INTEGRATING SUSTAINABILITY IN PRODUCT DEVELOPMENT THROUGH A STRATEGY FRAMEWORK AND SUPPORTING TOOLKIT.

Master thesis Industrial Design Engineering
Laura de Ridder
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UNIVERSITY OF TWENTE.

Gispen ahrend

To complete the Master Industrial Design Engineering, specifically the track Management of Product Development, I needed to search for an external company that fulfilled my requirements for a master assignment. Because of my interests in the furniture industry, the principles of the Circular Economy, and sustainable product development, several companies turned up as potentials for the execution of my master thesis. Via the cousin of my best friend, I managed to get in contact with Rick Veenendaal, Manager Circular Economy at Gispen. Gispen fulfilled all of my wishes for the master thesis as they are an office furniture manufacturer who stands for 'Sustainable Design'. They create environments that have a positive influence on people, and they encourage others to handle resources responsibly (Gispen, 2019). They are actively responding to the changes that are currently happening in the industry, they are up for the challenge, constantly improving their products and acting as a thought leader in the field of sustainable and circular furniture. This active attitude is what triggered my interest to complete my master at Gispen.

An introductory meeting took place in Culemborg, to discover the possibilities of writing my master thesis at Gispen. It got clear that Gispen is part of the Royal Ahrend group together with Ahrend, Presikhaaf and Techo. How this resembles within the organization is explained in the introduction. This introductory meeting led to a clear match in the needs and problems of Royal Ahrend and my interests in fulfilling these needs and solving those problems. The master thesis is written on behalf of Royal Ahrend, with Rick Veenendaal as my company mentor. Thus, the thesis is written in the working environment of Gispen in Culemborg and sometimes Ahrend in Amsterdam or Sint-Oedenrode. The details that outline the basis of the assignment and the further establishment of the assignment are described in the introductory chapter.

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Due to the growing public awareness of environmental and social responsibility and direct confrontation with the arising problems, markets and industries are increasingly aimed at the development of sustainable products. This is due to the changing customer demand and the emerge of governmental regulations and policies with the goal to counteract these environmental problems.

Royal Ahrend is one of the companies that is incorporating sustainability in their product development. Not only because of the customer demand and regulations but also because of the gained advantage as a thought leader. Furthermore, they are searching for clarity regarding sustainability in product development so the current internal ambiguity can be eliminated, and one design philosophy can be created with a clear focus on sustainable product development. However, the brand identities of Gispen and Ahrend need to be maintained.

Through literature research regarding sustainable development and product development in general, clear interpretations of sustainable product development and a sustainable product are established. Sustainable product development is about developing products whilst balancing society, environment and economy throughout the entire life cycle of a product with the goal to fulfil the needs of people, now and in the future. A sustainable product is a product that is designed, sourced, developed, manufactured, used and reused with circularity, ecology and well-being in mind. Circularity implies to keep products, parts and materials in use at a continuous high value. Ecology implies that products should positively contribute to the environment and ecosystem. And Well-being implies that products should contribute to the health and well-being of people.

Furthermore, different literature perspectives on the concept of closing the loops and analysing the resource states framework lead to the introduction of the resource value state. This term indicates that the product state is the highest resource value state, then the parts state and then the material state. The different resource value states are key in the development of sustainable products as they illustrate the complexity of a product by addressing specific parts of this complexity.

Analysing the corporate context of Royal Ahrend addresses the fact that the well-being aspect of sustainable development is becoming more important, and the urge for modular and flexible working environments to fulfil the changing needs of customers is increasing. Furthermore, the need for validation is substantiated by the fact that competitors try to distinguish themselves with their own frameworks, interpretations and measurement methods. The choice is made to create a solution that focuses on the start of the product development process, because this part of the process offers the most freedom and thus huge impact can be made here. This implies that product management and product development are the main stakeholders.

An extensive list of solution aspects shapes the basis of the to be developed solution. A strategy framework is created by expanding the impact areas and several discussions with the stakeholders. The strategy framework consists of three impact areas, circularity, ecology and well-being, with related strategies and sub-strategies. Furthermore, four general strategies are described that serve to illustrate the broader context of achieving more sustainable products. Specific indicators for Royal Ahrend are mentioned that can be used to communicate, demonstrate or measure if and how a sub-strategy is put into practice. The concept of value designing is introduced which implies that product development is applicable on different levels, meaning that a product development idea can be a complete product but also a specific part or connection method over a range of products or product categories.

