; §5.1.2	§6.2.2
Attribution Problem *§3.2*	Sensory-layer devices enable but cannot claim actuation-layer savings; system integrators absorb the full savings quota.	F12, F13	§6.2.1; §7
Composite Standard *§5.1.3*	Seven requirements synthesized from benchmarking, the WRI framework, and legitimacy theory; used as the baseline against which frictions are measured.	Table 5.2; §5.1.2	§6.2; §7

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Table A.1 – continued from previous page

Concept	Empirics	Evidence	Analysed in
Belimo Exception *§5.1.2*	Actuation-layer devices produce a binary physical state change that enables direct attribution; passive sensors cannot replicate this.	F13; §5.1.3	§6.2.2; §7
Bottom-Up Strategy *§5.1.4*	Pivot from a portfolio-wide white paper to verified customer cases as the most defensible near-term path to a credible Scope 4 claim.	R1-R3; §5.1.4	§6.3
Methodological Friction *§5.3.1*	No standardized Scope 4 framework exists; any chosen metric risks appearing arbitrary, leading to paralysis instead.	F1-F3	§6.2; §7
Organizational Friction *§5.3.2*	Technical core and strategic layer has conflicting professional frames; neither can solve the attribution dispute alone.	F8-F10; R1-R3	§6.2; §7
Structural Friction *§5.3.3*	Double-counting paradox is a property of the BACS hierarchy, not a data problem; cannot be solved through better measurement alone.	F12-F14	§6.2.1; §7

B

Appendix B

This appendix contains the structured guides used to facilitate the three Focus Group Discussions (FGDs) conducted as part of the white paper simulation. Each session targeted a distinct organisational layer within the Bemsiq Group:

- **R&D / Technical Core**
- **Sales / Commercial Front**
- **Strategic Management**

The guides were designed to surface frictions specific to each layer's professional frame. Participants were presented with statements or open questions and invited to respond based on their professional experience; the sessions were not scripted beyond the topic structure below.

The three guides are presented in the order in which the sessions were conducted with each subsidiary: R&D first, Sales second, and Management third. The Management guide (Section B.3) was designed to be informed by findings from the earlier two sessions, with Topic 2 left open to be populated from those results heading into the session.

B.1 R&D / Technical Core Session Guide

Session title R&D Session - Sustainability White Paper
Focus area Moving from *"what does this product do?"* to *"how do we prove that it works?"*

Topic 1 - Embedded Emissions & Environmental Product Declarations

Guiding premise: Environmental Product Declarations (EPDs) are a useful starting point but do not capture the full lifecycle picture. The session begins by mapping what is known and what remains uncertain beyond the manufacturing stage.

Participants are asked to reflect on the following:

- **Carbon payback.** If a subsidiary product saves a quantifiable amount of energy over its operational lifetime, how many years of use are required to offset the carbon emitted during its manufacture? How does subsidiary X's embodied carbon compare to that of competing products in the same category?
- **End-of-life and recycling.** EPDs typically cover the manufacturing stages (cradle to gate). What is known, or what can be reasonably estimated, about the end-of-life and recycling stage? What data gaps exist, and how material are they to the overall carbon balance?
- **Materials and components.** Are there specific components or materials that contribute disproportionately to the product's environmental impact? Is there a narrative to be developed around high-quality materials leading to longer product lifespans or superior measurement performance? How would that narrative be constructed?

Topic 2 - Deconstructing the Sustainability Calculation

Guiding premise: the session begins with a walkthrough of the existing sustainability calculations (if there are any). The goal is to stress-test assumptions and assess how transferable the methodology is to other Bemsiq holdings or new product lines. If no calculations exist, the topic reverted to how sustainability dimensions could bring value creation - connecting to "bridging the gap" between professional frames.

Participants should reflect on the following:

- **Baseline definition.** In the existing calculation, what was the assumed baseline? Was the comparison made against a building with *no control system*, against an *average competitor's system*, or against another product? The choice of baseline fundamentally determines the magnitude of the claimed saving and must be made explicit.
- **Scenario sensitivity.** If a building is poorly insulated or has an outdated HVAC system, does the percentage energy saving from Subsidiary X's sensors increase, decrease, or remain unchanged? Presenting a *range of impact* across building conditions - rather than a single peak-performance figure - may strengthen credibility by acknowledging variance.

- **Peer review and methodological precedent.** Has this specific calculation approach been used or validated by others in the industry (e.g. Schneider Electric, Belimo)? Is the methodology proprietary to Subsidiary X, or does it align with an established framework that could serve as an external reference point?

Topic 3 - Modeling & Reasonable Assumptions

Guiding premise: a credible white paper relies on a transparent and reproducible model. This topic maps the key modeling choices and tests whether the assumptions are defensible to a technically literate audience.

Participants are asked to reflect on the following:

- **The proxy building.** What does the average office building look like in terms of technical specifications relevant to the model? What is a realistic operating-hours assumption for European markets vs. the rest of the world? Does geography affect assumed product lifetime, and should the model account for this?
- **Conservative vs aggressive estimates.** What is the preferred approach to uncertainty? If the goal is to prioritize credibility over headline impact, what is the floor for energy savings? Is a rough range of outcomes easier to defend than a single point estimate?
- **Time and degradation.** Could the time horizon of the claim affect its validity? For instance, does sensor accuracy or system performance degrade over the assumed product lifetime in a way that should be modeled or disclosed?

