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Eco-product portfolio formulation in business-to-business manufacturing companies

Department of Management and Organisation

Master's thesis

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Abstract

The well-being of our generation and those to come depends on the active participation of companies in driving sustainable development and preservation of the natural systems (Sjåfjell, Johnston, Anker-Sørensen & Millon 2015, 79). Business-to-business (B2B) manufacturing companies play a pivotal role by providing solutions that enable sustainability transitions across industries. B2B manufacturing companies engage in product stewardship to maximize their environmental handprint – the beneficial environmental impacts that organizations can achieve by offering products and services that reduce the footprints of others (Pajula, Vatanen, Behm, Grönman, Lakanen, Kasurinen & Soukka 2021, 11 – 12).

An emerging approach to product stewardship is formulation of sub-portfolios of products distinctive for their environmental sustainability performance, defined in this thesis as eco-product portfolios. This thesis sets out to answer how B2B manufacturing companies can formulate eco-product portfolios. To address the main research question, the strategic considerations for the eco-product portfolio formulation are examined and two sub-questions are introduced: (1) what evaluation criteria and selection methods are used to select products into eco-product portfolios, and (2) how eco-product portfolios are externally verified and regulated. This thesis is commissioned to a B2B manufacturing company, referred to later as the case company.

To investigate these questions, this thesis applied a qualitative multi-method approach combining benchmarking research and interviews. The results show that eco-product portfolios remain an emerging and inconsistently applied approach in B2B manufacturing: Eleven of the 54 benchmarked companies have established an eco-product portfolio, and the formulation practices vary significantly. The interviews further revealed that the EU regulatory landscape is marked by uncertainty, with shifting policy developments and a lack of harmonized standards resulting in variable verification practices.

The results reveal that the eco-product portfolio formulation in B2B manufacturing companies is characterized by an absence of a widely established best practice and minimal, inconsistent regulatory and verification requirements. The results indicate that eco-product portfolio formulation practices are driven primarily by company-specific priorities in product stewardship rather than regulations or external verification. Additionally, this thesis adopted an applied research approach to translate the research results into practical insights for the formulation of eco-product portfolios. Ethnographic observations of the case company's eco-product portfolio provided practical context to which the research results were applied to.

Overall, this thesis advances understanding of eco-product portfolio formulation among both scholars and practitioners as an emerging approach to product stewardship and environmental handprint management. To accelerate sustainability transitions in business, further research in product portfolio management and product innovation on the implementation, governance, and use of sustainability-oriented sub-portfolios of products is required.

Keywords: Product stewardship, product portfolio management, sustainability product portfolio, environmental handprint, eco-product portfolio

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Tiivistelmä

Sukupolvemme ja tulevien sukupolvien hyvinvointi riippuu siitä, että yritykset osallistuvat aktiivisesti kestävän kehityksen edistämiseen ja luonnonjärjestelmien suojelemiseen (Sjåfjell, Johnston, Anker-Sørensen & Millon 2015, 79). Erityisesti yritysasiakasmarkkinoilla toimivat tuotevalmistajat (B2B-valmistaja; business-to-business manufacturers) ovat keskeisessä roolissa tarjoten ratkaisuja, jotka mahdollistavat kestävyyssiirtymiä eri toimialoilla. B2B-valmistajat harjoittavat tuotevastuullisuutta (product stewardship) kasvattaakseen ympäristökädenjälkeään (environmental handprint), eli niitä myönteisiä ympäristövaikutuksia, jotka organisaatiot voivat saada aikaan tarjoamalla tuotteita ja palveluja, jotka pienentävät muiden toimijoiden ympäristöjalanjälkeä (Pajula, Vatanen, Behm, Grönman, Lakanen, Kasurinen & Soukka 2021, 11–12).

Ympäristökädenjäljen johtamiseen on nousemassa uusi lähestymistapa, jossa muodostetaan eko-tuoteportfolioita (eco-product portfolio) eli ala-tuoteportfolioita, joiden tuotteet erottuvat muista ekologisen jalanjäljen suhteen. Tämä pro gradu -tutkielma on toteutettu toimeksiantona B2B-valmistaja yritykselle (case company). Tutkielman päätutkimuskysymys on, miten B2B-valmistajat voivat muodostaa eko-tuoteportfolioita. Pääkysymykseen vastataan tarkastelemalla eko-tuoteportfolion muodostamisen strategisia valintoja, ja esittämällä kaksi alatutkimuskysymystä: (1) mitä arviointikriteerejä ja valintamenetelmiä käytetään tuotteiden valitsemiseksi eko-tuoteportfolioon, ja (2) miten eko-tuoteportfolioita varmennetaan ja säännellään ulkoisesti.

Näitä kysymyksiä tarkastellaan kvalitatiivisella monimenetelmäotteella, jossa yhdistetään benchmarking- ja haastattelututkimus. Tulokset näyttävät eko-tuoteportfolioiden olevan B2B-valmistuksessa yhä nouseva ja epäjohdonmukaisesti sovellettu käytäntö: 54 vertailuyrityksestä yhdellätoista on eko-tuoteportfolio, ja muodostamiskäytännöt vaihtelevat huomattavasti. Haastattelut puolestaan osoittivat, että EU-sääntely-ympäristö on epävakaa: sääntely on murroksessa, ja harmonisoitujen standardien puute johtaa hyvin vaihteleviin varmennuskäytäntöihin.

Tulokset paljastavat, että eko-tuoteportfolion muodostaminen B2B valmistuksessa ei perustu vakiintuneeseen yhteiseen parhaaseen käytäntöön, ja sääntely- ja varmennusvaatimukset ovat toistaiseksi vähäisiä ja epäjohdonmukaisia. Eko-tuoteportfolioien muodostamista ohjaavat ensisijaisesti yrityskohtaiset tuotevastuullisuuden prioriteetit pikemmin kuin tutkitut ulkoiset tekijät. Lisäksi tutkielma käyttää soveltavaa tutkimusotetta havainnollistamaan, miten tulokset voidaan viedä käytäntöön eko-tuoteportfolioiden muodostamisessa tai kehittämisessä. Tapausyrityksen eko-tuoteportfolion etnografiset havainnot tarjosivat käytännön kontekstin, johon tutkimustuloksia sovellettiin.

Tämä tutkielma syventää sekä tieteellistä että käytännön ymmärrystä eko-tuoteportfolion muodostamisesta nousevana lähestymistapana tuotevastuullisuuden hallintaan ja ympäristökädenjäljen johtamiseen. Toimialojen kestävyyssiirtymien vauhdittamiseksi tarvitaan jatkotutkimusta tuoteportfolion johtamisen ja tuoteinnovoinnin alueilla siitä, miten kestävyyslähtöisiä alaportfolioita toteutetaan, hallitaan ja hyödynnetään.

Avainsanat: Tuotevastuullisuus, tuoteportfolion johtaminen, kestävät tuoteportfoliot, ympäristökädenjälki, eko-tuoteportfolio

TABLE OF CONTENTS

FIGURES

TABLES

1 Introduction

1.1 Background

While the past five decades has been time of notable progress in environmental protection, they have also been marked by notable failures that have led to the continuing degradation of the planet's natural systems. From 1990 to 2020, global fossil fuel consumption has increased by 30 percent, and the concentration of carbon dioxide in the atmosphere grew more than the whole period from 1700 to 1950. (Tortell 2020, 8683, 8688.) Consequently, humans have caused approximately 1.0 °C global warming by 2017 relative to pre-industrial levels, leading to an outburst of problems such as rising sea levels, increasing droughts, fires, floods and extreme weather events (IPBES 2019, 13). Out of nine planetary boundaries – set for processes critical for maintaining the stability and resilience of Earth system – six are transgressed suggesting that Earth is now well outside of the safe operating space for humanity (Richardson et al., 2023). This is unsurprising, given that in 2024, humanity was using nature's resources 1.7 times faster than earth's ecosystems can regenerate them. To supply the resources demanded by humanity yearly, 1.75 earths would needed – and if everyone lived like USA residents, amount of needed earth's would rise to 5. (WWF, 2024.)

According to the IPCC 2022 report, in order to limit global warming to 1.5 or 2 degrees Celsius, immediate, rapid, and large-scale reductions in greenhouse gas emissions are required – both now and throughout the coming decades (IPCC 2022). However, with the current policies, Armstrong et al. (2022) conclude that the world is heading toward ~2 to 3°C of global warming which would likely trigger multiple climate tipping points. Triggering tipping points leads to significant impacts such as substantial sea level rise from collapsing ice sheets, loss of ecosystems like the Amazon rainforest and coral reefs, and carbon release from thawing permafrost (Armstrong et al., 2022). Therefore, humanity is in danger to trigger unreversible changes in the natural systems which will cause complex and far-reaching consequences to societies around the world. Environmental problems do not solely affect nature; they also exacerbate the numerous challenges humanity is facing, such as poverty, inequality, health threats, water and food scarcity, and spiraling conflicts (UN the 2030 Agenda, n.d.). For example, rapidly growing loss of diversity poses serious risk to global food security (IPBES 2019, 12). The well-being of the environment therefore contributes significantly to the well-being of societies.

Environmental problems neither arise nor are resolved on their own. Humanity's patterns of consumption and exploitation of natural resources have led to the emergence and escalation of these

issues. Population growth and contemporary models of economics have caused unsustainable natural resources usage and numerous environmental challenges (Dasgupta 2021; Dyllick & Muff 2016). In the past 50 years, population has doubled, global economy has grown nearly four fold, and global trade has grown tenfold together driving up the demand for energy and materials (IPBES, 12). To meet the demands, for example, deforestation has increased by 3 million square meters (Tortell 2020, 8688). This land-use change has had the largest relative negative impact on nature's terrestrial and freshwater ecosystems since 1970 (IPBES 2019, 12). Also, human action threatens more species with global extinction now than ever before (IPBES 2019, 11) which will damage biosphere irreparably involving unknown number of tipping points (Dasgupta 2021). Indeed, there is growing scientific evidence that demonstrates planetary-scale human perturbations of the Earth system (Tortell 2020, 8683). Increased demand for energy and materials has therefore driven businesses to increasingly exploit natural systems causing various environmental problems.

At the same time, business has also the capacity and possibility to contribute to solving the environmental and societal problems of our time by supporting environmental sustainability. Environmental sustainability means "the protection of natural wealth, control of the consumption of non-renewable resources, control of the emission of polluting agents, maintenance of biodiversity, and preservation of flora and fauna and the health of the inhabitants" (Uzzel et.al. 2002 according to Jugend et al. 2017, 432). To this end, companies are critical, for example, in mitigating climate change. Reducing greenhouse gas emissions requires coordinated action across corporate supply chains, such as improving energy and material efficiency, utilizing low-emission energy sources, embracing circular economy practices, and transforming production processes (IPCC 2022, 28). Companies can contribute to emission reductions by allocating capital to clean energy production, innovating and developing new technologies, and influencing governmental actions (Sullivan 2017, 3). The well-being of our generation and those to come depends on this active participation of companies to drive the society's transition towards sustainability (Sjåfjell, Johnston, Anker-Sørensen & Millon 2015, 79)**.** Corporations can and should therefore play a major role in solving the world's environmental problems by leading the movement to care for the environment and to protect our shared natural asset (Esty & Winston 2006, 304 – 305).

Business-to-business (B2B) manufacturing companies play an especially central role to enable and support sustainable development. An example of the mining industry illustrates the role of B2B manufacturing companies in leading the transformation of industries toward more sustainable practices. The mining industry is critical for its contribution to sustainable transformation by providing minerals essential for example to clean technologies that underpin global climate change

mitigation goals. However, the sector is under scrutiny due to its contribution to sustainability challenges – when poorly managed, mining creates negative impacts with lasting implications for ecosystems, human rights, and the health, safety, and well-being of workers and local communities. (GRI 14 2024, 11.)

For example, mega-mining projects have radically modified the biological and social dynamics of territories, changing systematically the biodiversity and the equilibrium of the ecosystems, affecting the air, land, hydric resources, and the life quality of communities (Villamil 2023, 1). Mining operations have been high on public discourse due to causing environmental issues, e.g., the contamination by mercury (ABC, 2005), deforestation & sentiment run-off to biodiverse coral reefs (BBC 2025b) and soil erosion and chemical leaks into rivers and farmland (BBC 2025a). Furthermore, mining only one ton of rare earth minerals creates some 2,000 tons of toxic waste (BBC 2025a). In the aftermath, not only the environment, but also the local communities have suffered of mining activities. For example, in the decades leading up to 2010, villagers around the tailing pond in Baotou, China, were diagnosed with bone and joint deformities caused by too much fluoride in the water and acute arsenic toxicity (BBC, 2025a).

Due to posing serious threats to the natural environment and societies around the world, the mining industry is increasingly expected to shift toward renewable energy and adopt circular economy practices, such as reusing and recycling existing materials (GRI 14, 2024). This is where B2B manufacturers play a critical role in enabling the transition toward more sustainable mining through the provision of sustainable equipment and solutions. Similarly to mining, many other industries cause environmental challenges and face pressures to transition toward sustainable business practices. In this way, B2B manufacturers play a key role in supporting sustainable development of societies by providing solutions for the transformation of many industries toward more sustainable practices.

To fulfill their role in supporting sustainable development, B2B manufacturing companies are required to take action not only to minimize own environmental footprint – the negative environmental impacts caused throughout the lifecycle of a product or service – but to also maximize their environmental handprint – the beneficial environmental impacts that organizations can achieve by offering products and services that reduce the footprints of others (Pajula, Vatanen, Behm, Grönman, Lakanen, Kasurinen & Soukka 2021, 11 – 12). By focusing on maximizing the environmental handprint, B2B manufacturing companies can drive transformation of industries like the mining industry toward sustainability.

Environmental handprint management represents a recently emerging approach to the long-established concept of product stewardship. Product stewardship refers to the management of environmental, health, and safety effects of products across their entire lifecycle, integrating the "voice of the environment" into product design and development processes (De Bakker, Fisscher & Brack 2002, 459; Hart 1995, 993). Product stewardship aims to support developing a product portfolio that considers for example environmental dimensions. This environmental dimension inclusion into product portfolios is seen critical to reduce negative environmental impacts of firms (Jugend et.al. 2017, 433). The management of environmental handprint of B2B manufacturing companies is a critical lever for product stewardship, and so for reducing negative impacts of firms. Furthermore, environmental handprint management in B2B manufacturing companies serves as a critical mechanism for enabling industry-wide sustainability transitions and advancing broader societal sustainability goals.

1.2 Research motivation

The need to calculate and communicate the environmental handprint of companies is clear, yet there has been a lack of effective methods of achieving this (Pajula et. al. 2021, 10). Moreover, overall methods and approaches lack not only to manage environmental handprint but to overall integration of sustainability into product portfolios. A recent study of disruptive factors in product portfolio management for sustainable transition identified a research need to develop methods that support manufacturing companies in integrating sustainability criteria into their product portfolios (Gramberg et al. 2024, 17). One such method for integration and environmental handprint management is emerging from business practice – formulation of eco-product portfolios.

Companies have started to integrate sustainability into their product portfolios by formulating sub-portfolios of products distinctive for sustainability performance. The identification of this practice was initially made by a company that subsequently partnered with the researcher to conduct further investigation into the method. The emergence of eco-product portfolio formulation as a business practice to environmental handprint management was subsequently confirmed by the benchmarking research undertaken in this thesis. In this way, this thesis was initiated in response to a practical need identified by a company operating in the B2B manufacturing context and seeking to develop its sub-portfolio of products distinctive for environmental performance. The company recognized a gap in both internal knowledge and external guidance on how to formulate such product portfolio in a way that aligns with emerging regulatory and verification requirements. Hereafter, the company will be referred to as the "case company". However, it should be noted that this thesis does not

empirically examine the company's own eco-product portfolio as a case study but instead examines eco-product portfolio formulation at a general level and applies the findings to the case company's context.

The literature review conducted for this thesis supported the case company's experience of the lack of research on the formulation of sub-portfolios of products distinctive for sustainability performance. There is a growing interest in integrating sustainability into product portfolios (Villamil 2023), but previous studies on driving product sustainability have focused instead of formulating sub-portfolios of products on other dimensions such as sustainability integration into product innovation (e.g. Hallstedt 2017;), product evaluation (e.g. Mesa et al. 2018; NBS 2011) or the company's whole product portfolio management (e.g. Villamil 2023; Villamil & Hallstedt 2018; Jugend et. al. 2017; Tolonen et al. 2015; Gramberg et al. 2024; Artelt & Lukas 2020).

Due to the lack of definition in theory for the business practice to formulate sub-portfolio of products distinctive for environmental performance, this thesis introduces the concept of *eco-product portfolio.* Eco-product portfolio is "a compilation of products in a lower level of the main product portfolio that are (1) distinctive for their environmental performance, (2) fulfill a set of predefined, third-party or self-declared selection criteria, and (3) are distinguished through a shared eco-label".

In conclusion, the motivation for exploring eco-product portfolios in this thesis is two-fold. Firstly, there is a practical necessity for insights into the formulation of sub-portfolios of products distinctive for their sustainability performance. Secondly, there is an academic imperative to develop information on methods that support manufacturing companies in integrating sustainability criteria into their product portfolios (Gramberg et al. 2024, 17). Eco-product portfolio formulation is such method, and warrants further academic investigation, as existing research remains limited. Due to the above reasons, eco-product portfolios are chosen as the research objective of this thesis.

1.3 Research questions and methodology

Due to the limited research, there is little knowledge of how eco-product portfolios can be strategically formulated. To address this gap, this thesis sets the following main research question:

> **How can business-to-business manufacturing companies formulate eco-product portfolios?**

This research question is, firstly, aimed to be directly answered by exploring strategic considerations that define the central practices to eco-product portfolio formulation. In addition, to answer the main research question, two research sub-questions are formed:

RQ1: What evaluation criteria and selection methods are used to select products into an eco-product portfolio?

RQ2: How are eco-product portfolios externally verified and regulated?

These sub-questions aim to uncover both the current practices in B2B manufacturing companies to formulate eco-product portfolios (addressed as RQ1) and the external requirements for eco-product portfolio formulation (addressed as RQ2). To answer the research questions, this thesis adopts a qualitative, multi-method research approach (Figure 1). Three complementary methods are combined in this thesis to gather information. Additionally, this thesis adopts an applied research approach where the goal is to capture practical implications of empirical research. For this purpose, the thesis applies the information derived from the three methods to the case company's eco-product portfolio as represented in Figure 1.

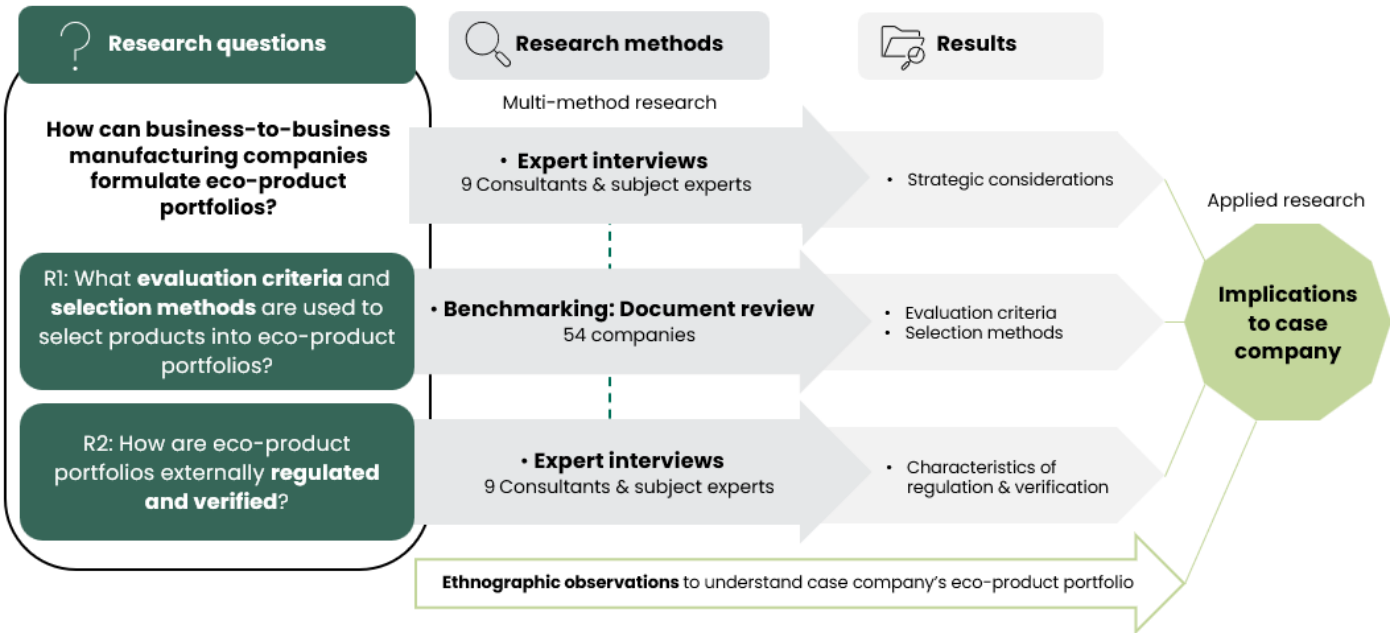


Figure 1: Research questions, methods and results

The three methods to gather information in this thesis are benchmarking through a document review of 54 companies, interviews of 9 experts and ethnographic observations of the case company. The first two methods, benchmarking and interviews, gather information that answers the research questions. The third method, ethnographic observations, gathers information on the case company's

eco-product portfolio to be able to apply the results from the two other methods to practice. The methods are shortly described next.

The benchmarking of 54 companies addresses RQ1 by examining how B2B manufacturing companies currently formulate eco-product portfolios – i.e. what evaluation criteria and selection methods are currently used to select products into a product portfolio. The benchmark data collection is guided by theoretical concepts. The following benchmark data analysis follows abductive logic and is characterized as theory-guided analysis.

The second research method, interviews with nine experts, addresses RQ2 by exploring how EU regulations and external verification practices influence the formulation of eco-product portfolios. Interviews are semi-structured and the analysis of the interview results is entirely data driven. Additionally, the expert interview method addresses the main research question by providing strategic considerations that companies should reflect on when formulating eco-product portfolios.

As applied research project for the case company, this thesis aims to generate practical knowledge while also contributing to the broader academic discussion of driving business sustainability via product stewardship. The practical knowledge is produced in this thesis by applying the results from benchmarking and interviews to the case company's eco-product portfolio's development. The third method, ethnographic observations of the case company, provides a basis this application by creating an understanding of the case company's eco-product portfolio. In conclusion, the two methods – benchmarking and expert interviews – used in this thesis aim to build an understanding of how eco-product portfolios are formulated in B2B manufacturing companies. The third method – ethnographic observations – provides a foundation against which the findings from the other two methods are applied. In this way, this thesis is characterized both as a multi-method research and an applied research project.

1.4 Scope

To ensure both practical relevance and academic contribution, this thesis's research objective and context is narrowed through four key scoping decisions. Scoping decisions are presented in the order that they were decided as the thesis scope was originally defined. All scoping decisions are pragmatic in that they provide practical implications to what is examined and in what context in this thesis. The first scoping decision limits the exploration to the B2B manufacturing industry. The second and the third decisions limit the research objective to eco-product portfolio formulation. The fourth decision limits the dimensions examined regarding the formulation.

The first scoping decision relates to the context of this thesis. The thesis is situated within the B2B manufacturing context, both due to the case company's industry and the broader relevance of sustainability in this sector. From a practical perspective, the research aims to provide actionable insights for B2B manufacturing firms, where knowledge on eco-product portfolio formulation is currently limited. Scientifically, product stewardship is significant in the industry due to the substantial environmental footprint of manufactured products – particularly heavy equipment – across their lifecycles, including energy and water use, emissions, and biodiversity effects. Enhancements in the environmental performance of these B2B manufacturing products through product stewardship can therefore generate significant benefits during their lifecycle, contributing to the broader transition toward a sustainable society.

The second scoping decision relates to choosing to focus on *formulating sub-portfolios* as a product stewardship approach. The broader concept of product stewardship encompasses various strategies for integrating sustainability into product portfolio management and product innovation. However, this thesis focuses specifically on the creation of sub-portfolios that distinguish products based on sustainability. This scoping was driven by the case company's interest in understanding how to formulate such sub-portfolios of products. Rather than comparing different sustainability integration strategies into product portfolios (e.g., full portfolio integration vs. sub-portfolio creation), this thesis concentrates on the formulation of sub-portfolios of products as a distinct and under-researched approach to product stewardship. The formulation of a sub-portfolio of products can become a vehicle for implementing a company's sustainability strategy through product portfolio decisions. Therefore, this thesis contributes to understanding how strategic management can support environmental responsibility by investigating how companies can operationalize sustainability through formulating sub-portfolios of products. This relevance to strategic management was a motivation to scope this thesis to focus especially on formulating sub-portfolios of products as a product stewardship approach.

Thirdly, while sustainability encompasses environmental, social, and economic dimensions, this thesis focuses on sub-portfolios of products distinctive for their environmental sustainability – eco-product portfolios. The scope defines this thesis to consider instead of all sub-portfolios distinctive for their sustainability, those sub-portfolios of products distinctive for their environmental performance. This decision was based on the case company's interest on sub-portfolios that are formulated to differentiate products distinctive for their environmental impact. This decision was also affected by the centrality of environmental considerations in product stewardship such as the

recent approach to focus on environmental handprint showcases. Additionally, this decision was made to maintain a manageable scope for a master's thesis.

Notably, the environmental focus scopes only the object of this thesis to be eco-product portfolios. Focus on environmental dimension therefore does not mean considering only the environmental evaluation criteria for selecting products into eco-product portfolio. Indeed, all criteria defining the selection to eco-product portfolio are examined beyond mere environmental evaluation criteria for products. Rather this scoping only means that sub-portfolios distinctive only for their social or economic sustainability, not including environmental sustainability, are excluded from this thesis. Although this thesis isolates sub-portfolios of products distinctive for their environmental performance, it acknowledges the interconnectedness of sustainability issues leading to the potential and the need for future research to build on this thesis to examine formulation of sub-portfolios of products distinctive in all three sustainability pillars.

The fourth scoping decision relates to choosing to focus on three themes within eco-product portfolio formulation. Within the broader topic of formulation, this thesis is further scoped to examine three themes: (1) how companies select products into eco-product portfolios – specifically, what evaluation criteria and selection methods are used, (2) what regulatory and verification requirements shape the formulation process, including constraints on labeling products and making marketing claims, and 3) what strategic considerations should be taken into account when formulating eco-product portfolios. This thesis excludes other formulation related themes such as determining optimal selection methods for specific strategic goals (e.g., profit maximization or environmental benefit), or examination of how companies measure products against the evaluation criteria. Instead, this thesis describes current practices, external requirements and strategic considerations to provide a grounded understanding of how eco-product portfolios can be formulated. Together, these four scoping decisions ensure that the research remains focused, feasible, and relevant to both academic discussions and the case company's practical needs.

1.5 Thesis structure

This thesis is structured into six main chapters, each building on the previous. Following the introduction, the chapter 2 lays the theoretical foundation for exploring eco-product portfolio formulation. Section 2.1. starts by presenting the concept of product stewardship as a business practice approach for addressing environmental challenges. Section 2.2. continues by description of two concepts – product innovation and product portfolio management – that are essential for understanding product portfolio formulation and product stewardship in practice. Section 2.3.

explores product stewardship closer in product portfolio formulation by examining how sustainability can be integrated to the formulation – i.e. to the evaluation and selection of products into a portfolio. The section 2.4. then introduces the concept of eco-product portfolios and research on eco-labels. This section lays the base for exploring the under researched approach – eco-product portfolio formulation – to product stewardship. In summary, Chapter 2 offers an overview of the theoretical foundations and key concepts underpinning the formulation of eco-product portfolios.

Chapter 3 presents the research methodology, outlining the qualitative multi-method and applied research approach adopted in this thesis. Chapter 3 details the adopted research methods alongside data collection and analysis. The section also discusses the credibility and ethical considerations of the research. Chapter 4 presents the empirical findings from the benchmarking of 54 companies. Firstly, in section 4.1. the evaluation criteria currently used in the formulation of eco-product portfolios are presented. Section 4.2. continues by presenting the identified selection methods used in the formulation of eco-product portfolios.

Chapter 5 continues by presenting the empirical findings of the nine expert interviews. Section 5.1. presents the characteristics of regulation of eco-product portfolios. Section 5.2. continues with presenting the characteristics of verification of eco-product portfolios. Concluding the chapter, section 5.3. presents the results regarding the strategic considerations that the experts described central to eco-product portfolio formulation.

Finally, chapter 6 summarizes the implications of the research results to theory and practice. Section 6.1 begins by examining how the research results contribute to addressing the research questions. Section 6.2. follows with an exploration of implications to regulatory, academic and business actors. Also, the suggestions for future research to further advance the understanding of product stewardship via formulation of sub-portfolios of products are presented. Notably, section 6.2.3. represents the applied research component of this thesis and illustrates how the research results can be applied into practice at companies who are formulating or refining eco-product portfolios. This is carried out by exploring the implications for refining the case company's eco-product portfolio. Chapter 6 ends with outlining the limitations of this thesis' research.

2 Product stewardship

2.1 Conceptual background of product stewardship

Environmental considerations have played a prominent role in sustainable management, particularly as organizations have started to seek solutions that both support sustainable business practices and enhance their long-term competitiveness. Hart (1995) introduced the natural-resource-based view of the firm, arguing that future competitive advantage will likely stem from capabilities that enable environmentally sustainable economic activity. This perspective reframes the firm's relationship with nature as a strategic asset, emphasizing that environmental constraints – such as resource scarcity and ecological degradation – will shape the competitive landscape. Within this framework, Hart identifies three interconnected strategies: pollution prevention, product stewardship, and sustainable development. (Hart 1995, 991.) This thesis adopts Hart's view and focuses on product stewardship as a strategic approach through which manufacturing firms can respond to environmental challenges while gaining competitive advantage.

The concept of *product stewardship* consists of the terms "product" and "stewardship". This thesis adopts Villamil (2023) definition of a product based on ISO 9001:2000 definition: "a product is the physical object, software or process developed by a manufacturing company, which is supported by services" (Villamil 2023, 7). Multiple factors contribute to the heightened emphasis on products within companies' environmental sustainability initiatives. Firstly, products are recognized as sources of environmental burden. Secondly, environmental policies are progressively targeting products. Thirdly, various stakeholders throughout the product lifecycle influence products' environmental characteristics. Lastly, manufacturing firms themselves play a crucial role in shaping these characteristics (Kärnä 1999 according to De Bakker, Fisscher & Brack 2002, 455).

The concept of product stewardship is multifaceted and subject to varying interpretations (Lane & Watson 2012, 1257). At its core, product stewardship refers to the management of environmental, health, and safety effects of products across their entire lifecycle (De Bakker et al. 2002, 459). It entails integrating the "voice of the environment" into product design and development processes (Hart 1995, 993). Integrating the "voice of the environment" refers internalizing the environmental impacts that are produced by activities throughout the value chain – from raw material extraction to production, use, and end-of-life disposal (Hart 1995, 993). Indeed, the objective of product stewardship is to minimize the environmental impacts associated with products throughout their lifecycles (Jensen & Remmen 2017, 379).

Historically, the idea of product stewardship evolved from a narrow focus on hazardous waste management toward a broader concern with resource conservation and recycling (Lane & Watson 2012, 1258; Jensen & Remmen 2017, 378). This evolution reflects a shift in emphasis from reactive compliance to proactive environmental responsibility embedded in product strategy. Product stewardship is often discussed in relation to Extended Producer Responsibility (EPR) which refers to the historical and regulatory dimensions of the concept. Although some researchers use the terms interchangeably, they differ in both scope and emphasis. EPR is generally understood as a legal obligation imposed and enforced by governments onto manufacturers (Lewis 2005, 49). In contrast, product stewardship may involve a wider range of actors along the supply and retail chain (Curtis, Collins, Cunningham, Stigler & Novotny 2014, 5), and is not often mandated by law. Product stewardship represents a broader and more voluntary approach to environmental responsibility.

Manufacturers engage in product stewardship voluntarily because it can yield strategic benefits. As Hart (1995) argues, firms that effectively address environmental constraints may achieve sustainable competitive advantage. De Bakker et al. (2002, 462) found that competitive advantage is an important motivator for managers to adopt product stewardship practices, and such advantages encompass enhanced firm's image, strengthened customer relationships, and improved knowledge of the own product and processes, hence improved transparency. Moreover, nowadays companies can profile themselves as trailblazers and gain competitive advantage with creating positive impacts with their products and services (VTT 2021). This thinking has led to surfacing of the concept environmental handprint "the beneficial environmental impacts that organisations can achieve and communicate by offering products and services that reduce the footprints of others" (Pajula et. al. 2021, 11). Managing the environmental handprint is an approach for companies to enact product stewardship.

While various actors – including distributors, users, recyclers, and disposers – can influence a product's environmental impact, primary responsibility of environmental impacts lies with the manufacturer who designs and manufactures the product. This is because manufacturers possess unique opportunities to prevent environmental harm through environmentally conscious product development (or eco-design). (Lindhqvist 1992, according to Lewis 2005, 48.) This positioning makes manufacturers central actors in implementing product stewardship, especially via management of their environmental handprint. The adoption of stewardship principles often requires rethinking product portfolios, integrating environmental criteria into product design decisions, and fostering innovation that aligns with sustainability goals. Thus, the next section 2.3. will describe shortly the concepts of product innovation and portfolio management.

2.2 Product innovation and portfolio management

2.2.1 Product innovation

Product innovation is used to develop new products and improve the characteristics of current products and can be incremental innovation, where the changes are made step by step, or radical, which involve drastic changes (Villamil 2023, 7). Roozenburg and Eekels (1995) separate the product innovation process into two phases: product development and realization (Figure 2). Product development phase encompasses all the activities to conceive, design, manufacture and launch a product (Ulrich & Eppinger 1995, 14). Product development starts with product planning and continues with development activities. Usually when a company plans a new product, a project is created. A project is a temporary group activity designed to produce a unique product, service or result (Villamil and Hallstedt 2018, 147). In product planning, several projects are assessed and evaluated according to the customer requirements, market push, among other facts, to determine the products and services that will be offered (Villamil & Hallstedt 2021, 2). Four methods that support project evaluation decisions are discount cash flow method, option pricing method, scoring and checklist method, and probing and learning method (Brook and Pagnanelli, 2014, 50).