With the strategy framework as a basis, the goal of the toolkit is to offer tools that enable users to apply the strategy framework in a structured way. Therefore, application categories are introduced. The application categories serve to categorise the indicators and capture the complexity of sustainable product development by securing both quantitative and qualitative aspects. Furthermore, supporting tools can be created that specifically focus on aspects within one of the categories. A set of tools is presented that offers both product management and product development guidance and support to integrate and improve sustainability in product development. The concept of value designing is highlighted as a tool to be used for the strategic positioning of development ideas.

Implementation of the solution requires some major organisational changes and a project dedicated to the further development of the solution. This shows the complexity of integrating sustainability in product development. Discussions with experts in the field of product development, design and the circular economy were held to assess the solution. The outcomes of these discussions are taken as valuable input for the further development of the solution.

The overall solution is generally applicable; however, the indicators and tools need to be determined or tailored for each specific situation. The solution adds to the development of the field by offering new perspectives on sustainable product development and the incorporation of both quantitative and qualitative aspects. In addition, it is relevant for the furniture industry as everyone is searching for solutions to integrate sustainability and to take responsibility over the product life cycle of the products they produce.

Door het groeiende publieke bewustzijn wat betreft milieu- en maatschappelijke verantwoordelijkheid en directe confrontatie met de opkomende problemen, richten markten en industrieën zich steeds meer op de ontwikkeling van duurzame producten. Dit wordt veroorzaakt door de veranderende vraag van klanten en de opkomst van regelgeving en beleid vanuit de overheid met als doel deze milieuproblemen tegen te gaan.

Koninklijke Ahrend is een van de bedrijven die duurzaamheid meeneemt in hun productontwikkeling. Niet alleen vanwege de klantvraag en regelgeving, maar ook vanwege het behaalde voordeel als 'thought leader'. Verder is Koninklijke Ahrend op zoek naar duidelijkheid over duurzaamheid in productontwikkeling zodat de huidige interne onduidelijkheid kan worden weggenomen. Daarnaast kan er dan één ontwerpfilosofie worden gecreëerd met een duidelijke focus op duurzame productontwikkeling. De merkidentiteiten van Gispen en Ahrend moeten echter behouden blijven.

Door literatuuronderzoek naar duurzame ontwikkeling en productontwikkeling in het algemeen worden duidelijke interpretaties van duurzame productontwikkeling en een duurzaam product vastgelegd. Bij duurzame productontwikkeling gaat het om het ontwikkelen van producten en het in evenwicht brengen van samenleving, milieu en economie gedurende de hele levenscyclus van een product met als doel te voldoen aan de behoeften van mensen, nu en in de toekomst. Een duurzaam product is een product dat is ontworpen, gedolven, ontwikkeld, geproduceerd, gebruikt en hergebruikt met het oog op circulariteit, ecologie en welzijn. Circulariteit houdt in dat producten, onderdelen en materialen continu in gebruik blijven. Ecologie houdt in dat producten een positieve bijdrage moeten leveren aan het milieu en het ecosysteem. Welzijn houdt in dat producten moeten bijdragen aan de gezondheid en het welzijn van mensen.

Verschillende literatuurperspectieven op het 'closing the loop' concept en het analyseren van het 'resource states framework' leiden tot de introductie van de grondstof waarde status. Deze term geeft aan dat de productstatus de hoogste grondstof waarde status is, dan de onderdeelstatus en vervolgens de materiaalstatus. De verschillende grondstof waarde staten zijn van belang bij de ontwikkeling van duurzame producten, aangezien ze de complexiteit van een product illustreren door specifieke delen van deze complexiteit te adresseren.

Door de bedrijfscontext van Koninklijke Ahrend te analyseren, wordt ingegaan op het feit dat het welzijnsaspect van duurzame ontwikkeling steeds belangrijker wordt. Bovendien wordt de behoefte aan validatie onderbouwd door het feit dat concurrenten zich proberen te onderscheiden met hun eigen frameworks, interpretaties en meetmethoden. Er is gekozen voor het creëren van een oplossing die zich richt op de start van het productontwikkelingsproces, omdat dit deel van het proces de meeste vrijheid biedt en er dus een enorme impact kan worden gemaakt. Dit houdt in dat product management en product development de belangrijkste stakeholders zijn.

Een uitgebreide lijst met oplossingsaspecten vormt de basis van de te ontwikkelen oplossing. Door de impactgebieden uit te breiden en verschillende discussies met de stakeholders te voeren, ontstaat er een 'strategy framework'. Het strategy framework bestaat uit drie impactgebieden, circulariteit, ecologie en welzijn, met gerelateerde strategieën en sub-strategieën. Verder worden vier algemene strategieën beschreven die de bredere context van het bereiken van duurzamere producten illustreren. Er worden specifieke indicatoren voor Koninklijke Ahrend genoemd die kunnen worden gebruikt om te communiceren, aan te tonen of te meten hoe een sub-strategie in de praktijk kan worden gebracht. Het 'value designing' concept wordt geïntroduceerd, wat inhoudt dat productontwikkeling toepasbaar is op verschillende niveaus. Dit betekent dat een productontwikkelingsidee een compleet product kan zijn, maar ook een specifiek onderdeel of verbindingsmethode voor een productcategorie.