General Discussion Points

The session closes with an open discussion on the following standing questions, which cut across all three topics:

- **Legitimacy over sales power.** The working principle for the R&D session is that the findings should be bulletproof rather than persuasive. Where are the current weakest points in the evidence?
- **Data and knowledge gaps.** Which specific gaps in technical data or measurement methods have been identified, and what are the concrete actions that could address them in future product development or data collection?
- **Functional unit.** What should the primary functional unit for the sustainability claim be - per sensor? per building? or per customer case? Is aggregation across units meaningful, or does it introduce too many assumptions?

B.2 Sales / Commercial Front Session Guide

Session title Sales Session - Sustainability White Paper
Focus area Finding a concrete customer case or a credible idea of one that can anchor the sustainability claims of the white paper in real-world evidence.

Topic 1 - Typical Configurations & the End-User

Guiding question: how does the customer actually use the products, and what problem are they trying to solve when they buy them?

Participants are asked to reflect on the following:

- **Go-to-market approach.** How is the product currently sold? Is sustainability features the primary sales argument, or is it positioned as a value-add on top of core functionality? Do customers actively value the sustainability dimension of the product, in terms of purchasing decision?
- **Customer problem and standards.** What specific problem is a customer trying to solve when they select a high-efficiency product over a lower-end alternative? Is the primary driver tenant comfort complaints, rising energy bills, regulatory compliance pressure, or certification requirements (e.g. LEED, BREEAM)? How many units are typically deployed per building, per customer, and per room?
- **Installation friction.** Are there specific sustainability features of the product that are difficult for installers to implement correctly in practice? Where does the gap between designed performance and actual performance most often appear?

Topic 2 - Retrofits vs. New-Builds

Guiding premise: The narrative for new-build projects is optimization and design. The narrative for retrofits is modernization and transformation. Given that approximately 80% of the building stock that will exist in 2050 is already standing today, the retrofit segment carries particular strategic and communicative weight.

Participants are asked to reflect on the following:

- **Volume split.** Roughly what proportion of current sales goes into existing buildings versus new construction? For the purposes of a white paper, which segment offers the stronger commercial narrative and the most accessible evidence? Does the product mix differ between the two segments?
- **Retrofit process.** In a typical retrofit project, what does the scope of work look like? Is it a complete HVAC overhaul in which sensors are one component among many, or is it a "low-hanging fruit" intervention where upgrading sensors and controls only delivers measurable energy savings? For new-build projects, what is your company's role within the broader system design?

Topic 3 - Success Stories & Evidence

Guiding premise: a white paper is only as credible as its best case study. The session aims to identify whether such a case exists within the current customer base, and if not, what the path to creating one looks like.

Participants are asked to reflect on the following:

- **A 'hero' project.** Is there a project from the last twelve months that best demonstrates your company's sustainability claims in an operational setting? Even where customer confidentiality prevents naming the project, can the specific performance data be shared (e.g. "a 20% reduction in heating energy in a 5,000 m^2 office building")?
- **The competitive factor.** When you have won business against a competitor, what were the deciding conditions? Was the decision driven by sustainability performance, price, service quality, or BACS integration capability? Understanding the winning argument helps frame the white paper's value proposition accurately.
- **Customer contacts.** Are there one or two customers who are particularly engaged on the topic of sustainability and might be willing to participate in a short interview or meeting to provide a verifiable data point for the paper? Customers who themselves make sustainability claims in their own marketing may have an aligned interest in being shown in a white paper.

General Discussion Points

The session closes with an open discussion on the following standing questions, which apply across all three topics:

- **Market value.** How does the white paper translate into a commercial benefit for the sales team? Is the primary value in opening new conversations, closing existing ones, or defending a price premium?
- **Sustainability pull vs push.** Is the demand for sustainability performance coming from customers proactively (pull), or are you pushing this agenda into conversations? Who in the customer base values the sustainability gains most - the procurement team, the facility manager, or the management team?
- **Competitive landscape.** How do direct competitors communicate their sustainability performance? What is your primary lever of differentiation, and how should that lever be made obvious in the white paper?

B.3 Strategic Management Session Guide

Session title Management Session - Sustainability White Paper
Focus area The "so-what": finding strategy, ownership, and what delivers the highest return on investment from the white paper process.

Topic 1 - Narrative & Stakeholders

Guiding question: if the reader only remembers one thing from this document, what should it be?

The purpose of this topic is to align on the storyline and the intended audience before any specific claims are finalized. Participants are asked to reflect on the following:

- **Slogan and overall message.** Do you have a preferred formulation in mind? Is the preference for a bold, aggregated quantitative statement (e.g. with a percentage saving) or a qualitative positioning statement? What is the single most important sustainability performance claim within your company?
- **Use cases for the sales team.** How should the white paper be deployed in practice? Is it primarily a door-opener for new customer conversations, a validation tool for premium pricing, or something else? Where on the spectrum between *academic research report* and *product brochure* should the document sit?
- **Stakeholder mapping.** Whose opinion matters most, and who are those stakeholders? Participants are invited to consider the full chain: Investor (Latour) → Bemsiq Group → Company X → first-tier customers → second-tier customers → end-users → environmental stakeholders → regulators.

Topic 2 - Resolving Findings & Hurdles

Content to be populated from findings of the R&D and Sales sessions (see Sections B.1 and B.2).

Topic 3 - Future & Scalability

Guiding question: how does management keep this project going without it becoming an open loop or collecting dust?