The evaluation process of innovation ideas and innovation project proposals in the front end of new product development is critical for successful product development (Brook & Pagnanelli 2014, 50). Moreover, the front end of product development is essential for determining product's environmental impacts (Hallstedt, 2017; Villamil 2023). Product development's early stages are therefore central for product stewardship and the development of more sustainable solutions. Although firms increasingly recognise the importance of incorporating sustainability considerations into their product innovation processes, such integration usually occurs in the later phases of the innovation process when the potential for improvements is limited (Villamil 2023, 2).

However, there are numerous product design approaches and methods aimed to develop sustainable innovations, such as eco-design, cradle to cradle, biomimicry, design for the environment (DfE), circular economy (CE) and sharing economy (Villamil 2023, 3). These approaches incorporate sustainability into the product development, supporting firms in their product stewardship efforts. Following product development, the product innovation process continues and ends with product innovation realization where the product is produced, distributed and sold (Figure 2). Once product innovation is finalized, the products are incorporated into the company's product portfolio.

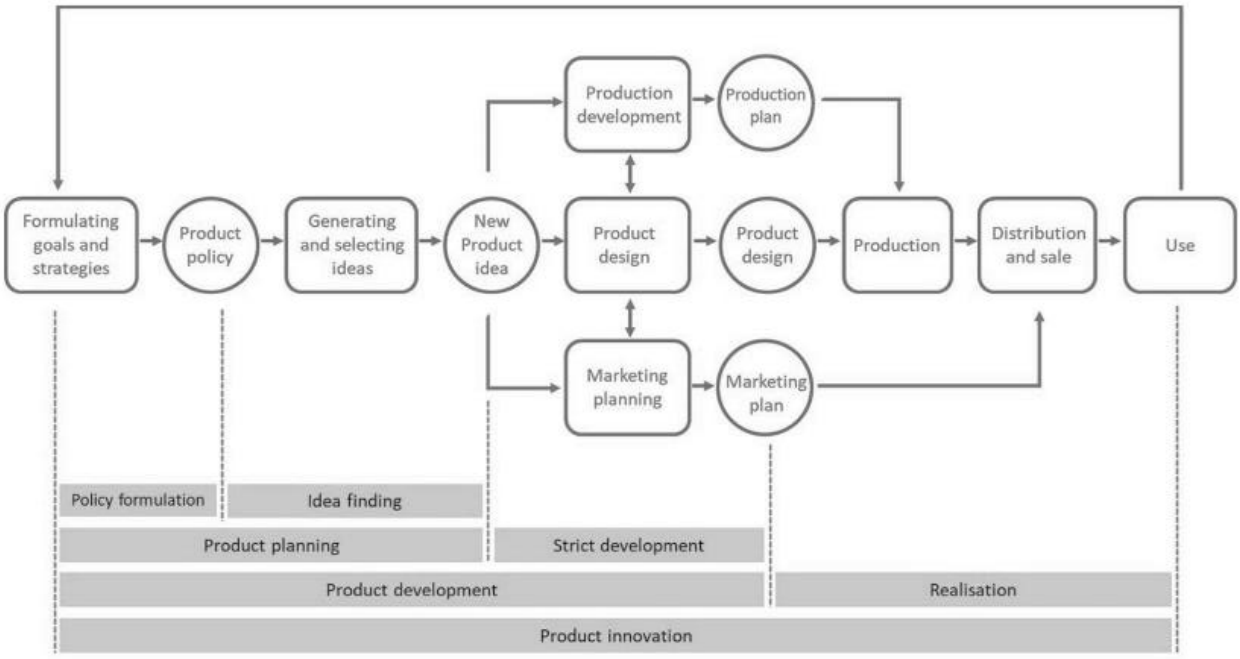


Figure 2: Product Innovation Process (Roozenburg & Eekels 1995)

2.2.2 Product portfolio management

Most companies offer a wide variety of products and, therefore, use *a product portfolio* to deal with the complexity of their offering (Villamil 2023, 11). A company's product portfolio is a cluster of different products, services and solutions that manufacturing companies offer to their customers based on the company's strategy (Villamil & Hallstedt 2021, 1). A product portfolio can consist of hardware (HW), software (SW), services and documentation types of products, which are connected to higher and lower level groups and items (Tolonen, Shahmarichatghieh, Harkonen, Haapasalo 2015, 4). The products inside a portfolio are related and have similar characteristics that cluster them into portfolio (Villamil & Hallstedt 2018, 149). The products in a portfolio can be classified in many ways; for example by customer segments, technology generations or product families (Tolonen et al. 2015, 4). The classifications might divide products into sub-portfolios, that are compilations of projects and programs in a lower level of the main portfolio (Villamil 2023, 9).

Product portfolios evolve over time. *Product portfolio renewal* means adding new products to the product portfolio, enhancing and modifying the existing products and removing obsolete ones (Tolonen et al. 2015, 469). To control what new products will be added to portfolio and to balance the portfolio, companies exercise product portfolio management. *Product Portfolio Management* (PPM) is a strategic subdiscipline that focuses on the long-term evaluation, optimization, and

control of a firm's product-market activities. Unlike product management, which concentrates on the execution of individual product strategies, PPM adopts a higher-level perspective to allocate resources based on strategic relevance and prioritization. (Gramberg et al. 2024, 2.) It is inherently dynamic and subject to fluctuation, requiring continuous balancing with market attractiveness and responsiveness to changes over time (Villamil and Hallstedt 2021, 2).

The PPM process enables firms to enhance their competitiveness by identifying new technologies, understanding the market, involving different company functions, identifying long-term profitability, and supporting companies to manage their resources such as budget, people, and capacity (Jugend et al., 2017). Main product portfolio performance focus areas can be summarized as follows: (1) the product portfolio strategic fit, (2) value maximization, and (3) the balance of the product portfolio between short-term profitability and long-term growth opportunities (Tolonen et al., 2015, 472; Gramberg et al. 2024, 2). The portfolio management process has four phases a) strategic planning process, b) aligning process group, c) monitoring and controlling process group and d) component process, see Figure 3 (PMI, 2013). Companies use various approaches to portfolio management. These can be classified into financial, strategic, behavioral and mapping approaches (Cluzel et al. 2016, 4331).

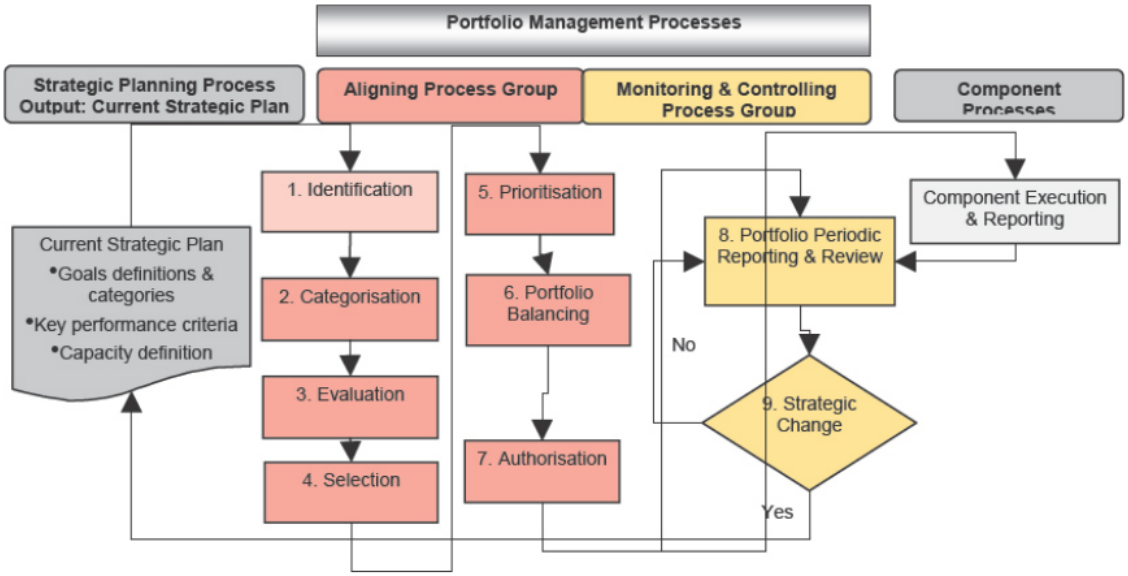


Figure 3: The Portfolio Management Process with several steps for the selection of the portfolio components (PMI, 2013)

To select portfolio components into a product portfolio, firms establish evaluation criteria for the portfolio and its products. It is important to note that products may undergo evaluation twice for

inclusion in the portfolio – initially during product development and subsequently as part of product portfolio management. The evaluation criteria used in product portfolio management include factors such as revenue potential, customer needs, and anticipated market success, among others (Villamil and Hallstedt 2021, 5). The setting of the evaluation criteria is dependent on the company's industry sector, needs, market, legislation and stakeholders (Villamil and Hallstedt 2021, 11).

Business-to-business manufacturing companies are increasingly confronted with transformative trends, such as sustainability, digitalization and servitization. This is changing how product portfolios are developed, and how products evaluated. To deal with the challenges of a disruptive contemporary context, companies are adjusting product portfolio evaluation to consider various strategic drivers such as sustainability. In particular, the growing significance of sustainability in product development and portfolio management call for the integration of sustainability criteria into the evaluation process. (Gramberg et al. 2024, 1, 15.) Indeed, integrating sustainability into the evaluation process and product portfolio management is central for product stewardship.

2.3 Product stewardship in product portfolio formulation

Companies' approaches to integrating sustainability into their product portfolio and evaluation process varies. Prior literature studying the inclusion of sustainability in product portfolios has focused on three dimensions. Firstly, to collaboration between internal and external stakeholders. Secondly, to evaluation and prioritization of the company offers. Thirdly, to integrating eco-design in the product portfolio management through methods, tools, organizational changes and strategy development. (Villamil & Hallstedt 2021, 3; Jugend et al. 2017, 433.) This section 2.4. focuses on the second dimension – the integration of sustainability into the evaluation and prioritization of the company offers – with a focus on evaluation and prioritization when product portfolios are formulated. Notably, while direct research on sub-portfolio formulation lacks, the presented processes and concepts of product portfolio formulation are researched in the entire product portfolio context. These concepts form a basis for understanding also sub-portfolio formulation.

Product portfolio formulation encompasses both the evaluation of products and selection of them into product portfolio. Sustainability integration into evaluation and selection of products is crucial for managing company's environmental handprint. In line with the thesis scoping decisions (see 1.4.), the focus in this section is to create a basis for understanding sub-portfolios distinctive for their their environmental performance. Therefore, focus is given in this section – instead of theory on comprehensive integration of sustainability into product portfolio formulation – to environmental sustainability integration.

Firstly, integration of sustainability into product portfolio formulation is explored in chapter 2.4.1. by examining the evaluation of product's environmental performance. This evaluation creates the base for selecting product into a product portfolio. Various approaches – *selection methods* – can be used for integrating sustainability into the selection. These selection methods are explored in chapter 2.4.2. Section 2.4.3. describes the challenges involved in integrating sustainability into product portfolio. This leads to section 2.5. that introduces an emerging business practice to address these challenges – the formulation of eco-product portfolio.

2.3.1 Evaluation of product's environmental performance

A product portfolio formulation starts by evaluation of products against a set of *evaluation criteria*. The evaluation criteria are then used to select products into portfolio. To set evaluation criteria, companies need to decide *evaluation indicators* and *evaluation categories* to which set the criteria in. When environmental sustainability is integrated into the formulation of product portfolio, these three (evaluation criteria, indicators and categories) reflect environmental dimensions. Evaluation categories, criteria and indicators are used to evaluate products both in product innovation and in product portfolio management.

Evaluation categories refer to the thematic focus of a specific group of evaluation criteria. Evaluation category can be related to sustainability or to other dimensions of products such as profit, fit to market or to rest of company's portfolio. To evaluate the environmental sustainability of products, companies select evaluation categories that reflect the environmental dimensions of products that are relevant to them. Based on a literature review, Mesa et.al. (2018) identified four main environmental dimensions – referred also as environmental aspects in literature –that are most often employed to evaluation of products: 1) material consumption of a product, related to the raw material needed to manufacture the product, 2) energy consumption of a product related to the energy required in manufacturing, assembling, using and disposal phases of a product's lifecycle, 3) generated emissions produced in the product development and following lifecycle phases, and 4) use of hazardous materials in a product (Mesa et al. 2018, 1431).

The choice of which environmental evaluation categories are employed depends on the actor and use-case. For example, third-party eco-label schemes employ multiple environmental evaluation categories showcasing there to be variety depending on actor and use-case for evaluation. Figure 4 shows all environmental evaluation categories that were covered by the analyzed 456 third-party eco-labels from EcoLabel Index (Nakaishi & Chapman 2024, 10). The most used environmental evaluation categories were biodiversity, climate change (greenhouse gases), protection of natural

resources (water, land, and energy), management of chemical pollutants, and waste and recycling management (Nakaishi & Chapman 2024, 3).

Furthermore, evaluation categories are defined at various levels of depth, depending on the defining entity. For example, researchers Nakaishi & Chapman (2024) separated environmental dimensions into more detailed categories than businesses and policymakers often do: Some environmental dimensions in Figure 4 (such as "Material use" or "Recycling") are by businesses and policymakers often combined under one, higher level environmental category called Circular Economy. For industrial actors, Circular Economy (CE) aims to close material and energy loops by promoting efficient use of resources and minimizing waste. It shifts production away from a linear 'extract–produce–discard' model toward designing durable, repairable goods with components that can be reused, remanufactured, and recycled (IPCC 2022, 1179). This demonstrates that product categories are established by the evaluator, resulting in variations depending on the intended purpose of the evaluation. Therefore, evaluation category use and definitions also vary between companies depending on what they see relevant to evaluation.

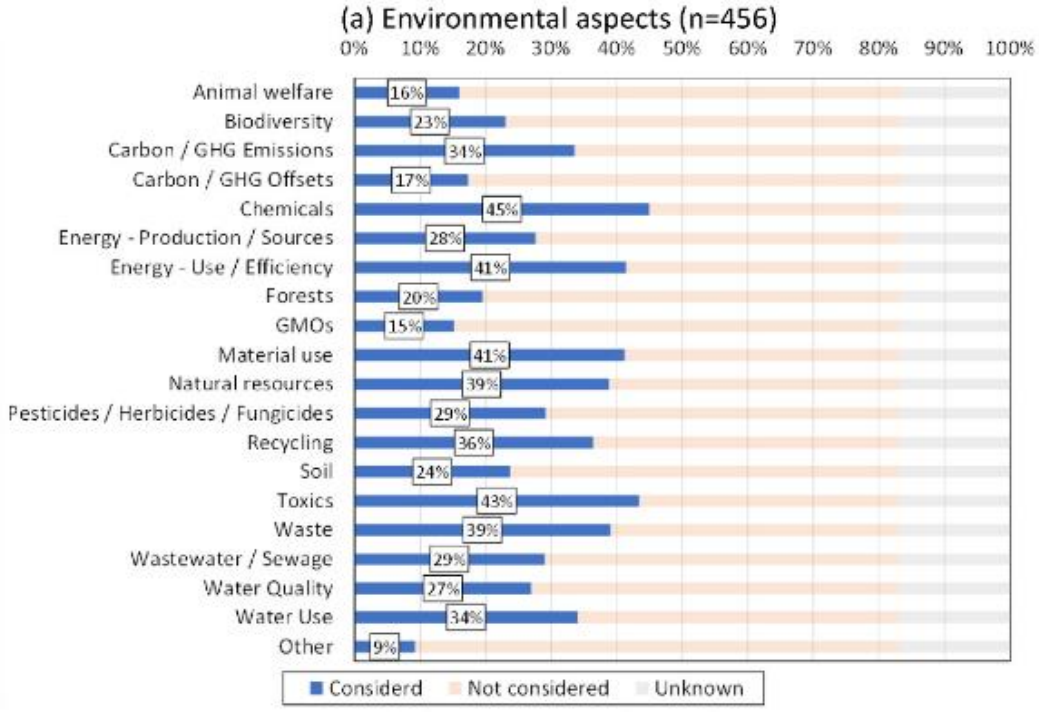


Figure 4: Environmental aspects used by eco-labels (Nakaishi and Chapman, 2024, p. 10)

After choosing relevant categories, companies set *evaluation criteria* to set target levels of product performance in the chosen categories. A criterion is "a target of a prioritized aspect or the level of the aspect that we strive for (e.g. "no raw material used" and "no hazardous chemicals used")

(Hallstedt 2017, 2). Sustainability can be integrated into the product portfolio evaluation criteria either as a separated evaluation criterion or integrated with other criteria. Figure 5 (Villamil & Hallstedt 2021, 8) shows the advantages and disadvantages of both approaches.

	Sustainability integrated with all criteria	Sustainability as a separated criterion
Advantages	Everyone will work with it (diversity).	It will be measured, visible, and implemented
	It will be part of all the requirements.	Pushes for change
	Becomes a natural part of the company culture	Good for transformation period
	Makes sure sustainability has the right weight	More control and clarity
	Shares responsibility/involvement	Special function that sets targets, actions, etc.
	Reduces risk (more resilience)	Will speed up implementation
	Long-term success	Easier requirement setting
		Included in decision-making process
Disadvantages	Not visible, lack of importance	Trade-offs weighting
	Lack of direct guidance	Lack of interdependencies (criteria connection)
	Takes longer to implement and measure	Fewer people involved

Figure 5: Advantages and disadvantages of sustainability integration with all versus separated criteria (Villamil & Hallstedt 2021)

Adopting specific sustainability evaluation criteria is relevant for the choice and allocation of resources among product innovation projects (Jugend et.al. 2018, 433). In this way, sustainability evaluation criteria influence the development of sustainable solutions. The sustainability evaluation criteria support the balancing of aspects such as market success, cost, revenue, quality, resources, and risk from a short- and long-term perspective (Villamil and Hallstedt, 2021, 10). Setting sustainability evaluation criteria for products helps to reduce environmental impact, avoid costs and use sustainability as a driver for product-service system innovations (Hallstedt 2017, 1). Hallsted (2017, 1) continues to describe how numerous researchers, including Waage (2007), Kaebernick et al. (2003), and Pujaria et al. (2004) have emphasized the importance of defining sustainability criteria for evaluation.

To define the sustainability criteria for product evaluation, companies need to choose indicators that measure products' performance against the evaluation criteria. An *evaluation indicator* is "a measurement or fact (qualitative or quantitative) that can indicate the state or level of the criterion" (Hallstedt 2017, 2). Indicators measure performance aspects such as material management, energy consumption, worker health and profit among others (Mesa et. al. 2018, 1431). Indicators enable comparing and measuring relative differences between products. Sustainability indicators or metrics

have been explored more than sustainability evaluation criteria during past decade (Hallstedt 2017, 2). However, there is no globally accepted indicators to measure and compare the sustainability performance of products from a holistic perspective (Hallstedt 2017; Mesa et al. 2018, 1431). Figure 6, directly derived from Mesa et. al.'s (2018, 1431) research, summarizes their findings of the conventional indicators employed in research to assess the sustainability of products. A level of ambition is set to an indicator for it to be used to define evaluation criterion. For example, when the required level of 10% is set to an evaluation indicator "recycled content" the combination defines the evaluation criterion "minimum 10% recycled content".

Conventional Indicators employed to assess the sustainability of products.

Author	Dimensions			Oriented to
	Economic	Environmental	Social	
(Bao and Bodapati, 2011)	People Technology Process Leadership Strategy	Carbon monoxide Nitrogen dioxide Particulate matter PM10 Particulate matter PM 2.5 Sulfur dioxide Presence of: Cadmium, Mercury, Lead, Chromium, Nickel, Zinc, Hazardous Non-Hazardous Recycle Landfill	Investment & Procurement practices Labour/Management relations Occupational Health & Safety Training and education Customer health & safety Product & Service labelling Market communications Customer privacy Community Public Policy	Product and Processes
(Jawahir et al., 2006)	Raw material cost Labour cost Production cost Packaging cost Energy cost Transportation cost Maintenance cost Repair cost Consumer injury cost Consumer warranty cost Recycling cost Disassembly cost Disposal cost Remanufacturing cost	Material Extraction Production energy used Hazardous waste produced Renewable energy used Emissions Functionality Hazardous waste generated Recyclability Remanufacturability Redesign Landfill contribution	Worker Health Ergonomics Work ethics Work Safety Product pricing Human safety Upgradeability Complaints Take back options Re-use Recovery	Products in general
(Kim et al., 2014)	Material cost Manufacturing cost Transportation cost Use cost EOL cost	CO2 CFC 14 Nitrogen Oxides	SO2 Hg - Mercurium	Products in General
(Ma and Kremer, 2015)	Product Innovation Risk management Profit Cost savings Energy Efficiency, Life cycle management	Emission Reduction Natural resource management Environmental assessment	Human diversity Human rights Labour relations Client safety and health	Modular Products

Figure 6: Conventional indicators employed to assess sustainability of products (Mesa et. al. 2018)

To conclude, product portfolio formulation is underpinned by a structured evaluation process encompassing the determination of evaluation categories and indicators to define evaluation criteria. It should be noted that the concepts of evaluation criteria and selection criteria are used in the literature sometimes interchangeably. To avoid confusion, the two are separated in this thesis as follows. In this thesis *evaluation criteria* create a base for the product selection into a product portfolio by setting target levels of product performance in chosen dimensions. Therefore, evaluation criteria are the target levels of dimensions that are assessed of a product. Often product

selection into a portfolio is defined through multiple evaluation criteria. The evaluation criteria are often combined or valued to determine which products are selected into a product portfolio.

These approaches to employing evaluation criteria for product selection into a product portfolio are defined as *selection methods*. The outcome of a selection method are *selection criteria* – defined in this thesis as the requirements to select products into a product portfolio. Therefore, in other words, selection method is the approach to employing evaluation criteria to determine the selection criteria for a product portfolio. Altogether, a selection method determines how the selection criteria – which define how products are selected into a product portfolio – are formed by employing the evaluation criteria which define product assessments. Figure 7 illustrates the concepts central to the formulation of product portfolios.

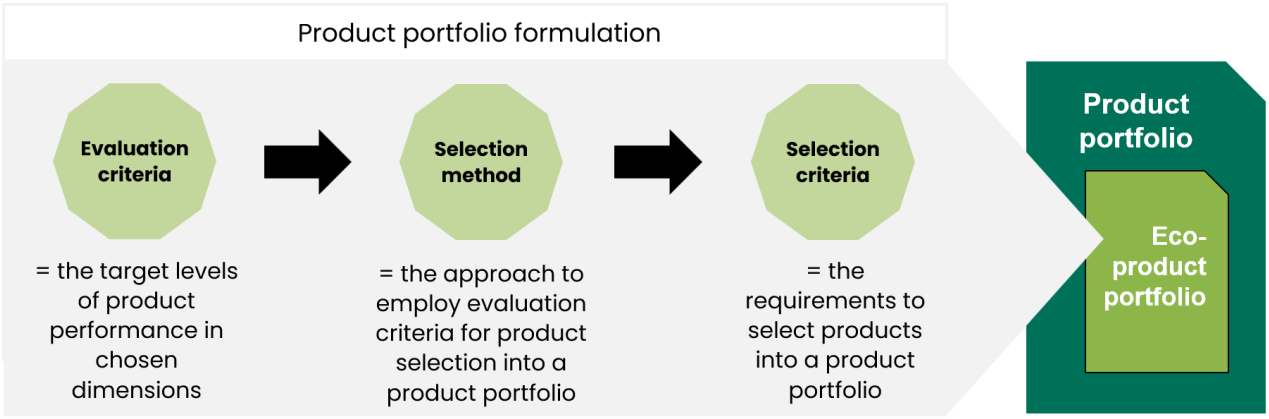


Figure 7: Product portfolio formulation key concepts

2.3.2 Selection methods for portfolio formulation

In this thesis a *selection method* describes the approach a company has chosen for its product portfolio formulation – i.e. the approach to employing evaluation criteria to determine the selection criteria for a product portfolio. In their systematic literature review, Villamil and Hallstedt (2018, 153) found that the selection criteria for product components were in most referenced sources based on tools, had several steps for setting the criteria and had graphic representations of criteria. Therefore, the selection method for portfolio formulation often includes the use of tools and a stepwise process. The most used tools for portfolio selection and evaluation are shown in Figure 8 by Villamil & Hallstedt (2018, 152) with Life Cycle Assessment (LCA) being the most used tool.

Management / product dev. tool	#	References
Balance Score Card BSC	8	(Akzonobel, 2016) (Damghani & Nezhad, 2013) (Epstein & Wisner, 2001) (Figge et al., 2002) (Kohl, 2016) (Sánchez, 2015) (Solvay, 2010) (Ölundh & Ritzen, 2004)
Stage-Gate Model	6	(Brones & Carvalho, 2015) (Clariant & CSCP, 2015) (Henkel, 2014) (Solvay, 2010) (Vandaele & Decouttere, 2013) (Ölundh & Ritzen, 2004)
Multi-criteria	4	(Brook & Pagnanelli, 2014) (Cluzel et al., 2016) (Janssen & Stuart, 2010) (Pimentel et al., 2016)
Stakeholder analysis	4	(Sánchez, 2015) (Silvius & Schipper, 2015) (Martens & Carvalho, 2017) (Carvalho & Rabechini, 2017)
Data Envelopment Analysis DEA	2	(Vandaele & Decouttere, 2013) (Sánchez, 2015)
Sustainability perspective tool	**#**	**References**
Life cycle assessment (LCA)	15	(Akzonobel, 2016) (BASF, 2015) (Buchert et al., 2014) (Cluzel et al., 2016) (Grießhammer et al., 2010) (Henkel, 2014) (Janssen & Stuart, 2010) (Mansoornejad et al., 2010) (Meinrenken et al., 2012) (Pimentel et al., 2016) (Sánchez, 2015) (Schmidt et al., 2004) (Solvay, 2010) (Uhlman & Saling, 2010) (Zvezdov & Hack, 2016)
Eco-Efficiency Analysis	4	(BASF, 2015) (Grießhammer et al., 2010) (Schmidt et al., 2004) (Uhlman & Saling, 2010)
Social LCA	2	(Pimentel et al., 2016) (Grießhammer et al., 2010)
Other Sustainability perspective tools		
Corporate Responsibility Portfolio Matrix (Ketola, 2010), Eco-Value Analysis (Buchert et al., 2014), Eco-design matrix (Wever et al., 2008), Eco-design wheel (Cluzel et al., 2016), Product development Check lists (Ölundh & Ritzen, 2004), Opportunity-strength matrix (Wever et al., 2008)		

Figure 8: Most used tools for portfolio selection and evaluation (Villamil & Hallstedt 2021)

Additionally, eco-design and eco-efficiency methods together with Global Reporting Initiative (GRI) were found to be used to integrate sustainability into the evaluation criteria (Villamil and Hallstedt 2018, 153). A more recent study from same researchers in 2021 followed suit and added some of the most used methods companies currently used for assessment and integration of sustainability in the product portfolio are LCA, corporate social responsibility (CSR), REACH legislation, eco-design & eco-efficiency tools and sustainability checklist (Villamil & Hallstedt, 2021). Particularly in the context of portfolio product evaluation, a review of 180 studies published between 2000-2010 presented a comprehensive list of tools used for product's environmental performance measurement (Figure 9, NBS 2011, 14). LCA and Ecological Footprint were found in the review to be the most used tools.

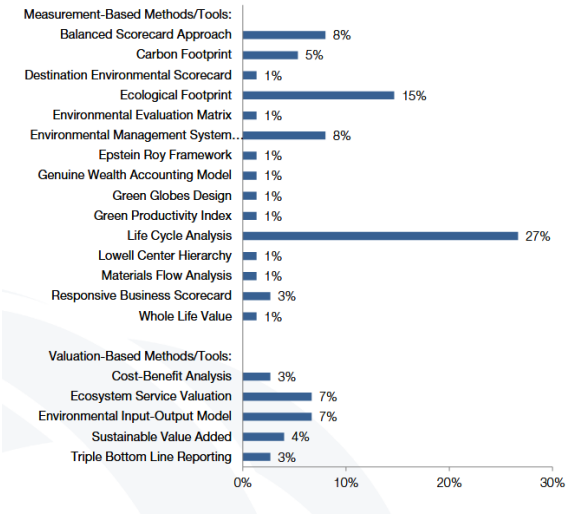


Figure 9: Percentage of studies reporting the use of a specific tool (NBS 2011)

2.3.3 Challenges in integrating sustainability into product portfolios

While companies express an interest in embedding sustainability into their product portfolio, they encounter challenges in the integration and implementation (Villamil & Hallstedt 2021, 1). Currently, product portfolio components are often evaluated from a management perspective and sustainability has a small role in the evaluation criteria. Most often-used variables for the evaluation process are cost, risk, time and resources (Villamil & Hallstedt 2018, 152-154). A similar challenge exists in product development, which directly influences the potential to create more sustainable product portfolios.

Hallstedt (2017, 2) identifies two underlying problems to integrating sustainability into product development. Firstly, the breadth and complexity of sustainability, and secondly, the time and data restrictions in the early stages of the product innovation process. The complexity of sustainability makes defining appropriate sustainability criteria problematic. Commonly used evaluation indicators, such as CO_2 emission reduction, are often selected due to their familiarity rather than their comprehensiveness, resulting in an incomplete representation of sustainability dimensions (Hallstedt 2017, 2). Indeed, criteria existing in product requirements are often developed based on effects that are assumed to be desirable or not, while being easy to measure (Hallstedt 2017, 1).

Additionally, a lack of strategic planning perspective and a deficient knowledge for the implementation of eco-design and lifecycle thinking are identified as challenges in integrating sustainability into product portfolios (Villamil et al. 2022, 4). In industrial practice, the lack of time and data also limits the ability to analyze sustainability properly (Hallstedt, 2017, 2). The process to implement sustainability in the portfolio demands a high amount of resources such as time, knowledge, trained teams, and moreover, requires the planning and assessment of a high number of products (Villamil 2023, 52). For example, the product development team must know what sustainability means, how it can be achieved and measured to reach more sustainable solutions (Hallstedt 2017, 2). Even when there are resources, in the implementation there are trade-offs in the decision-making process (Villamil 2023, 15) which may lead to deprioritizing sustainability.

Companies need to navigate trade-offs such as those between cost and environmental impacts in the product portfolio. However, prioritization is challenging due to evaluation criteria interdependencies and because each function might have different targets that guide the portfolio development. (Villamil and Hallstedt 2021, 3, 11.) Given the internal challenges associated with integrating sustainability to their product portfolios, companies would need external standards and guidance to effectively set sustainability criteria for products. However, there is a lack of practical

guidance documents for measuring and setting environmental and sustainability targets for product portfolios (Tolonen et al. 2015, 5).

In addition to above, a barrier in the integration of sustainability into product portfolio is a lack of clear environmental benefit and commercial disadvantage. These factors contribute to increased project complexity, heightened information requirements, greater uncertainty regarding outcomes, and elevated costs. (Jugend et al. 2017, 433.) To address the challenges presented in this section, organizations need more methods and approaches for product stewardship to effectively incorporate sustainability into their product portfolios. One such approach is the formulation of sub-portfolios of products distinctive for their environmental performance – eco-product portfolios.

2.4 Eco-product portfolio formulation as product stewardship approach

2.4.1 Eco-product portfolio

When sustainability criteria guide the evaluation and selection of products into a portfolio, product portfolio can be called a sustainability product portfolio. Villamil (2023, 46) defines a sustainability product portfolio as *"a company platform of solutions, i.e., a cluster of products, services, technologies, and/or customized options, based on the company strategic plan and assessed by a strategic sustainability perspective"*. Furthermore, a sustainability product portfolio is one that promotes socio-ecological sustainability. (Villamil, 2023.)

Instead of setting sustainability criteria for the entire product offering – as in a sustainability product portfolio – some companies define sustainability criteria for a sub-portfolio of products. In this way, companies may separate the products that perform better against predetermined sustainability criteria than the rest of their products. In the research review conducted for this thesis, it was found that previous research has lacked on such sub-portfolios. The prior research has focused on sustainability product portfolios on the level of companies' entire product portfolio. In the level of the entire product portfolio, the prior research has focused mainly on sustainability integration into product portfolio management and product innovation (e.g. Villamil 2021; Villamil & Hallstedt 2018; Artelt & Lukas, 2020; Gramberg et al., 2024; Hallstedt, 2017; Jugend et al., 2017; Schmidt et al., 2008; Tolonen et al., 2015). However, research on formulation of sustainability sub-portfolios at the lower level of the main product portfolio seems to be limited.

However, there is some research done on sub-portfolios of products in eco-label related research. Some companies use eco-labels to set requirements for sustainability of products and to select them into a product portfolio (Villamil & Hallstedt 2021, 12). Regardless that eco-labels are used to set

sustainability requirements for sub-portfolios of products, research on sub-portfolios distinguished by self-declared eco-labels is scarce. Research on eco-labels focuses often on business-to-consumers context, and on third-party eco-labels – not self-declared eco-labels. In a review of 1 246 articles globally, third-party eco-labelling (ISO type I) was found the most studied, following a growing number of publications of eco-labels that based on verified LCA calculations and on forming Environmental Product Declarations (EPDs) (ISO type III). Self-declared eco-labels (ISO type II) were the least studied in the 1 246 articles. (Dórea et al. 2022.) Research on self-declared eco-labels is therefore limited. Because of limited research both in eco-label and sustainability product portfolio research fields, a concept to describe sub-portfolios of products distinct in sustainability performance and marked with a self-declared eco-label is lacking.

In the absence of a widely accepted academic definition – and for the scope and purpose of this thesis to focus on environmental dimensions – this thesis introduces a concept of "*eco-product portfolio*", as defined below. The concept definition reflects both the business practice identified in this research to label sub-portfolios distinctive for their environmental performance (e.g. ABB's "EcoSolutions", Siemens's "EcoTech" & Kalmar's "Eco Portfolio") and the concept of a sustainability product portfolio: *"a company platform of solutions, i.e., a cluster of products, services, technologies, and/or customized options, based on the company strategic plan and assessed by a strategic sustainability perspective"* (Villamil 2023, 46). Based on these backgrounds, the concept of eco-product portfolio is defined in this thesis as follows:

Eco-product portfolio is *a compilation of products in a lower level of the main product portfolio including products that are*

- *distinctive for their environmental performance,*
- *fulfill a set of predefined, third-party or self-declared, selection criteria,*
- *and distinguished through a shared eco-label.*

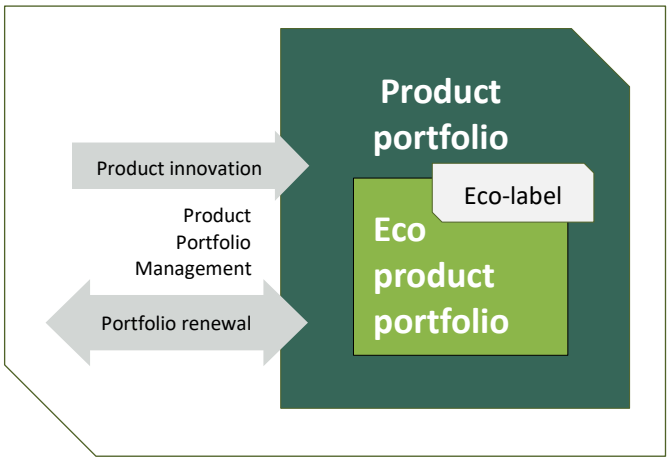


Figure 10: Eco-product portfolio visualization

An eco-product portfolio is shaped by product innovation, portfolio renewal and product portfolio management as presented in Figure 10. Following the definition of the portfolio, an *eco-product* refers in this thesis to a product that is distinctive for its environmental performance, fulfill a set of selection criteria and is distinguished through a shared eco-label. Similarly to a company's entire

product portfolio, eco-product portfolios formulation bases on chosen evaluation criteria and selection method. This thesis focuses on eco-product portfolios that are formed based on company's self-declared predefined selection criteria for the portfolio. Such criteria can include both evaluation criteria of product's environmental performance and other criteria that relate for example to the governance of portfolio.