Het doel van de toolkit is om tools aan te bieden waarmee gebruikers het strategy framework gestructureerd kunnen toepassen. Daarom worden toepassingscategorieën geïntroduceerd. Deze categorieën dienen om de indicatoren te categoriseren en de complexiteit van duurzame productontwikkeling vast te leggen. Er wordt een set tools gepresenteerd die zowel product management als product development begeleiden en ondersteunen om duurzaamheid in productontwikkeling te integreren en dus duurzamere producten te kunnen ontwikkelen. Het value designing concept wordt uitgelicht als een tool die kan worden gebruikt voor de strategische positionering van ontwikkelingsideeën.

Implementatie van de oplossing vereist enkele grote organisatorische veranderingen en een project gewijd aan de verdere ontwikkeling van de oplossing. Dit toont de complexiteit van het integreren van duurzaamheid in productontwikkeling. Er is gesproken met experts op het gebied van productontwikkeling, design en de circulaire economie om de oplossing te beoordelen. De resultaten van deze discussies worden als waardevolle input gebruikt voor de verdere ontwikkeling van de oplossing.

De oplossing is algemeen toepasbaar; de indicatoren en tools moeten echter voor elke situatie worden bepaald of ontwikkeld. De oplossing draagt bij aan de ontwikkeling van het veld door nieuwe perspectieven te bieden wat betreft duurzame productontwikkeling en het meenemen van zowel kwantitatieve als kwalitatieve aspecten. Ook is het relevant voor de meubelindustrie omdat iedereen op zoek is naar oplossingen om duurzaamheid te integreren en verantwoordelijkheid te nemen over de producten die ze produceren.

C2C	Cradle to Cradle
CE	Circular Economy
CSR	Corporate Social Responsibility
EC	European Commission
ECM & ACC	Electrification, cable management and accessories
EMF	Ellen MacArthur Foundation
ISO	International Organisation for Standardization
IWBI	International WELL Building Institute
LCA	Life Cycle Analysis
LCT	Life cycle thinking
M&C	Marketing and communication
MVI	Maatschappelijk Verantwoord Inkopen
NEN	NEderlandse Norm
NPR	Nederlandse Praktijk Richtlijn
PLC	Product Life Cycle
RA	Royal Ahrend
RIVM	Rijksinstituut voor Volksgezondheid en Milieuhygiëne
SD	Sustainable development
SDG	Sustainable Development Goal
SPD	Sustainable Product Development
UN	United Nations
WCED	World Commission on Environment and Development
WEF	World economic forum

Application category
Categories for applying the strategies in a structured manner. The indicators are linked to a specific application category.

Development idea
A new or further product development concept in its first shape.

Distributed ledger technology
A digital system for recording the transaction of assets. The transactions and their details are recorded in multiple places at the same time, without a central database or administrator (WEF, 2019).

Impact area
Dimension of sustainable product development with a described goal.

Indicator
A way to communicate, demonstrate or measure if and how a sub-strategy is put into practice. Each sub-strategy can be divided into one or more indicators.

Life Cycle Thinking
A philosophy with the main goals to reduce a product's resource use and emissions to the environment as well as improve its socio-economic performance through its life cycle.

Product development
All of the stages involved in bringing a product from concept or idea, through market release and beyond.

Product life cycle
The life cycle of a product encompasses all issues involved from the start to the end of the existence of the physical product.

Resource value state
A resource state with a specific value. The product state is the highest resource value state, then the sub-assembly state, part state, thereafter the material state. In addition, a higher resource value state corresponds with higher complexity. This is due to the fact that a product consists of sub-assemblies and parts that are made out of materials.

Strategy
Translation of an impact area into a specific description to achieve the goal of the impact area.

Strategy framework

A combined framework of:
-         Definition of a sustainable product & sustainable product development
-         General strategies
-         Impact areas
-         Impact area strategies
-         Sub-strategies

Sub-strategy

Lower strategy level. Each impact area strategy is split into several sub-strategies.

Sustainability

Sustainability is commonly interpreted in relation to three dimensions: society, environment and economy. This interpretation is called the triple bottom line and has become the most accepted interpretation of sustainability.