- **Defining success.** What is the sustainability agenda in relation to the product roadmaps? How should the team assess whether the white paper process is valuable and worth continuing? What criteria would indicate that the document should be renewed or retired?
- **New content pipeline.** If the process continues, what is the plan for refreshing or extending the document over time? Which product lines, customer segments, or geographies are candidates for inclusion in a future version?
- **Use-plan.** What actions can be taken to maximize the reach of the white paper? Possibilities include converting chapters into LinkedIn posts, hosting webinars, or running internal training sessions across the Bemsiq Group to

establish a shared forum for sustainability development as part of business development.

General Discussion Points

The session closes with an open discussion on the following standing questions, which apply across all three topics:

- How does the white paper create and preserve a distinct subsidiary identity, rather than becoming a generic Bemsiq Group document?
- What are the concrete next steps following this session, and what is the longer-term vision for sustainability claims?
- What are the key takeaways from the earlier R&D and Sales sessions that should inform management decisions?

C

Appendix C

C.1 The Scope 4 Calculation

Faced with the pivot to customer cases, an idea discussed during the FGDs and in several of the exploratory interviews was how a Scope 4 calculation would look like in practice if a portfolio-wide claim would be made. By theorizing one, it would be easier to understand the uncertainties and data gaps that prevent it from being a desired first-stage deliverable. The value of presenting these equations lies not in the output figures but in making each assumption explicit, thereby feeding the friction log.

So, this appendix will walk through an intuitive quantitative model to estimate the greenhouse gas (GHG) emissions that Bemsiq's building-automation products saves annually. The exercise follows four steps: (1) establishing a baseline, (2) stating all assumptions explicitly, (3) calculating the intervention effect, and (4) extracting the saved emissions across "reasonable" attribution scenarios.

Note: For confidentiality, all Bemsiq-specific figures (market share, installed base, and embodied emissions) are replaced with dummy values throughout. The numerical outputs are therefore figurative and serve only to illustrate the method and its assumptions.

The calculations are based on the international standard International Organization for Standardization (2021), International Energy Agency (2023), and CO2-equivalent conversion factors estimated by COWI A/S (2023). All numerical inputs are presented in the table below; the stepwise equations are shown in sequence for transparency. Note again that these calculations and findings are not deliverables or factual truth, but rather additions with a purpose to show the assumptions required to make sustainability claims on the entire portfolio level. These are summarized in the end of the appendix.

C.1.1 Establishing the Baseline

A baseline answers the question: 'What would happen to energy use and GHG emissions if nothing changes?' Without this the saved-emission figure is impossible to understand.

The baseline scenario assumes that the buildings in which Bemsiq products would otherwise be installed instead continue to operate without automation technology. In the context of International Organization for Standardization (2021), those buildings are denoted as Class D - the non-energy-efficient category. Class D systems provide no automatic control over HVAC equipment, meaning that it is completely analogue.

Class D is used as the baseline since controls are absent or purely manual. This is the relevant baseline for two reasons. First, EU policy (EPBD) targets renovation and new construction on buildings without modern controls. Second, Bemsiq's largest market is the renovation segment, where the majority of customers are transitioning towards more control systems.

The baseline therefore assigns an energy-saving rate of 0% since no building automation or improvement is happening. All savings calculated below represent reductions relative to this no-controls scenario of the ISO-standard.

C.1.2 Assumptions

The model rests on seven categories of assumptions, A-G.

A. Energy Saving per BACS Installation
International Organization for Standardization (2021) defines efficiency factors for each BACS class relative to a Class C (standard) baseline, which is different from this study. The standard derives these factors from empirical measurements across multiple European commercial building types (offices, retail, hotels, hospitals).

Translating the energy-saving rate for each class relative to the savings baseline is calculated by comparing each class factor to Class D (factor = 1.40): Class C is the baseline (factor = 1.00). Factors for Class B and A are 0.83 and 0.63 respectively. Translating these into the new savings rate is done as follows:

$$\text{Savings rate}_i = 1 - \frac{\text{ISO Factor}}{\text{Factor D}} \tag{C.1}$$

Applying Equation C.1 to each class:

$$\begin{aligned} \text{Class A:} \quad & 1 - 0.63/1.40 = 0.550 \rightarrow 55\% \\ \text{Class B:} \quad & 1 - 0.83/1.40 = 0.407 \rightarrow 41\% \\ \text{Class C:} \quad & 1 - 1.00/1.40 = 0.286 \rightarrow 29\% \end{aligned}$$

Table C.1 list these key values with the addition of which building class Bemsiq sells their units to, here divided into equal thirds across Classes A, B, and C:

Table C.1: BACS efficiency classes, ISO factors, and dummy portfolio shares

Class	Description	ISO Factor (vs. Class C)	Energy Saving (vs. Class D)	Portfolio Weight
A	High-energy performance - communicative, demand-controlled	0.63	55%	1/3
B	Advanced - automated control	0.83	41%	1/3
C	Standard - central control (baseline = 1.0)	1.00	29%	1/3
D	Non-energy efficient - no automatic control	1.40	0%	-

The Bemsiq-specific weighted average then becomes:

$$\overline{S} = \sum_i w_i \cdot \text{Savings rate}_i \tag{C.2}$$

Substituting the equal-thirds portfolio weights and class savings from Equation C.1:

$$\begin{aligned}\overline{S} &= \tfrac{1}{3}(0.55 + 0.41 + 0.29)\\ &= \tfrac{1}{3} \times 1.25\\ &= 0.407 \rightarrow 41\%\end{aligned}$$