Companies have eco-product portfolios for various reasons. Including sustainability dimensions into product portfolios is for example a means to communicate the sustainability performance of the products internally and externally, while accelerating the development of more sustainable solutions (Villamil and Hallstedt, 2018, 146). Following this line of thought, eco-product portfolios can be used in product stewardship as tools, firstly, to accelerate the development of more sustainable solutions. In this way, an eco-product portfolio can be used as a strategic tool for business' sustainability transformation. In the early stages of innovation processes, such as in product planning stage, there are opportunities to develop sustainable solutions if sustainability considerations are integrated to the process (Hallstedt, 2008; Wever et al., 2008). In this way, eco-product portfolios can drive the creation of sustainable solutions if the selection criteria of an eco-product portfolio are used in early product development to guide product innovation. Therefore, leaders can use an eco-product portfolio as a product stewardship tool to drive environmental sustainability of their own and their customer operations.

Secondly, eco-product portfolios can be used in product stewardship as tools for transparency, information sharing, marketing and offering separation. Marking eco-product portfolio products with an eco-label supports this use-case. Therefore, research on eco-labels provides understanding of how labeling eco-product portfolio products brings both advantages and challenges. For this reason, the next section 2.4.2. presents an overview of eco-label research to understand both why and how eco-product portfolios are labeled. In summary, formulating eco-product portfolios seems to represent an under researched approach to product stewardship amid its importance to product stewardship. Therefore, eco-product portfolios are the focus of this thesis.

2.4.2 Eco-labels

Stakeholders are increasingly requesting transparent and holistic sustainability data from companies (Artelt & Lukas 2020, 69). To provide stakeholders with information on the environmental characteristics of products and services, companies use Environmental product information schemes (EPIS) as communication tools (Rubik & Frankl 2017, 13). Eco-labels represent one type of environmental product information scheme as illustrated in Figure 11 (Rubik & Frankl 2017, 13).

Eco-labels, as a subset of environmental labels, identify products with environmental preferability compared to other products in the same product group. While most labels are voluntary, some, such as the EU Energy label, are mandatory under regulation. (Frydendal et al. 2018, 569-571.) Environmental labels communicate the environmental aspects of products or services to non-environmental experts, aiming to inform and influence purchasing decisions and enabling consumers and professionals to support sustainable development with their buying decisions (Frydendal, Engel & Bonou 2018, 568).

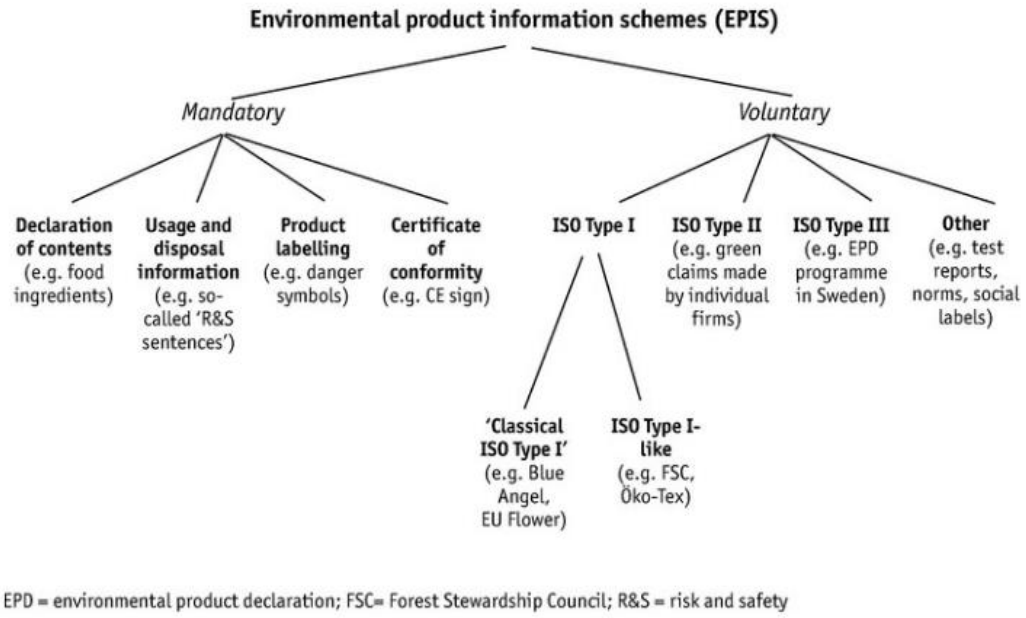


Figure 11: Classification of environmental product information schemes (Rubik & Frankl 2017)

Environmental labels first appeared in the 1970s but gained momentum after the late 1980s, particularly following the 1992 UN Conference on Environment and Development, which introduced Agenda 21 and placed sustainable development on the global political agenda. Growing environmental concern created new market opportunities for producers, leading to the rise of "green marketing" and the capitalisation of environmentally friendlier practices, via use of green claims through logos, declarations, and labelling. Initially, these labels lacked standards or guidelines, resulting in credibility issues and risks of misleading consumers – a phenomenon known as greenwashing. To address this, standardization initiatives emerged, most notably the ISO 14000 family, which began in 1991 to provide an objective basis for verifying environmental claims. (Frydendal et al. 2018, 568.) Now, the use of eco-labels is growing in business and in academic interest. A research review that evaluated 1246 articles on environmental labelling topics published

between 2000-2022 found an increase in application of environmental labelling worldwide, with Europe leading in publications and demanding higher label quality (Dórea et al. 2022, 195).

To strengthen voluntary initiatives, the International Organization for Standardization (ISO) introduced rules and guidelines for environmental labels through the ISO 14020 series. This framework defines three main types of eco-labels: Type I and Type III, which are life cycle based, and Type II, which is not. ISO also established general principles for labels outside these categories. (Frydendal et al. 2018, 570.) Type II eco-labels are defined as "environmental self-declarations by manufacturers, importers or product distributors without the intervention of an independent certification board (self-declarations also include "Recyclable", "Compostable")". In comparison, Type I, known as ecolabelling schemes, award logo or a mark to products or services upon fulfilling a set of criteria subject to external certification by an independent body. Type III, then, contains quantification of the environmental impacts associated with the product life cycle through LCA, and is also subject to an independent check. Most commonly known the International Environmental Product Declarations (EPD) system is among these. (ISO 14024, in Iraldo et al. 2020, 834.)

However, not all voluntary labels fit neatly into this typology; for instance, some third-party certified labels lack lifecycle considerations and multifaceted aspects (commonly known as Type I like labels), prompting criticism and proposals for alternative classifications. These proposals suggest additional criteria such as award format, end-user type (B2B or B2C), evaluated object (product, production process or organization), owner (private, government, NPO or NGO), operating capital, frequency of updating, transparency, and comparability etc. (Nakaishi & Chapman 2024, 3.) In this thesis, ISO classification is used as a base together with a specification on end-user-type for specifying what is meant by a shared eco-label in the definition of eco-product portfolio: *A shared eco-label* marking products in an eco-product portfolio are Type II & III eco-labels for business-to-business end-users.

Type II environmental labels are voluntary self-declared environmental claims made by manufacturers and businesses to promote products and services with reduced environmental impact. The claims aim to provide accurate and verifiable information of these products. (Ecomatters, n.d.) ISO 14021:2016 aims to harmonize the use of self-declared environmental claims and reduce inaccurate or misleading information (Frydendal et al. 2018, 571). The standard 14021 identifies and clarifies commonly used terms in claims and specifies evaluation methods for each term to ensure validity and scientific soundness. It also includes general requirements for undefined terms and guidance on label-related aspects such as the use, placement, and size of symbols and graphics.

(ISO 2019, 7.) Key requirements for these claims based on ISO 14021 include truthfulness, accuracy, substantiation, possibilities for verification. Additionally, ISO 14021 requires consideration of relevant environmental aspects, with clear indication of whether the claim applies to the whole product or part of it. (Rubik & Frankl 2017, 37; Ecomatters n.d.) Claims must be explicit, accompanied by explanatory statements, and consider relevant lifecycle phases to avoid shifting environmental burdens. Responsibility lies entirely with the claimant, who must maintain documentation for verification. (Ecomatters n.d.) However, many self-declared environmental claims do not follow the ISO standard, and might even be in conflict with marketing regulation (Frydendal et al. 2018, 571).

Companies have different reasons to use eco-labels type II that also describe partly the possible use purposes of eco-product portfolios. System of International Certification (SIC) describes the advantages of using of type II eco-labels according to ISO 14021 being 1) Transparent marketing by ensuring truthful and reliable environmental claims, 2) Consumer trust by building brand reputation with credible green messaging, 3) Legal compliance by reducing risk of false advertising or regulatory penalties, and 4) Market differentiation by highlighting environmental leadership through clear communication (SIC, n.d.).

Eco-labels generally are seen as a driving force for both closing the information asymmetry between consumer and producer, and for boosting eco-innovation (Nakaishi & Chapman 2024, 4; Dórea et al. 2022, 185). The effectiveness of an eco-label depends on how it communicates to consumers the information that the label signifies (Maze 2023, 270). Therefore, it is critical when formulating an eco-product portfolio to focus on how to communicate to consumers what does the self-declared eco-label on a product signify. An eco-product portfolio will not bring advantages if buyers wonder why a product has an eco-label. Similarly, eco-product portfolio will not boost eco-innovation if portfolio's selection criteria are not used to guide the product innovation process. To reap the benefits of having an eco-product portfolio therefore necessitates strategic considerations in marketing and R&D functions.

If companies fail to communicate effectively and transparently about the basis and purpose of their eco-product portfolio, they can face challenges and risks. While eco-labels are essential tools to inform consumers about products' environmental characteristics, eco-labels can also confound consumers causing misperception and greenwashing claims. Greenwashing means providing incomplete, unclear, or false environmental information which confuses social awareness of consumers and investors. (Dórea et al. 2022, 185–186.) Indeed, using eco-labels also carries

responsibility due to the greenwashing risks involved. The research on eco-labels provides a critical understanding to eco-product portfolio formulation. Most importantly, the research warrants companies to consider the responsibility related to greenwashing when using eco-labels in eco-products marketing and the requirements for evidence of their eco-product claims.

In summary of chapter 2, the theory presented examined product stewardship through integrating sustainability into product portfolios. The introduced concepts form a base for understanding the formulation of sub-portfolio of product. Firstly, the company processes central to product stewardship – product innovation and product portfolio management (PPM) – were explored. Building on these foundations, product portfolio formulation encompassing product evaluation and selection was explored as a key mechanism for product stewardship. Next the chapter continued by developing the concept of an eco-product portfolio to define an under researched approach to product stewardship and sustainability integration into product portfolios. Insights from eco-label research demonstrated that the purpose of eco-product portfolios varies. Importantly, for eco-product portfolios to function as instruments of product stewardship, they must actively guide innovation processes and PPM rather than serve solely as marketing objectives.

This thesis continues building on these theoretical foundations by exploring how companies in practice formulate eco-product portfolios, particularly regarding the evaluation criteria and selection methods applied and the role of regulation and verification in guiding these choices. To gather this information, this thesis as an applied research project employed a qualitative multi-method approach. Chapter 3 continues by presenting the research methodology. Chapters 4 and 5 subsequently report the empirical findings of the research. Building on these results, Chapter 6 discusses how the findings contribute new insights that address the identified gap in prior research on product stewardship, particularly with respect to the formulation of sustainability-oriented sub-portfolios of products.

3 Research methods

3.1 Research approach

This thesis adopts a qualitative research approach, as the aim is to explore and understand how B2B manufacturing companies formulate eco-product portfolios – a topic that is both under-researched and context-dependent. Qualitative research is well-suited for examining complex, real-world phenomena where the goal is to gain in-depth insights rather than to test hypotheses or quantify relationships (Patton 2015). The information interest in qualitive research is to provide information that helps to understand the phenomenon. Given the novelty of the topic and the lack of established frameworks in both academic literature and practice, a qualitative approach allows for a more flexible and exploratory investigation of the topic.

To enhance the credibility and depth of the research, this thesis applies methodological *triangulation* defined by Denzin (1978, 291) as "the combination of methodologies in the study of the same phenomenon.”. This thesis uses triangulation by combining two qualitative data collection methods: benchmarking through a document review and expert interviews. This triangulation strengthens the research by enabling the comparison of multiple perspectives and data types. The research method is therefore a multi-method qualitative research, combining two distinct but complementary empirical methods to address the research questions.

This thesis constitutes an applied research project and, as such, has been informed by a case company, although it does not adopt a case study design. Applied research is “an original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective” (OECD Frascati Manual 2015, 29). Applied research’s primary objective is therefore to generate practical knowledge that can directly be applied to practice. In comparison, basic research is “experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view” (OECD Frascati Manual 2015, 29). This thesis has a practical aim to provide information on eco-product portfolio that can be applied to practice. Application is done in this thesis by describing – based on the research results – recommendations to improve a case company’s eco-product portfolio. However, the eco-product portfolio of the case company is not the objective of empirical research in this thesis. Moreover, the eco-product portfolio of the case company is the objective to which the results of the empirical research are applied to.

Due to this thesis aiming to acquire new knowledge that can be applied – and is relevant – to practice, the case company has influenced the research method decisions. Case company's influence was given though insights from a company representative who works in a sustainability function and due to their position, is well-informed of both case company's business and eco-product portfolio formulation. The case company has influenced the choice of the topic for this thesis, the research questions and the scoping decisions of this thesis. The case company also influenced how these questions were decided to be explored i.e. the choice of research methods. Additionally, the case company influenced the data collection sample by giving input on which companies should be examined in the benchmark research, and which type of people should be chosen to be interviewed. The data collection was guided by the scoping decisions which were influenced by the case company. Therefore, data collection decisions were indirectly influenced by the case company.

After data collection, the case company had very little influence on the research. During result analysis, only the creation of evaluation categories of criteria found in benchmark research was influenced by the case company: Two out of six categories were highlighted as *key categories* partly because of their relevance to the case company. However, main reason for forming key categories was that they included critical criteria for product selection into an eco-product portfolio. The case company influence to key category formulation is described more in detail in data analysis section.

Regardless of the choice of the term "case company", this thesis is not a case study exploring a phenomenon in one or several cases (see for example Yin 2009) as the research objective is not the case company's eco-product portfolio. Only the ethnographic observations examined the case company's eco-product portfolio. However, ethnographic observations are not intended to provide insights for academic discussion, but rather insights for the researcher to apply the research results into practice. Due to effort to ensure anonymity of the case company, these ethnographic observations are not disclosed in this thesis. Therefore, this thesis is not a case study that aims to describe the case company's eco-product portfolio formulation. Rather this thesis is, firstly, multi-method research studying the formulation of eco-product portfolios more generally, and, secondly, an applied research project where the results are applied to practice. Unlike in a case study, where descriptive details are provided of how workplaces function and findings can rarely be generalized (Brown 2008, 9) the results of this thesis' qualitive multi-method research informs more generally academic and business actors.

Rather than aiming to produce universal truths, this thesis seeks to provide actionable insights that can be applied to a specific organizational context. Additionally, this thesis aims to contribute to the broader academic discussion on product stewardship by providing information on how one approach – formulating eco-product portfolios – is used in practice to support sustainable business transformation. Therefore, this thesis aims to provide both practical and scientific value.

3.2 Data collection

This thesis data collection consists of two methods. First method adopted consists of a benchmarking study, which involves a systematic review of publicly available documents and websites of 54 companies to, firstly, identify which companies have an eco-product portfolios as defined in this thesis, and to, secondly, describe current practices in eco-product portfolio formulation (RQ1). The second method adopted consists of nine semi-structured expert interviews with sustainability consultants and subject-matter experts. The interviews, firstly, explore regulatory and verification requirements (RQ2) and, secondly, gather insights into strategic considerations for eco-product portfolio formulation. The research is designed to answer the research questions through three distinct data sources: benchmarking, expert interviews, and ethnographic observations (Table 1). By addressing each data type separately, the chapter provides a transparent overview of how the empirical material was gathered.

Table 1: Data collected in this thesis

Data type	Description	Source type	Purpose in research
Benchmarking: Document review	Systematic review of sustainability reports, websites, and public documents from 54 benchmarked companies.	Secondary data	To benchmark current practices in eco-product portfolio formulation meaning the selection methods and evaluation criteria & indicators used (RQ1).
Interviews	Semi-structured interviews with 9 sustainability consultants and subject-matter experts.	Primary data	To explore regulatory and verification requirements (RQ2) and strategic considerations for eco-product portfolio formulation.
Ethnographic observations of the case company	Informal discussions combined to case company's internal & external material review.	Contextual data	To understand the case company's current eco-product portfolio and support practical application of results.

3.2.1 Benchmarking: Document review

The document review was conducted as benchmarking research to explore how companies in the B2B manufacturing industry formulate eco-product portfolios – in other word to explore what selection methods and evaluation criteria are used to select products into eco-product portfolios (RQ1). This method was selected because it enabled the researcher to examine current practices based on publicly available information, which was considered the most feasible and appropriate approach for this research. Given the competitive nature of the topic, it was anticipated that companies – especially competitors, customers, and industry leaders – would be reluctant to share detailed information through interviews. Therefore, reviewing sustainability reports, websites, and other public documents allowed for a comprehensive and non-intrusive way to gather relevant data.

The benchmarking was designed in collaboration with the case company, and the selection of companies to be benchmarked followed four inclusion criteria. Firstly, the top 21 customers of the case company were included. Secondly, the main competitors were identified by the researcher through the case company's internal materials, and the list was refined together with a case company representative. Thirdly, the researcher identified leading Finnish and European B2B manufacturers through online and AI searches using search words such as "Top 10 most sustainable manufacturing companies in Europe," and "Top 10 European manufacturing companies." This list was initially compiled also based on the researcher's prior knowledge of Finnish manufacturing companies and then reviewed and supplemented with input from the case company. Lastly, in the literature review conducted for this thesis, some companies were mentioned to have an approach to integrate sustainability into their product portfolios. These companies were also included in the benchmarking. The final benchmarking sample consisted of 54 companies: 7 from literature, 16 industrial leaders, 10 competitors, and 21 customers. Most of the 54 companies operate in business-to-business commerce while some exceptions is found in the literature-based benchmarks where companies operate in both B2B and B2C. Also, some industrial leader benchmarks operate in both B2B and B2C context.

Data collection was carried out in two phases. In the first phase, the sample of 54 companies was reviewed to identify companies that have an eco-product portfolio. This was done by reviewing company websites, the latest sustainability reports of 2024, and other public documents such as manuals for their product portfolio assessment tools. To streamline the process, the researcher used AI tools to identify relevant links to each company's sustainability-related content, including the most recent sustainability reports and pages related to product innovation, development, or portfolio

management. During the review, the companies that were identified to have formulated an eco-product portfolio – defined as a compilation of products in a lower level of the main product portfolio including products that are (1) distinctive for their environmental performance, (2) fulfill a set of predefined selection criteria, and (3) distinguished through a shared eco-label – were selected for a deeper analysis. The companies that did not fulfill the criteria were excluded from the deeper analysis. In total, 11 companies were identified as having an eco-product portfolio and were included to the second phase of data collection – the deep analysis.

Before the deep analysis of the 11 companies, the researcher and the case company jointly defined the key themes to be explored in companies identified to have an eco-product portfolio. The concepts used to guide the second phase of data collection were derived from theory. These concepts that were explored in the data sources included the selection method, selection criteria and the evaluation criteria used to formulate an eco-product portfolio. Notably, the theory described in this thesis in section 2 highlighted evaluation criteria from environmental point of view. However, in the benchmark data sources, the researcher looked at all evaluation criteria – expanding the point of view from mere environmental criteria to whatever was evaluated of products for selection into eco-product portfolio. Additionally, verification practices of portfolios were examined, but due to lack of publicly available credible information, the researcher decided to leave these results out from the analysis.

After defining these concepts, all relevant documents and webpages of the 11 companies were examined in detail using keyword searches such as “eco-product portfolio,” “eco-products,” or the specific portfolio name. The collected data on selection methods, selection criteria and evaluation criteria were compiled into an Excel file. Notably, some companies did not specify publicly exact evaluation criteria and indicators, but shared evaluation categories. In these cases, the evaluation categories without specific thresholds were included in the excel instead of clear evaluation criteria. A sustainability or an annual report from the year 2024 of each of the 11 companies were reviewed. Additionally, each company’s websites were explored. Also, the researcher reviewed additional documents found from 9 out of 11 companies directly related to the benchmark company’s eco-product portfolio. The data collection process took place over approximately one and a half months, with the majority of the benchmarking conducted in October 2025 and the remaining literature-based benchmarks reviewed in early November 2025. The final weeks of November were dedicated to analyzing the benchmarking results in parallel with conducting and analyzing the expert interviews.

3.2.2 Interviews

The second data collection method used in this thesis was a semi-structured theme interview, designed to gather expert insights on the evolving regulatory landscape and verification requirements relevant to eco-product portfolio formulation. This method was selected because the field of eco-product portfolio formulation is still emerging, and there is limited publicly available information – particularly regarding how regulation and verification practices are developing and how they may affect companies' sustainability-related product claims. Consultants working in sustainability, verification, and communication roles were identified as the most up-to-date and knowledgeable actors in this space, making interviews with them the most suitable method for capturing current developments, key trends, and expert interpretations.

The interviewee group was selected through multiple approaches. First, large international consultancy firms were identified, and professionals working in sustainability, sustainability verification, auditing, innovation, or sustainability communication teams were targeted. The researcher used LinkedIn to send 79 personalized InMail messages between 30 September and 16 October 2025. Of these, 12 were accepted. However, many recipients declined participation due to limited topic knowledge or time constraints, though some referred the researcher to more suitable colleagues. This initial outreach resulted in three interviews.

To expand the interviewee pool, the researcher also searched for smaller consultancy firms using keywords such as "product portfolio consultancy" and "eco-label consulting," and contacted potential participants via email and LinkedIn. Additionally, the researcher leveraged personal contacts as well as those of the case company. The researcher asked several case company employees for names and contact details of consultants who might be relevant to interview. This approach proved more effective, especially after a second round of follow-up messages, and led to the remaining interviews. In two cases, interviewees recommended colleagues within their own firms, resulting in two interviews from the same organization but with different expert profiles. This led to a final interviewee sample of nine interviews comprising of eight sustainability consultants and one head researcher from a governmental research institute.

Interview experts were from seven different organizations. Table 2 shows that while from five organizations one expert was interviewed, from two organizations (organization 2 marked in red and organization 4 marked in green) two people with differing expertise were interviewed. From both organizations one of the two interviewees were communication specialists who had expertise on eco-label use in marketing. Interviewees were anonymized and marked for identification with

letter IDs from A to I (Table 2). The interviewees varied in age, gender, and years of experience in sustainability-related roles. The experience ranged from a few years to over a decade. Many of the interviewees work across multiple sectors and all have experience working with B2B manufacturing companies. This information was derived in the beginning of each interview, when participants described their current role, direct work with verification, years of experience in sustainability, and the typical industries they work with. This information of interviewees is summarized in Appendix 2 which expands Table 2 with additional information.

Table 2: Information on interviews and interviewees

ID	Organization	Date	Length	Organization type	Position
A	1	20.10.2025	45 min	Consulting	Assistant Manager, Sustainability Advisory
B	2	21.10.2025 22.10.2025	~60 min ~30 min	Consulting	Sustainability Consultant
C	3	22.10.2025	~50 min	Research Institute	Group manager, Leading Researcher
D	4	23.10.2025	~45 min	Consulting	Director, Sustainability Consulting and Communications
E	5	23.10.2025	~55 min	Consulting	Director, Sustainability Consulting in metal & mining
F	6	29.10.2025	~60 min	Consulting	Manager, Sustainability Services
G	2	6.11.2025	~60 min	Consulting	Head of Communications / Senior Consultant: Sustainability Consultancy
H	7	7.11.2025	~60 min	Consulting	Sustainability Auditor (KRT), KHT, Senior Manager
I	4	14.11.2025	~35 min	Consulting	Senior Sustainability Advisor

The interviews were conducted between 20 October and 14 November 2025. Most were scheduled for one hour while two interviews (D and I) were scheduled shorter due to the participants' limited availability. Interview duration ranged from 35 to 60 minutes. Seven of the interviews were held in Finnish and two, A and E, in English. The interviews followed a semi-structured format, guided by a pre-prepared question set (Appendix 1) that was shared with participants in advance, along with *an information deck* of the thesis. The interview questions were structured into four sections reflecting the thesis's focus: (1) the European Union regulatory framework and reporting requirements for product sustainability claims; (2) the processes and criteria for verifying product

sustainability claims; (3) the relationship between regulatory requirements and verification practices; and (4) strategic considerations for companies formulating eco-product portfolios. The pre-prepared questions in these sections were formed together with the case company representative to mirror the knowledge gap in practice on the regulation and verification practices. In addition, a summarizing question was added in the end to the interviews to capture expert insights on the strategic considerations for eco-product portfolio formulation.

The information deck sent to interviewees included definitions of key concepts such as "eco-product portfolio" and "self-declared eco-labels," an overview of the research, the interview themes, and options for the level of analysis based on expertise. Each interview began with a review of the information deck, especially if the participant had not read it beforehand. Data privacy and consent were addressed at the start of each session, with participants given the option to review the full data privacy and management information verbally or via chat. Full privacy notice (Appendix 4) on personal data collection was sent to interviewees upon first contact. Key data protection and management information – such as voluntary participation and the right to withdraw at any time – were explained verbally in all interviews, and the rest if requested, sent via chat to the participants in the start of the interview.

The interviews were conducted in a conversational and flexible manner. While the thematic structure guided the discussion, the order of questions varied, and not all questions were asked in every interview. The conversation was allowed to flow naturally, with emphasis placed on topics where the interviewee had the most expertise or interest. Each interview concluded with a reflective discussion, where participants were asked to share their key considerations and advice for companies beginning to formulate eco-product portfolios. After each interview, the researcher wrote down the characteristics of the interview, such as interruptions or atmosphere of the interview. Based on these notes, the interviews can be characterized by a generally open and engaged atmosphere. Notably, interview B required two sessions: the first recording failed, so the researcher reconstructed the discussion from memory. A second interview was conducted the following day, during which the same themes were revisited and expanded upon. The quotes used in Chapter 4 from Interviewee B are drawn from this second, recorded session.

In total, nine interviews were conducted, generating a rich dataset of expert perspectives. In the last interviews, the same conclusions came up which led to conclusion that no further interviews are needed. The interviews were next transcribed and analyzed thematically, with particular attention to the characteristics of regulation, verification and strategic considerations for eco-product portfolios.

3.2.3 Ethnographic observations

The third data source in this thesis consists of firstly, internal observations of the case company's eco-product portfolio and, secondly, of informal discussions with the representatives of the case company. While this material was not collected for the systematic analysis, it played a central role in fulfilling the applied research objective of the thesis – namely, to provide practical implications for the development of the case company's eco-product portfolio. This part of the research can be described as ethnographic in nature, as it involved observing the organization's practices and engaging in informal dialogue over an extended period. The researcher followed the development and use of the case company's eco-product portfolio throughout the thesis process, which enabled a deeper understanding of how the portfolio is formulated and managed in practice.

The data was collected by reviewing all available internal materials, SharePoint pages, and external webpages related to the company's eco-product portfolio. In addition, three informal discussions were held with members of the case company's sustainability team who had been involved in the portfolio's development from the beginning. These discussions clarified aspects of the eco-product portfolio that were not fully documented, such as the historical background, selection methods, evaluation criteria, and the internal process for including products in the portfolio. The meetings were recorded. The observations took place from September to December 2025. This long-term involvement and access to internal materials allowed the researcher to observe the organization's sustainability work in its natural context, which is a defining feature of ethnographic research.

A Word document was compiled to consolidate all internal findings, which was later used to apply the results of the benchmarking and the interview data to the case company's context. While the detailed findings of the ethnographic observations cannot be disclosed in this thesis due to preserving the case company's anonymity, high-level implications are presented in Chapter 6. More detailed implications were shared directly with the case company.

3.3 Data analysis

The analysis of the empirical data in this research was conducted through a structured process that combined typification and thematic analysis, applied consistently across the analysis of both benchmark and interview data. According to Eskola and Suoranta (2000, 181–185) typification refers to grouping data into types that represent certain patterns or models, allowing for the identification of similarities, exceptions, and distinctive features within the material. In this thesis,

typification was used to organize the benchmark data into two primary analytical types (see 3.3.1), and the interview data into three primary analytical types (see 3.3.2.). Within each type, themes were identified to further interpret the content and structure the findings. The benchmark data analysis followed abductive logic and was characterized as theory-guided analysis. In contrast, the interview data analysis was entirely data-driven, allowing themes to emerge inductively from the material. This dual approach enabled a systematic and meaningful interpretation of the data, aligning with the research's aim to explore both current practices and requirements in eco-product portfolio formulation.

3.3.1 Analysis of benchmark data

The analysis of the benchmark data followed an abductive approach, combining both theory-driven and data-driven elements. The analysis was theory-guided analysis where theoretical concepts informed the identification and interpretation of types and themes, but the analysis was not bound by theory (Tuomi & Sarajärvi 2009, 96–97, 100). Moreover, theory served as a tool to support the construction of interpretations from empirical material. Concepts related to product portfolio formulation – such as selection method, selection criteria, evaluation criteria, and evaluation categories – served as the analytical lens through which the data was interpreted.

The benchmark data consisted of descriptions of how each company selected products into their eco-product portfolio. The analysis began by organizing the data two typification categories: evaluation criteria and selection methods. The researcher created summary slides of each company's evaluation criteria and selection methods as found in public documents and websites. If something was left unclear, the researcher went back to the data sources and collected the missing information that allowed a comprehensive understanding of the selection methods and evaluation criteria.

The first phase of analysis focused on the first type of benchmark data. This meant focusing on identifying themes and categories of the evaluation criteria used by benchmarked companies. The researcher used theoretical concept of evaluation category – that is the thematic focus of specific group of evaluation criteria – as a starting point. The process of forming evaluation categories was iterative: the researcher grouped together similar criteria found in benchmarked companies based on their shared purpose or environmental focus. This was done by asking questions from the data such as what is common for the criteria for example whether the criteria aimed to mitigate climate change, improve transparency, or ensure regulatory compliance.

Also, the researcher asked of the benchmark data that do these commonalities relate to specific categories that were identified in the theory. Therefore, some of the created categories, such as *GHG emissions* and *Circular Economy*, were derived from theory to capture the thematic focus of found evaluation criteria. Other categories, like *Lifecycle phase integration*, emerged only inductively from the data. Additionally, some companies had formed own categories of evaluation criteria. During the analysis, the researcher consolidated the companies' lower-level, self-defined categories into broader categories. For example, some companies listed CO_2 emissions and energy efficiency as own categories for evaluation. These categories were grouped in the analysis under a single *GHG emissions and Energy* category due to the shared relevance to climate impact and decarbonization.

The analysis of evaluation criteria ended when all the criteria were included into the created categories. In total, eleven evaluation categories were created as a result of the analysis. The final set of eleven evaluation categories were then analyzed to classify them as *key* or *other categories.* The analysis of categories for classification looked firstly if the category includes key defining criteria for product selection into an eco-product portfolio. If this was true, one of the following criteria needed to be true for being classified as key category: Either the category is frequently used among benchmarked companies or the category is of relevance to the case company. The frequency analysis was done by forming an Excel where the evaluation criteria were divided under each evaluation category to see the popularity of each category. The analysis of the relevance to the case company based on the ethnographic observations of the case company made by the researcher.

Based on the analysis, six categories were identified as *key categories* and five as *other categories*. All key categories fulfilled the first characteristic – inclusion of key defining criteria for product selection. Four out of six categories were the most frequently used among benchmarked companies, and the rest two categories were identified relevant to the case company regardless of being less frequently used than rest of the key categories. A further distinction was made between environmental evaluation categories – those categories including criteria that directly relate to the environmental performance of products – and other types of categories.

It should be noted that two of the *other evaluation categories* relate to social and economic sustainability. Hence, the product portfolios that use the criteria in these categories are distinctive not only in environmental performance, but in all three pillars of sustainability. These sub-portfolios could therefore be described as *sustainability product portfolios*, rather than only *eco-product portfolios*, as their sub-portfolio criteria relate to sustainability holistically. However, these

sustainability product portfolios were included in this thesis' benchmarking research because the portfolios meet the definition of eco-product portfolios (see Section 2.5.) even though they go beyond the definition. Notably, the evaluation criteria related to social and economic sustainability were found employed mainly in literature-based companies that operate in the chemical industry.

Although the focus of this thesis is on evaluation criteria for environmentally distinctive product portfolios, the social and economic criteria used are briefly described in Section 4.2.7. The reason to elaborate on the found social and economic criteria is twofold. Firstly, the thesis aims to describe the evaluation criteria of benchmarked sub-portfolios of products factually without leaving any evaluation criteria out from the results. It would be a misleading representation of the chemical industry's sub-portfolios if only the environmental evaluation criteria were presented. Secondly, the descriptions of social and economic categories of evaluation criteria demonstrate how eco-product portfolios can be formulated with a comprehensive view of sustainability. This comprehensive integration of sustainability into business practices is argued to be the main requirement for transformation toward truly sustainable business and so, sustainable societies (see Gramberg et al. 2024, Dyllick & Muff 2016). To include descriptions of the economic and social evaluation criteria therefore provides critical information for companies aiming to transform their operations toward truly sustainable business. In this way, the inclusion brings this thesis into the wider scientific discussion of enabling transformation toward truly sustainable business.