Sustainable development (WCED)

Developing whilst balancing society, environment and economy with the goal to fulfil the needs of people, now and in the future.

Sustainable product

A product that is designed, sourced, developed, manufactured, used and reused with circularity, ecology and well-being in mind.
 - Circularity: Keep products, parts and materials in use at a continuous high
   value.
 - Ecology: Products should positively contribute to the environment and
   ecosystem.
 - Well-being: Products should contribute to the health and well-being of
people.

Sustainable product development

Developing products whilst balancing society, environment and economy throughout the entire life cycle of a product with the goal to fulfil the needs of people, now and in the future.

Tender process

A tender document is a written request send to potential suppliers to ask for information required for the buyer to then evaluate and select a preferred supplier. This is the basis of a tendering process that helps a business select qualified and interested suppliers based on contract conditions (price, quality).

Tool

A part of the toolkit that is specifically focussed on a subject within one of the application categories. It and offers support for product management and development to achieve more sustainable product development.

Toolkit

Set of dedicated tools to support product management and product development in structurally applying the strategy framework and thus achieving more sustainable product development.

Value designing

With value designing, the sustainability of products can be reached on different levels. The resource value states plus the connectors between these states shape the basis for the levels (levels: material, process, part, connection, subassembly, product). Value designing means that a product development idea can be a complete product, but also a specific part or connection method over a range of products, product categories or over the whole collection.

INTRODUCTION

Introducing the assignment

This thesis report is the result of the master assignment for Industrial Design Engineering that is executed on behalf of Royal Ahrend. This introductory chapter elaborates on the starting points for this assignment. To illustrate the corporate context, the first section introduces Royal Ahrend and its brands. The following section outlines the research motive. Thereafter, the problem statement that will be addressed is explained. This chapter is concluded by describing the assignment, approach, scope and structure of the report.

COMPANY PROFILE

In this section, a general description of Royal Ahrend is given to provide an impression of the corporate context of this research. Chapter 2 describes the corporate context of Royal Ahrend in more detail and specifies a research focus within the company.

Royal Ahrend

Royal Ahrend, founded in 1896, delivers furniture and fit-out services for office, education, healthcare and retail environments through a portfolio of four furniture brands: Ahrend, Gispen, Techo and Presikhaaf. Internationally, these four brands go together under the name of Royal Ahrend. Royal Ahrend's ambition is to be the international leader in creating and providing inspiring and highly collaborative workspaces that excel in durability, ergonomics and flexibility and thereby contribute to people's health, wellbeing and performance (RA, 2018a). The focus of this research is on office furniture in the Netherlands. This implies that the brands Gispen and Ahrend are included and the brands Presikhaaf (school furniture) and Techo (Czech Republic) are not. The brand Ahrend represents Royal Ahrend in the Netherlands. Gispen was fully acquired by the Royal Ahrend Holding in 2015.

Ahrend

Ahrend focusses on creating vitalizing working environments. What defines their products, ambitions and culture, is the philosophy and way of working of Friso Kramer, one of the former designers of Ahrend. This philosophy of ''form follows function'' and ''less is more'' aims to remove all unnecessary detail until an object is in full harmony with the user and the environment and unobtrusively supports him in what he does best. Similarly, they work to make their designs logical, sustainable and timeless (Ahrend, 2020a). Ahrend is currently located in Sint-Oedenrode and Amsterdam.

Gispen

Gispen is a designer of office-, healthcare- and learning environments. They strive to create optimum and inspiring environments by designing and using sustainable products that influence people positively (Gispen, 2019). Gispen was founded in 1916 and is currently located in Culemborg. They challenge and inspire their clients and partners to create innovative connections between sustainability and other requirements. These other requirements could be; increasing efficiency and the well-being of employees but also flexibility and cost-effectiveness.

RESEARCH MOTIVE

Royal Ahrend is currently working on a Corporate Social Responsibility (CSR) strategy towards 2025. This strategy consists of several projects that need to be executed to be able to achieve the overall goals that are set in the CSR strategy. One of those projects is the establishment and development of a design philosophy that encompasses their ongoing circular practices and can function as a basis for sustainable furniture development. This project as part of the CSR strategy illustrates the context of this master thesis and the execution of this project is what shapes the assignment.

Royal Ahrend's need for establishing and developing a design philosophy is motivated by several drivers, some external and some internal drivers. These drivers are identified to improve the understanding of why this research is conducted and how a meaningful solution can be created.