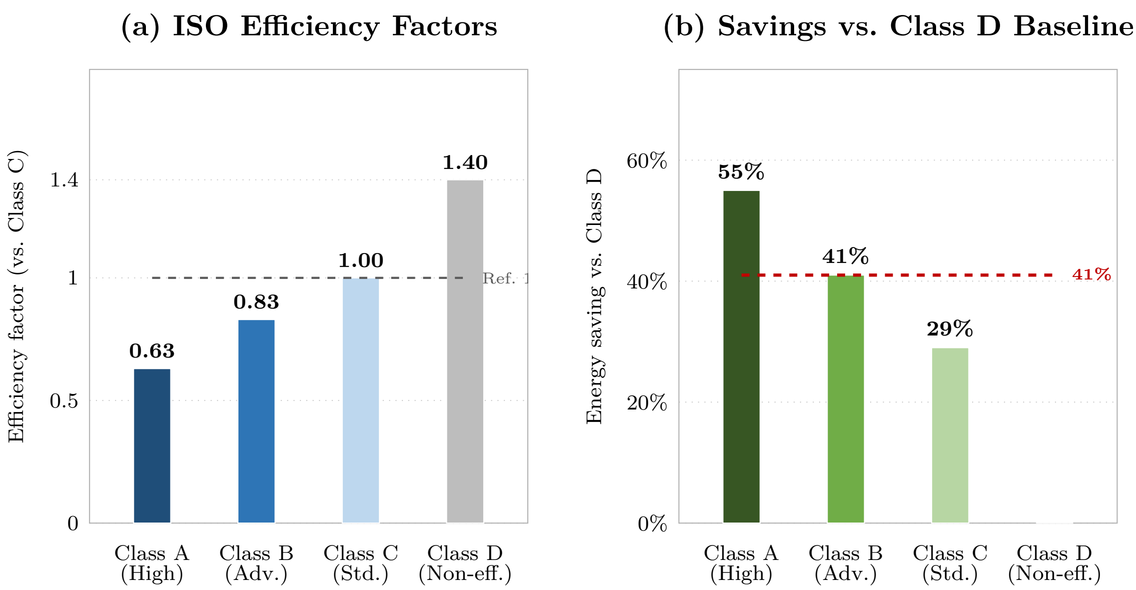

Figure C.1: BACS efficiency classes according to ISO 52120-1:2021.
(a): Original efficiency factors relative to Class C - lower is better.
(b): Energy savings relative to the Class D with equal-thirds class distribution in sales for A, B and C; the dashed red line marks the 41% weighted average saving.

B. Annual Addressable Energy

The simulation covers five explicit geographic markets - Germany, Sweden, USA, Italy, and Finland plus an aggregated 'Other' category that captures Bemsiq's global footprint. Total final energy use in non-residential buildings is taken from three sources:

- **EU countries:** Eurostat (2020) final energy data by sector and country (TJ/year, converted to TWh).
- **USA:** 2,700 TWh/year - U.S. Energy Information Administration (2018)
- **Global total:** 17,100 TWh/year - International Energy Agency (2023). 'Other' = global total minus EU countries and USA.

Only the fraction of that building stock that is being renovated or newly built in a given year is addressable by Bemsiq products. The addressable share is computed as:

$$E_{\text{addressable},r} = E_{\text{total},r} \times (r_{\text{renovation}} + r_{\text{new-build}}) \tag{C.3}$$

where $r_{\text{renovation}}$ is the annual proxied share of building stock undergoing renovation and $r_{\text{new-build}}$ is the annual growth rate of non-residential building stock (1% globally).

Table C.2: Annual addressable energy by region.
Inputs from Eurostat (2020); U.S. Energy Information Administration (2018); International Energy Agency (2023). With renovation rates from European Union (2024)

Region	Total Energy [TWh/yr]	Renovation Rate	Stock Growth	Addressable Energy [TWh]
Germany	312	0.8%	1.0%	5.6
Sweden	47	1.9%	1.0%	1.3
USA	2,700	1.2%	1.0%	59.4
Italy	190	2.7%	1.0%	7.1
Finland	32	1.2%	1.0%	0.7
Other	13,800	1.56%	1.0%	352.7
TOTAL	**17,100**	-	-	**426.8**

C. BACS Adoption Rate

Not all renovated or new-build non-residential buildings install BACS of Class A, B, or C. Some may still be Class D. The model uses estimated adoption rates by region, coming from market research studies:

Table C.3: BACS adoption rates by region compared to Class D baseline. (Source: Bemsiq internal research)

Region	**Adoption Rate** (vs. Class D)	**Source / Rationale**
EU (Germany, Sweden, Italy, Finland)	80%	EPBD mandates support high adoption
USA	60%	Lower regulatory drivers
Global average (Other)	50%	Conservative estimate; many markets lack BACS mandates.

D. Bemsiq Market Share (Dummy Value)
Bemsiq's market share within the addressable BACS segment is set at a uniform **2.5%** across all regions for the purposes of this simulation. This is a placeholder figure used to protect commercially sensitive information. The true market share varies by region and is known internally. The dummy value is chosen to be conservative and to demonstrate the mechanics without disclosing competitive data.