Once the evaluation categories were established, the second phase of analysis focused on the second type of benchmark data – understanding the selection methods used by companies. This involved examining themes of how evaluation criteria were applied in practice: whether they were used directly as selection criteria or whether companies employed tools or frameworks to structure the selection process. Initially, the use of tools was interpreted as a single selection method. However, a deeper analysis revealed that companies used tools in different ways – some relied entirely on tools to define selection criteria, while others used tools to inform only part of the selection criteria, supplementing them with additional evaluation criteria not related to the tool used. This realization led to a more nuanced categorization of selection methods, reflecting the diversity of approaches observed in the data.

The analysis process of benchmark data can therefore be described both iterative and abductive, grounded in theory but responsive to the data. The analysis aimed at identifying patterns and practices that could inform the formulation of eco-product portfolios in B2B manufacturing

contexts. In the results chapter 4, selection methods and evaluation criteria are described of the benchmarked companies.

3.3.2 Analysis of interview data

The interview data was analyzed using a data-driven, inductive approach, where the goal was to understand how experts describe the current and emerging landscape of regulation, verification, and strategic considerations related to eco-product portfolios. The analysis followed the factual perspective of interviews, focusing on what the interviewees said about the subject matter itself (Koskinen, Alasuutari & Peltonen 2005, 71–73). The analysis was entirely data-driven, with no theoretical framework imposed on the material (Glaser & Strauss 2017). Instead, the researcher aimed to identify and interpret the themes that emerged from the interviews, allowing the experts' perspectives to guide the understanding of the topic. This data-driven approach was chosen due to the novelty and evolving nature of the subject matter of eco-product portfolio formulation. The limited prior research and rapidly developing practices made it essential to let the themes emerge directly from the empirical material rather than impose predefined theoretical frameworks (Glaser & Strauss 1967, 95 – 97).

The interviews were primarily conducted in Finnish, except for interviews A and E, which were held in English. All interviews were recorded and transcribed with the use of case company's protected AI. Quotes from the Finnish transcripts were translated into English when writing up the results section. The data was first organized guided by the research questions into three typification categories: regulation characteristics, verification characteristics, and strategic considerations. These types served as the highest-level analytical structure.

Within each type, themes were identified iteratively. The analysis began with a close reading of the transcripts, during which the researcher identified recurring themes and patterns in the responses of each type. The researcher asked questions of the data such as: What are the recurring concerns or insights across interviews? How do different experts describe similar phenomena? What distinctions or contradictions emerge between interviewees? These questions helped guide the thematic coding and ensure that the categories and themes reflected the actual content of the data rather than preconceived theoretical assumptions. This approach followed Gioia method where the approach is to have a structured approach to inductive qualitative analysis that moves from informant-centered data to researcher-developed theoretical concepts (Gioia, Corley & Aimee 2012). The method in practice started as researcher concluded based on the questions the most frequently mentioned and conceptually significant themes from the interviews. These themes were

then grouped into higher-level thematic categories. For example, within the regulation characteristics type, eventually analysis let to identifying two main themes: general trends and key regulations. These were further broken down into sub-themes such as “uncertainty” under general trends and “reporting regulations” under key regulations. This step-by-step process of identifying, grouping, and refining themes was repeated for each of the three typification categories.

The categorization was based on the content and context of the interviewees’ responses. The relevance and coherence of the themes were ensured by comparing them across interviews and checking for consistency in how they were discussed. To further validate the themes, the researcher revisited the transcripts multiple times to confirm that the themes accurately captured the nuances of the data. The results of the interview analysis are presented in Chapter 4 using the typification structure – regulation, verification, and strategic considerations – and elaborating of the main themes and their sub-themes of each type. This structure allows for a clear and organized presentation of the findings and reflects the data-driven way of analysis.

3.4 Trustworthiness and research ethics

3.4.1 Trustworthiness

The credibility of this thesis was evaluated using Lincoln and Guba’s (1985) four criteria for trustworthiness: credibility, transferability, dependability, and confirmability. These dimensions are relevant in qualitative research, where the researcher plays an active role in interpreting the data. The first criterion, credibility, refers to the confidence in the truth of the findings and degree of investigators voice to different constructions of reality. In this thesis, credibility was strengthened through the use of multiple data sources – benchmarking and expert interviews – which allowed for triangulation of perspectives. The interview data was collected from nine experts across seven organizations, ensuring a diverse range of views. All interviews were transcribed carefully, and the analysis was conducted systematically using typification and thematic coding.

The benchmark data was also collected from a wide range of companies (54), and the sample of 11 companies that had eco-product portfolio also creates confidence that most significant formulation practices were able to be derived. The researcher maintained a neutral stance throughout the data collection process, using a hypothesis-free approach to avoid steering the discussion in any direction. However, the researcher had a role especially in analyzing the interview results when forming categories and themes of the results. The categorization was not peer reviewed against the data which slightly decreases credibility.

The second criterion, transferability, concerns the extent to which the findings can be applied to other contexts. While the thesis is focused on a specific industrial context, transferability was supported by providing detailed descriptions of the research setting, data sources, and analytical procedures. The benchmark data includes companies from various sectors within B2B manufacturing, offering a broader view of current practices. As the thesis is limited to B2B manufacturing industry, transferability decreases especially if results are applied in B2C business. For instance, regulations and verification were discussed in the context of B2B manufacturing and heavy equipment which limits the transferability into other industries as regulation might differ.

Dependability, the third criterion, refers to the consistency and reliability of the research process. This was ensured through a transparent and well-documented research design. The data collection and analysis procedures were described in detail, and the analysis followed a logical, step-by-step process. For the interviews, the researcher used a consistent semi-structured interview structure, while allowing flexibility for the conversation to flow naturally. This can decrease dependability, as interviewee responses might have varied due to having different questions in the interview. The results of a qualitive interview research are always the creation of interaction between the two people present in the interview, and so, it can't be replicated which decreases dependability.

The benchmark data was analyzed using a structured process which helped maintain consistency across cases. The iterative nature of the analysis – particularly in the development of evaluation categories and selection methods – was documented to ensure traceability of analytical decisions. The results from benchmarking research have high dependability compared to interviews, as the results should be objective and fact-based, and researcher interpretation did not have significant impact on the results. However, the researcher had a role in interpreting the evaluation criteria into evaluation categories which could be done in multiple ways depending on what was seen significant for the case company and in comparison, to theoretical background.

The final criterion, confirmability, addresses the extent to which the findings are shaped by the participants and data rather than researcher bias. Confirmability was supported by grounding the findings in direct quotations from interviewees and in publicly available documents. The use of established theoretical concepts in the benchmark analysis further enhanced objectivity. The researcher's role as a thesis worker who had the chance to observe the case company was acknowledged, but efforts were made to minimize subjectivity by maintaining a reflective stance and separating personal interpretations from empirical observations.

3.4.2 Research ethics and researcher's role

In terms of research ethics, all participants were informed about the purpose of the thesis, the voluntary nature of their participation, and the confidentiality of their responses. Interview invitations were sent via LinkedIn or email and included an information deck outlining the thesis' objectives and key concepts. Additionally, a privacy notice was sent about the data handling practices. Before each interview, participants were asked for consent to record the session, and the data privacy terms were reviewed either verbally or via chat. No identifying information about the interviewees or their organizations is disclosed in the thesis, and the case company remains anonymous. The collected data is stored securely and will be deleted after the completion of the thesis process in accordance with ethical research guidelines. These measures ensured that the thesis adhered to high ethical standards and respected the rights and privacy of all participants.

The researcher's embedded role within the case company enabled access to internal materials and informal discussions that enriched the contextual understanding of the case company's eco-product portfolio and enabled applying the research results to practice. However, this position also introduces ethical considerations. While internal observations were based on available internal and external documents and three informal discussions with sustainability team members, access to certain materials – such as documents restricted to leadership or other functions – was limited. Moreover, the absence of engagement with R&D and marketing functions may have constrained the breadth of insights, particularly regarding product development and communication perspectives. These limitations affect the credibility and transferability of the applied findings, as the internal view may not fully capture the cross-functional dynamics of portfolio formulation. Nevertheless, the researcher maintained a reflective and neutral stance, and the applied insights were used only to contextualize the broader research findings, not to draw independent conclusions. This transparency and critical self-awareness support the confirmability and dependability of the applied research component.

4 Evaluation criteria and selection methods

This thesis employed a document review approach to examine 54 companies to create an understanding of the current practices in eco-product portfolio formulation – i.e. in setting evaluation criteria and selection methods to eco-product portfolios. In this chapter, insights are provided to the research question RQ1 via presenting the results of the document review (Figure 12). First, section 4.1. gives an overview of the sample of 54 companies whose documents were reviewed. This section elaborates which companies had an eco-product portfolio and what other approaches to product stewardship were identified in the sample. Secondly, section 4.2. presents the evaluation criteria used by benchmarked companies to evaluate products for selection into an eco-product portfolio. The evaluation criteria are organized into categories which are elaborated upon in sub-sections 4.2.1. – 4.2.7. Lastly, section 4.3. looks at selection methods employed by companies. Selection methods elaborate how evaluation criteria identified in section 4.2. were used to select products into an eco-product portfolio.

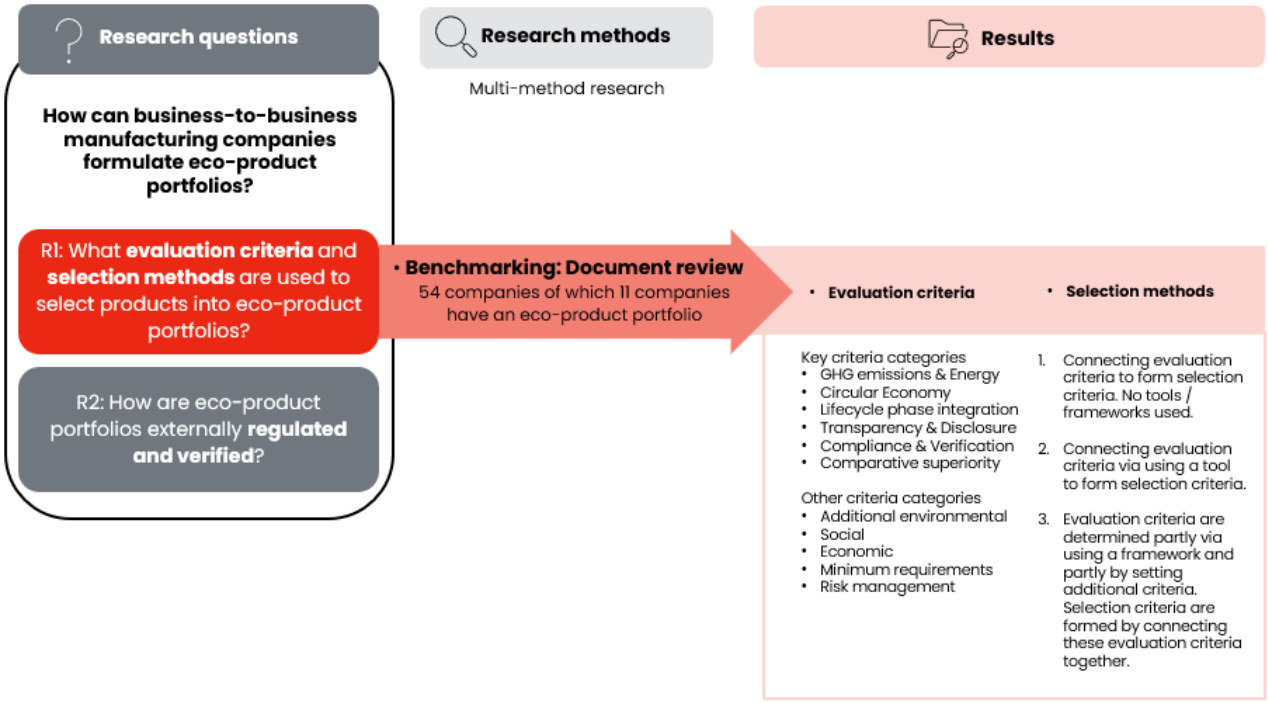


Figure 12: Benchmarking results

4.1 Overview of the sample

This section offers an overview of the sample studied. The benchmarking sample comprises 54 companies categorized into four groups based on source for selecting benchmarks into the research: literature-based benchmarks (7 companies), industrial manufacturing leaders (16 companies),

competitors (10 companies), and customers (21 companies). Yet not all benchmarked companies had eco-product portfolios. Within this sample, only 11 companies listed in Table 3 have established an eco-product portfolio that meets the definition requirements outlined in section 2.5. in this thesis. Specifically, five of the seven literature-based benchmarks, five of the sixteen industrial manufacturing leaders and one customer have formulated such portfolios. In contrast, none of the competitors were found to have an eco-product portfolio.

Table 3: Identified eco-product portfolios

Benchmark group	Company	Eco-product portfolio name (Eco-label)
Literature-based	LANXESS	Scopeblue®
Literature-based	Clariant	Ecotain®
Literature-based	BASF	Sustainable-Future Solutions
Literature-based	Solvay	Sustainable Solutions
Literature-based	Heidelberg Material	EvoBuild®
Industrial leaders	ABB	EcoSolutions™
Industrial leaders	Siemens	EcoTech
Industrial leaders	Hiab	Eco Portfolio: Climate Solutions and Circular Solutions
Industrial leaders	Kalmar	Eco Portfolio: Climate Solutions and Circular Solutions
Industrial leaders	ArcelorMittal	XCarb® recycled and renewably produced
Customers	Customer X	Eco-product portfolio

After identifying the eleven companies that formulate eco-product portfolios, the researcher identified other approaches to product stewardship used by companies in the sample. These alternative approaches to integrate sustainability into product portfolios or product development processes are elaborated in Table 4. Notably, Table 4 does not present an exhaustive set of approaches for integrating sustainability into the product portfolio. This is due to, firstly, that the researcher identified and summarized only approaches that were related to eco-product portfolio formulation. These approaches include forming for example product categories that do not meet the criteria defined in section 2.5. for eco-product portfolios and therefore were left out from the deeper

analysis. Secondly, some companies in the sample of 54 did not have publicly available information regarding the integration of sustainability into product development or portfolio management. These companies may either have such practices without disclosure or have not incorporated sustainability into their product development processes. Due to these two reasons, the approaches identified in Table 4 do not represent an exhaustive, rather an exemplary, set of approaches to product stewardship in the sample.

Table 4: Identified product stewardship approaches

Product stewardship approach	Characteristics	Example cases
Eco-product portfolio	• Compilation of products on lower level of the main product portfolio that are *1) distinctive for their environmental performance* *2) fulfill a set of predefined selection criteria* *3) distinguished through a shared eco-label*	ABB, Siemens, Heidelberg Material
Offering categorization or **branding** No selection criteria or shared eco-label disclosed	• Categorizing or branding offering on company's website; no selection criteria or usage of a shared eco-label disclosed • Categorization=Grouping products under a general sustainability characteristic (e.g., "low-carbon") without strict numeric criteria. • Branding=Assigning a specific label to individual products (e.g., *"Green Hydrogen"*).	Wärtsilä – *Decarbonisation Solutions* category Neste – *Renewable and circular products* branding e.g. *Neste MY Renewable Diesel*™
Offering classification Based on a model / method	• Classification all offering based on a model / method that assess sustainability of products (e.g. sustainability assessment methods, portfolio management models) • The best performing class might be an eco-product portfolio • Method/model guides classification by defining selection criteria into classes • Methods/models may be used to guide innovation process	Clariant, BASF, Solvay
Eco-design model used in innovation process No sub-portfolios mentioned	• Setting up a multi-criteria eco-design approach • No publicly disclosed sub-portfolios of products as an outcome of their eco-design model. • Often lifecycle and circularity approaches utilized • May include outcome-based targets for company's entire product portfolio	UPM – *Sustainable Product Design* eco-design model
Sustainability targets set to innovation process No sub-portfolios mentioned	• R&D (often qualitive) targets include sustainability • No publicly disclosed eco-design model, nor creation of sub-portfolios of products	Wärtsilä, Neste
Transparency efforts	• Increasing transparency of products' sustainability dimensions in communication • E.g. Information schemes to provide visibility to some sustainability dimension • E.g. Providing EPDs	Clariant (Separate brochure of PPM model) KONE (EPDs)

Additionally, the identified approaches to product stewardship are not mutually exclusive. Firms may adopt multiple strategies in combination. Table 4 therefore is intended to illustrate that benchmarked companies employ diverse strategies to embed sustainability into their product portfolios, and that formulation of eco-product portfolio represents only one approach. Next sections describe how the eleven identified companies have formulated their portfolios.

4.2 Evaluation criteria

To formulate an eco-product portfolio, i.e. to evaluate and select products into a portfolio, companies define evaluation criteria. The benchmark analysis revealed that companies use a range of evaluation criteria to select products into an eco-product portfolio. The identified evaluation criteria are grouped together into evaluation categories which describe the thematic focus of a specific group of evaluation criteria. Some companies were identified to have also formed groups of their evaluation criteria. The analysis of the evaluation criteria and companies' own groupings show 11 categories of evaluation criteria (Figure 13) used by the benchmarked companies.

The identified evaluation categories are divided into six *key categories* and five *other categories*. From six key categories two are environmental categories, defined as the environmental dimensions of a product that a company sees meaningful to evaluate. These two environmental categories (identified with green color in Figure 13) are 1) *GHG emissions & Energy* and 2) *Circular Economy*. Other key evaluation categories are 3) *Lifecycle phase integration*, 4) *Transparency and disclosures*, 5) *Compliance and verification* and 6) *Comparative superiority*. Other categories are *Additional environmental, Social, Economic, Minimum requirement* and *Risk management.*

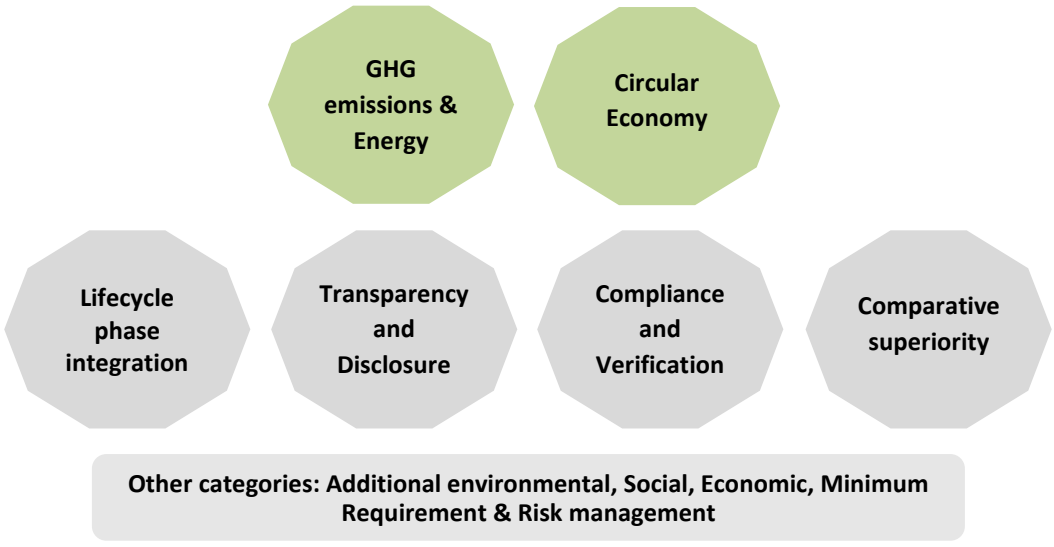


Figure 13: Categories of identified evaluation criteria

The division to key and other categories base on the centrality of the category to the selection of products into an eco-product portfolio. In more detail, the first way of defining a key category is that the criteria in that category are most frequently used among benchmarks (GHG emissions & Energy, Circular Economy, Compliance & Verification and Comparative superiority). The second way is that if the criteria in the category are not frequently used among benchmarks, the criteria still play a key role defining selection of products into an eco-product portfolio in companies closest in their operations to case company (Lifecycle phase integration and Transparency & Disclosure). In comparison to key categories, the criteria in other categories are not the defining selection criteria in any of the companies closest in their operations to the case company. Other categories were employed almost entirely only by literature-based benchmarks – these companies' operations are not close to the case company.

In conclusion, the division into six key and five other categories base on centrality of the category to the selection of products into eco-product portfolio – either the categories are central for selection to most benchmarked companies or they are central to the benchmarks significant to case company. Figure 14 shows the popularity of each evaluation category among benchmarked companies that had an eco-product portfolio. The numbers in the figure's pie indicate the number of companies that have employed evaluation criteria in that category. The most popular categories among benchmarks were the GHG emissions & Energy and the Circular Economy categories – all eleven companies set evaluation criteria related to these thematic topics. The next popular categories were the Compliance & Verification, and the Comparative superiority categories – seven of the eleven companies set criteria related to these thematic topics.

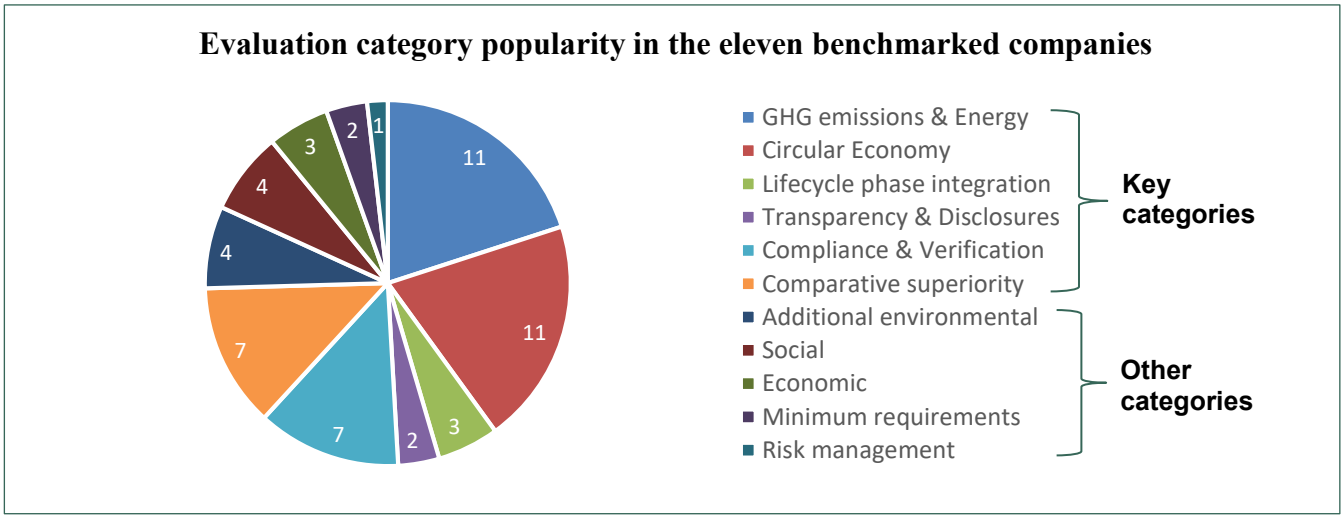


Figure 14: Evaluation category popularity in benchmarked companies

This section next moves to the detailed elaboration of each evaluation category. In the following sub-sections, direct examples derived from the benchmarked documents demonstrate the evaluation criteria of each category. Table 5 summarizes definitions of the evaluation criteria categories and provides examples of the evaluation indicators and criteria identified to be used in each category by the eleven benchmarks. However, it should be noted that the evaluation criteria in Table 5 are edited examples from the benchmark data as the specific numeric threshold values are left out and minor wording edits were made. This was done for simplification of the results into the table. The directly derived versions of the evaluation criteria are presented in the sub-sections in the following format:

> **Company name**: Evaluation criteria derived directly from the benchmarked documents [the researcher's elaborations or explanatory text].

Table 5: Identified evaluation categories, indicators and criteria

Evaluation category	Category definition	Evaluation indicators used by benchmarks	Evaluation criteria used by benchmarks
GHG emissions & Energy	Criteria that focus on climate impact of products through GHG emission reduction and energy efficiency targets.	• Total PCF lower than a benchmark • Lower CO2 emissions in production • Use- or production-phase energy efficiency • Use of renewable energy in production • Enablement the use of electric equipment	• % reduction in CO_2 per unit (e.g. kg CO2/kg product) vs. conventional product or industry standard • % renewable electricity used in manufacturing • Energy consumption per use or production phase • Part enables the use of electric equipment (e.g. chargers)
Circular Economy	Criteria that focus on circularity and efficient use of materials to reduce waste and extend lifecycle products contributing to circular economy.	• Recycled/reduced raw materials • Product life extension: Via product design or Services • Design for recyclability • End-of-life considerations • Waste reduction and management	• % recycled or biobased materials • % reduced use of raw materials • Sustainable packaging materials • Upgradability, repairability, possibility to maintenance, durability • Recyclability rate • Ease of disassembling • Have end-of-life instructions • Take-back scheme available • Biodegradability (chemical products) • % waste to landfill
Lifecycle phase integration	Requiring sustainability criteria to be met across multiple product *life-cycle stages*.	• Criteria across lifecycle phase	• Number of criteria fulfilled per life-cycle phase (e.g. 1 criterion fulfilled in each phase) • Number of lifecycle phases where minimum number criteria need to be fulfilled (e.g. in minimum 2 phases 1 criterion fulfilled)

Transparency and Disclosures	Criteria that require disclosing information on product's environmental performance.	• Product environmental information disclosure required • Product profile required	• Availability of EPD per product • Publicly available product data sheets that show how criteria for portfolio is met / product's environmental performance • Availability of a transparent validation statement
Compliance and Verification	Criteria that require verification, or compliance to external stakeholder requirements.	• Third-party verification required • Compliance with relevant regulation • Compliance with internal policies • Compliance with international standards	• Verified LCA / PCF / EPD required • Regular assurance for portfolio classification required • Number of SDGs product contributes to • Pass/fail compliance with DNSH / REACH / Substance of concern regulation • Alignment requirement to EU Taxonomy substantial contribution to circular economy • Pass/fail compliance with Code of conduct • Pass/fail compliance with ISO14040/44, ISO14025, or ISO 14067 standard
Comparative superiority	Criteria that set performance requirement against a comparison.	• Outperforming a previous generation, market alternative or existing norm/standard	• Improvement in chosen metric compared to last model • Outperform industry standard
Other categories: Additional environmental, Social, Economic, Minimum requirement, Risk management	Criteria that is mentioned infrequently. These focus on additional environmental dimensions than mentioned above, social and economic dimensions, risk management or setting minimum requirements.	Many of the infrequently mentioned criteria did not have indicators publicly disclosed. • Environmental indicators relate to: Water protection, Biodiversity, Pollution reduction, Sustainable bioeconomy • Social dimension indicators relate to: Material origin, Health & safety, Social value creation • Economic dimension indicators relate to: Profitability or Reputational risk considerations • "Do no harm" minimum requirement set as indicator • Risk management requirement as an indicator	• Environmental: Land-use, Acidification, Water depletion indicators • Social: No conflict minerals used • Economic: Cost savings downstream, Eco-label type 1 eligibility (seen as reputational benefit) • Minimum requirement: Solution does not have any adverse effects in any of defined sustainability criteria throughout the value chain. • Risk management: max. 3 medium risks that can be controlled

4.2.1 GHG emissions & Energy

The *GHG emissions & Energy* key category covers criteria that focus on climate impact of products through, firstly, reducing greenhouse gas (GHG) emissions and, secondly, usage of energy. The document review revealed that all the 11 benchmarked companies set evaluation criteria for their products related to either reduction of GHG emissions or energy (Figure 14). The GHG emission-related evaluation criteria in this category aim predominantly to reduce the carbon emissions. For instance, the quotes below showcase criteria that require the eco-product portfolio products to

demonstrate a Product Carbon Footprint, PCF, (LANXESS) or GHG emissions (Hiab) below a certain benchmark value or threshold:

> **LANXESS:** [To be identified as Scopeblue®, product needs to meet at least one of following two criteria:] 1) They consist of at least 50% sustainable (recycled or biobased) raw materials and have 10% reduced carbon footprint [or] 2) The carbon footprint is at least 50% lower than for conventional products.
>
> **Hiab:** [Hiab's Eco Portfolio's *Climate Solutions* cover low-emission equipment that are defined as] providing substantial lifecycle GHG emission savings aligned with the 1.5C pathway meaning that products need to demonstrate -25% GHG savings compared to the 2022 conventional alternative.

The energy-related evaluation criteria in this category focus on topics such as improving energy efficiency associated with the product either in use- or production-phase, switching to renewable energy in production, ensuring product's renewable energy compatibility or electrifying machines For example, Siemen's has an evaluation criterion requiring each eco-product portfolio products to be manufactured in facilities using renewable energy:

> **Siemens:** [EcoTech products are] manufactured in production facilities using 100% renewable electricity.

Some benchmarks combine GHG emission and energy related requirements. For example, Customer X sets criteria for products to meet both PCF and energy targets:

> **Customer X:** Low-carbon products are produced using fossil-free electricity and have a CO_2 footprint significantly below global average.

Together, these GHG Emissions and Energy related criteria aim to ensure that products qualifying for eco-product portfolio contribute to climate change mitigation through reduced emissions and smarter energy use.

4.2.2 Circular Economy (CE)

The evaluation criteria in the *Circular Economy* category focus on circularity of products and on efficient use of materials – with an aim to reduce waste, to extend the lifecycle of products and to keep materials in use. The document review revealed that all the 11 benchmarked companies set evaluation criteria for their products related to Circular Economy (Figure 14). Criteria focus for

instance on requirements to use recycled or reduced amounts of virgin raw materials in product manufacturing (Heidelberg Material), design for recyclability (ABB), incorporation of features or services that extend the product's lifetime (Kalmar), and measures for waste reduction or strict landfill (ABB) avoidance, as the quotes below illustrate:

> **HeidelbegCement**: [EvoBuild® circular products are required to have] Reused materials 30% recycled content or Reduced materials 30% less material.
>
> **ABB**: [EcoSolutions™ are required to meet in each lifecycle phase one criterion such as] *Recyclability rate, Produced in a zero waste to landfill site, Sustainable materials used in the packaging,* [or] *End-of-life instructions.*
>
> **Kalmar***:* [Kalmar's Eco Portfolio's *Circular Solutions* category encompasses] solutions that contribute to the transition to a circular economy by promoting resource efficiency throughout the value chain. *Circular Solutions* include lifecycle services such as repair, refurbishment, and resale of used equipment to extend operational lifetime.

All these Circular Economy related criteria reflect an emphasis on closing the loop of product lifecycles – minimizing resource extraction and waste generation by making products more regenerative and long-lasting.

4.2.3 Lifecycle phase integration

The *Lifecycle phase integration* category emphasizes a holistic lifecycle approach, requiring sustainability considerations to be met across multiple phases of a product's lifecycle, from design and manufacturing to use and end-of-life. Out of the eleven benchmarked companies three set evaluation criteria that aims to ensure that every lifecycle phase is addressed (Figure 14). For example, companies might require that a certain number of sustainability criteria are fulfilled in each phase of the product's life (design, production, distribution, use, and disposal).

Companies differ in the ambition level of how many criteria need to be fulfilled. For example, Siemens and ABB require similar ambition level: Eco-product portfolio products need to meet minimum one criterion in each lifecycle phases. For Siemens this means three criteria as the *Robust Eco Design* framework separates the lifecycle to three phases, and for ABB's EcoSolutions™ this means four criteria as their *Circularity Approach* separates the lifecycle into four phases. In comparison, Clariant requires minimum one sustainability benefit not in all, but in two out of four lifecycle phases. These examples illustrate variety in ambition levels in lifecycle phase integration-

related evaluation criteria. Siemens and ABB have similar ambition – one criterion per each lifecycle phase – whereas Clariant has a lower ambition with a requirement of one criterion only in two lifecycle phases.

By mandating coverage of all lifecycle phases, the evaluation criteria in this category ensure that sustainability is not concentrated in only one part of the product's development but is integrated end-to-end. To avoid confusion, it should be noted that although both evaluation categories – the Circular Economy and the Lifecycle phase integration – promote circularity, they differ in the intent of what exactly is required of the product. On the one hand, Circular Economy criteria focus on product's environmental performance e.g. material flows and product design strategies. On the other hand, Lifecycle phase integration criteria address the procedural completeness of sustainability considerations across all phases of a product's lifecycle, without prescribing specific circularity performance criteria for the product. Therefore, Lifecycle phase integration-related evaluation criteria function to ensure that sustainability considerations are distributed across lifecycle phases – while CE related criteria ensure in each lifecycle phase circularity related environmental performance.

4.2.4 Transparency and Disclosures

The *Transparency and Disclosures* category includes criteria that set requirements for transparency about a product's environmental performance. Criteria under this category ensure that companies publicly disclose or document how the product meets sustainability targets. Out of the eleven benchmarked companies, seven have set evaluation criteria for their products' transparency and disclosure dimensions (Figure 14). For example, some companies require their eco-product portfolio products to have an Environmental Product Declaration (EPD) – a standardized document that reports the product's environmental impacts across its lifecycle:

> **Siemens:** [EcoTech products need to as mandatory requirement have] Environmental transparency guaranteed through EPDs Type II/III (Environmental Product Declarations), including LCIA (Life Cycle Impact Assessment).

Similarly, some companies – such as below quote from ABB illustrates – require products to provide, in addition to an EPD, a sustainability profile or report that specifies which criteria the product in question fulfilled to be selected into the eco-product portfolio:

> **ABB**: [EcoSolutions™ need to be accompanied with] Type III Environmental Product Declarations (EPDs) to show environmental impact transparently. Additionally,

> EcoSolutions™ have EcoSolution Profiles showing how product fulfills criteria for portfolio.

These transparency and disclosure related criteria serve to increase accountability, allowing external stakeholders (customers, regulators, or third-party auditors) to verify and trust the eco-product portfolio's sustainability claims.

4.2.5 Compliance and Verification

Evaluation criteria in the *Compliance and Verification* category encompasses adherence to external standards and verification processes. Out of the eleven benchmarked companies, seven have set as evaluation criteria for their products compliance and verification requirements (Figure 14). For instance, of verification-related criteria, some companies require a third-party verified Life Cycle Assessment for the eco-product portfolio products (Hiab and Kalmar) and some mandate regular assurance checks to confirm that product portfolio classifications remain accurate and credible over time (Clariant):

> **Hiab and Kalmar:** [Eco Portfolio's] climate solution equipment needs to have a lifecycle assessment (LCA) done and verified by a third party, supplemented with a DNSH assessment, for it to be considered taxonomy aligned.

> **Clariant:** The percentage of the product portfolio [classification into 4 categories of which the best category form an eco-product portfolio] assessed is reviewed annually by an independent third-party.