External drivers

Changing customer demand

The public awareness of environmental and social responsibility is growing as a direct confrontation with arising problems is a daily subject. To give an example, Rutger Bregman (de Correspondent), recently published a story concerning the Netherlands and the rising sea levels (Bregman, 2020). It is meant as a wake-up call for action because more than half of the Netherlands will no longer exist if we continue in the way we do now. This example clearly illustrates the inevitable need for change.

Markets and industries are already increasingly aimed at the development of sustainable products (Bevilacqua, Ciarapica, & Giacchetta, 2008). Additionally, companies justify themselves by publishing Corporate Social and Environmental Responsibility reports (Lee & Shin, 2010). Nonetheless, customers are pushing the boundaries even further by demanding companies to fulfil their challenging requirements. This also accounts for Royal Ahrend. Some examples that describe the requirements that Royal Ahrend currently has to deal with are: all government related tender processes must be performed in a circular way; the demand for the use of different materials is increasing (meaning certified and sustainable materials); transparency is asked throughout the whole life cycle of the product, down to the smallest details.

Government regulations and policies

The second driver that motivates Royal Ahrend is the emergence of governmental regulations and policies. These regulations and policies are the results of concerns regarding environmental issues on global, European and national level.

The European and national levels are relevant for Royal Ahrend. An example on the national level is the 'Transition Agenda Circular Economy'. This document is written specifically for the manufacturing industry as result of the commodity agreement from January 2017 that has been signed by more than 300 social organisations (Kaanen, 2018). The goal of this transition agenda is to decrease the ecological footprint of the Netherlands to a level on which humans use only one earth and to comply with the agreements that are made in the Paris agreement, by 2050. Furthermore, Van den Hout created an overview of European legislation on sustainability[1]. He describes several European directives and initiatives that relate to environmental concerns. This legislation also accounts for the Netherlands.

Advantage as a thought leader

The third driver that urges Royal Ahrend to develop a design philosophy, is the obtained advantage when being the thought leader regarding the development and production of sustainable furniture. According to Berns et. al., thought leaders with experience in sustainability practices, can capture business advantage because of surprising opportunities that open up because of this understanding of the subject (Berns, 2009). Moreover, when aiming high concerning sustainable furniture development, competitors are automatically challenged to do the same. This will bring the whole furniture industry to a new 'sustainable level'.

With an eye on the future, answering to the customer demand is expected to become even more challenging because of changing ambitions of customers. Additionally, as governments and organizations aim to reduce (or even eliminate) their climate change impact, incentives like policies to lower CO_2 emissions are likely to become stricter in the future. For example, through the use of CO_2 taxes or restrictions on emissions. Nonetheless, sustainability and environmental impact are much broader topics than CO_2 emissions alone. As a thought leader in the furniture industry, not only competitors are challenged, also a good example is set within the industry. This may cause the development of changes in other industries.

[1]Retrieved from Niek van den Hout, Master Thesis report (Developing a dedicated tool to support the development of domestic boilers for a circular economy, 2017)

Internal drivers

Obtain clarity regarding sustainability

The urge for a design philosophy is, along with the identified external drivers, caused by some internal drivers and challenges. As said, Royal Ahrend consists of several brands, for office furniture in the Netherlands, the brands Ahrend and Gispen. Royal Ahrend wants to design, produce and sell sustainable products. Achieving this requires the incorporation of sustainability in the corporate culture, setting clear objectives, keeping track of the progress of these objectives, and radiating sustainability to the outside. Furthermore, both Ahrend and Gispen should maintain their brand identity. In practice, it turns out that it is difficult to obtain clarity about what sustainability and sustainable products imply. What is a sustainable product? How can sustainable products be designed and developed? What is Royal Ahrend's point of view on sustainable products? And how does this point of view reflect itself on the brands Ahrend and Gispen? This unclarity causes internal ambiguity and poor explanation towards customers about the sustainability of products.

Create one design philosophy

Internal ambiguity is furthermore caused by the fact that Ahrend and Gispen are already applying some concepts to achieve more sustainable product development. Yet, the internal interpretation and implementation vary depending on the brand, department and discipline. This results in several unconnected sustainability-related practices. An example is the circular design framework of Gispen that has been developed in 2015 (Gispen, 2015). This framework is still in use but cannot be applied for both brands as it is specifically focused on the brand Gispen. Besides, the framework has become outdated due to further developments in the field of sustainable product design.

Subsequent to the external future changes that are expected to happen, by obtaining clarity regarding sustainability, internal ambiguity is avoided and the explanation regarding the sustainability of products towards customers is improved. Additionally, with clear definitions, the variety of interpretations of sustainability is limited. With limited is meant that the two brands should maintain their brand identity and therefore, a distinction in interpretation is possible.