E. Grid Emission Factors
Saved energy only translates into avoided GHG if the non-used energy carries an associated emission factor. The model use a weighted regional emission factor by combining the national energy mix (International Energy Agency, 2023) with fuel-specific CO2e conversion factors from COWI A/S (2023):

Table C.4: Fuel-specific CO2e conversion factors

Fuel Type	**CO2e Factor** [kg/kWh]	**Source**
Coal	1.20	COWI estimate.
Oil	0.75	COWI estimate.
Natural gas	0.60	COWI estimate.
Nuclear	0.01	COWI estimate.
Wind / Hydro / Solar / Geothermal	0.02 (avg)	COWI estimate; plain average of renewables.
Biofuels and waste	0.26	COWI estimate.

The weighted grid emission factor for each region is:

$$\mathrm{EF}_r = \sum_f \phi_f \times \mathrm{EF}_f \tag{C.4}$$

where ϕ_f is the share of fuel type f in the regional energy mix and EF_f is its CO_2e emission factor. For Germany 2023 as an example:

$$\begin{aligned}\text{EF}_{\text{DE}} &= (0.18 \times 1.20) + (0.34 \times 0.75) + (0.26 \times 0.60) \\ &\quad + (0.01 \times 0.01) + (0.08 \times 0.02) + (0.13 \times 0.26) \\ &= 0.216 + 0.255 + 0.156 + 0.0001 + 0.0016 + 0.034 \\ &= 0.66 \text{ kg CO}_2\text{e/kWh}\end{aligned}$$

F. Product Lifecycle Emissions (Dummy Values)
Since Bemsiq-specific lifecycle assessment data is also kept confidential, the embodied emissions per unit are proxied using UK Department for Environment, Food and Rural Affairs (2021) GHG conversion factors for electronic equipment, which estimate approximately 24.9 kg CO_2e per kilogram of manufactured electronics. Assuming an average device weight of 0.5 kg (including housing, PCB, sensors, and packaging), the cradle-to-grave embodied carbon is estimated at **12.5 kg CO_2e per unit**.

A cross referencing of Memoori Business Intelligence (2023) and Juniper Research (2022) brings the IoT connected BACS units sold globally per year to roughly five hundred million. With the dummy market share of 2.5%, in this fictive scenario Bemsiq would have to supply 12.5 million units, bringing the embedded emissions to:

$$E_{\text{own}} = 12{,}500{,}000 \times 12.5 \text{ kg} = 156 \text{ kt CO}_2\text{e/year}$$

G. Product Lifetime
The previous six assumptions are all flow-based: they describe what happens in a single year. But embodied carbon is a one-time event at manufacturing, while operational savings happen every year the unit is installed and functioning. Unit lifetime is therefore the bridge between the two.

Two framings are possible:

- **Annual snapshot (steady state).** Assume Bemsiq ships a constant 12.5M units per year, replacing an equal number of retiring units. The installed base is then lifetime × annual shipments, but the annualized embodied burden is e_{unit}/lifetime per operating unit. At steady state the two terms multiply back to the same 156 kt/yr regardless of lifetime. This made the model have consistent numbers without lifetime appearing explicitly. This framing is appropriate for annual disclosures (CSRD, GHG Protocol Scope 1-3).
- **Cohort lifetime.** Take a single year's shipment (12.5M units) and follow it through its useful life. Embodied carbon is incurred once (156 kt); operational savings accumulate as $g_{\text{avoided/unit}} \times$ lifetime per unit. This framing is what the GHG Protocol's draft Scope 4 guidance prefers because it avoids growth rate issues. It is, however, more sensitive to assumptions about $Lifetime$ and to forward-looking grid decarbonization.

Manufacturer specifications for BACS sensors typically state lifetimes of 10-15 years, but field replacement often happens earlier due to battery failure, aging communication protocols, or building-level retrofits that swap entire control layers. The model therefore tests three lifetime scenarios:

Table C.5: Product lifetime sensitivity scenarios

Scenario	Lifetime L	Rationale
Short	7 years	Early field replacement; communication protocol aging; battery-driven device swap.
Central	10 years	Industry rule-of-thumb for BACS sensors.
Long	15 years	Manufacturer-spec design; assumes no premature retrofit.

The cohort-lifetime avoided emissions are calculated as:

$$G_{\text{lifetime}} = g_{\text{avoided/unit}} \times L \times N_{\text{cohort}} \tag{C.5}$$

and the lifetime net is:

$$G_{\text{net, lifetime}} = G_{\text{lifetime}} - E_{\text{own, cohort}} \tag{C.6}$$

where $E_{\text{own, cohort}} = N_{\text{cohort}} \times e_{\text{unit}} = 156$ kt happens once for the cohort, regardless of L.

C.1.3 The Intervention Scenario

With the baseline and assumptions in place, the gross avoided emissions are calculated in three steps.

Step 1 - Bemsiq Avoided Energy [TWh]
For each region, the energy that Bemsiq's installed units avoid using each year is the product of four factors: the addressable energy, the BACS adoption rate (α_r), Bemsiq's market share in region r (m_r), and the average energy-saving rate $\overline{S}$:

$$E_{\text{avoided},r} = E_{\text{addressable},r} \times \alpha_r \times m_r \times \overline{S} \tag{C.7}$$

For the USA as an example:

$$E_{\text{avoided,USA}} = 59.4 \times 0.60 \times 0.025 \times 0.41 = 0.37 \text{ TWh/year}$$

Table C.6: Bemsiq avoided energy by region (calculated based on factors)