However, not all benchmarks had verification of product's performance as a criterion, but rather verification was required e.g. through CSRD report verification:

> **Siemens**: The approach and assessing methodology of Siemens EcoTech is externally validated by TüV Rheinland according to ISO standards 14020 & 14021.

In addition to verification related criteria, this category encompasses the compliance-related criteria that aim to ensure that eco-product portfolio's products comply with 1) relevant regulations, 2) company policies or 3) follow established standards. Next, examples are given of these three compliance-related criteria. Regulatory compliance criteria may require for instance products to meet EU Taxonomy Do No Significance Harm, DNSH, principle (Kalmar) or contribute to SDGs (LANXESS):

> **Kalmar:** [Eco Portfolio products are] aligned or expected to be aligned with the respective substantial contribution and DNSH criteria of EU Taxonomy & EU Taxonomy's minimum safeguards.
>
> **LANXESS:** Scopeblue® products must contribute to at least one Sustainable Development Goal (SDG).

Some companies have set criteria demanding adherence to internal policies like business code of conduct. For example, BASF has as a part of their minimum requirements for the eco-product portfolio products a criterion that product's need to adhere to BASF's Code of Conduct. In addition to regulatory and internal policy compliance, products might also be required to conform to international standards when calculating environmental impacts:

> **Kalmar**: GHG savings for zero-emission and transitional equipment are calculated in accordance with ISO 14067:2018.

By integrating compliance and verification requirements, the evaluation criteria in this category ensure that a product's sustainability meets external quality and credibility requirements.

4.2.6 Comparative superiority

Evaluation criteria in the *Comparative superiority* category require that a product's sustainability performance is better relative to a certain reference point – such as an earlier product version, a competitor, or an industry standard. Out of the eleven benchmarked companies, seven have set evaluation criteria related to comparative performance ambitions (Figure 14). Performance improvement requirements often relate to topics of the two environmental evaluation categories (the GHG emission & Energy and the Circular Economy) such as GHG emission reduction, energy efficiency or resource circularity improvement. Due to this factor, one evaluation criterion can be categorized in this thesis to be part of two different categories. For example, a benchmark may stipulate that the eco-product portfolio products must achieve a lower CO_2 emission per unit of output compared to global average (Customer X) or the previous generation of the product (Hiab):

> **Customer X**: Low-carbon products have a CO_2 footprint significantly below global average.
>
> **Hiab***:* [Climate Solution low-emission equipment needs to provide] -25% GHG savings compared to the 2022 conventional alternative.

As illustrated above, one evaluation criterion might set two kinds of requirements for the product – like comparative superiority and GHG emission target requirements. Therefore, an evaluation criterion can be categorized into more than one evaluation category. For instance, the customer X's evaluation criterion above is categorized in this thesis both to the GHG emissions and Energy category and to the Comparative superiority category.

In addition to global average (illustrated by Customer X above) and previous generation product (illustrated by Hiab above), comparison criteria can be made against the industry's standard performance on selected sustainability metrics (Siemens, Kalmar) or a third-party set standard (Heidelberg Material):

> **Siemens:** [Product needs to fulfill] minimum one criterion in each dimension of the Siemens EcoTech framework by proving its performance compared to existing norm, standard or predecessor product.
>
> **Kalmar:** [LCAs compare Kalmar's Eco product portfolio equipment to the] best-performing alternative, typically a diesel-powered version with the same functionality and capacity.
>
> **Heidelberg Material: [**EvoBuild® low-carbon cement products are required to have] 30% lower CO_2 emissions vs. the definition from the Global Cement and Concrete Association (GCCA) for CEM I from 2020.

Through comparative criteria, benchmarks ensure that products are not only meeting static targets but are also driving sustainability leadership by being demonstrably better than what came before or what else is available.

4.2.7 Other evaluation categories

In addition to the key categories described above, the benchmarking research also revealed a set of less frequently mentioned evaluation criteria. These other evaluation criteria were grouped – similarly to key criteria – into topical categories. Other categories identified in this thesis are *Additional environmental, Social* and *Economic, Minimum requirements* and *Risk management* categories. Four or less of the benchmarked companies set evaluation criteria in each of these categories (Figure 14). The categories are elaborated in this section in order of popularity among benchmarks. Mostly only the literature-based benchmarked companies (4 out of 5 literature-based benchmark companies) have employed evaluation criteria of these categories. The other categories highlight that some benchmarked companies have taken a broader view of sustainability when

forming an eco-product portfolio: These companies have employed evaluation criteria that aim to tackle a boarder set of issues – from biodiversity to social responsibility to economic viability – compared to companies who merely evaluate products in the key categories that do not consider social or economic sustainability.

Additional environmental

In addition to GHG emission, energy and circularity targets, the literature-based benchmarks incorporate environmental criteria in the *Additional environmental* category. These criteria address broader set of ecological concerns such as water protection, pollution reduction, and biodiversity. Out of the eleven benchmarked companies, four have set evaluation criteria related to additional environmental dimensions (Figure 14). For example, BASF's product portfolio sustainability assessment framework – that guides selection of products to eco-product portfolio – includes nine sustainability categories, of which three are directly tied to additional environmental concerns: pollution reduction, water protection and biodiversity.

One benchmark, Solvay, stands out with a comprehensive framework for product assessments that included a wide range of other environmental criteria beyond GHG emissions and circularity. Solvay's framework is divided into two assessment dimensions that form the final matrix to classify products and formulate eco-product portfolio: 1) *Operations Vulnerability* that measures product's environmental footprint based on LCA and 2*) Market Alignment* that uses a questionnaire and decision tree to measure how in their applications products bring benefits or face challenges from a market perspective. In both dimensions additional environmental dimensions is set as evaluation criteria. For instance, in *Operations Vulnerability* dimension environmental impact criteria include e.g. Ozone Depletion, Acidification, Land-use, Ecotoxity, Water Depletion. In *Market Alignment* dimension environmental criteria include e.g. Scarce Materials, Freshwater & Availability categories under Resource criteria. Other environmental criteria are designed to ensure that products within the eco portfolio align with a broad environmental agenda, addressing a wide range of environmental challenges beyond greenhouse gas emissions, energy use, or circularity considerations.

Social

The *Social* category encompasses social sustainability criteria, though less frequently applied, are present in several benchmark frameworks and reflect a growing recognition of the social dimensions of product sustainability. Out of the eleven benchmarked companies, four have set

evaluation criteria related to social sustainability (Figure 14). These criteria may include responsible sourcing, health and safety, and the creation of social value throughout the product lifecycle. Clariant's Portfolio Value Program (PVP), for instance, evaluates products across multiple lifecycle phases and includes social criteria in safety and social value creation evaluation categories. Also BASF has social dimensions included as evaluation categories: *Zero Hunger & Poverty* and *Health & Safety* categories include criteria that address social sustainability. Likewise, outside chemical industry, research found one other benchmark that seemed to include social sustainability into evaluation criteria– Siemens has included in eco-product portfolio's *Sustainable Materials* life-cycle stage a criterion *Substances of concern*. Although an indicator could not be identified, the context suggests that this criterion relates to the social dimension of product materials.

Solvay differs here from the others by specifying publicly in the social evaluation category evaluation criteria. Solvay defines as evaluation category *Health & Safety* (in Market Alignment dimension). Criteria in *Health & Safety* category are set to the following aspects: Human Toxicity Classifications, Eco toxicity classifications, substance lists, SIN list, medical care, chronic diseases, healthy habits, food availability, water and air quality, safety and prevention, limitation from ageing, and topical care. Integrating social criteria such as mentioned above, companies ensure that products not only minimize environmental harm but also contribute positively to societal well-being, aligning with broader corporate responsibility goals and stakeholder expectations.

Economic

The *Economic* category encompasses criteria that are typically related to cost-effectiveness, profitability, or strategic value. Out of the eleven benchmarked companies, three have set evaluation criteria related to social sustainability (Figure 14). Based on the public documents found in this research, only the literature-based benchmarks include economic sustainability in eco-product portfolio criteria. For instance, Solvay's Market Alignment assessment (used to classify products and select them into eco-product portfolio) includes evaluation category *Opinion Leaders* which entails criteria related to Countries, Major Customers, Ecolabels and Downstream Sustainability. Despite that this thesis' document review did not find specific definitions for these criteria, the context suggest that these criteria relate to the economic sustainability dimension of products performance.

BASF has adopted an alternative approach in which the economic criteria is set in addition to other evaluation criteria to guide classification of products as a minimum requirement. BASF's TripleS framework includes economic dimension as one of its nine sustainability evaluation categories, *cost*

savings downstream. Additionally, BASF has set for every product stakeholder requirement *Reputational risk* to be analysed for product classification. Highest classes of products (Pioneer and Contributor) form an eco-product portfolio, and all these products need have reputational risk assessment completed and cleared. If the product does not clear the assessment, it will be classified into bottom two categories, Monitored or Challenged:

> BASF: If a solution and/or its raw materials and/or production process entails a risk to the company's reputation, the solution is to be viewed as having an issue or a strong issue respectively, and consequently classified as Monitored or Challenged.

While not primary evaluation criteria for eco-product portfolios, the economic criteria support the holistic and comprehensive view of sustainability adding into economic viability.

Minimum requirement

The *Minimum requirement* evaluation category includes criteria that require that products as a minimum requirement must not cause harm in any defined sustainability dimension. Out of the eleven benchmarked companies, two have set minimum requirement evaluation criteria (Figure 14). This "*do no harm*" principal functions as a minimum threshold that products must meet before any positive contributions are considered. It is typically framed as a binary pass/fail condition, and it is used to filter out products with significant negative impacts, as illustrates in Kalmar and BASF evaluation criteria:

> **Kalmar:** Eco Portfolio products need to fulfill EU Taxonomy's do no significant harm (DNSH) criteria.
>
> **BASF**: Initial check that product is not intended to be used in a controversial business area.

This criterion reinforces the integrity of the eco-product portfolio by ensuring that sustainability claims are not undermined by trade-offs or unintended consequences in other areas.

Risk management

The *Risk management* category encompasses criteria – employed by only one benchmarked company (Figure 14) – that ensure that products included in eco-product portfolios do not introduce significant sustainability-related risks. Clariant allows products to qualify for their eco-product portfolio only if they present more benefits than risks, with a limit on the number of risks permitted.

> **Clariant:** Ecotain® products are required to have *more benefits than risks, considering maximum 3 medium risks which can be controlled.*

Such criteria act as a safeguard, ensuring that products labelled as sustainable do not carry hidden liabilities that could undermine the credibility of the portfolio's sustainability claims.

4.3 Selection methods

A selection method defines the approach to employ evaluation criteria for product selection into a product portfolio. The selection method outcome that defines what products are selected into a product portfolio are selection criteria. This section 4.3. describes the three selection methods identified for eco-product portfolio formulation in benchmarked companies. In other words, this section presents the three approaches that were identified for employing evaluation criteria to determine the selection criteria for an eco-product portfolio. The first selection method is to combine the predefined evaluation criteria to form the selection criteria without using any tools or frameworks. The second and third methods use tools or frameworks to combine and value evaluation criteria to form selection criteria. Tools and frameworks may establish the complete set of selection criteria by combining and valuing evaluation criteria (second selection method), or they may establish only a part of the selection criteria (third selection method). It should be noted that the first method does not exclude the use of tools for determining the evaluation criteria, even though no tool is utilized for forming selection criteria. The selection methods and benchmarked companies using them are summarized in Table 6.

Table 6: Identified selection methods

Selection method	Description of the selection method	Companies using the method
1. method	Connecting evaluation criteria to form selection criteria. No tools / frameworks used.	• Heidelberg Materials • Hiab • Kalmar • ArcelorMittal • LANXESS • Customer x
2. method	Connecting evaluation criteria via using a tool to form selection criteria.	• Clariant • BASF • Solvay
3. method	Evaluation criteria are determined partly via using a framework and partly by setting additional criteria. Selection criteria are formed by connecting these evaluation criteria together.	• ABB • Siemens

4.3.1 Connecting evaluation criteria to form selection criteria

Using the first type of selection method, the benchmarked companies connect predefined evaluation criteria together to form selection criteria for a product portfolio without using any tools or frameworks. The defined connection could be exclusive (one or the other) or inclusive (one and the other). The determined connection between the evaluation criteria forms the basis for selection into a product portfolio. In other words, when companies define how products must meet the evaluation criteria products, they form the selection criteria for product portfolio formulation.

For example, a company might have set two evaluation criteria for their eco-product portfolio products: 1) 10% reduced product carbon footprint and 2) 20% recycled material. Then, the company connects these criteria exclusively or inclusively to form the selection criteria. The exclusive connection forms selection criterion such as “to be selected for the eco-product portfolio a product must have 10% reduced product carbon footprint or 20% recycled material to be selected for the portfolio”. The inclusive connection would form selection criterion requiring both evaluation criteria to be fulfilled: “a product must have 10% reduced carbon footprint and 20% recycled material”. This example shows a simplified version of how benchmarked companies identified to use the first selection method determine a connection between evaluation criteria forming the selection criteria. In practice, the selection criteria determination is more complicated but follows the logic of the example.

In the sample of 11 benchmarks, this selection method was found used by six companies: Heidelberg Material, LANXESS, ArcelorMittal, Hiab, Kalmar and Customer X. The analysis of the companies using this first selection method explored how predefined evaluation criteria are connected by the companies. Firstly, Heidelberg Material, Hiab and Kalmar were found to form exclusive connections between the evaluation criteria to form selection criteria.

Heidelberg Material connected evaluation criteria exclusively – products in the eco-product portfolio, evoBuild®**,** are required to meet one criterion. EvoBuild® connects products that are distinctive either regard to CO_2 footprint compared to industry standard or regard to reused/reduced materials. The connection formed between evaluation criteria is therefore exclusive – Either products in the eco-product portfolio are low-carbon products or circular products fulfilling one of the four evaluation criteria as illustrated in the Figure 15 from Heidelberg Material’s website:

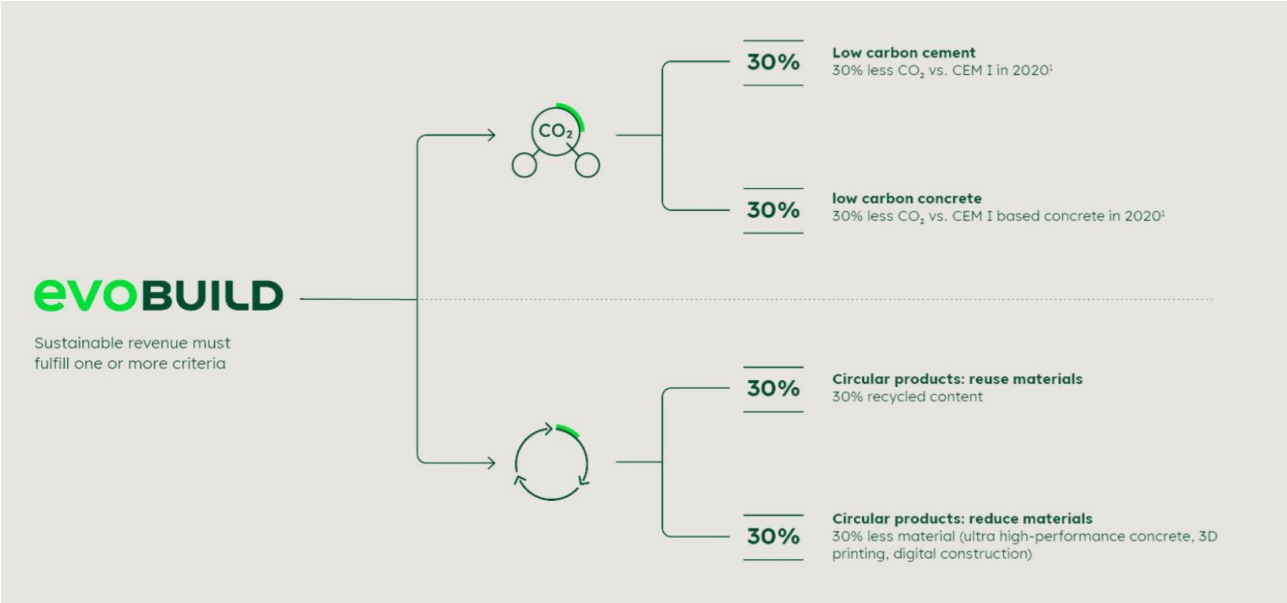


Figure 15: Heidelberg Material's eco-product portfolio evaluation and selection criteria (HeidelbergMaterial.com)

In other words, evoBuild® product portfolio's selection criterion is that a product meet one evaluation criterion out of four. Similarly, Hiab and Kalmar form exclusive connection between the evaluation criteria. Hiab and Kalmar had more evaluation criteria that a product can meet. Still, the selection criterion of the eco-product portfolio is to meet only one evaluation criterion – either to become a climate or circular product of the eco-product portfolio. The below Figure 16 illustrates the evaluation criteria of Hiab, which are very similar to Kalmar's:

Climate solutions	Climate solutions include equipment that are: 1. Zero-tailpipe-emission equipment 2. Zero-tailpipe-emission installed equipment 3. Low-emission equipment (-25% compared to conventional alternative) And: GHG reductions are calculated in accordance with ISO 14067:2018 and validated by an independent third party. Definitions: *Zero-tailpipe-emission equipment:* Hiab equipment that does not produce direct emissions from exhaust due to design, including electric power takeoff. *Zero-tailpipe-emission installed equipment:* Hiab equipment that is installed onto platforms with no tailpipe emissions (e.g. electric truck or wind turbine). *Low-emission equipment:* equipment that provides substantial life-cycle GHG emission savings aligned with the 1.5°C pathway. Low-emission equipment shall demonstrate -25% GHG savings compared to the 2022 conventional alternative.
Circular solutions	Circular solutions include services and used equipment falling under the following groups: 1. Repair and maintenance service work and parts 2. Refurbishment and remanufacturing 3. Rental and leasing services 4. Sales of use equipment 5. Digital services supporting preventive maintenance and extended lifetime

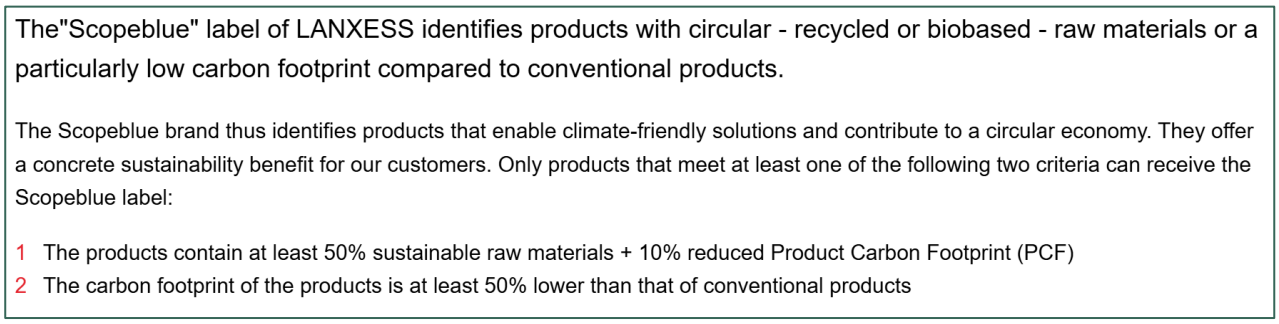
Figure 16: Hiab's eco-product portfolio evaluation and selection criteria (Hiab 2025)

Secondly, ArcelorMittal was found the be the only one of the six companies using the first selection method to form inclusive connections. To be included into the *Xcarb® recycled and renewably produced* eco-product portfolio – in other words the selection criterion of the eco-product portfolio is that – a product must fulfill a set of two evaluation criteria inclusivele. The two evaluation criteria are 1) manufacture via Electric Arc Furnace route using high levels of scrap steel an 2) manufactured with 100% renewable energy as represented from ArvelorMittal's website in Figure 17:

XCarb® recycled and renewably produced applies to products made via the Electric Arc Furnace route using high levels of scrap steel and 100% renewable energy.

Figure 17: ArcelorMittal eco-product portfolio evaluation and selection criteria (ArcelorMittal)

LANXESS Scopeblue® product portfolio represents a more complex approach that has characteristics of both inclusive and exclusive connection between evaluation criteria. LANXESS has combined three evaluation criteria to form two selection criteria as illustrated in Figure 18 from the company's website:


The"Scopeblue" label of LANXESS identifies products with circular - recycled or biobased - raw materials or a particularly low carbon footprint compared to conventional products.

The Scopeblue brand thus identifies products that enable climate-friendly solutions and contribute to a circular economy. They offer a concrete sustainability benefit for our customers. Only products that meet at least one of the following two criteria can receive the Scopeblue label:

1 The products contain at least 50% sustainable raw materials + 10% reduced Product Carbon Footprint (PCF)
2 The carbon footprint of the products is at least 50% lower than that of conventional products

Figure 18: LANXESS's eco-product portfolio evaluation and selection criteria (Lanxess)

The first selection criterion includes two evaluation criteria which both need to be fulfilled. Therefore, the connection between LANXESS Scopeblue® evaluation criteria in the first selection criterion is inclusive – a product must contain at least 50% sustainable raw materials and have 10% reduced PCF. The second selection criterion only contains one evaluation criterion which requires a product to have at least 50% lower PCF than conventional products. Therefore, the connection between 50% raw material and 10% reduced PCF evaluation criteria is inclusive when defining the first selection criterion. However, the connection between these two evaluation criteria toward the third "50% lower PCF" evaluation criterion is exclusive – either one can be true for selection into the portfolio. In summary, LANXESS eco-product portfolio has two selection criteria – one containing two inclusively connected evaluation criteria and one containing one evaluation criteria.

Similarly to LANXESS, Customer X forms two selection criteria by connecting evaluation criteria. In the first selection criterion, a product must meet two evaluation criteria and so the connection between evaluation criteria is inclusive. In the second selection criterion, a product must meet only one evaluation criteria. Due to the anonymity of Customer X, these criteria are not disclosed further in this thesis. In summary, this first selection method represents the most straightforward selection method, relying on connecting a set of predefined evaluation criteria without extensive use of tools or frameworks. While relatively simple, it ensures consistency while allowing different selection criteria to be fulfilled for selection into the eco-product portfolio. Overall, this most frequently used method among the benchmarked companies reflects a practical yet less tool-intensive strategy compared to more advanced approaches discussed next.

4.3.2 A tool connecting evaluation criteria to form selection criteria

In the second identified selection method, companies were found to use tools to form selection criteria. The tools determine and connect evaluation criteria. The connecting resembles the first method while the connections defined by the tools introduce greater complexity. The tools found to be used by the benchmarked companies were product portfolio management tools guiding both product development and eco-product portfolio formulation.

Out of the 11 benchmarked companies three – Clariant, BASF and Solvay – based the selection criteria for their eco-product portfolio entirely on a product portfolio management tool. These companies were found to use proprietary sustainable portfolio management tools – the *Portfolio Value Program* (PVP) at Clariant, *Sustainable Solutions Steering* (TripleS) at BASF, and *Sustainable Portfolio Management* (SPM) at Solvay – that connect evaluation criteria. The evaluation criteria are connected, combined and valued for classification of products in the entire product portfolio. The classes form sub-portfolios of products. The top tier class or two top classes form the eco-product portfolio. In this way, the tools determine how evaluation criteria are connected to form selection criteria for the eco-product portfolios. The sustainable product portfolio management processes are complex, vary between the three companies and include unique ways to connect evaluation criteria. Therefore, the selection method used to form the selection criteria of evaluation criteria vary between the three companies using tools.

Taking a closer look at these three examples, Clariant's PVP assesses in 6-step process (Figure 19) each product of Clariant's offering across the full lifecycle by using 39 evaluation criteria under 8 themes. Based on this sustainability assessment, the products are classified as four sub-portfolios. The sub-portfolio that includes products that perform the best in regard to the PVP process – the Ecotain® product portfolio – is the eco-product portfolio of Clariant. Hereby, Clariant's PVP tool connects multiple evaluation criteria together to form selection criteria which define to which class a product belongs to. If the product belongs in the Ecotain product portfolio, it is a part of the company's eco-product portfolio.

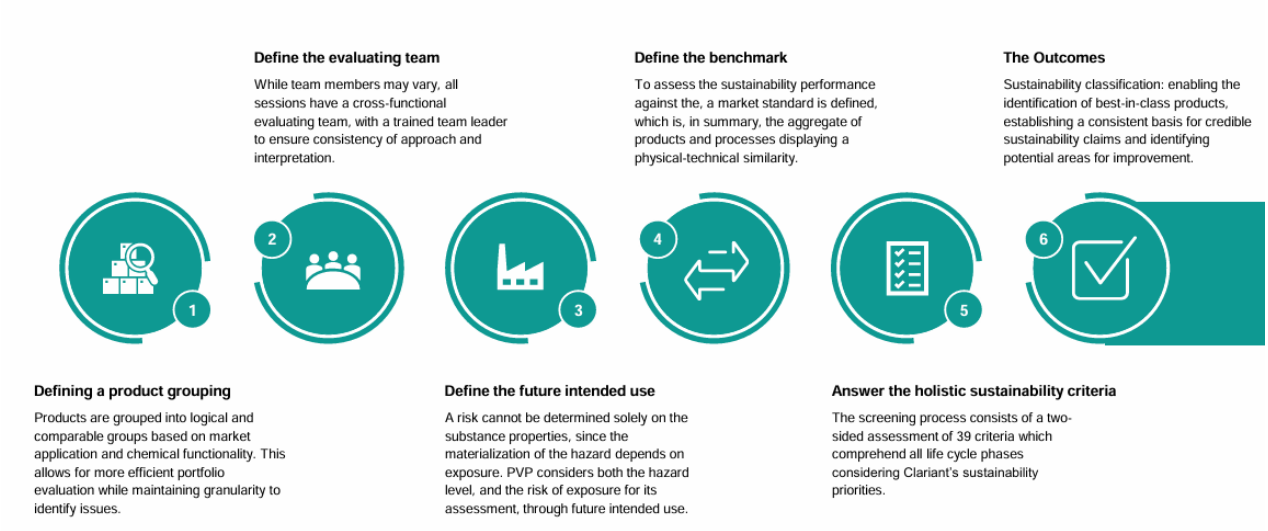


Figure 19: Clariant's Portfolio Value Program (PVP) process (Clariant PVP Guide, 2024)

Similarly, BASF's TripleS tool (Figure 20) evaluates products in nine sustainability categories each containing various evaluation criteria. Based on the evaluation, the products are classified into five categories. Products rated as "Pioneers" – outperforming the market in at least one category – or "Contributors" – performance on par with market standard – collectively form BASF's *Sustainable-Future Solutions* portfolio (BASF's eco-product portfolio). Therefore, the selection criteria of the eco-product portfolio are defined with the TripleS tool that connects the evaluation criteria.

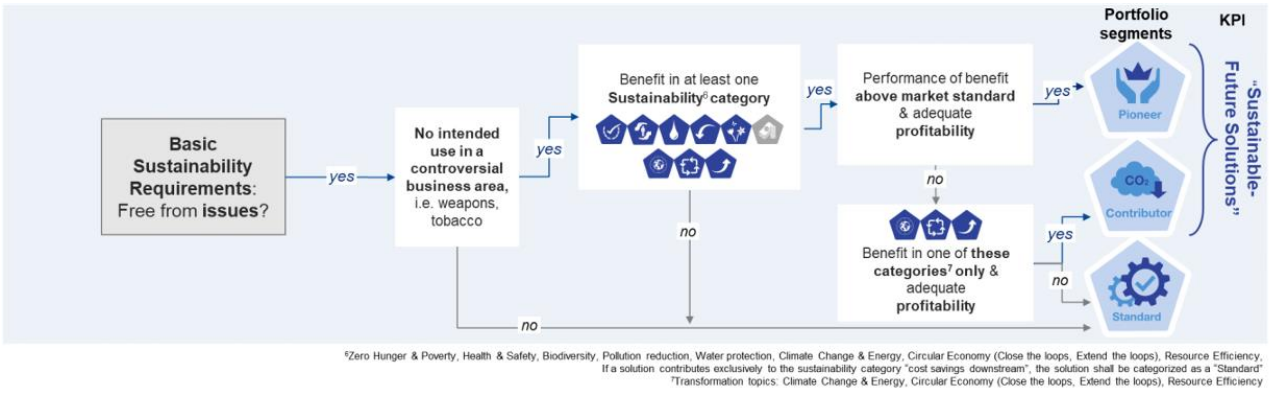


Figure 20: BASF's Sustainable Solution Steering (Triple S) process (BASF TripleS manual, 2025)

Similar to the other approaches yet characterized by greater complexity, Solvay's SPM tool (Figure 21) combines quantitative life-cycle impact assessment of a product with a qualitative evaluation of market sustainability drivers of that product. The two-fold assessment classifies Solvay's offering into four classes. The top-class products represent Solvay's *Sustainable Solutions portfolio*. The SPM tool therefore connects the evaluation criteria into two-fold selection criteria categories which together determine the products that are included into Solvay's eco-product portfolio.

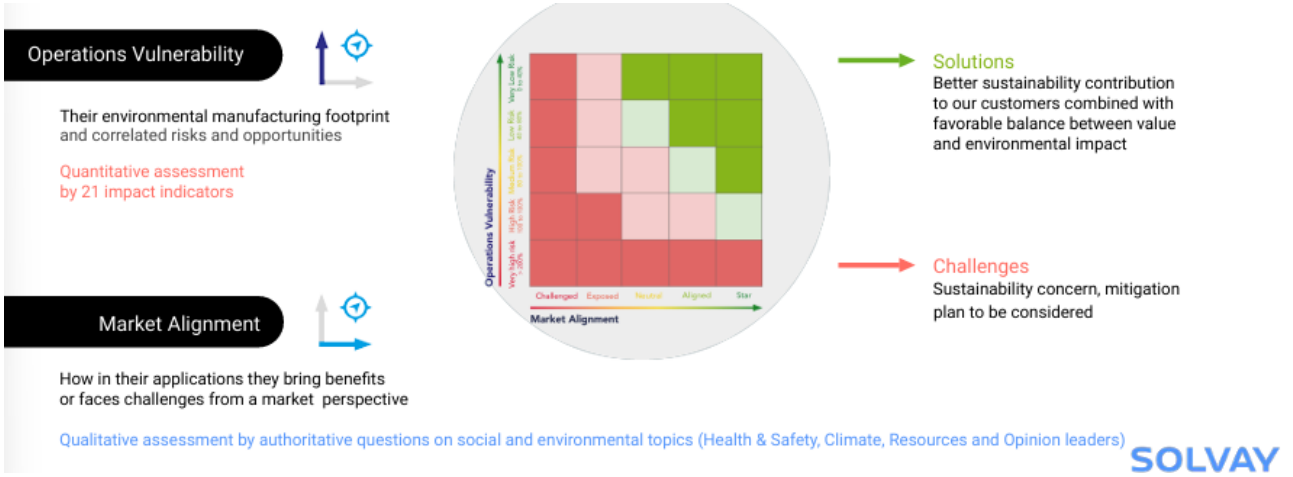


Figure 21: Solvay's Sustainable Portfolio Management (SPM) assessment (Solvay SPM 3.0 toolkit, 2025)

In summary, three of the benchmarked companies based the selection of products into their eco-product portfolio to tools. The selection method is characterized by using tools which guide the sustainability integration into the entire product portfolio by forming classes of products. The class in which products have the best sustainability performance according to the criteria set in the tool forms the eco-product portfolio. This tool-driven selection method ensures that the eco-product portfolio is distinctive for its sustainability performance of products defined by rigorous, internally standardized criteria. These tools ensure that comprehensive sustainability metrics are embedded effectively into portfolio management and eco-product portfolio formulation processes.

4.3.3 Connecting evaluation criteria defined partly by a framework to form selection criteria

In the third identified selection method, the benchmarked companies – similarly to the first method – connect evaluation criteria together without using a tool. However, the benchmarked companies using this selection method employ frameworks to determine a part of the evaluation criteria, and their categories. The companies in the first selection method did not use any frameworks or tools to define evaluation criteria nor selection criteria. Furthermore, the product portfolio management tools in the second selection method determine the selection criteria by connecting evaluation criteria. However, the frameworks used in this third selection method solely determine the evaluation criteria – they do not make connection between evaluation criteria to form selection criteria. Instead, the final selection criteria are formed by connecting the evaluation criteria from the framework to additional evaluation criteria.

Out of the 11 benchmarked companies, two – ABB and Siemens – apply this selection method. The frameworks – ABB's *Circularity Approach* and Siemens' *Robust Eco Design (RED)* – set evaluation criteria across product lifecycle phases. Furthermore, both companies form the selection criteria based on the evaluation criteria both from the frameworks and from additional criteria. Eco-product portfolio products are, firstly, required to fulfill a minimum number of evaluation criteria from the framework. Secondly, eco-product portfolio products are required to meet other evaluation criteria. These evaluation criteria, from the framework and additional, are inclusively connected to form the selection criteria for eco-product portfolio.

Taking a closer look at the examples of this selection method, ABB determines part of the evaluation criteria with its *Circularity Approach* framework. The framework defines four lifecycle phases: design & sourcing, manufacturing, use, and end-of-life. To each lifecycle phase, evaluation criteria for products are set. To form the first part of their selection criteria for the eco-product portfolio, ABB has defined that products must meet at least one evaluation criteria in each lifecycle phase. The exact evaluation criteria of each phase are not externally disclosed. Second selection criterion is that products are required to have a verified Environmental Product Declaration (EPD). These selection criteria define ABB's eco-product portfolio formulation. Figure 22 illustrates the selection criteria by showing how ABB requires that products in the eco-product portfolio must 1) fulfill minimum of 4 evaluation criteria, one from each lifecycle phase, and 2) have a verified EPD. Together, these two criteria form the selection criteria for products to be included in the eco-product portfolio.