In short, embracing sustainable development by establishing and developing a design philosophy is evidently of significant relevance.

RESEARCH MOTIVE

Not only the internal interpretation of sustainable product development varies. In academic literature, the interpretation of sustainable product development differs too. A wide variety of concepts is developed and used to make sustainable product development understandable and to achieve the development of sustainable products (den Hollander, 2018)(Foundation, 2019)(Blomsma et al., 2019). Following, the different concepts and different interpretations of these concepts each have their influence on the design decisions that are made in the development process.

Summarizing, the problem can be defined as:

No clear concept is available that provides a structural and concrete design approach for Royal Ahrend to achieve the development of sustainable furniture.

Researching this problem and finding a fitting solution will contribute to the development of the sustainable product development field. Moreover, it creates academic value by offering new perspectives on current literature. Finally, it challenges other companies within the furniture industry to make a change, all in pursuit of sustainable development.

ASSIGNMENT, APPROACH AND SCOPE

Responding to the stated problem and the drivers that outline the research motive, Royal Ahrend is working on a Corporate Social Responsibility Strategy (CSR) 2025. This strategy is applied through several projects that together contribute to the achievement of the overall goals that are set. The CSR strategy and its projects are explained in Chapter 2, section 2.2.5. One of the projects is the development of a design philosophy. With a design philosophy is meant: "assumptions, foundations and implications that are our standard for designing sustainable products. Our design philosophy includes sustainable design principles with a focus on ecology, circularity and well-being." (RA, 2018b).

The continued development of this design philosophy is what shapes this graduation assignment. This leads to the following primary research question:

How can the design philosophy (as described in the CSR 2025 of Royal Ahrend) be translated into a solution that facilitates the integration of sustainability in the product development of Royal Ahrend?

This primary research question is further specified by five secondary research questions.

1. What are sustainable products and how can sustainable products be developed?
2. What aspects regarding the current situation of Royal Ahrend are important to consider for the development of sustainable products?
3. What are the characteristics of a theoretical framework for the development of sustainable products for Royal Ahrend?
4. How can the theoretical framework be translated into a concrete, functional and supporting toolkit?
5. How can the theoretical framework together with the corresponding toolkit be integrated in the product development process of Royal Ahrend?

The secondary research questions are answered through the development of a strategy framework and sustainable design toolkit that translate the design philosophy into strategies and supporting tools. This toolkit is meant to be implemented at the start of the product design and development process of Royal Ahrend. The framework and toolkit together offer an overarching solution for Royal Ahrend. However, the solution can be applied brand-specifically for Ahrend and Gispen whilst maintaining their brand identities.

Research through design is the research method that is used (Eggink & Mulder-Nijkamp, 2016) (Frayling, 1994). This research method implies that design is used for the development of the solution. Hereby, the underlying problems and solution principles are better understood. This enables to better extract the theoretical contribution, next to the designed solution itself (Savic & Huang, 2014).

Figure 1 provides a schematic representation of the most important research results. This overview is meant to help the reader understand how relations between different topics are established and how the results from each secondary research question are combined into a sustainable design toolkit. Furthermore, the overview shows which information is used as input for the design of the toolkit, where this information is retrieved and where it is used for. The structure of this report is supporting this overview. Each secondary question corresponds to a chapter in this report. Thereafter, conclusions are drawn, points of discussion are addressed, and recommendations are given.

Figure 1 indicates that the information regarding Royal Ahrend is obtained through interviews. Furthermore, brainstorm meetings with relevant stakeholders are held throughout the process. The interviews are conducted with employees from several departments and brands of Royal Ahrend. The

relevant stakeholders are employees with specific knowledge in the areas of the CSR strategy, innovation, product management, concept management, product development, sales and marketing.

Royal Ahrend is the primary stakeholder in this research. Therefore, the company name that is used throughout this thesis is 'Royal Ahrend'. The focus of this research is on office furniture produced by Royal Ahrend in the Netherlands. This indicates that the brands Ahrend and Gispen are mentioned in this report when the organizational distinction is relevant. The primary research question appoints the continued development of the design philosophy, one of the projects as described in the CSR strategy for 2025. The scope of this research is limited to only the 'design philosophy' project. In Chapter 2 the corporate context of Royal Ahrend is specified more extensively. Therefore, the scope of this research is further defined in section 2.3.

CSR PROJECT DESIGN PHILOSOPHY

DRIVERS

Changing customer demand,
Governmental regulations & policies,
Advantage as a thought leader,
Internal drivers & challenges

Develop a solution that facilitates the integration of sustainability in the product development of Royal Ahrend

LITERATURE REVIEW
Sustainable product development

SUSTAINABLE PRODUCTS   CH. 1

A product that is designed, sourced, developed, manufactured, used and reused with circularity, ecology and well-being in mind.