Region	Addressable Energy [TWh]	BACS Adoption	Savings Rate	Bemsiq Share	Avoided Energy [TWh]
Germany	5.6	80%	41%	2.5%	0.05
Sweden	1.3	80%	41%	2.5%	0.01
USA	59.4	60%	41%	2.5%	0.37
Italy	7.1	80%	41%	2.5%	0.06
Finland	0.7	80%	41%	2.5%	0.01
Other	352.7	50%	41%	2.5%	1.80
TOTAL	**426.8**	-	-	-	**2.30**

Step 2 - GHG Emissions Avoided [Tonnes CO2e]
Each TWh of avoided energy is converted to avoided GHG using the regional emission factors computed in Assumption E. The conversion uses a unit factor of 10^6 kWh per GWh and 10^3 GWh per TWh, then divides by 1,000 to convert kilograms to tonnes:

$$G_{\text{avoided},r}\ [\text{kt CO}_2\text{e}] = E_{\text{avoided},r}\ [\text{TWh}] \times \text{EF}_r\ [\text{kg CO}_2\text{e/kWh}] \times 10^3 \tag{C.8}$$

where the factor 10^3 combines the unit conversion from TWh to kWh ($\times 10^9$), from kilograms to tonnes ($\times 10^{-3}$), and from tonnes to kilotonnes ($\times 10^{-3}$), giving a net multiplier of $10^{9-3-3} = 10^3$. For Germany as an example (using unrounded 0.0459 TWh):

$$G_{\text{avoided, DE}} = 0.0459 \times 0.66 \times 10^3 \approx 30 \text{ kt CO}_2\text{e/year}$$

The full results across all regions are shown in C.7. With energy prices, an annual saving in monetary terms can also be computed. This is shown in C.11 based on global average energy prices from International Energy Agency (2023) and not elaborated on further in this thesis.

Table C.7: Gross GHG avoided emissions by region (un-attributed, derived values)

Region	Avoided Energy [TWh]	Grid EF [kg CO_2e/kWh]	GHG Avoided [kt CO_2e/yr]	% of Total
Germany	0.05	0.66	30	1.9%
Sweden	0.01	0.27	3	0.2%
USA	0.37	0.62	230	14.4%
Italy	0.06	0.58	34	2.1%
Finland	0.01	0.36	2	0.1%
Other	1.80	0.72	1,301	81.3%
TOTAL	**2.30**	-	**1,600**	**100%**

Note: The 'Other' category accounts for approximately 81% of total gross avoided emissions in the dummy scenario, driven by the numerous countries it represents and the large global building stock coupled with a high average emission factor (0.72 kg CO_2e/kWh). The high emission factor reflects many emerging markets with carbon-intensive grids. If grids decarbonize, these relative savings will actually diminish over time - a dynamic not captured in this static model. The dominance of the 'Other' category is further amplified by the uniform 2.5% market share assumption, which removes the differentiation between primary and secondary markets. In reality with the correct market shares, Bemsiq will have significantly more impact allocated their primary markets

C.1.4 Net Avoided Emissions

The 1.6 million tonnes CO2e from above represents the total GHG savings from all building automation installations in Bemsiq's addressable market at the dummy market share, before any attribution. However, those savings could instead be claimed by the system integrator (management layer) or even property owner. The following section applies an attribution percentage and then removes the own life-cycle emissions to find the net avoided GHG. Worth noting is that the initial take from FGDs was to assign a 5-15% range denoted between Low (5%), Mid (10%) and High (15%).

Empirical Grounding of the Attribution Range
Before applying the attribution, it is worth pausing on *why* the 5-15% range was chosen and whether empirical evidence supports it. The Low/Mid/High scenarios are intuitive but unmotivated. A stronger defense of the range comes from the cost share of physical devices within a complete BACS project. The cost shares are used here as a proxy for economic value added to the value chain. The underlying assumption is that if Bemsiq's hardware represents X% of the total investment in a BACS project, then a claim to X% of the avoided emissions is reasonable.

The best public data on BACS project cost breakdowns comes from Trenbath et al. (2022), a National Renewable Energy Laboratory / Joint Institute for Strategic Energy Analysis (NREL/JISEA) study combining a wide range of data. The study made complete cost breakdowns for five U.S. Department of Energy building types and broke the total project cost into seven categories: general contractor fee, commissioning, installation labor, testing and balancing, programming and graphics, engineering labor, and hardware.

Table C.8: Complete BACS project cost breakdown by building type, adapted from Trenbath et al. (2022). Hardware includes all field devices, field controllers, automation controllers, and front-end equipment. The remaining six categories are labor-related. Control points indicates how complex the system is.

Building Type	**Control Points**	**Hardware Share**	**Labor-related**	**Total Project Cost**
Small Office	52	~5%	~95%	∼$75k
Stand-Alone Retail	125	~6%	~94%	∼$180k
Medium Office	305	~6%	~94%	∼$430k
Primary School	545	~8%	~92%	∼$760k
Secondary School	1,032	~9%	~91%	∼$1.09M (national avg.)

The main finding from the NREL/JISEA study is that 50-75% of a complete BACS project cost comes from labor alone, with hardware representing only **5-9%** of total cost. Larger and more complex buildings show a slightly higher hardware share (because they require more devices per control point), but the share never exceeds roughly 10% in this example.