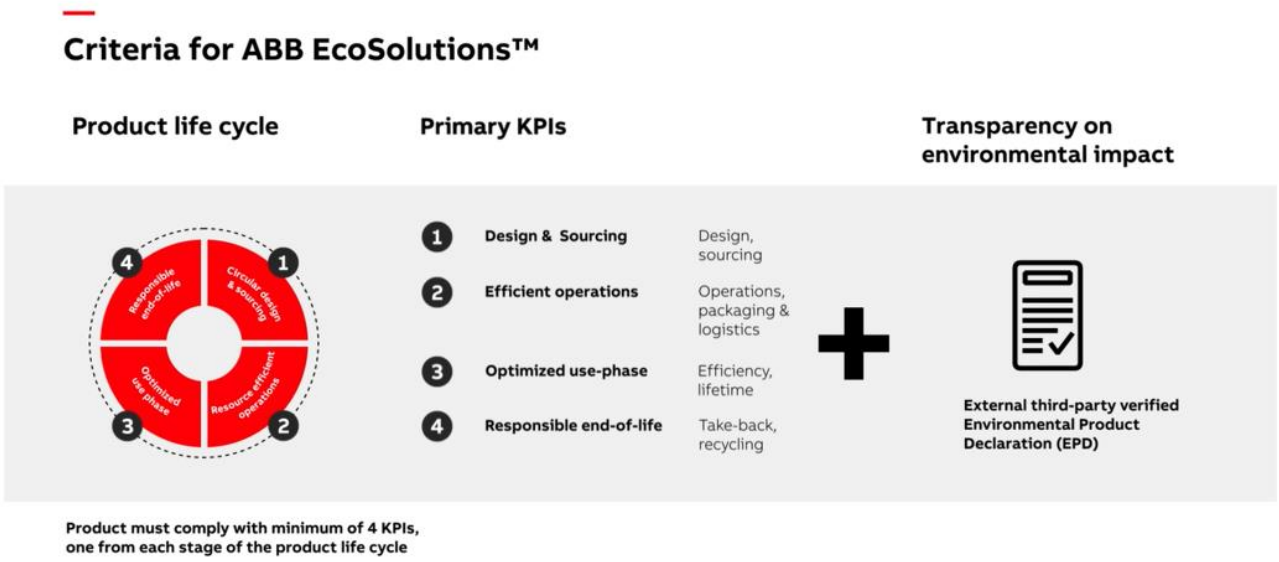


Figure 22: ABB's eco-product portfolio selection criteria (ABB)

Similarly, Siemen's Robust Eco Design (RED) framework defines evaluation criteria into three lifecycle phases – Sustainable Materials, Optimal Use, and Value Recovery & Circularity. Each phase includes 3-5 evaluation criteria. Siemens discloses the evaluation indicators underlying the criteria but does not reveal the specific threshold values. The first part of selection criteria bases on the framework evaluation criteria: To be included in their eco-product portfolio, a product must fulfill at least one criterion in each of the three dimensions. Siemens also imposes additional evaluation criteria beyond the RED framework as mandatory selection criteria. These additional selection criteria are the requirement of the product 1) to have an EPD with life-cycle impact assessment, 2) to be compliant with current substance of concern regulations and 3) to be manufactured using 100% renewable energy. Together, the requirements set toward the evaluation criteria in the RED framework and the additional evaluation criteria form the complete set of selection criteria of Siemen's *EcoTech* eco-product portfolio. Siemen's full selection criteria can be seen in Figure 23.

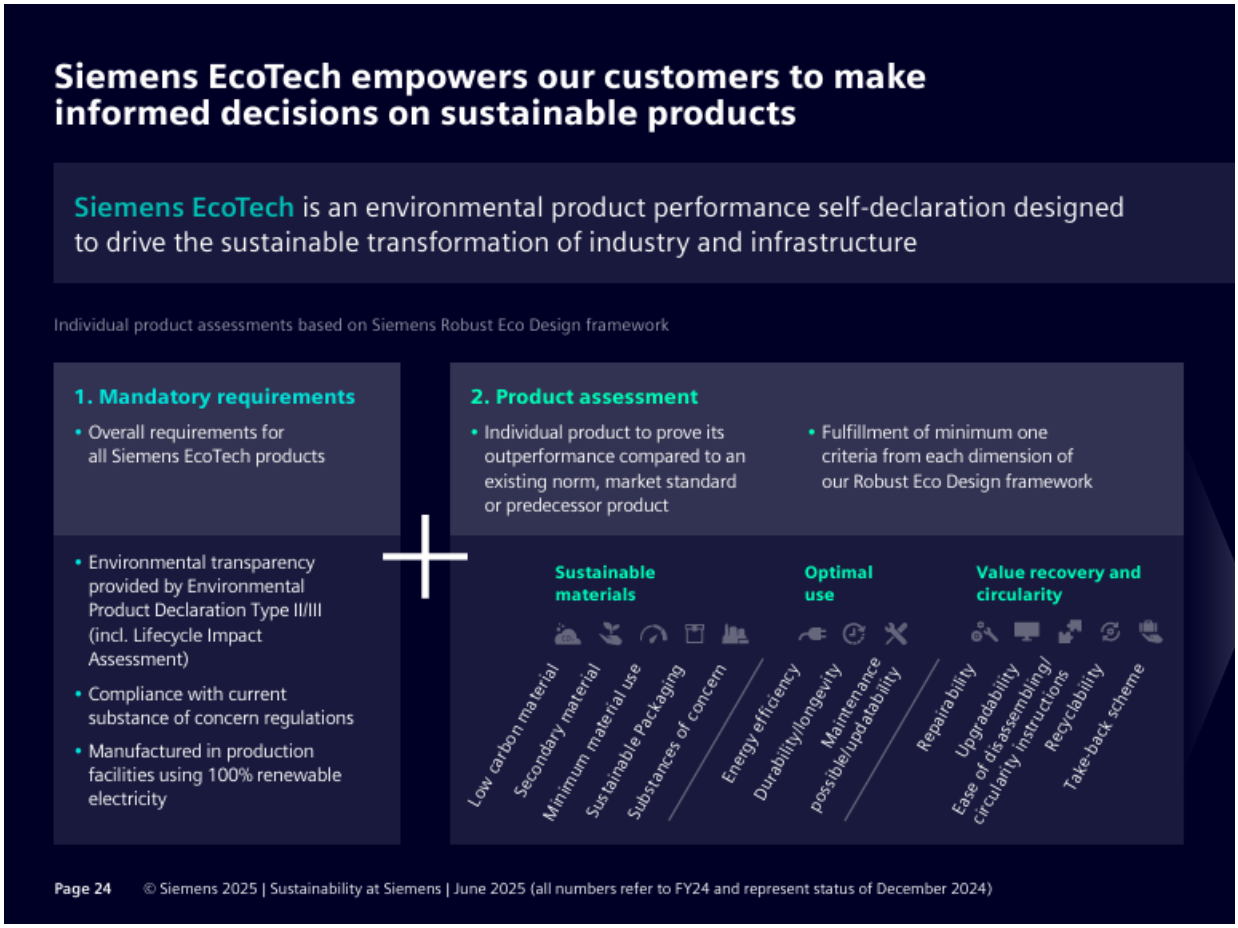


Figure 23: Siemens eco-product portfolio selection criteria (Siemens 2025)

In summary, the third selection method combines framework-based and company-specific evaluation criteria in the formulation of eco-product portfolio selection criteria. Unlike product portfolio management tools that directly derive selection criteria, the frameworks applied in this method define evaluation criteria only, which are subsequently connected with additional criteria to form the final selection criteria. ABB and Siemens exemplify this approach by requiring products to meet minimum framework-based lifecycle criteria alongside additional mandatory requirements. In addition to examining the evaluation criteria and selection methods currently employed by B2B manufacturing companies, this thesis also explores regulatory, verification, and strategic considerations related to eco-product portfolio formulation. Chapter 5 therefore presents the results concerning these dimensions of eco-product portfolio formulation.

5 Characteristics of regulation, verification and strategic considerations

In this thesis nine expert interviews were conducted to gain insight to regulation and verification characteristics and strategic considerations related to eco-product portfolio formulation. This chapter presents the interview results which provide insights into the research questions as described in Figure 24. Firstly, section 5.1. describes the regulation characteristics related to eco-product portfolio formulation. Section 5.2. continues by describing the verification characteristics of eco-product portfolio verification. Lastly, the strategic considerations for eco-product portfolio formulation highlighted in the interviews are summarized in section 5.3. The participant pool was international: it included Finnish professionals as well as experts from other European countries. Therefore, interviews were conducted in both English and Finnish which means most of the quotes presented in this chapter are translated versions from direct quotes.

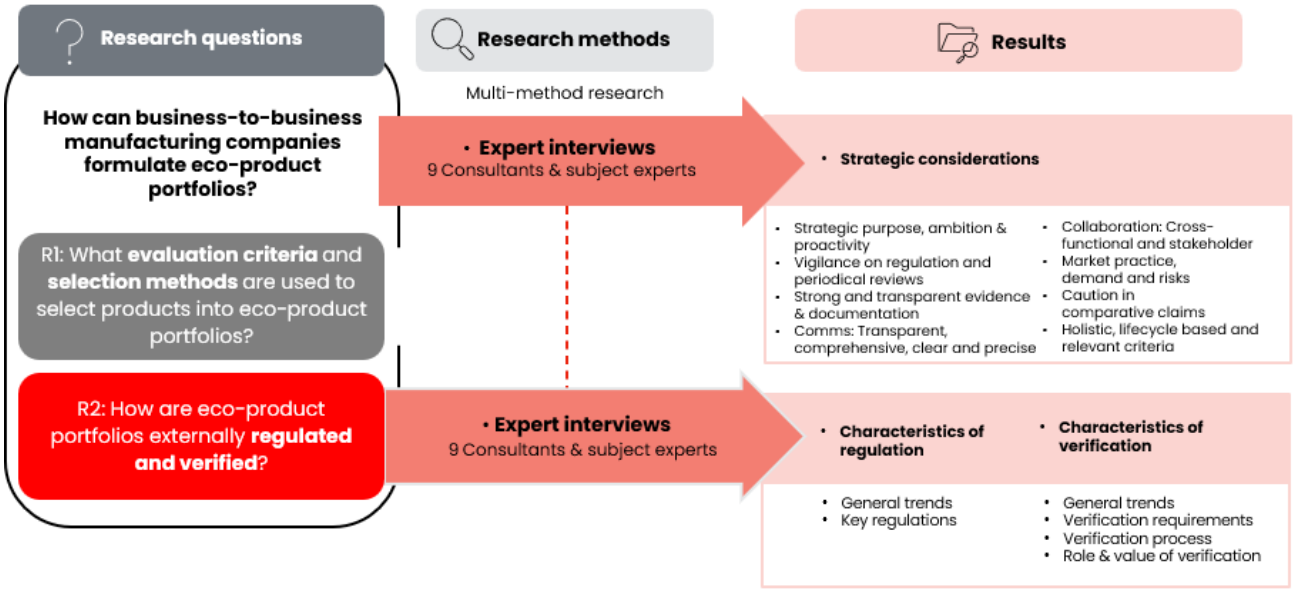


Figure 24: Expert interview results

5.1 Regulation characteristics

The interviews conducted for this thesis provided insights into the regulation characteristics of eco-product portfolios – i.e. into the regulation of self-declared product-level sustainability claims. This section 5.1. presents the regulatory insights derived from the interviews in the order presented in Table 7. Firstly, section 5.1.1. presents the five general trends of EU's regulatory landscape related to eco-product portfolio regulation. Secondly, section 5.1.2. presents the key regulations that were mentioned to affect eco-product portfolio formulation. The key regulations that were mentioned in

the interviews concern different perspectives of eco-product portfolio formulation – such as reporting of the portfolio or communication of the portfolio. Accordingly, the mentioned key regulations are divided into four groups – each elaborated upon in section 5.1.2.

Table 7: Regulation characteristics related to eco-product portfolio formulation

Regulation characteristics	General trends	• Uncertainty, instability and turbulence - Green Deal > Competitiveness Compass • Climate centrality • Increasing demand for precision and clear evidence • B2C standards trickling down B2B • Global drive for stricter regulation of sustainability claims and EU harmonizing
	Key regulations	• Reporting (ESRS, CSRD, SFDR) • Communication (Green Claims, UCPD, EmpCo) • Product development & product sustainability calculations (ESPR & DPP, EU Taxonomy & DNHS, PEF, REACH) • Supply chain (EUDR, CSDDD, EU Battery Regulation)

Notably, the general trends presented in 5.1.1. are interconnected to the key regulations. The experts derived their insights into the general trends partly by looking at the recent developments of the key regulations. This was observed in that the experts referenced the key regulations as examples of where they have identified the trends described of the EU regulatory landscape. Therefore, the general trends are observed in the development and implementation of the key regulation frameworks presented in 5.1.2.

5.1.1 General trends

The analysis of the interviews identified five trends consistently described by all the interviewees of the EU's regulatory landscape regarding eco-product portfolios. The five general trends are 1) Uncertainty, instability and turbulence, 2) Climate centrality, 3) Increasing demand for precision and clear evidence, 4) B2C standards trickling down B2B and 5) Global drive for stricter regulation of sustainability claims and EU harmonizing. These five trends surfacing from the interviews are described below in detail with explanatory quotes.

Uncertainty, instability and turbulence

The EU regulatory field regarding eco-product portfolios was described consistently as uncertain, instable and in strong turbulence. Several experts noted frequent policy shifts and political reversals, which create confusion for companies. For instance, interviewee D remarked the current situation where regulations are proposed and then retracted in short "*unlike anything before*" as regards to volatility. Such volatility was mentioned to be illustrated in the developments of regulations such as the Corporate Sustainability Reporting Directive (CSDR), Corporate Sustainability Due Diligence Directive (CSDDD) and Green Claims Directive. Overall, predicting the EU Commission's decisions was described in the interviews as a challenge as illustrated in the quotes below:

> "You never know what the Commission is thinking about exactly" (E)

> "EU regulatory situation is at the moment chaotic, confusing, rising doubt […] it's a full- time job to follow what is going on." (H)

A related observation of the EU Commission was the apparent pivot in EU policy priorities following the latest European Commission change. One consultant explained that the ambitious *Green Deal* agenda – that encompassed several directives that guide also product sustainability and product claims – has now shifted to a *Competitiveness Compass,* implying a reduced emphasis on new sustainability initiatives in favor of economic competitiveness:

> "If the previous Commission made the EU a superpower in sustainability legislation, then the next one will focus on increasing competitiveness." (F)

The shifting priorities and regulatory turbulence influenced experts to be unsure how eco-product portfolios will be regulated in the future. The uncertainty of the EU's regulatory bodies makes it challenging to say what regulations will affect, and how, the formulation of eco-product portfolios as illustrated in the quote below:

> "We are currently living through a major transition, where politics are at the extremes and the focus on where Europe is being steered is still changing. That's why I cannot now assess how they [the regulations] will come into play." (C)

All together on a higher level, sustainability was described consistently being deprioritized currently in the EU's regulatory landscape. Interviewee I described how earlier positive developments to require standardized sustainability information of products have ceased: While earlier the general opinion was that the EU sustainability regulation has gone too far, now it has turned around as the move to fix over-regulation has gone too far causing a cease. The sustainability

initiatives that were previously pushed forwards in EU, are now left to the background as explained by the quote from interviewee G below:

> "Regulation related to sustainability has been pushed forward, but now it's starting to roll back downhill." (G)

Furthermore, interviewee F noted an example how together the deprioritization of sustainability and the regulatory uncertainty within the EU has impacted companies' sustainability actions. Around the year 2020, F's consulted clients showed a significant interest in sustainability initiatives and reporting. However, due to the current turbulence in the EU, sustainability concerns appear to have become less prominent, with clients now focusing only on actions that directly deliver financial benefits. Furthermore, some interviews revealed skeptical opinions toward the possibility of there being more regulation on sustainability claims as the quote below illustrates:

> "There really isn't any regulation. […] There would absolutely be a need for regulation, because right now everyone is using different methods. […] But realistically, I don't see that it's necessarily coming from the EU level." (B)

In summary, the interviewees described consistently the regulatory field of EU to be uncertain, instable and in turbulence. This uncertainty and turbulence in EU regulatory landscape were described as major challenges, for example regarding risks of greenwashing. Interviewees described the situation as requiring regulatory intervention, as illustrated by the quotes below:

> "Hopefully, there will be more strict regulation of what can be said, because in my opinion this jungle where you can say anything about your product and everything is now 'the most sustainable' really undermines the whole thing we are doing. […] This is an absolutely an intolerable situation." (C)

> "There's a need for more standards and regulation to base verification to." (B)

The changes in goals, actions, and vision for the EU's sustainability agenda underscore a period of transition and uncertainty about the future of regulations and the impact on eco-product portfolios. Collectively, the results highlight the necessity for further regulatory development to reduce uncertainty and improve consistency.

Climate centrality

The second general trend described in the interviews was that the EU climate targets will remain central in EU's agenda, despite the uncertainty and turbulence around sustainability initiatives. The quote below illustrates how climate is described to stay central theme for regulators amid changing political winds:

> "What clearly remains is climate. Climate issues are still highly central, so the EU's climate target has not disappeared. – And in my view, that [climate] is the most crucial aspect that is also reflected in product-level claims in B2B business. They are considered at the organizational level, which means they are considered at the product level." (F)

The quote underscores that climate considerations are deeply embedded in both organizational and product-level strategies, making them a persistent priority in formulation of eco-product portfolios. In summary, climate issues were described as a priority for EU and for companies, and therefore, climate impact of products is and will be regulated making the criteria addressing products' climate impact central for future-proofed eco-product portfolio products.

Increasing demand for precision and clear evidence

Another prominent trend is an increasing demand for precision and clear evidence. Results highlight that precision was described to be needed when defining the sustainability claims related to eco-product portfolio products. Interviewees D and G stressed – as below quotes illustrate – the centrality to avoid of ambiguous claims and aim for more specific, detailed and impact-driven claims and criteria:

> "Show the impact directly, without using words like responsible, ecological, or green, or any leaf or globe icons. Let's get straight to the point and talk specifically about what we mean. […] The strengthening direction is to get rid of both ambiguous claims and home-made calculations." (D)

> "In the context of green claims, the challenge is that it should be transparent and fact-based. […] People [who formulate product-level sustainability claims] use language that is self-evident to those inside the bubble, but to those outside, it's just empty words." (G)

Following the same line of thought, interviewee D elaborated that the policies that are currently forthcoming focus, firstly, to the "*first-line of defense*". This means that policies focus to getting rid of ambiguous claims. Secondly, the policies aim to provide common frameworks for proving product-level sustainability claims. Indeed, interviewees described consistently how regulations are increasingly demanding clear evidence for sustainability claims. In practice, this means companies are expected to provide transparent data, use standardized methods (instead of ad-hoc calculations), and make claims that are precisely defined and quantifiable (e.g. stating a specific percentage reduction in emissions rather than calling a product "eco-friendly"). Several interviewees emphasized the demands for transparency and truthfulness – which is illustrated by the below quote that describes how every claim should have verifiable backing:

> "Starting point is that everything you say, you need to be able to prove." (G)

In addition to future developments, interviewee H pointed out how current reporting standards (like ESRD & CSRD) require already concrete information from companies who claim something of their products. Because verification requirements reflect current regulation, this thesis elaborates these current requirements for evidence and documentation further in section 5.2.2. *Verification requirements*. Regardless of the current regulations, interviewee C noted – as the quote below illustrates – that even if companies are not allowed to make arbitrary claims, enforcement and clarity of these regulations is weak:

> "There is quite a lot of variation [in regulation]. I don't really see that reliability in environmental claims is being realized." (C)

In summary, the findings indicate a clear trend toward stricter expectations for precision, transparency, and evidentiary support in product-level sustainability claims. At the same time, despite increasing formal requirements, inconsistencies in enforcement and regulatory clarity continue to limit the full realization of reliable and credible environmental claims in practice.

B2C trickling down to B2B

Interviewees also noted as a trend that consumer-market (B2C) regulations and standards are trickling down into the business to business (B2B) market context. Although many EU sustainability rules initially target consumer products and marketing, they are indirectly influencing business-to-business practices. For example, as large B2C companies respond to stricter rules on green marketing, they are in turn demanding better evidence from their B2B suppliers. Interviewee D explained this so that even if a certain loose claim might still be legally permissible for a supplier, companies are asking themselves: "*Just because it's legal, is it advisable?"*. The interview findings indicate this trend toward self-regulation to avoid reputational or legal risk. Furthermore, established best practices within the market are consistently shared across both B2B and B2C environments as the quotes below illustrate:

> " Even though regulation is officially for B2C, it brings good market practices that are indirectly trickling into B2B." (I)

> "If a B2C company must follow a certain directive, it will affect of course the requirements that the company makes on the B2B side like the information they require and things like that. So, I think all the directives that would come into force as planned, would affect the B2B quite a lot as well." (A)

Simultaneously, the lines between B2C and B2B business are described as blurring because the same products might be marketed to different end-users. Interviewee G also highlighted that it is increasingly challenging to differentiate between B2C and B2B since media platforms now serve both contexts. The audience for any given message is uncertain, and ultimately, regardless of our roles, all buyers are consumers regardless the context.

In short, predominantly the interviewees described the traditional boundary between B2B and B2C regulation to be blurring which implies companies formulating eco-product portfolios to adopt the clarity and rigor expected in B2C sustainability communications to future-proof their sustainability claims.

Global drive for stricter regulation and EU harmonizing

Two participants mentioned that considerations from global regulatory field beyond EU is central to portfolio formulation. Interviewee D mentioned – as the quote below shows – that countries like Canada, Australia, and Singapore have recently advanced bold rules against greenwashing, contributing to a global drive toward stricter and harmonized regulation of sustainability claims – and that EU will follow this trend:

> "Looking at the global picture [referring to ambitious regulating in Canada, Australia and Singapore], it is hard to see the EU reversing for an endlessly long time. I believe B2B regulation will increase on the marketing side in the EU as well. Whether this happens during this parliament or in five years remains uncertain. […] So, looking at global picture, I believe the direction is toward broader regulation of sustainability marketing and the creation of common rules." (D)

Furthermore, Interviewee E pointed out – as the quote below illustrates – that the regulations vary globally making monitoring of regional regulations like carbon taxes critical to avoid market access risks:

> "If you don't follow the regulation development in different countries where you export to, then you might have a problem later. […] Regulation and political sanctions [related to supply chains] are very important in our geopolitical world" (E)

These discussions underscore a growing global alignment toward stricter sustainability claims regulations, emphasizing the strategic importance of monitoring both EU and international developments in portfolio decisions. Also, interviewees expect EU to eventually follow this international trend despite the current delays – pointing towards more harmonized standards and less tolerance for disparate national rules or "wild west" situations in green marketing.

Interviewees C and E, for instance, pointed to ongoing developments such as the Product Environmental Footprint (PEF) and sector-specific standards as signs of a shift toward standardized calculation methods and clearer expectations for evidence. Interviewee C noted that while current frameworks are fragmented, the direction is toward convergence of product sustainability via introduction of category specific rules for eco-design and environmental performance calculations in e.g. Ecodesign for Sustainable Product Regulation (ESPR) and Product Environmental Footprint (PEF) framework. Interviewee E similarly predicted that carbon footprint calculations and other forms of product-level evidence will become mandatory across sectors as the quote below illustrates:

> "[…] it's not there today, but in the next 5 to 10 years, I'm 100% sure that you will need to have carbon footprint calculated, reported and verified for your products." (E)

Together, these insights suggest that companies should prepare for a future where harmonized standards for eco-design and mandatory evidence-based claims become the norm, reinforcing the need for early alignment with emerging regulatory frameworks.

5.1.2 Key regulations

In addition to general trends of EU regulatory landscape, the interviews shed light on the key regulations that affect eco-product portfolio formulation. The interviewees identified multiple regulatory frameworks that target distinct perspectives of eco-product portfolio formulation. Variation emerged in the regulatory frameworks identified by the interviewees. For instance, some of the interviewees highlighted reporting regulations – such as CSRD – that set overall transparency and disclosure requirements for eco-product portfolios, while others stressed marketing and sustainability claims regulations – such as Green Claims – governing how eco-product portfolio products can be promoted.

Out of all mentioned regulations, the most consistently and frequently highlighted regulations affecting eco-product portfolio formulation were the reporting regime CSRD – discussed in all interviews – and the anticipated Green Claims directive discussed in all except one interview. Other regulations were mentioned with varying frequency across the interviews. The regulations mentioned in the interviews were divided in the analysis into four categories which describe the dimension of eco-product portfolios that the regulation targets (Table 8).

Table 8: Key regulations affecting eco-product portfolio formulation

Key regulation category	Regulation
Reporting	• Corporate Sustainability Reporting Directive (CSRD) • European Sustainability Reporting Standards (ESRS) • Sustainable Finance Disclosure Regulation (SFDR)
Communication	• Green Claims Directive (Green Claims) • Empowering Consumers for Green Transition (EmpCo) • Unfair Commercial Practices Directive (UCPD)
Product development and product sustainability calculations	• Ecodesign for Sustainable Products Regulation (ESPR) and Digital Product Passport (DPP) • EU Taxonomy and Do No Significant Harm (DNSH) • Product Environmental Footprint (PEF) framework • EU Battery Regulation
Supply chain	• EU Deforestation Regulation (EUDR) • Corporate Sustainability Due Diligence Directive (CSDDD / Triple D)

Reporting regulations

Regulations targeting sustainability reporting practices were consistently highlighted by the interviewees as affecting the formulation of eco-product portfolios. This is because eco-product portfolios are often disclosed in sustainability reports. In this way the reporting regulations set expectations for transparency, data quality, and the structure of sustainability disclosure of eco-product portfolios. The Corporate Sustainability Reporting Directive (CSRD) was mentioned by all interviewees to affect eco-product portfolio formulation. CSRD is a key EU sustainability regulation that mandates large companies to disclose detailed sustainability information, including environmental impacts at the product level. It was referenced as a driver for companies to define and document the environmental performance of their eco-product portfolios in a structured and comparable way. The European Sustainability Reporting Standards (ESRS) – mentioned by the interviewee H and developed under CSRD to give detailed rules for reporting – were noted to require that all reported information be concrete, verifiable, and balanced as the quote below illustrates:

> ”ESRS standard sets requirements for information in reports such as information needs to be verifiable, understandable, clear and concrete.” (H)

Therefore, CSRD and ESRS influence how eco-product portfolios should be justified and communicated in the sustainability reports. Interviewee H further explained that CSRD has pushed companies to transition from utilising sustainability disclosures as marketing tools to presenting strictly evidence-based information. Information stated in the sustainability reports are required to have similar standards than those applied in financial statement disclosures. The interviewees see that reporting regulation will evolve and affect sustainability claims – including the claims made of eco-product portfolio products – also in the future as the quotes below explain:

> “I see the value of self-declared claims and labels [set for products] to decrease in the future because reporting requirements will become stricter no matter what happens to CSRD and Omnibuses.” (G)

> “In the future developments [referring to CSRD and verification developments that affect eco-product portfolios] I see increasing demands for neutrality, possibility to compare, clarity, and an increasing demand for concrete claims and evidence.” (H)

However, many interviewees also expressed uncertainty if and how reporting regulations will in the future affect eco-product portfolio formulation. Many interviewees noted reporting regulations, such as the CSRD, to be in midst of turbulence with Omnibus initiatives causing uncertainty of who the standard will affect in the future. The quote below illustrates how the interviewees described the regulatory uncertainty and the frustration caused by it:

> “It is very frustrating that first you prepare for something [referencing to CSRD], and then that doesn’t come and then you have to think what is relevant for who, CSDR, VSME or what?” (G)

Additionally to CSRD and ESRS, interviewee F mentioned the Sustainable Finance Disclosure Regulation (SFDR) to affect eco-product portfolio formulation in the context of investor expectations cascading down to product-level sustainability performance. While SFDR primarily targets financial market participants, the standards reflect into disclosure requirements of eco-product portfolios.

In summary, the mentioned reporting regulations – CSRD, ESRS and SFDR – were seen as a central mechanism that indirectly shapes both the formulation and communication of eco-product portfolios by enforcing transparency and traceability of environmental performance.

Communication regulations

Regulations affecting communication of eco-product portfolios were frequently mentioned. The regulations were described to regulate how companies can credibly and legally present their eco-product portfolios to stakeholders. These regulations were highlighted to set requirements to communicating sustainability of eco-product portfolio products via eco-label usage or claims creation. The Green Claims Directive – which is currently under negotiation – was mentioned by all others but one (interviewee H) to be a key upcoming regulation. Green Claims was described to require companies to substantiate environmental claims – such as "eco-friendly" or "low carbon" – with scientific evidence and, in many cases, third-party verification. Green Claims was described to directly affect how eco-product portfolios can be labelled and marketed, ensuring that claims are not misleading and are based on robust data as the below quote illustrates:

> "I think Green Claims will come to show so that you can't say those kinds of vague, roundabout claims anymore. […] The regulation would intervene so that companies doesn't end up saying 'Here is our greenlined collection' and same time having no idea what that means." (F)

Green Claims Directive was described to be a welcomed regulation to bring clarity to uncertain sustainability claims field full of variance in ways of working. However, similarly to the reporting regulations, the interviewees expressed uncertainty regarding the future of Green Claims. The interviewees differed in their expectations regarding whether the directive will be adopted. The quotes below illustrate how for instance interviewee D described there to be a chance for it to be adopted while interviewee C described it already fallen through:

> "If you think about the Green Claims Directive, which is still in the political process […], it was described by my colleagues in Brussels, to be in a kind of fifty-fifty situation in that whether it will come through or not. […] It's very hard to say what will happen to the Green Claims Directive." (D)

> "We had high expectations for the Green Claims Directive, that it would be the development we've been waiting for, as it has been on the table for many years and would have provided a fairly comprehensive umbrella for these sustainability claims. Now it fell through." (C)

In line with this, Interviewee G expressed concern that, should the Green Claims Directive not be adopted, companies may assume that anything goes:

> "Challenge is that Green Claims got a lot of media attention, and now if it doesn't come, business tend to think anything goes." (G)

Because of the uncertainty around Green Claims directive, interviewee G highlighted that it's important to remember that the Unfair Commercial Practices Directive (UCPD) still sets requirements for making sustainability claims. Additionally, the Empowering Consumers for the

Green Transition Directive (EmpCo, entered in force in 2024) was mentioned by interviewees D, G, and I to have updated the UCPD. EmpCo was described as the legal base for the current regulation of environmental claims via prohibiting vague or unsubstantiated claims and requiring companies to provide accessible evidence, such as through QR codes or online disclosures. Interviewees emphasized that while EmpCo rules are formally aimed at B2C markets, they are increasingly relevant in B2B contexts due to rising stakeholder expectations.

Overall, communication regulations – Green Claims, UCPD, EmpCo – were seen to set requirements to eco-product portfolio claim creation and eco-label usage. In this way, these regulations are seen to affect the formulation of eco-product portfolios now and in the future.

Product development and product sustainability calculation regulations

Regulations affecting product development and sustainability calculation of eco-product portfolio products were mentioned less frequently than reporting and communication regulations. These regulations were discussed in relation to how they affect defining the environmental performance criteria that products must meet to be included in an eco-product portfolio. The Ecodesign for Sustainable Products Regulation (ESPR) – mentioned in interviews B, C and E – was described as a major upcoming regulatory framework that will set mandatory requirements for eco-design of products. The below quote from interviewee B describes these requirements:

> "ESPR creates an overarching framework that includes prioritized product groups considered particularly challenging or impactful [in terms of sustainability]. To these groups ESPR sets general product design requirements, such as recyclability and reusability. It also establishes delegated acts for priority products at the product-group level […] setting very specific requirements, for example requiring the calculation of a PEF. In this way, the two [ESPR and PEF] are linked to each other." (C)

A key component of the ESPR framework, The Digital Product Passport (DPP) (mentioned in interviews C and E), was described as a tool that supports transparent communication of product-level environmental data. The quote below from interviewee C describes the uncertainty around DPP:

> "The passport would then provide the relevant information not only about energy efficiency but much more broadly from the perspective of the product's circularity and its impacts. But the Digital Product Passport is a bit of a tricky concept; expectations for it are huge. However, how it will actually be integrated into the product and what information it should contain is still evolving." (C)

Interviewee C further elaborated on the current turbulence within the EU, which makes it difficult to predict exactly how ESPR and DPP will be implemented. Nonetheless, the interviews described

it evident that the revised ESPR will be more comprehensive than its predecessor, which was limited to energy-related products and prompted companies to focus on communicating their products' energy efficiency. Although that ESPR including DPP will certainly affect the requirements for products in eco-product portfolios, the interviewees were not sure how – this due to the EU's regulatory uncertainty.

Another regulation framework affecting the product development of eco-product portfolio products is the EU Taxonomy's Do No Significant Harm (DNSH) principle (mentioned by B, F, I). The EU Taxonomy and DNHS were referenced as determining whether a product's environmental impacts are within acceptable limits which influences selection of product into eco-product portfolios. Indirectly, the taxonomy and DNHS may influence then product development if the selection criteria of eco-product portfolio guide the innovation process of a company. As an example, interviewee B described that the Taxonomy introduces requirements for disassemblability or recyclability of a product. These requirements then become a part of the selection criteria for products to include them in an eco-product portfolio. If these criteria are additionally used to guide product development, the Taxonomy requirements indirectly influence a company's product innovation.

Additionally, the Product Environmental Footprint (PEF) methodology (mentioned in interviews C and E) was discussed possibly affecting eco-product portfolio formulation. PEF is a standardized LCA tool that helps to quantify environmental impacts across multiple categories. The below quote explains further how PEF guides the creation of environmental claims from a lifecycle perspective:

> "PEF has been under development for 15 years, and its purpose is to provide very detailed, product-group-specific guidance on how to make these environmental claims from a lifecycle perspective: what data must be used, how to make allocation decisions, and how to structure the entire modeling. […] It is much more precise than an LCA ISO standard." (C)

In this way, PEF supports both product development and claim substantiation related to eco-product portfolios. The EU Battery Regulation – mentioned in the interviews A and E – was discussed as an example of evolving regulations that set strict carbon footprint and lifecycle requirements for products. These requirements include mandatory use of the PEF method for environmental impact calculation. In this way, the EU Battery Regulation may, like PEF, affect the requirements for selection criteria of eco-product portfolios.

Although PEF was recognized as providing valuable guidance for the assessment of environmental impacts of products, also the regulatory challenges of it were highlighted. Specifically, interviewee

C described the development of guidance to each product group to be resource-intensive and time-consuming. The interviews identified that the development of the category guidelines in PEF has already started for some B2B manufacturing products such as certain metal components.

Altogether, these regulations were described to affect the technical and environmental thresholds that products must meet to be considered part of a credible eco-product portfolio. However, some interviewees described that the regulation around product sustainability assessments in heavy manufacturing side is inefficient: More regulation would be needed to harmonize product sustainability assessment practices as the quote below summarizes:

> "In my work, in the equipment site it is quite visible that really there isn't any regulation. […] There absolutely is a need for regulation now that […] everyone is doing it [product sustainability assessments e.g. LCA or supplier checks] with different methods." (B)

Supply chain regulations

Supply chain regulations were mentioned in relation to how upstream sourcing and material traceability influence the credibility and eligibility of products within an eco-product portfolio. The EU Deforestation Regulation (EUDR) – mentioned solely in the interview A – was cited as a regulation that requires companies to ensure that raw materials like timber or rubber are not linked to deforestation. Thereby A described EUDR to affect which products – e.g. those that are not linked – can be included in an eco-product portfolio.