WELL-BEING   CIRCULARITY   ECOLOGY

ANALYSIS & INTERVIEWS
Royal Ahrend's corporate context

FOCUS AREA   CH. 2

Focus on new product development, the start of the development process.

PRODUCT MANAGEMENT   PRODUCT DEVELOPMENT

THEORETICAL FRAMEWORK   CH. 3

Impact areas | Strategies | Sub-strategies

Circularity

Well-being   Ecology

SUSTAINABLE TOOLKIT   CH. 4

Tools to support product management and product development in designing and developing sustainable products

Strategic approach
Sustainable ambition
Value designing
Design briefing

PRODUCT MANAGEMENT   PRODUCT DEVELOPMENT

Product passports
Material database
Insight in impact of choices
Sustainability assessments

IMPLEMENTATION & VALIDATION   CH. 5

Figure 1 | Schematic representation of the most important research results

CHAPTER 1

What are sustainable products and how can sustainable products be developed?

This first chapter corresponds with the secondary research question: What are sustainable products and how can sustainable products be developed? In the problem definition these questions are addressed because answering them turns out to be rather difficult. The broader context of this research is addressed by explaining sustainable development in short. Thereafter, the first part of the research question is answered by defining sustainable product development. This is relevant since it sets a baseline for the development of the solution. Then, literature research is conducted to identify existing concepts that are used to achieve sustainable product development. Furthermore, the three dimensions of sustainability, economy, environment and society are explained using several identified concepts. Subsequently, the gathered insights lead to a meaningful interpretation of sustainable products for Royal Ahrend.

1.1 INTERPRETATIONS OF SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

This section serves to specify a clear interpretation of sustainable product development. Therefore, it is needed to take a step back and first focus on sustainable development. Next, the focus shifts towards sustainable development in relation to the development of products.

1.1.1 Sustainability and sustainable development

Sustainable development is a broad social theme that originates from the inevitable need for change regarding the environmental issues that humans are currently facing. As a reaction on these issues and the need for change, the United Nations (UN) has set up seventeen Sustainable Development Goals (SDG's). The goals focus on ending poverty, health, education, clean drinking water, avoiding inequality, sustainable energy and climate change. The goal that can be directly related to this research is goal 12: responsible consumption and production. Although, several other goals have commonalities with this research as well. The goals are not legally binding, but governments are expected to take ownership and establish national frameworks for the achievement of the 17 goals (UN, 2018b). In figure 2 the sustainable development goals are depicted. For readers that are interested in more information on the environmental issues and planetary boundaries specifically, Appendix A provides an explanation.

SUSTAINABLE DEVELOPMENT GOALS

1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY	8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION	14 LIFE BELOW WATER	15 LIFE ON LAND	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	17 PARTNERSHIPS FOR THE GOALS	

Figure 2 | The Sustainable Development Goals of the United Nations.

To be able to define sustainable development the notion 'sustainability' needs to be tackled first. Sustainability is a very complex notion to define, but it is commonly interpreted in relation to three dimensions. These three dimensions – society, environment, and economy – were introduced as the triple bottom line by John Elkington in 1994. Over the years, the triple bottom line has become the most accepted interpretation of sustainability (Gmelin & Seuring, 2014).

Sustainable development was introduced already in 1987 by the World Commission on Environment and Development and is defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987).

The triple bottom line interpretation of sustainability and sustainable development as defined by the WCED combined lead to the following interpretation of sustainable development.

Sustainable development is about developing whilst balancing society, environment and economy with the goal to fulfil the needs of people, now and in the future.

This interpretation is clear and succinct and fits well within the scope of this research. It is used as a baseline for the further development of the solution.

1.1.2 Product development

A way of fulfilling the needs of the current and future generations is developing products that people can use. Product development typically refers to all of the stages involved in bringing a product from concept or idea, through market release and beyond (Eger, Bonnema, Lutters, & Voort, 2012). The life cycle of a product encompasses all issues involved from the start to the end of the existence of the physical product[2]. The basic components are production – use – disposal. In each component different stakeholders are involved. In a possible future situation, these stakeholders are perhaps collaborating or are the same when the disposal component is eliminated, or different components become part of the product life cycle.

Currently, an extraordinary amount of resources is turned into an extraordinary number of products. The industrial revolution is marked as the start of continuous technological progress since then. As a consequence, many people now have access to products from all over the world at affordable prices. However, this way of consuming and producing is reaching its limits. Resources are taken from the earth and turned into products that are used. When the products are no longer needed or replaced by a 'newer' version, they are thrown away. This so-called linear economy revolves around take – make – waste (EMF, 2019b).