This is an empirical finding for the attribution question, despite not being perfect. The BACS industry has three layers: sensory (sensors, field controllers), actuation/automation (supervisory controllers, network engines, valves), and management (front-end software, analytics, dashboards). Bemsiq operates almost exclusively in the field-device layer, with some presence in automation. Applying the NREL cost shares to Bemsiq's likely position in the value chain:

Table C.9: Attribution ranges for Bemsiq based on BACS cost-share data

Scope of Bemsiq's contribution	**Attribution β**	**Justification**
Field-device hardware only (pure sensor/actuator supplier)	3-5%	Lower end of NREL hardware share.
Field devices + field controllers	5-8%	NREL hardware share including controllers.
Field + automation controllers	8-12%	Full hardware layer; matches the Mid scenario.
Field + automation + enabling role in commissioning/programming	12-20%	Assumes Bemsiq's hardware is supporting the commissioning and programming labor; upper bound of the High scenario.
Full building-level saving (unattributed)	100%	Not defensible at all; ignores all other value-chain actors.

Two important flaws apply to this cost-based attribution. First, the NREL data are based on U.S. only. The European labor-hardware share may differ. Second, "attribution by cost share" is only one of several potential allocation rules. A second rule could be *marginal value-added*, where you would weight each actor by the magnitutde of saving that would be lost if that actor were removed. This is not elaborated on further, but it is a valid thought.

Returning back to the simulation, the original Low/Mid/High scenarios (5/10/15%) are rather reasonable and can be re-interpreted as: **Low** = pure field-device supplier, **Mid** = field + automation hardware, **High** = full hardware provider plus some enabling credit for the commissioning or programming steps.

Attribution Correction

Connecting the attribution to the calculations, it is time to adjust the saved values downward to reflect only the share of emissions that Bemsiq could claim. The model uses Bemsiq's estimated market share as the input value, tested across the Low/Mid/High scenarios:

$$G_{\text{attributed}} = G_{\text{avoided}} \times \beta \tag{C.9}$$

where β is the attribution percentages. Applying Equation C.9 to each scenario:

$$\begin{aligned} \text{Low:} \quad & 1{,}600 \times 0.05 = 80 \text{ kt } CO_2\text{e/yr} \\ \text{Mid:} \quad & 1{,}600 \times 0.10 = 160 \text{ kt } CO_2\text{e/yr} \\ \text{High:} \quad & 1{,}600 \times 0.15 = 240 \text{ kt } CO_2\text{e/yr} \end{aligned}$$

Net Avoided Emissions

The savings above represent annual flows. Factoring the lifetime, and removing the embedded emissions gives the net value.

$$G_{\text{net}} = G_{\text{attributed}} \times L - E_{\text{own}} \tag{C.10}$$

where $G_{\text{attributed}}$ is the annual attributed avoided emissions, L is the product lifetime in years, and E_{own} is the embedded emissions (156 kt CO_2e, incurred once at manufacturing).

Applying Equation C.10 across the three attribution scenarios and the three lifetime scenarios from Assumption G can be seen in Table C.10

Table C.10: Lifetime net avoided emissions across attribution and lifetime scenarios. Embedded emissions for the 12.5M-unit cohort are 156 kt CO_2e, incurred once at manufacturing. All values in kt CO_2e.

Attribution	**Short** ($L = 7$)	**Central** ($L = 10$)	**Long** ($L = 15$)
Low (5%)	+404	+644	+1,044
Mid (10%)	+964	+1,444	+2,244
High (15%)	+1,524	+2,244	+3,444

Every combination of attribution and lifetime gives a positive net result. Even the most conservative case - Low attribution (5%) combined with the shortest lifetime (7 years) - gives a cumulative net of +404 kt CO_2e. The empirical grounding in Table C.9 places Bemsiq's defensible attribution at 3-8%, which is close to the Low scenario, meaning that even the weakest case the model supports remains net-positive. At the Mid and High scenarios the net climbs to between +1.4 and +3.4 Mt CO_2e depending on lifetime assumption.