Lastly, the Corporate Sustainability Due Diligence Directive (CSDDD or "Triple D") was mentioned in interviews B and D as a regulation framework that would require – if came to be enforced – companies to assess and mitigate environmental and human rights risks in their supply chains. The quote below notes how experts referenced preparing for CSDDD important:

> "CSDDD that was at some point coming would require companies to know about their value chain […] and that is something that companies should start preparing for." (B)

The requirements of CSDDD toward company's supply chain management could affect what is required of eco-product portfolio products – supply chain management might become a required criteria for any products claiming to be sustainable. In summary, the regulations related to supply chain management were seen as expanding the scope of eco-product portfolio formulation beyond the product itself to include the environmental integrity of its components and sourcing practices. In summary, supply chain regulations were viewed as critical for ensuring that eco-product portfolios are not undermined by unsustainable or non-compliant upstream practices.

Overall, the key regulations identified by the interviewees span four key dimensions of eco-product portfolio formulation: reporting, communication, product development and sustainability calculations, and supply chain management. Reporting and communication regulations – particularly CSRD and the anticipated Green Claims Directive – were emphasized most consistently, reflecting their central role in shaping eco-product portfolio formulation. Regulations related to eco-design and supply chains were mentioned less uniformly, indicating varying degrees of regulatory relevance to eco-product portfolio formulation. To navigate the regulatory landscape and build trust in the sustainability claims of eco-product portfolios, companies seek verification for their portfolio-level claims. The following section examines these verification practices.

5.2 Verification characteristics

The interviews conducted for this thesis also provided insights into the characteristics of eco-product portfolio verification, focusing on how sustainability claims are assessed. This section 5.2 presents the verification-related insights derived from the interviews in the order presented in Table 9. Firstly, section 5.2.1 outlines the general trends identified in eco-product portfolio verification. Secondly, section 5.2.2 describes the verification requirements for eco-product portfolios, followed by section 5.2.3, which examines the verification process. Lastly, section 5.2.4 discusses the role and value of verification in the context of eco-product portfolios.

Table 9: Characteristics of eco-product portfolio verification

Verification characteristics	General trends	• Lack of standards and harmonized practices > Variety of practices, evolving field • Harmonizing in future, more standards
	Verification requirements	• Depend on level of verification: CSRD report vs. Product standards • Evidence and documentation (e.g. Clear system boundaries, calculation method and data source) • Services inclusion to portfolio
	Verification process	• Process from method and data review to audit for confirmation • Scope and limitations of verification
	Role & Value of verification	• Role as gatekeeper & police • Value through credibility & quality • Importance of competence

5.2.1 General trends in verification

The sustainability claim verification field – in which companies' compliance to sustainability related regulatory requirements and standards is confirmed – was described as an diverse and evolving field, with practices differing widely across companies. The experts highlighted consistently fragmented verification practices due to the regulatory unclarity (illustrated below in quote F) and uncertainty (illustrated below in quote A):

> "When talking about verification of sustainability reports, it is a very young field where practices and capabilities are evolving both in reporters and verificators. […] Compared to product-level verification where ISO standards are relatively easy to read, looking at CSRD standard nobody would know how to read that […] meaning it [what to verify against] already being interpretative leading to differences in understanding it, and then, to varying verification practices. This explains the difference seen in current sustainability reports." (F)

> "Big directives are affecting and will affect the verification: What we're going to verify, on what level and from which companies is going to continue to change until there's a clear guideline from the EU." (A)

The lack of regulation and fragmented verification practices has allowed companies to define largely for themselves the selection criteria into an eco-product portfolio as illustrated in the quote below:

> "If there would be a standardized way to verify, there could be some limitations [of what companies can define as a sustainable product] […] now it's a bit of a grey zone." (B)

Due to lack of regulation and harmonized verification practices of product-level sustainability claims, trust among stakeholders in the claims also lacks as the quote below summarizes:

> "The value of verification depends on how robust the set of rules against which the third party verifies is. […] Unfortunately, it [verification] doesn't always inspire trust for reader because of the lack of general rules." (C)

However, a trend toward future harmonization was highlighted. As regulatory frameworks mature, common standards are expected to emerge. For instance, interviewee H anticipated that after the initial adjustment to CSRD, the verifying practices of sustainability reports will harmonize:

> "The first year has been the most challenging, and now the second round has opened resources to look again the reports to see what was missed in the first round." (H)

Therefore, also the eco-product portfolios' sustainability claims disclosed in these reports may also be expected to harmonize. In summary, eco-product portfolio verification trend is characterized by considerable variation in practices. This variation, driven by the lack of harmonized regulations and

standards, has contributed to reduced trust in the verification of product-level sustainability claims. However, as stricter, more standardized norms are likely on the horizon, verification practices are predicted to harmonize in the future. In conclusion, the expert advised companies to prepare resources to refine their eco-product portfolio criteria and claims when verification practices evolve.

5.2.2 Verification requirements

When discussing what requirements eco-product portfolios need to meet to be verified, interviewees emphasized requirements to depend on level of verification (report vs. product) and requirements to demand clear evidence and documentation. Additionally, the verification practice regarding inclusion of services to eco-product portfolio was discussed. First general dimension described by interviewees was that verification requirements can differ by context. This was also reflected in the distinct topics discussed by interviewees, depending on their experience in either report or product verification. At a reporting level (e.g. CSRD report), verification often provides limited assurance – a broader, risk-based check that is "not detailed", but requires information to be balanced, neutral, concrete and comparable:

> "A report provides limited assurance verification, so the purpose is not to scrutinize everything in depth. It is risk-based. […] In materiality definition and risk assessment, the focus is on areas that need closer examination. […] Product-level sustainability claims are definitely a risk area, and exactly the kind of things reviewed in sustainability reports." (H)

In contrast, product-level verification was described usually to follow specific standards (like LCA standard by ISO) for each claim. When talking about requirements of verifiers for eco-product portfolios, interviewee F described product-level verification to be simpler than report-level:

> "It is good to distinguish between product-specific verification and report verification. For products, standards are followed strictly, and it is very straightforward compared to the reporting world." (F)

Second and most strong dimension described by all interviewees was the requirement for clear evidence and documentation:

> "Starting point is that everything you say, you need to be able to prove." (G)

> "As a company, you should always have some kind of things to back up the claim. Empty claim with nothing behind it, is never a good idea." (A)

> "Verifier works as a gatekeeper […] who block weak or light claims from reports so that there's only product information with factual base." (H)

> "In order to genuinely say that we have a product more responsible than a standard one, for it to fly and be credible, there must be sufficient evidence for each product. What is sufficient, then, depends on company and sector." (I)

This was seen central to eco-product portfolio verification regardless of the level on which verification is conducted. A recurring point was the need for definitions for vague terms, well-defined system boundaries, calculation methods, and data sources for every claim:

> "You have to exactly define what you understand as more sustainable or low carbon. For example, low carbon means 40% better than Zinc association average value. This is then low carbon for your company. […] When you say exactly the system bar, nobody can claim anything against you."

> "During the assurance process there almost always comes up something that we ask company to specify or make clear […] and sometimes they just don't have the data to the claim they are trying to make. And of course, we can't verify something that isn't supported by data." (A)

> "LCA and derived EPD or product declaration is the best and most clear evidence [for eco-product portfolio selection]." (I)

Additionally, the need for proof to be up to date and claims to be clear statements with concrete targets was highlighted by interviewee A. Fluff and fancy words will not go. Also, interviewee H highlighted that small sustainability improvements must be reported with honesty about their magnitude as neutrality and balance is one key requirement for the reports and verification:

> "Sustainability information is not a marketing tool. They should be reported as balanced than you report your financial statements." (H)

All interviews underscored that every sustainability claim must be backed up with data or analysis. Clear, transparent and comprehensive documentation and evidence therefore is the key requirement for eco-product portfolio formulation, documentation and communication. This means that eco-portfolio criteria and indicators should be documented with transparency and precision to satisfy third-party scrutiny.

However, how these requirements relate to services was a topic of conflicting opinions among the interviewees. The verification requirements for sustainability claims of services lifted a lot of conversation. Especially, interviewees conflicted in their views on whether the mere nature of a service (for example, a maintenance service that prolongs a product's life) is sufficient for including the service into an eco-product portfolio, or if specific evidence of service's environmental benefit is required. All participants noted that verifying such claims is difficult in the absence of clear standards or regulations, leading to varied interpretations. Responses ranged across a spectrum:

some felt that a service's inherent characteristics could be acceptable proof of its eco benefit, others insisted on concrete evidence case-by-case or by product group of environmental impact. Many described that the evidence required depends on what is claimed and what service is in question. These differences underscore how, without standardized guidelines, verification practices can diverge by subjective interpretations.

One interviewee leaned toward the view that the nature of the service itself can justify its inclusion—provided the rationale is clearly explained. Interviewee H described if a service inherently contributes to extending a product's lifecycle or reducing its environmental impact, a well-founded explanation of that effect might suffice for verification. Interviewee H also highlighted the difficulty of it being a fine line between what is universal truth, and what knowledge needs evidence suggesting that articulating how a service naturally prolongs a product's life or saves energy could be enough without calculations to back it up, if the reasoning is strong enough. In other words, when the sustainability benefit of the service is intuitively evident and well-argued, detailed quantitative proof may not be necessary.

On the other hand, many other interviewees contended that tangible evidence is necessary to validate a service's environmental benefit before adding it to the eco-product portfolio (A, B, C, E, F, I). Interviewee A described how any sustainability claim about a service should have proof to back it up. Interviewees differed in how strictly proof should be provided. Interviewee E, for example, argued that services must demonstrate proof of lifecycle extension or efficiency improvements, but not for every individual case – evidence should be provided at a product-group level (e.g. long-term maintenance records showing an overall increase in product lifespan). In comparison, Interviewee I highlighted specifically that in eco-product portfolio selection, case specific calculations are crucial. The performance of equipment should be compared with and without provision of a service or parts. Claim was described to be weak if, for example, the lifecycle prolonging is not measured case by case.

Interviewee B took the strictest approach and described how offering such as repair services is the industry standard, and sustainability should be defined as what additional value you can bring with your products, assessments or criteria:

> "In my opinion, if we're talking about sustainability, you have to have more than that equipment can be repaired and you have spare parts for it." (B)

However, interviewees C and F noted that benefits of services can be hard to quantify. Interviewee F talked about difficulties of quantifying services environmental impact framing it to be the best to

define service-specific emission factors or calculating the carbon footprint associated with services. Interviewee C continued referring to their experience in B2B manufacturing company and elaborated how companies should investigate more quantifying the sustainability impacts of services:

> "Here would be a good project for companies to think how to define services and how to get closer to possibility to show concrete impacts better of services." (C)

In summary, expert opinions on including services in eco-product portfolios highlight a divide between those who accept well-argued, intuitive benefits and those who require concrete, standardized evidence, underscoring the ongoing need for clear criteria and verification practices.

5.2.3 Verification process

The interviews shed light on how verification of eco-product portfolios is carried out and its inherent limitations. Verification can be carried out as report-level or product-level verification. Also, verification was described to have two sides: Verification against existing regulation or standard, and verification of company's own methods. If verification follows standards, verifiers describe them to simply look at the requirements of the standard and compare that to the company's process. The standards mentioned for product sustainability verification were ISO 14040/14044 (LCA) and ISO 14067 (CPF). Interviewees (D, F, G, H, I) also highlighted that challenges arise in verification when companies use self-defined criteria without standard references. Interviewee E also noted that on top of verification, companies sometimes ask for reviews of their sustainability claims – which leads to recommendations rather than verification.

For verification, typically, the process was described to start with a thorough review of data and methods, followed by an audit to confirm everything aligns with the claim. The review of data and methods has several perspectives:

> "For verification you [companies] have to generate a report with the data use. Then we verify the calculation model […] where does the data come from, is the data measured and in which form, and how data is used in the calculation model. […] We look into your calculations if everything is done correctly." (E)

Interviewee A and H described the review and audit process of verification very similarly summarizing and detailing what other interviewees also described. The process was described as follows. Process starts with understanding client's process and their business. Here, interviews are conducted with relevant people. Then, if product claims rise in the report, verifiers focus on understanding the data collection and selection criteria. Focus is on credibility and clarity.

Next is auditing where the verifiers interview key people, trying to see if they understand what they are claiming. Additionally, the documentation of how the data is produced is checked. This means confirming on what the claims base on, and if the claims are understandable, concrete and proven. It was described crucial that in the process it's checked if the data and claims match. In limited assurance, verifiers were described to do sample checks on the data rather than go through all the data. If something arises that verifiers do not understand, they go back and interview the customer. After interviews and sample checks, verifiers have "analytical measures" which means checking if a claim is represented in the report in a right ratio considering the whole business, volumes and impact. If a claim is vague or overhyped, it may be rejected or challenged. The whole process is described based on risk management, where unverifiable or exaggerated claims in reports are raised as areas of concerns.

Interviewees cautioned that verification has a bounded scope. Crucially, verifiers do not judge whether a claim is "sustainable enough" – they only ensure the claim is truthful and complies with the chosen method or standard. Another practical limitation is how exhaustive the verification is for the provider and customer. Often, not every single detail is checked. One interviewee described how there's always a need to prioritize and everything can't be verified openly questioning:

> "Is it necessary that every number and detail is verified?" (B)

suggesting that verification should focus on the most material elements. Indeed, due to resource constraints, verifiers tend to prioritize high-risk or high-impact claims rather than verify everything exhaustively. For eco-product portfolio formulation this means setting up claims and data such that verifiers can efficiently review the most important categories. It's wise to use well-established calculation standards (ensuring the verifier isn't just validating a "homemade" method) and to be aware that verification will confirm accuracy but not push the company to higher ambition – that part must come from company's own strategy.

5.2.4 Role and value of verification

The interviewees saw third-party verification as a crucial "gatekeeper" that creates credibility to an eco-product portfolio. Interviewee H emphasized the gatekeeper role of the verifier in corporate reporting, noting that they challenge claims, especially high-risk product claims, and only let through those with solid backing. In the absence of verification, companies might be tempted to make bold claims with little substance, which can erode customer trust in the portfolio. One interviewee described verification bodies as "police" of green claims:

> "If everyone followed the law, then no police would be needed." (G)

In other words, because not every company is honest or competent in its sustainability disclosures, independent verifiers are needed to enforce fairness and prevent a "wild west" of unsubstantiated eco-claims. Interviewee G notably pointed out that companies may sometimes make claims without adequate evidence unintentionally, indicating that greenwashing is not always deliberate. This underscores the critical role of verifiers in pointing out blind sports and ensuring impactful sustainability actions. When done properly, all interviewees described verification to add tremendous value through increased credibility and quality assurance:

> "Especially if there is no sector rules like official EPD requirements, verification carries significant role and provides a quality stamp [for your evidence and portfolio]." (I)

Crucially, few interviewees pointed out that verification reliability can depend on the competence of the verifier. Verification adds credibility, but must be done by experts familiar with the industry and processes:

> "You need to have someone who understands the process behind it [verification object] […] Sometimes I feel there's no experts at all, and then verifications loses value." (E)

Interviewee F similarly emphasized when making a comparison to financial auditors auditing CSRD reports without the understanding of environmental issues that most important would be that the verifier had the competence to properly do the verification. Results of how interviewees describe the role of verification indicate that eco-product portfolios that are independently verified would strengthen the portfolio's legitimacy, functioning as a trust signal to skeptical customers and an assurance of quality to internal and external stakeholders.

5.3 Strategic considerations

The strategic considerations for companies formulating eco-product portfolios were identified in the interviews. Emerging themes were categorized in the analysis into eight strategic consideration categories (Table 10). Each category contains strategic considerations for the leadership and employees involved in formulating eco-product portfolios. Considerations cover a wide range of themes and have implications for several business functions such as R&D, marketing and legal.

Table 10: Strategic considerations for eco-product portfolio formulation

Strategic considerations	Strategic purpose, ambition, and proactivity	• Set a purpose and an ambition level for eco-product portfolio • Consider how to position the eco-product portfolio in relation to the rest of the portfolio • Align eco-product portfolio to strategy: Proactiveness needed to be leader in sustainability • Ensure leadership commitment and awarness
	Vigilance on regulation and periodical reviews	• Regulation evolves > Keeping ears open and reviewing portfolio regularly against regulation and market practice • Criteria based on measurement through time; Driving more sustainable products
	Strong and transparent evidence and documentation	• Use existing frameworks for calculations (LCA, PEF...) • Calculations methods vary: Document clearly if using own • Document uncertainties, choices and assumptions in detail • Ensure external verification of claims
	Communications: Transparent, comprehensive, clear and precise	• Avoid vague, binary & cliché terms (Eco-friendly, sustainable...) use precise, factual & impact-driven statements – Details and accuracy resonate with consumers • Provide definitions of key concepts and criteria - risks of jargon and assumptions of knowledge • Communicate contextual strengths of sub-portfolio vs. Clear comms on sustainability of all products • Think first, communicate later: Communicate only what you 100% can promise • Transparency about improvement areas and limitations

	Collaboration: Cross-functional and stakeholders	• Alignment and implementation cross-functionally • Seeking stakeholder input on criteria selection; Customers, Researchers and industry
	Market practice, demand, and risks	• Ensure criteria reflects best market practice • Ensuring criteria works in and meets expectations for all markets
	Caution in comparative claims	• Comparisons against competitors have a high-risk of being inaccurate or misleading • Base on existing methods: LCA, PEF • Focus on how your product brings additional value and enables differentiation
	Holistic, lifecycle-based, and relevant criteria	• Three pillars (people, planet and profit) of sustainability considered • Supplier responsability included to criteria • Criteria should consider all lifecycle phases: Include use-phase and end-of-life • That which criteria dimensions are relevant depend on the industry and the product

5.3.1 Strategic purpose, ambition, and proactivity

The first key consideration is ensuring the eco-product portfolio has a clear strategic purpose that aligns with the company's overall goals. As interviewee E put it, companies should reflect the thought of "We are here, but where do you want to go?" when formulating eco-product portfolios. This refection focuses on the purpose of the eco-product portfolio – is it used for transforming the business toward sustainability or a mere marketing tool? The interviewees stressed that companies should define the eco-product portfolio's purpose and targets up front, positioning the "eco" sub-portfolio in relation to the rest of the product offering. Importantly, companies should ensure that sustainability is embedded into the whole product portfolio instead of to only eco-product portfolio. Interviewee G was the strictest in pointing out the criticality of these strategic considerations as the quote below shows:

> "You are not sustainable, if your whole portfolio isn't." (G)

Communication experts (D & G) warned to the same breath that accidently positioning the eco-product portfolio as “sustainable” and rest of the offering “non-sustainable” can create an unfavourable image of the company. Unfavourable, as it implies that the majority of the offering is unsustainable, with sustainability limited to products in the eco-product portfolio. Therefore, positioning was highlighted as a strategic consideration and eco-product portfolio recommended to be highlighted for example as including the best performing products in regard to sustainability. Additionally, the interviewees stressed that it should be ensured that a company’s stakeholders understand this positioning i.e. the relationship between an eco-product portfolio product and the rest of the portfolio.

When positioning the eco-product portfolio, the purpose and ambition for it needs to be defined clearly. Interviewees highlighted that the purpose of an eco-product portfolios can vary. It can be created to be a mere information or a marketing tool, or it can be a strategic method to transform the business toward more sustainable practices. In practice, defining a purpose for an eco-product portfolio includes setting an ambition level for it. For example, deciding whether a company wants their eco-product portfolio products to lead in sustainability or just meet minimum external compliance requirements. Interviewee D concluded the importance on setting and communicating the purpose and the ambition of an eco-product portfolio:

> “Think carefully about the positioning: explain why such a portfolio exists, what it serves, what its impact is, and whether it is intended to scale. Ensure that customers and stakeholders also understand the minimum level of responsibility across the entire portfolio.” (D)

Additionally, the purpose and the ambition for an eco-product portfolio should reflect, and be embedded, to the company’s overall strategy and goals. In this way companies can avoid a risk of greenwashing as strategy ensures that products are designed and developed to be sustainable from the start rather than only marketed as sustainable. The quote below illustrates the importance of setting parameters for eco-products already in the strategic level to avoid greenwashing:

> "Parameters for products should be set in strategy: Product design and production, and marketing should follow that. […] Biggest risk to greenwash is when only after product development, you think about how to communicate the sustainability of the product.” (G)

In relation to the company’s strategy, the interviewees additionally stressed that sustainability should be integrated widely into a company’s strategy, and eco-product portfolio formulation should only reflect one part of implementing that strategy. If sustainability is not embedded into the

strategic level of companies, eco-product portfolios might end up being a one-off sustainability action as the quote below explains:

> "If sustainability isn't embedded on a strategic level, then inevitably sustainability action will end up being one-off actions." (G)

To embed sustainability into the strategic level, the importance of leadership commitment (quote G below) and awareness (quote B below) was highlighted:

> "If the leadership is not committed to this type of comms [to talk openly about the whole spectrum of sustainability], the organization is not ready for sustainability […] Then you can't ride anywhere with sustainability." (G)

> "In my opinion, the most important thing in sustainability is awareness […] One must be aware of their own actions and developing them in some direction." (B)

Additionally, the interviewees stressed the importance of proactivity in relation to external requirements when embedding sustainability into the strategic level. Especially, when defining a purpose and ambition level for an eco-product portfolio on a strategic level, going beyond regulatory and verification requirements was seen crucial. This was because external requirements were seen lacking the power to drive true sustainability in companies. Therefore, being proactive and choosing a high ambition level were seen as key factors for businesses to drive sustainability of their business via eco-product portfolios.

The choice between a proactive and a reactive approach was described as a strategic leadership decision where companies choose a stance – whether to proactively exceed regulatory requirements or simply react once rules are in force. Especially, when setting a purpose and an ambition level for an eco-product portfolio, choosing proactivity means to choose to go beyond the evolving external requirements by setting a higher ambition than required regarding sustainability for the eco-product portfolio. This proactivity, when formulating an eco-product portfolio, was seen as determinant for the success in driving sustainability of a company via eco-product portfolio formulation. Determinant because anticipating future standards and voluntarily going beyond can position a company as a leader of sustainability as one expert succinctly advised:

> "Because everything's changing so quickly, I think it's good to decide on a ambition level. […] Where do you want to sit within the competition? Do you want to be seen as a leader within sustainability? Then you might have to push the envelope yourself as a company and not wait to see what the EU does." (A)

The interviewees indicated that waiting for clear regulations to be settled (i.e. choosing a reactive stance) when formulating an eco-product portfolio may cause a firm to fall behind. By contrast, a

proactive stance – such as adopting rigorous selection criteria and demanding strong evidence for inclusion – was seen as both a risk mitigation tactic and a competitive advantage.

Furthermore, Interviewee D noted that going beyond legal requirements is crucial for financial risk perspective. To illustrate this, interviewee D described that if a company would make a sustainability claim related to the materials of a product without clear evidence, the company would undermine their client's integrity and introduce risks for clients further down in supply chain. Even if such claim would be legally permissible, the company making the claim might face negative consequences in form of losing business and trust of customers & investors. This illustrate how going beyond the legal requirements when creating claims during eco-product portfolio formulation is crucial from a financial risk perspective. Furthermore, market forces (e.g., investor pressure and client expectations) are already rewarding companies who proactively aim for robust processes and transparency for sustainability as the two quotes below explain:

> "I think also the investment side shouldn't be forgotten […] you can, for example, get better loans if you follow some sustainability targets […] remembering that it can affect your financials positively if you are a bit more transparent and a bit more ambitious, it's good to remember." (A)

> "Nowadays, if you say something completely nonsense, then the market will remind you for it afterwards." (F)

In summary, a proactive approach when setting a purpose and ambition for an eco-product portfolio should be a strategic consideration. Additionally, by focusing on the dimensions described in this section related to the strategic purpose and ambition of an eco-product portfolio, companies can position as sustainability leaders, reap financial benefits and manage risks. Thus, the key conclusion for B2B manufacturers who are formulating eco-product portfolios and are looking to be a sustainability forerunner is to set an ambitious, compliance-plus purpose for their eco-product portfolio. Additionally, this purpose should be supported through clear positioning, strategic integration, and demonstrated leadership commitment to sustainability.

5.3.2 Vigilance on regulation and periodical reviews

Another strategic consideration for eco-product portfolio formulation was to consider staying vigilant toward evolving regulations while formulation and continuous development of the portfolio. Companies were advised to regularly review their eco-product portfolio selection criteria against new requirements and market practices. Because sustainability regulations and standards are rapidly evolving, experts advised keeping "ears open" to legal changes both in EU and in the

countries a company export to. Vigilance was described critical both to maintain market leadership (below quote C) and to avoid risks (below quote E):

> “If products are claimed to be spearhead products, the spearhead is lost if it becomes the minimum legal baseline.” (C)

> "If you don’t follow the regulation development in different countries where you export to, then you might have a problem later." (E)

In the formulation of an eco-product portfolio, staying vigilant means establishing a process to periodically audit and refresh the selection criteria and the product-level claims, ensuring they still meet or exceed the latest norms. For instance, reviews are needed to stay on top of evolving EU sustainability directives and emerging industry guidelines.

In summary, to exceed latest norms, maintain competitive advantage and a sustainability leader position, vigilance toward regulation on product sustainability was encouraged. This vigilance not only future-proofs the eco-product portfolio against compliance risks but also helps companies maintain leadership by anticipating changes rather than scrambling to catch up.

5.3.3 Strong and transparent evidence and documentation

Experts emphasized that any sustainability claim made of products in an eco-product portfolio must be backed by robust evidence and documentation (see e.g. section 5.4. *Verification requirements*). The interviewees advised to consider using established frameworks for environmental calculations – for example, Life Cycle Assessment (LCA) or the EU Product Environmental Footprint (PEF) method – to quantify product sustainability impacts. In this way, evidence for the claims made of company’s eco-products would be strong.

If a company still would want to develop its own calculation methods, the interviewees advised to document all assumptions, system boundaries, and data sources transparently. Several experts noted that these self-defined calculation methods vary significantly which makes it crucial to clearly explain how the metrics and the data are derived. This is particularly the case when calculations differ from commonly used standard methods. Uncertainties or choices – such as cut-off criteria or impact weighting – should be openly recorded, so that the claims remain credible and can be understood by stakeholders. The consistent advice from experts was for companies to have strong and transparent evidence and documentation to prove their eco-product portfolio’s sustainability claims, as illustrated by the quote below:

> "Verificators want to know how calculations are done: Material volumes, units of measurement, is data estimated or measured with 100% trust, data sources (active vs. primary data), who has collected it. […] Overall data collection needs to be documented: Especially if it involves assumptions or exclusions […] relating to how environmental impacts are chosen, defined and measured. […] Documentation is everything." (F)

The importance of strong and transparent evidence and documentation was highlighted due to the litigation risk involved, as pointed out in the quote below:

> "There's lots of suing going on there [making sustainability claims without proof]." (E)

In summary, companies are recommended to build their eco-product portfolios on a strong foundation of evidence and traceable documentation, ensuring that every claim can be proven – and the proof communicated.

5.3.4 Communications: Transparent, comprehensive, clear, and precise

The strategic considerations regarding the communication of an eco-product portfolio to customers and stakeholders were highlighted consistently. Especially, the communication experts G & D stressed the importance of well-planned communication practices. The advice was for companies to avoid vague or cliché terms in their eco-product related claims. Words like "eco-friendly," "green," or "sustainable" was described to mean little unless clearly defined. Therefore, communication of eco-product portfolios should aim to be precise and fact-based, highlighting the concrete environmental impacts or improvements of the products in the portfolio. This argument was supported, for example, by Interviewee D, who referred to research in the B2C eco-label domain demonstrating that impact-driven claims resonate most strongly with customers. Interviewee D continued the line of thought with below quote describing how also B2B companies should strive for impact-driven communications of their eco-products:

> "Show the impact directly, and it doesn't require the words 'sustainable' or 'ecological', nor any leaf or globe icons. Let's get straight to the point and talk in detail about what we mean." (D)

The interviews highlighted the importance to provide definitions for any key concepts or labels used in the portfolio criteria. Only this way, the audience understands what qualifies a product for selection into an eco-product portfolio – e.g., what threshold of emissions the products in eco-product portfolios need to fulfill. Sometimes companies were described to be blind to their own knowledge assumptions which lead to using language that might seem like jargon to others (quote G below):

> “What’s self-evident to those in the bubble sounds like empty buzzwords to an outsider." (G)

Moreover, experts noted that companies should be transparent about the contextual strengths of their eco-product portfolios. This means they should explain in what context or compared to what baseline the products in the eco-product portfolio are more sustainable. Communicating the contextual strength is important to create understanding of the sustainability of the overall product range as quote below illustrates:

> "If you have a separate eco-product portfolio it raises the thought of ‘what then are the other products?’” (G)

Communicating the strengths in context of the whole product portfolio helps to prevent customers from wondering if the other products outside eco-product portfolio are non-sustainable. Another consideration related to communication of eco-product portfolios was to think first, and communicate later that what you can 100% promise as illustrated by the quote below:

> “I would communicate that where I’m 100& sure: If you want to communicate results of CO2 [of product emissions], just do it first internally, do the verification, check it, and then go ahead. It’s too dangerous to say something if you are not sure.” (E)

The danger to say something that a company is not sure of relates to the increasing awareness of B2B customers on sustainability issues as quote below describes:

> “Procurement functions, also on the B2B side, are increasingly aware of what can be expected from those [product sustainability] claims and, in a way, their ability to apply source criticism is strengthening.” (G)

This increased awareness highlights the need to be 100% sure of what you communicate. In practice, this means also that the marketing material or the sustainability reports should never oversell or over-promise environmental benefits of eco-product portfolio products that a company isn’t sure it can deliver. Interviewee H highlighted this by describing that in sustainability reports there is a risk that companies may disproportionately highlight certain products or segments of their portfolio, drawing attention to them beyond their actual contextual value. Instead, companies should consider what is meaningful enough to highlight when communicating something about their eco-product portfolios in sustainability reports.

In summary, the interviews stressed honesty and transparency about limitations and ongoing improvements of their sustainability initiatives such as formulation of eco-product portfolios. Rather than only talking up the positive, it builds credibility to acknowledge what a company is still working on to improve. In summary, transparent, comprehensive, clear and precise communication

– with accurate claims, appropriate context, and no exaggeration – should be strategically considered to successfully marketing an eco-product portfolio.

5.3.5 Cross-functional collaboration and stakeholder engagement

Formulating and implementing an eco-product portfolio is not purely a technical exercise; it requires collaboration across the organization and with external stakeholders. Accordingly, an important strategic consideration for an eco-product portfolio formulation is the collaboration between both the internal functions of a company and the external stakeholders. Internal cross-functional alignment was consistently highlighted as crucial. This means that e.g. sustainability, research & development (R&D), supply chain, marketing, compliance and sales functions should all be involved in setting the criteria and rolling out the eco-product portfolio. This cross-functional approach ensures that the selection criteria for the portfolio are practical (e.g. R&D can implement them), meaningful (e.g. sustainability team ensures true impact), verifiable (e.g. compliance and legal team ensure alignment with regulations), and resonate with customers (marketing and communication team perspective). Below quote describes how cross-functional collaboration was highlighted in the interviews:

> "Best results are gotten when experts from different fields think together, especially already in the strategy phase not in execution." (G)

Involvement of all relevant departments can drive the necessary culture and operational changes for achievement of the goals set for the eco-product portfolio. Beyond internal teams, companies should seek input from external stakeholders when formulating their eco-product portfolios. For example, companies might engage key customers to learn which sustainability aspects they value. On the other hand, industry groups and researchers could be consulted to ensure best practices and emerging standards are considered in the formulation of an eco-product portfolio. Involving stakeholders like customers (quote B below) and academic experts (quote C below) can lend insight into market expectations and enhance the credibility of the criteria chosen:

> “Stakeholders are an important part of defining the criteria, for example by asking what is important to customers.” (B)

> “The most embarrassing thing is if something gets forgotten [when setting selection criteria for eco-product portfolio] […] Bringing in outside academical experts helps avoid the worst slip-ups." (C)

Additionally, bringing in expert opinions can signal to the market that the company’s approach is informed and serious. In summary, when formulating an eco-product portfolio, collaboration

internally and externally was highlighted as a strategic consideration for companies. This would support breaking silos inside the firm and build dialogue with external parties, to ensure the eco-product portfolio is well-rounded, credible, and aligned with internal and external stakeholder needs.

5.3.6 Market practice, demand, and risks

Experts advised that companies should consider market trends and expectations when formulating eco-product portfolios. This consideration encompasses two perspectives. Firstly, selection criteria of eco-product portfolio products should reflect best practices in a market. This means that a company should benchmark what competitors and leaders in the industry are doing. In this way, companies can ensure their eco-product portfolio criteria are at least on par, if not more ambitious than the criteria of competitors. Quotes from interviewee E and I below describe the expert advice to benchmark the best practice on the market:

> "First of all, look at other competitors, and see what they are reporting because that is what I need to report. Also, I would look where I am better than the others, what are the KPIs that I'm good like energy or carbon, and use that as criteria." (E)

> "Even if there is no official standard for the industry, look what the competitors are doing. What is the general way of communicating about the portfolios, and if possible, go beyond that." (I)

Secondly, companies operating in multiple regions need to ensure the eco-product portfolio's claims and criteria work in all target markets. Different markets vary in their regulatory requirements and customer expectations. For instance, what is considered as an acceptable sustainability claim in regulation of a one country might be viewed skeptically in another's as the quote below explains:

> "Consider parameters like which market you are selling to, is there regulation that affect your product? […] The risks and advantages of these markets define your [selection] criteria. For example, if a carbon tax is coming to a market, criteria aimed at reducing energy make sense." (E)

In conclusion, staying attuned to market signals is a key strategic consideration. Tying the eco-product portfolio formulation to market reality – both to the current best practices and to the evolving developments – will help to ensure that selection criteria are relevant, credible, and reduce the risk of backlash or missed opportunities.