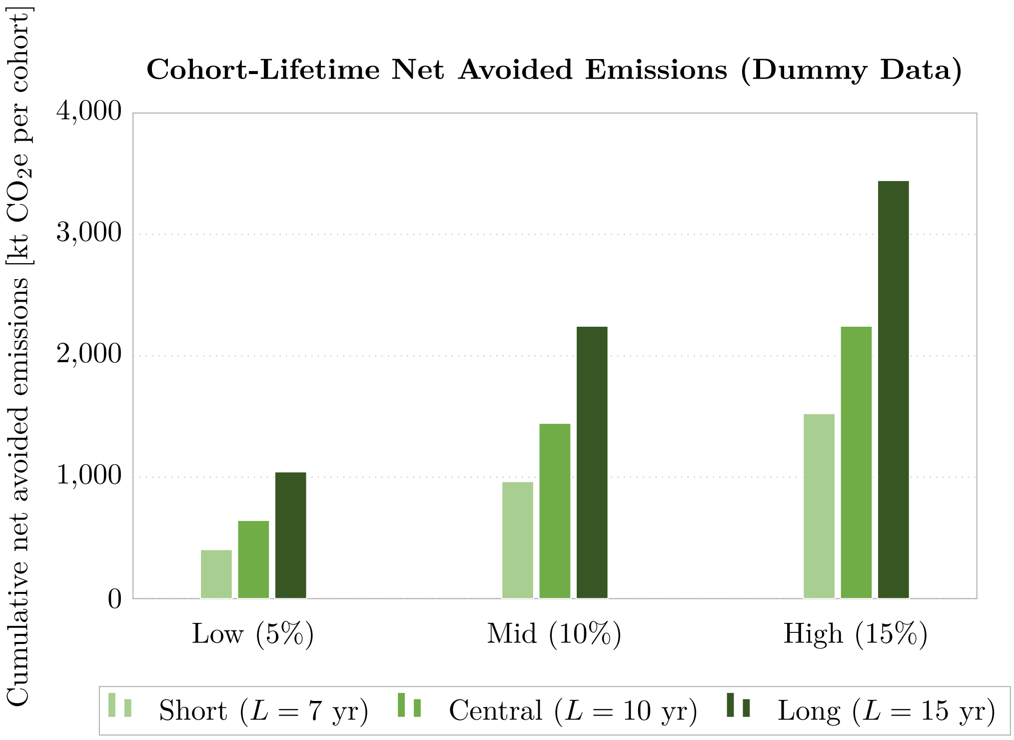

Figure C.2: Cumulative net avoided emissions for one cohort of 12.5M units across three attribution scenarios and three product lifetime assumptions. Embedded emissions of 156 kt CO_2e are subtracted once. All Bemsiq-specific inputs are dummy values.

CO_2 Payback Time

At the per-unit level, one can compute a CO_2 payback period which is the time it takes for the annual GHG savings from one unit to offset the embodied carbon of manufacturing that unit:

$$T_{\text{payback}} = \frac{e_{\text{unit}}}{g_{\text{avoided/unit}}} \tag{C.11}$$

where e_{unit} is the embodied CO_2 per unit (12.5 kg) and $g_{\text{avoided/unit}}$ is the annual GHG avoided per attributed unit. Substituting values for each attribution scenario:

$$\text{Un-attributed:} \quad \frac{12.5}{128} \approx 0.10 \text{ years}$$
$$\text{Low (5\%):} \quad \frac{12.5}{6.4} \approx 1.95 \text{ years}$$
$$\text{Mid (10\%):} \quad \frac{12.5}{12.8} \approx 0.98 \text{ years}$$
$$\text{High (15\%):} \quad \frac{12.5}{19.2} \approx 0.65 \text{ years}$$

The payback period is at most around two years even under the Low attribution scenario, well within the 7-15 year operating life range tested in Assumption G. The absolute numbers depend heavily on the dummy inputs (low per-unit emissions and a conservative installed base). The actual payback would differ but would be expected to remain well within the product lifetime.

Table C.11: Full output summary across attribution scenarios, using the Central lifetime ($L = 10$ years). Annual flows describe one year of operation; lifetime values describe the cumulative impact of one year's shipment compared to its useful life. All Bemsiq-specific inputs are dummy values.

Metric (Dummy values)	**Un-attributed** (Total Market)	**Low** (5%)	**Mid** (10%)	**High** (15%)
GHG avoided, annual [kt CO_2e/yr]	1,600	80	160	240
GHG avoided, cohort lifetime [kt CO_2e]	16,000	800	1,600	2,400
Embedded emissions, cohort [kt CO_2e]	156	156	156	156
Cohort-lifetime net [kt CO_2e]	15,844	644	1,444	2,244
Annualized net [kt CO_2e/yr]	1,584	64	144	224
CO_2 payback period [years]	0.10	1.95	0.98	0.65
Saved energy cost [Million USD/yr]	163.5	8.2	16.4	24.5
GHG saved per unit, annual [kg CO_2e/unit/yr]	128	6.4	12.8	19.2
Embedded emissions per unit [kg CO_2e/unit]	12.5	12.5	12.5	12.5

Interpretation and Limitations

The lifetime calculation produces a positive net climate contribution under every attribution and lifetime scenario tested, ranging from +404 kt CO_2e (Low attribution, 7-year life) to +3,444 kt CO_2e (High attribution, 15-year life). The empirical grounding in Table C.9 places Bemsiq's defensible attribution at 3-8%, making the Low to lower-Mid range realistic. The CO_2 payback period is at most around two years, well within the product's operating life. The customer also saves real money regardless of how the carbon is accounted for. Approximately USD 24.5 million annually for all Bemsiq customers in energy costs in the most favorable scenario, and USD 8.2 million in the Low case.

What the exercise actually reveals, then, is not a dispute about whether the product saves emissions. It appears to do so in every accounting scenario with the modeled inputs.

Several important limitations must be acknowledged. First, the model uses a static 2023 snapshot of the building stock and grid emission factors. As grids decarbonize, the per-kWh saving will fall, and the lifetime numbers in particular would need to be adjusted somehow. By 2040, EU markets are likely to see emission factors decline by roughly 30-50% under the IEA Net Zero Emissions scenario, which would reduce any long-life gains quite significantly. Second, market share (2.5%) is a dummy value. The real figure is commercially confidential, and the three-scenario adjustment is therefore essential. Third, the 'Other' global aggregate hides considerable differences where high emission grids in South Asia and sub-Saharan Africa are grouped with some low-emission grids in other places. Adding more granularity for this category in future iterations of the model would improve precision. Fourth, the embodied emissions proxy (12.5 kg CO_2e per unit) may over- or understate the true value. Real numbers would support findings. Fifth, product lifetime (L) is itself a soft assumption: manufacturer-spec life of 10-15 years is rarely realized in field conditions, and the Short/Central/Long range used here doubles or halves the numbers without any change to the product. Sixth, the cost-share attribution rule is one of several defensible choices and not perfect. Also, the NREL/JISEA data come from U.S. studies, so a European or Asian equivalent study would likely produce a different hardware-to-total ratio.

Lastly, the emissions saving assumption is based on International Organization for Standardization (2021) for generic building automation efficiency grades. These values, while valid, are by no means exclusive to Bemsiq and are not actively assessed against actual sales.

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