5.3.7 Caution in comparative claims

A notable piece of advice described consistently by the interviewees was to be careful when making comparative claims. Instead of comparisons, claims should emphasize each product's unique sustainability features. The interviewees cautioned that direct comparisons between a company's products and those of competitors entail a high-level of risk. Unless there is reliable and comparable data – which is rare as companies calculate sustainability impacts differently or do not disclose all relevant information – such comparisons are inaccurate or even misleading. Interviewee B described the problem with a project where carbon footprints of A4 papers where compared. In the project the interviewee found that the LCA calculation methods varied and so, making comparisons would have been misleading. Interviewee G referred to the same difficulty, and described comparative claims to be very problematic as the quote below illustrates:

> "As talking about vague claims being a problem, any comparative claim is even more problematic times four." (G)

Additionally, interviewee C noted that obtaining reliable data from competitors can be very difficult. Therefore, expert advised that if comparisons are needed, they should be grounded in standardized methods or verification as the below quotes illustrate:

> "So, if you want to compare, I would be very careful as long as this value [from competitor] is not verified or certified. […] you can compare when you know exactly that this is the standard they [competitors] are following. (E)

> "I would compare to generic industry specific averages like from ecoinvent. [a sustainability data base] […] That what I wouldn't do, is compare directly to competitors for marketing purposes." (F)

In summary, rather than focusing on beating the competition on sustainability, companies are advised to consider what makes their product unique in relation to sustainability. The strategic consideration was to have precise claims, built on each product's merits, and to approach any external comparison with caution.

5.3.8 Holistic, lifecycle-based, and relevant criteria

As the last strategic consideration, the interviewees highlighted that the evaluation and selection criteria for an eco-product portfolio should be holistic, lifecycle based and relevant. Holistic in this context refers to consideration of all relevant dimensions of sustainability, not just one metric. The interviewees described that a holistic approach ensures being truly sustainable actor. For instance, measuring only one aspect of a product is not truly sustainable as the quote below explains:

> "In my opinion, all perspectives and overall comprehensiveness must be taken into account in it [setting evaluation criteria for eco-product portfolio products], because if the portfolio's product meet only one aspect, it is not necessarily sustainable." (B)

Following this line of thought, the interviewees mentioned the three pillars of sustainability – environmental, social, and economic – and suggested that while an eco-product portfolio naturally emphasizes environmental performance, companies shouldn't ignore related social (quote B below) nor economic (quote E below) aspects:

> "If a company wants to be a sustainable actor, social responsibility needs to be included. Such as where materials come from, how is the product produced, who is working on the product, in what kind of working conditions and with what salary, or the manufacturing done in a corrupt state." (B)

> "Look from market to market that your portfolio will sell." (E)

Economic viability and social considerations were suggested to be included at least as minimum requirement criteria for eco-product portfolio products due to the risks associated to these dimensions. For instance, if a machine performs excellent in relation to energy efficiency (environmental criterion) but is produced in a way that ignores labor rights or safety (social criterion), the social aspects will undermine the product's claim to sustainability. This would then expose the company who has made that claim to the risk of litigation.

Following the line of thought in the above example, the interviewees highlighted supplier responsibility in relation to having holistic criteria for risk management. The awareness of product's supply chain – especially of where product's materials are sourced from – was stressed as the minimum requirement for the criteria of products that are claimed to be sustainable:

> "'I don't know' is the worst answer – you need to know your suppliers and materials." (B)

The evaluation of product's suppliers needs to be – similarly than the criteria for eco-product portfolios – holistic. This means considering all lifecycle phases and pillars of sustainability in supplier evaluation. The interview findings indicated that both – considering the lifecycle and the three sustainability pillars – are essential to holistic assessment of a product's sustainability. This applies both when the assessment object is a supplier's product or a product in an eco-product portfolio. Accounting for the entire lifecycle – encompassing raw material extraction, production, usage, and end-of-life disposal or recycling – is especially critical. By ensuring that all lifecycle phases are accounted for, companies avoid simply shifting impacts from one stage to another.

Interviewee B gave an example of a holistic approach by presenting their organization's approach to product's suppliers' sustainability assessment which is based on the ESPR regulation and evaluates suppliers in six categories each including multiple evaluation criteria. The separation into six categories is detailed below and shows what a lifecycle-based approach to evaluating products can encompass. The listing below illustrates as an example what criteria can be used also for eco-product portfolio formulation as evaluation criteria:

> **End-of-life & hazardous waste:** Disassemblability, reuse/recyclability of parts, hazardous waste prevention, and waste recovery.
>
> **Use phase & maintenance:** Equipment usability, spare part availability, and maintenance needs.
>
> **Operational resources:** Electricity, water, and chemical use.
>
> **Materials & hazardous chemicals**: Recycled materials, critical raw materials, origin of materials, and hazardous chemical use.
>
> **Manufacturing site & emissions**: Location and origin, fossil energy and fuels, water use, and waste reduction.
>
> **Packaging & transport**: Packaging materials, recyclability, transport emissions, and container fill optimization.

Using similar approach to setting evaluation and selection criteria for eco-product portfolio would ensure that the whole lifecycle of a product is considered. Furthermore, interviewees also stressed that evaluation and selection criteria should be relevant to each product's context. Depending on the product type or industry, different impact areas matter most – e.g., water usage might be critical for a mining machine, whereas recyclability and material sourcing might be key for an electronics component. Interviewees stressed that companies should identify the most material sustainability aspects for each product category and build the evaluation and selection criteria around those. In their expert view, interviewees referred the most prominent or widely recognised aspects for B2B manufacturing product sustainability assessments in general to be responsible procurement, carbon footprint, emission and pollution, energy efficiency, water consumption and circularity aspects:

> "[In the case company's industry] carbon and energy are the most common aspects considered, followed by water and then biodiversity. […] The use phase is often the interesting part for machine environmental aspects." (E)
>
> "One central aspect highlighted is that your loop is sustainable." (A)

However, emissions were clearly the most highlighted by interviewees as being the leading environmental category considered in B2B manufacturing:

> "If you do LCA and there are 25 impact categories, only one is looked at and nobody really looks at the others. They [other indicators, such as the use of recycled materials] are often considered through the lens of emissions." (F)

Therefore, when defining evaluation categories and selection criteria for eco-product portfolio, the interviewees recommended as relevant categories for B2B manufacturing firms GHG emissions, energy use, water consumption and circularity. Additionally, several interviewees noted that the criteria should be tightened over time as measurement capabilities improve and as overall industry performance advances. In other words, companies are advised to use metrics that drive continuous improvement so that the eco-products become increasingly more sustainable over time:

> "Measuring over time can be a more rational [selection criterion] than comparing to other products, meaning that the aim would be always to reduce and further reduce environmental impacts." (C)

Criteria that drive continuous improvement will help ensure that the eco-product portfolios remain relevant. In summary, experts suggested holistic, lifecycle and relevancy considerations for a more robust eco-product portfolio – one that drives improvement thought time and captures the overall sustainability profile of products including supplier sustainability. Including these considerations signals to stakeholders that the company's eco-product portfolio isn't just a narrow marketing label, but genuine action to drive sustainable business and develop offering.

In conclusion, chapters 4 and 5 presented the empirical findings of this thesis outlining key insights from the benchmarking and expert interviews. Chapter 4 analysed the evaluation criteria and selection methods used in the benchmarked sample, revealing a diverse set of approaches and decision-making logics for evaluating and selecting products into an eco-product portfolio. Chapter 5 examined regulatory and verification characteristics as well as strategic considerations influencing eco-product portfolio formulation, highlighting uncertainty related to external requirements and proactivity in response to the uncertainty. Building on these results, Chapter 6 synthesizes the findings in relation to the research questions and discusses their implications from both academic and practical perspectives.

6 Discussion

Due to the limited prior research, there is little knowledge of how eco-product portfolios can be strategically formulated and how they are shaped by external requirements in B2B manufacturing setting. To address this information gap, this thesis set out to explore how B2B manufacturing companies can formulate eco-product portfolios. To answer the main research question, two sub-questions were set: RQ1 examining what selection methods and evaluation criteria are currently used to select products into eco-product portfolios and RQ2 examining how eco-product portfolios are externally verified and regulated.

To answer the research questions, this thesis adopted a qualitative, multi-method research approach. This chapter discusses the implications of the research results for theory and practice. Section 6.1 begins by examining how the research results address the research questions. Section 6.2. follows with an exploration to the implications of the results to regulatory, academic and business actors. In more detail, section 6.2.1 presents the main implication which sets the base for further discussions. Section 6.2.2. continues by discussing the theoretical contributions of this thesis. Section 6.2.3. represents the applied research component of this thesis and presents how the results can be applied into practice at companies who are formulating or refining eco-product portfolios. The application is based on insights derived of the research results and their implications for the development of the case company's eco-product portfolio

6.1 Research results in relation to research questions

RQ1 was answered in this thesis by benchmarking the current practices in eco-product portfolio formulation in B2B manufacturing companies. The benchmarking analysis sample included 54 companies, of which 11 were identified to have an eco-product portfolio. The 11 companies were selected for a deeper analysis to understand the evaluation criteria and the selection methods used to formulate the eco-product portfolios. The evaluation criteria used by the benchmarked companies were categorized into eleven evaluation categories. The categorization revealed that GHG emissions, energy usage and circularity are the most popular dimensions evaluated of products to select them into eco-product portfolios. Other environmental dimensions or social and economic dimensions were revealed to be less often evaluated of products for selection. Additionally, the benchmarking analysis identified three selection methods that are used in variety of ways by the benchmarked companies. The three identified selection methods show that the usage of tools and frameworks in setting the evaluation and selection criteria for products varies.

Taking the results of the benchmarking research together, the current approaches to eco-product portfolio formulation exhibit significant variation. The benchmarked companies were found to use a variety of evaluation criteria and selection methods to formulate eco-product portfolios. Additionally, the evaluation and selection of products into eco-product portfolios was not defined only by environmental dimensions of products. Rather companies used additional dimensions, such as transparency and disclosure requirements, in product evaluation. The variation in the used evaluation criteria shows, firstly, that companies go beyond mere environmental impact evaluation and consider a broader set of criteria for their products for inclusion to eco-product portfolio. Secondly, the variation shows that no single best practice has been definitively established in the field to formulate eco-product portfolio.

RQ2 was answered in this thesis via conducting nine expert interviews that examined the external requirements for eco-product portfolio formulation. The interviews provided insights into both the regulation and the verification characteristics that affect eco-product portfolio formulation. The results regarding regulation revealed, firstly, five general trends – such as uncertainty – in the EU regulatory landscape related to eco-product portfolios. Secondly, the key regulations that affect formulation of eco-product portfolios were found to focus on regulating eco-product portfolios' claim creation and eco-design choices.

On the other hand, the results regarding the verification characteristics of eco-product portfolios revealed two trends. The verification was described as currently lacking standardized and harmonized practices, while at the same time being expected to become more harmonized in the future as regulation and standards evolve. Notably, the verification trends seem to mirror identified regulatory trends which are also described by a lack of standards amid the need for it. Additionally, results revealed what are the verification requirements for eco-product portfolios, such as a requirement for strong evidence and documentation. The results also revealed expert insights on the verification process, and the role & value of verification of eco-product portfolios. These insights shed light into the verification practices and value providing practical information for companies interested in verifying their eco-product portfolios. Additionally, the intervies provided understanding directly to the main research question via expert insights into the strategic considerations to formulating eco-product portfolios. The expert insights were summarized into eight strategic considerations. Next, the implications of these research findings are discussed.

6.2 Implications of research results

6.2.1 Eco-product portfolio formulation determined by firm-specific strategic priorities

Together the research results imply that an approach to eco-product portfolio formulation is determined in B2B manufacturing companies by the firm-specific strategic priorities and ambitions – rather than by the best practice in the industry or regulatory and verification requirements. This is due to the finding of a significant variance in the approaches to eco-product portfolio formulation. If the industry best practices or the regulatory and the verification requirements were the main drivers of formulation, the approaches would likely be more harmonized. Therefore, a central implication of the results of this thesis is that the formulation of eco-product portfolios seem to be determined by firm-specific strategic priorities. Therefore, the results of this thesis inform any interested party – such as researchers and regulators – on what companies currently prioritize to manage and communicate of their products. This information can carry significant implications as illustrated below.

For instance, the identified evaluation and selection criteria used for eco-product portfolio formulation reflect the priorities in sustainability related decision-making in B2B manufacturing companies. To be more precise, the criteria reflect the strategic decision of which product dimensions are seen important to manage and communicate in B2B manufacturing companies. Therefore, the results of this thesis implicate that the prioritized product dimensions to manage in their product stewardship efforts in B2B manufacturing companies who formulate eco-product portfolios are GHG emissions, energy usage and circularity of products. Other environmental dimensions, such as biodiversity, were less featured in the evaluation and selection criteria of the benchmarked companies. This information of the priorities carries implications to both business actors and regulators.

For business actors, the information can be applied to selecting product stewardship priorities. Companies can either follow the identified general practice – i.e. managing products' GHG emissions, energy use and circularity – or they can differentiate themself by addressing additional dimensions beyond these standard areas. For regulators, the priorities indicate the success of the current regulatory efforts. If the primary objective of the current regulations is to drive companies to address the currently prioritized three dimensions, the research results support the effectiveness of existing policies. However, if the objective of the current regulations is to drive companies to manage a broader range of product impact categories, the results imply a need for additional measures. Furthermore, the latter – companies managing a broad range of sustainability impacts – is

essential to achieve truly sustainable business which supports the society's sustainable transformation (see UN 2030 Agenda; Dyllick & Muff 2016). In this way, the results of this thesis support the call for more action from regulators to push companies to take a more comprehensive approach to product stewardship.

6.2.2 Theoretical implications and future research suggestions

This thesis has several implications for academic research. Firstly, this thesis contributes to the product stewardship research field by introducing the concept of an eco-product portfolio as a strategic approach to managing a company's environmental handprint. As the previous literature has focused on integrating sustainability into the entire product portfolio or into the product innovation processes, the formulation of sub-portfolios as an approach for environmental handprint management has remained largely unexplored. This thesis addressed that gap by conceptualizing an eco-product portfolio as a practical and strategic approach to managing environmental handprint and implementing product stewardship. This adds to the theoretical understanding of product stewardship by offering a new level of analysis – sub-portfolios of products distinctive for their sustainability performance – that can be used to operationalize sustainability goals of companies and societies.

Additionally, this thesis advances the product stewardship research by supporting the view of the centrality of a company's strategy and leadership in product stewardship. The results describe how the leadership of companies can support sustainability transformation by formulating eco-product portfolios. The identified strategic considerations highlighted the importance of leadership to set a clear strategic purpose for an eco-product portfolio to guide the processes of its formulation and implementation. This implies the centrality of a company's strategy and leadership for the formulation of eco-product portfolios, and for product stewardship. This implication supports prior research of sustainability integration into the entire product portfolio where the role of strategy in product portfolio development supportive to sustainability transformation is highlighted (Villamil & Hallstedt 2021, 5).

This thesis also contributes to the product portfolio management literature by providing empirical insights into how companies define evaluation criteria and selection methods for sub-portfolios of products. Additionally, the results contribute to the sustainable product innovation literature. The results indicate that eco-product portfolios may influence product innovation processes, particularly when the selection criteria of the portfolios are embedded to guide early-stage product development. While this connection was not the primary focus of the research, it suggests a potential role for eco-

product portfolios in steering innovation toward more sustainable outcomes. In this way, eco-product portfolios are suggested to be further researched both in the product innovation and the portfolio management research fields to explore the characteristics and the implementation practices of eco-product portfolios that could support sustainable business transformations.

The results of this thesis also highlight the practical challenges that companies face when integrating sustainability into their product portfolios, such as uncertain regulatory environments and knowledge gaps. In this context, formulating eco-product portfolios may offer a more feasible entry point for sustainability integration than the full product portfolio transformation. This suggests that the future sustainability product portfolio research should focus on creating understanding of the formulation, implementation and contribution of sub-portfolio of products, such as eco-product portfolio, to society's sustainable transformation.

In summary, this thesis contributes to the prior theory by (1) introducing the concept of eco-product portfolios as a sub-product-portfolio-level approach for product stewardship and environmental handprint management, (2) highlighting the role of strategy and leadership in driving sustainability transformation via product portfolios, and 3) expanding the understanding of approaches that drive sustainability in product innovation and product portfolio management. These contributions offer a foundation for the further research to explore how sub-portfolios of products distinctive for their sustainability performance can support business transformations towards truly sustainable business.

6.2.3 Practical implications to case company's eco-product portfolio

This section applies the research results into practice as implications to the case company's eco-product portfolio. The implications are formed based on combining the research results to the ethnographic observations of the case company's eco-product portfolio. In this way, this section serves as an illustrative example of how the results of this thesis can be applied to practice. Three focus areas are implied for the case company to consider when refining its eco-product portfolio. Firstly, the case company is implied to focus on the strategic decisions related to the definition of the purpose and ambition of the eco-product portfolio. Secondly, the case company is implied to take actions related to the internal and external communication of the eco-product portfolio. Thirdly, the case company is implied to enhance the eco-product portfolio's selection method. This includes developing further the evaluation and selection criteria of the eco-product portfolio. Next these focus areas are further elaborated on.

The first focus area concerns the strategic decisions related to the definition of the purpose and ambition for the case company's eco-product portfolio. The ethnographic observations identified a lack of clarity regarding the purpose of the case company's eco-product portfolio. Therefore, the case company should define the long-term purpose of the eco-product portfolio guided by the insights of the research findings. The findings for instance highlight the importance of aligning the purpose with the case company's broader sustainability strategy and targets. Additionally, the results indicate that eco-product portfolios may serve different purposes varying from a transparency and marketing mechanism to a lever for transforming product development toward sustainability. The results show that eco-product portfolios are not only used for external communication, but also for internal transformation, as they enable companies to set specific targets for a subset of products and monitor progress toward environmental objectives. Therefore, there's a variety of purposes for eco-product portfolios. The decided purpose for the case company's eco-product portfolio should reflect how the case company intends to position itself relative to competitors and evolving external requirements.

If the case company wants to be a true leader in sustainability, it's eco-product portfolio purpose should intend to drive sustainable innovation for maximization of the company's environmental handprint. To enable this, eco-product portfolio's sustainability criteria should be embedded into early-stage product development, not merely used as a gatekeeper after products are finalized. This integration ensures that new products are designed with sustainability performance in mind from the outset. Determining the eco-product portfolio as a flagship initiative for product stewardship and industry's sustainability transformation can further enhance credibility of the case company as a sustainability leader. The purpose to drive sustainable innovation and maximize the case company's environmental handprint enables the eco-product portfolio to be implemented as a strategic instrument for reducing environmental impacts and advancing industry sustainability.

When defining its eco-product portfolio's purpose, the case company must also determine an ambition level toward external requirements – whether to meet regulatory & verification minimums or proactively exceed them. Given the uncertain external landscape, a proactive approach is implied by the results. This includes for example setting evaluation and selection criteria that surpass current requirements for eco-design and ensuring strong evidence and documentation for the portfolio's sustainability claims. These actions position the company as a sustainability leader and future-proofs the portfolio against regulatory challenges and changes.

The second focus area concerns communication of the eco-product portfolio. Firstly, the chosen purpose for the eco-product portfolio must be communicated clearly to both internal and external stakeholders to avoid misconceptions, such as implying that products outside the eco-product portfolio are unsustainable. Secondly, the case company should focus on robust internal communication and cross-functional collaboration to both formulate and implement the eco-product portfolio across the organization successfully. All relevant functions – e.g. high-level leadership, R&D, marketing, sustainability, and legal – should share a common understanding of the portfolio's purpose and criteria.

Thirdly, in light of the research results, the ethnographic observations indicate that the case company could improve the external communication of their eco-product portfolio. For instance, the case company could provide clear, detailed profiles for eco-portfolio products, explaining the selection criteria of the product in question and its environmental benefits. This is the best practice identified in the benchmarked companies. Additionally, the selection method of the products should be clearly stated in external communications supported by visualization of the evaluation and selection criteria. For example, some companies offer an information deck that shows and details the selection method for the portfolio. For the case company, developing similar documentation would not only support internal alignment and verification readiness but publicly sharing the selection logic enhances transparency and stakeholder trust. Furthermore, active engagement with customers and sustainability experts – such as researchers – is an recommended to help refine criteria ensuring they resonate with stakeholder priorities.

The third focus area concerns the case company's selection method which defines the used evaluation and selection criteria. The research results highlight the importance of holistic and lifecycle -based evaluation criteria supported by rigorous evidence. The ethnographic observations imply that the selection method could be developed in relation to these three dimensions. The currently used evaluation criteria of the case company's eco-product portfolio focus primarily on environmental performance evaluation of products. Expanding to include social and economic dimensions will create a more holistic sustainability profile. Supply chain responsibility should also be integrated, reflecting the full footprint of products and ensuring no adverse effects are caused in any part of the supply chain of a product claimed to be sustainable. Additionally, implementing a tiered internal classification system for the entire product portfolio can clarify the relationship between the eco-portfolio and the broader product range, driving comprehensive improvement across all offerings.

Furthermore, the selection method could more explicitly incorporate the product lifecycle perspective. The evaluation criteria should cover all phases of the product lifecycle – from raw material extraction and manufacturing to use and end-of-life. Requiring products to meet minimum standards in each phase ensures a balanced approach and aligns with emerging regulatory frameworks, such as the EU's Ecodesign for Sustainable Products Regulation.

Additionally, the observations imply that the case company's selection method would benefit from more rigorous, or at minimum publicly disclosed, supporting evidence. Each product's inclusion in the eco-portfolio should be justified with comprehensive documentation, reliable comparison data, detailed criteria and evaluation results. Especially, comparative claims as a base for product selection into the eco-product portfolio should be made cautiously to avoid unintentional greenwashing. This underscores the importance of reliable data source of the comparison and clear definitions. No product should be included in the eco-portfolio without a defensible, evidence-based rationale. For the case company, this could mean externally disclosing the evidence in the form of for example EPDs of eco-product portfolio products. By strengthening the selection methods, the case company ensures that the eco-product portfolio genuinely reflects sustainability excellence and drives meaningful improvements.

In summary, the practical implications for the case company's eco-product portfolio development center on, firstly, the strategic clarity and alignment on the portfolio's purpose, secondly, on the transparent and inclusive communication, and thirdly, on the holistic, lifecycle-based criteria supported by rigorous evidence. These measures could enable the case company to refine a more credible and impactful eco-product portfolio that supports both business objectives and broader sustainability goals. Together these practical implications showcase how the results from this research can be applied into practice in business when formulating – including updating and developing – eco-product portfolios.

6.3 Research limitations

Given the exploratory nature of this thesis, several limitations warrant mention. First, the research focused on large, industry-leading B2B manufacturing firms. This relatively narrow sample and context mean that the practices and the perspectives from smaller companies were underrepresented, potentially meaning that the implications drawn may not directly translate to other industries or to firms of different sizes. Secondly, the semi-structured interview approach inherently guided the conversation along predetermined themes. This structured format could have constrained the range of responses, as interviewees might have focused only on the areas prompted

by the questionnaire. With a relatively small pool of nine expert interviewees, there is also a limit to the diversity of viewpoints captured on the regulation and the verification related to eco-product portfolio formulation.

Thirdly, like many qualitative studies, this thesis involved an interpretive analytical process that introduces subjectivity. The data from the interviews were analysed and interpreted by a single researcher. In this way, despite efforts to maintain rigor, the identification of themes and the synthesis of insights inevitably reflect the researcher's judgment. Additionally, as an applied research project, the case company had influence to the ways the research was conducted. Therefore, the identification of themes and insights not only reflect the researcher's judgement, but also the case company's priorities. Therefore, different analysts and different research setting might have led to categorizing or emphasizing the data differently.

Lastly, the data collection methods themselves had constraints. The benchmarking analysis was based on publicly available documents and sustainability reports of chosen companies. These data availability limitations mean that some nuances of eco-product portfolio practices might not have been captured or fully explored. Likewise, confidentiality considerations limited how much detail from the case company's internal ethnographic observations could be disclosed in the thesis. Therefore, data limitations also constrain the reliability of the applied research where implications for the case company's eco-product portfolio were described. In conclusion, acknowledging these limitations is important to view the findings as context-specific explorations rather than universally applicable principles. Future research could mitigate the limitations in scope and data breadth by including a more diverse set of companies or by expanding the exploration beyond formulation of sub-portfolios of products distinctive for environmental sustainability performance.

Overall, this thesis provided qualitative insights into eco-product portfolio formulation in B2B manufacturing context. These contributions advance the understanding of eco-product portfolio formulation among both scholars and practitioners as an emerging approach to product stewardship and environmental handprint management. The thesis sets a foundation for further research to explore how sub-portfolios of products distinctive for their sustainability performance can support industry-level sustainability transitions.

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Appendices

Appendix 1: Interview questionnaire

Master's thesis interview questionnaire *Eco product portfolio formulation in B2B manufacturing firms*		
Start of interview: • *Information about data protection and confidential use of data* • *Brief introduction into research and objectives (info deck)* *Start recording.*		
General part: Creating general understanding about interviewee		
No.	**Question**	**Theme of Question**
1	Could you briefly describe your current role and responsibilities in your current company? *If not mentioned: Do you, or have you, worked with verification or regulations related to product sustainability claims?*	Basic information Clarification
2	How long have you been working with sustainability related topics?	Basic information
3	What kind of clients or industries do you typically work with?	Basic information
4	Do you specialize in any frameworks, standards, or methodologies when it comes to product sustainability or sustainability assurance?	Basic information
Part 1: EU regulation and reporting requirements of product sustainability claims		
5	How would you describe the current EU regulatory landscape regarding self-declared product-level sustainability claims? *If not mentioned: Which regulations affect product sustainability claims in B2B business, especially regarding heavy manufacturing products and their services?* *Additional: How would you describe the current EU regulatory landscape regarding products' environmental performance requirements?*	Current regulatory landscape Specification Additional

6	In your view, what kinds of regulatory challenges do companies face when making product-level sustainability claims?	Current regulatory landscape
7	What kind of documentation or evidence is typically required to ensure compliance with current EU regulations for self-declared product sustainability claims?	Current regulatory landscape
8	What developments do you see in EU regulation that would influence the use of product sustainability claims in the future? *Are there any regulations you expect to evolve to influence heavy manufacturing products sustainability claims?* *Do you see reporting requirements evolving regarding product sustainability claims?*	Future regulatory landscape Specification Specification
Part 2: Verification process of product sustainability claims		
9	How do you define the purpose and value of third-party verification in the context of product sustainability claims?	Purpose of verification

10	What are the requirements for verification of product-level ecological sustainability claims? *Can you elaborate in detail on the evidence required for the verification of sustainability claims?* *If not mentioned: How do the requirements differ between limited or reasonable assurance?* *Can you give an example of a situation where verification revealed gaps in a client's product sustainability claim?*	Requirements of verification Clarification Clarification Example
11	What are the typical steps involved in verifying product-level ecological sustainability claims? *If not mentioned: Could you describe how the reliability of the data provided by clients is assessed during verification?* *Which standards or frameworks (e.g., ISAE 3000) is most commonly used, and how do they shape the verification process?*	Process of verification Clarification Additional
12	What trends do you see shaping the future of sustainability verification in the EU?	Future of verification
Part 3: Relationship between regulations and verification		
13	How do you see the relationship between regulatory requirements and third-party verification? *In your experience, what are the main differences in expectations between regulators and assurance providers when it comes to sustainability claims?*	Relationship between regulations and verification Clarification
14	Can you share examples of how specific EU regulations have impacted the way sustainability claims are verified in your consulting work?	Relationship between regulations and verification
Closing of the interview		
15	Is there anything you would like to add or bring up that we haven't yet covered?	Additional inputs
Interview ends.		

Appendix 2: Interviewee information

Additional information of the interviewees, such as the expertise, the main industries expert works with and the direct experience of verification of eco-product portfolios.

ID	Date	Length	Organization type	Position	Expertise	Worked with verification	Main industries
A	20.10.2025	45 min	Consulting	Assistant Manager, Sustainability Advisory	Sustainability, Verification, Reporting	Yes (CSRD)	Mixed - Industrial manufacturing, Banking, Medical
B	21.10.2025 22.10.2025	~60 min ~30 min	Consulting	Sustainability Consultant	Sustainability, LCA, EU Taxonomy, Responsible Procurement	No	Mixed - Paper, Infrastructure, Machinery, Heavy manufacturing
C	22.10.2025	~50 min	Research Institute	Group manager , Leading Researcher	Sustainability, LCA, Supply chain	No	Mixed - Critical Raw Materials, Mining, Textile, Plastic, Circular economy
D	23.10.2025	~45 min	Consulting	Director, Sustainability Consulting and Communications	Sustainability communication and regulation Reporting	No	Global & Mixed - Heavy industry, manufacturing, Technology
E	23.10.2025	~55 min	Consulting	Director, Sustainability Consulting in metal & mining	Mining, Sustainability, LCA, ISO 14000 series	Yes (extensive experience)	Mining, Metals, Heavy Industry
F	29.10.2025	~60 min	Consulting	Manager, Sustainability Services	Sustainability, GHG calculations, LCA&EPDs, Reporting	No	Mixed - Industrial, Heavy manufacturing, Energy, Waste, Mining
G	6.11.2025	~60 min	Consulting	Head of Communications / Senior Consultant: Sustainability Consultancy	Sustainability communication and regulation	No	Mixed – Industrial, infrastructure, Commercial, Energy, Public Sector

H	7.11.2025	~60 min	Consulting	Sustainability Auditor (KRT), KHT, Senior Manager	Auditing, Verification, Reporting	Yes (CSRD)	Mixed – Mainly manufacturing, also service, media
I	14.11.2025	~35 min	Consulting	Senior Sustainability Advisor	Sustainability, Reporting	Yes (CSRD)	Mixed – Industrial manufacturing and infrastructure

Appendix 3: Explanation of the use of AI

In the creation of this thesis, generative artificial intelligence was utilized for limited support tasks. The AI tool used, its purpose, and the verification measures are described below. I confirm that I have used the AI tool with the necessary care and caution, have fully disclosed its use in accordance with university policy, and take full responsibility for all content presented in this thesis.

1. Tool: Microsoft Copilot with Commercial Data Protection (via case company license)

- **Stage of Use:**
  Composition/Editing; Theory and methodology source exploration; Benchmarking design; Collection of data (benchmarking)

- **Purpose of Use:**

  - Microsoft Copilot was used primarily as a language-support tool. During the composition and editing stages, it was used throughout the writing process and during final read-throughs of the thesis chapters to improve linguistic clarity and academic tone in English. Typical uses included requesting alternative formulations to express ideas more formally, academically, and precisely, without altering the substantive content or arguments. Other typical use was to translate an idea from Finnish to English.

    - ***Example Prompt*** *(December 2025):*
      "Suggest alternative academic formulations for the sentence "A product is chosen to a portfolio based on how its features" to improve clarity and formality in a master's thesis."

  - In the theory and methodology sections, Copilot was used to support the initial identification of potentially relevant academic literature. The tool was used to

generate preliminary lists of commonly cited authors, books, and articles related to qualitative research, case study methodology, product portfolio management, and product stewardship. These AI-generated suggestions served only as an initial mapping of the literature landscape.

- ***Example Prompt*** *(September 2025):*
  "Make a list of most referenced sources that define the basic theory of product portfolio management"

- In the methodology section, Copilot was additionally used to assist in identifying European manufacturing companies considered leaders in sustainability. The tool was used to generate an initial exploratory list of candidate companies. This list was subsequently reviewed and refined jointly by the researcher and a representative of the case company to form the final benchmarking sample. Additionally, during the document review of the benchmarking companies, AI was used to identify relevant links to each company's sustainability website and 2024 sustainability report, thereby facilitating efficient access for the researcher.

  - ***Example Prompt*** *(October 2025):*
    "List large European B2B manufacturing companies that are mentioned as leaders in sustainability."

  - ***Example Prompt*** *(February 2025):*
    "Find and list the official sustainability webpage and the most recent (2024) sustainability or integrated report for the following European manufacturing companies…"

- **Verification:**

  - All AI-assisted text was carefully reviewed and edited by the researcher to ensure accuracy, consistency, and appropriate academic tone. No AI-generated text was included verbatim without revision.

  - All academic sources suggested by AI were independently explored by consulting the original publications, and only the sources with relevant information were cited in the thesis. The literature review was supplemented with the researcher's own database searches.

- The final selection of benchmarked companies was determined through human judgment and discussion with the case company representative. AI outputs were used solely as supportive inputs and not as authoritative sources. This was also the case for verifying that no additional material was overlooked on the websites of the benchmarked companies. Although AI assisted in identifying initial links, the researcher systematically reviewed the webpages to ensure that all relevant documents and sites related to eco-product portfolios were captured in the data.

Appendix 4: Privacy notice

The below privacy notice was sent as an attachment to the interviewees upon first contact. The notice provided the research participants with further details on how their personal information will be handled in the study.

A privacy notice

1. **Name of the register:**

Consultants' views on sustainability product portfolios, verification processes and related regulation.

2. **Data Controller:**

Nelli-Maija Pekola, *phone number and email of the researcher.*

University of Turku, Department of Economics, Rehtorinpellonkatu 4, Turku

3. **Contact information of the responsible person:**

Nelli-Maija Pekola, *phone number and email of the researcher.*

4. **Purpose and legal basis for the processing of personal data:**

The research collects consultants' views and experiences related to sustainability product portfolios, verification processes, and the impact of EU regulations. Email addresses are used to send out interview invitations. The interviews focus on understanding current practices, challenges, and opportunities in developing and verifying sustainable product portfolios.

The legal basis for processing personal data in the Article 6 of the EU General Data Protection Regulation is:

x Processing is necessary for scientific research (public interest, Point 1a of the Article 6)

☐ Data subject has given their consent to processing personal data (consent, Point 1e of the Article 6)

☐ Other, what_____

5. **Processed personal data:**

The following information of the data subjects is stored in the register:

Email address, job title, organization. If interview is conducted, also views and experiences related to sustainability product portfolios, verification processes, and relevant EU regulations.

6. **Recipients and recipient groups of personal data:**

The data will not be transferred or disclosed to parties outside the research group.

7. **Information on transferring data to third countries:**

Personal data will not be disclosed to parties outside the EU or the European Economic Area.

8. **Retention period of personal data or criteria for its determination:**

The recorded interviews will be transcribed into text files and the recordings will be destroyed. Simultaneously, the research data will be anonymised by erasing identifiable personal data. Personal data is stored until 31. January 2026, after which the data is disposed of securely.

9. **Rights of the data subject:**

The data subject has the right to access their personal data retained by the the Data Controller, the right to rectification or erasure of data, and the right to restrict or object the processing of data. The right to erasure is not applied in scientific or historic research purposes in so far as the right to erasure is likely to render impossible or seriously impair the achievement of the objectives of that processing.

The realisation of the right to erasure is assessed on a case-by-case basis.

The data subject has the right to lodge a complaint with the supervisory authority.

10. **Information on the source of personal data:**

Email addresses are collected from publicly available sources or via professional networks for the purpose of sending interview invitations. The other data is collected directly from those who participate in the interviews for the study.

11. **Information on the existence of automatic decision-making, including profiling:** The data will not be used for automatic decision-making or profiling