To improve the understanding of the product life cycle (PLC), figure 3 illustrates a simplified version of the basic stages of the PLC. The PLC starts with the extraction of raw materials that are turned into materials, then parts are manufactured, then products are manufactured, distributed, used and disposed.

[2]Retrieved from Ir. Marten Toxopeus. Product Life Cycle lectures, 2019.

This is the image that most people have of the PLC and currently, a lot of processes in the economy are fulfilled in this linear way.

1.1.3 Sustainable product development

As explained in section 1.1.2, product development is an aspect of development that can serve to fulfil the needs of people. Referring to the product life cycle, the final stage as depicted in figure 3, disposal (waste), is what should be avoided when talking about sustainable product development (de Pádua Pieroni, Blomsma, McAloone, & Pigosso, 2018). Therefore, a way of approaching this problem is life cycle thinking (LCT), a philosophy with the main goals to reduce a product's resource use and emissions to the environment as well as improve its socio-economic performance through its life cycle (LCI, UNEP, & SETAC, 2019).

Adding to the interpretation of sustainable development with the explanation of product development and the life cycle thinking philosophy in mind, leads to the following interpretation of sustainable product development (SPD):

Sustainable product development is about developing products whilst balancing society, environment and economy throughout the entire life cycle of a product with the goal to fulfil the needs of people, now and in the future.

This definition of SPD serves to gain a better understanding of the impact of sustainability on the development of products and indicates that in every product life cycle stage the three dimensions, society, environment and economy are important.

1.2 IDENTIFYING EXISTING CONCEPTS THAT CAN CONTRIBUTE TO SUSTAINABLE PRODUCT DEVELOPMENT

Mentioned in the problem definition, a wide variety of concepts for achieving SPD is already available. To promote a better understanding of the variety, Van den Hout has introduced a classification model[1] in which he identified four classes: approaches, frameworks, methods and tools. The 28 concepts that Van den Hout classified can be found in Table 1. Additionally, the table is supplemented with concepts that Royal Ahrend is already familiar or working with by reviewing the concepts. This led to the following general insights:

- All concepts are very different and therefore hard to compare and categorize.
- Most concepts try to incorporate a measurement aspect. However, every concept uses a different way of measuring and not all aspects of sustainability can be easily measured.
- Noticeable are several concepts that focus on giving insight into the sustainability of products and subsequently compare and select products, indicating that these concepts focus on products that are already produced. This addresses the lack of concepts that are focused on new development and thus the need for a concrete solution that integrates sustainability aspects at the start of the product development process.
- Every reviewed concept considers at least 3 focus themes regarding sustainability. This addresses the fact that sustainable product development cannot be captured easily but consists of more interrelated subjects

Figure 3 | Linear view of the basic stages in a product life cycle.

| Extraction of raw materials | Manufacturing of materials | Manufacturing of parts | Manufacturing of products | Service provider | Use | Disposal |

The overview in Table 1 shows that Royal Ahrend itself already uses or relates to a wide variety of concepts for the development of sustainable products. This is consistent with the internal ambiguity and a variety of internal interpretation as addressed before. Not only the internal interpretation within Royal Ahrend varies, also the balance between society, environment and economy in each concept differs and the interpretation of these concepts is diverse. The concept of circular economy (CE) is a good example of the diversity in interpretation.

[1]Retrieved from Niek van den Hout, Master Thesis report (Developing a dedicated tool to support the development of domestic boilers for a circular economy, 2017)

Kirchherr et al. conceptualized the circular economy by analysing 114 definitions to create transparency regarding the understandings of the CE concept (Kirchherr, Reike, & Hekkert, 2017). The fact alone that 114 different definitions can be found, indicates that CE means different things to different people.

SUSTAINABLE PRODUCT DEVELOPMENT CLASSIFICATION MODEL		
	VAN DEN HOUT	ROYAL AHREND
FRAMEWORK	Blue Economy, Circular Economy, Industrial Ecology	Gispen CE design framework, Kinnarps the better effect index, WELL building standard, Circular Economy (EMF CE100)
APPROACH	Biomimicry, Cradle to Cradle, Cleaner Production, Eco-design, Natural Capitalism, Zero-waste	Cradle to Cradle (C2C), Biomimicry, Eco-design, Life Cycle Thinking (LCT)
METHOD	Corporate Social Responsibility, Design for Disassembly, Eco-efficiency, Life Cycle Engineering and Design, Recycling, Refurbishment, Triple Bottom Line, Triple Top Line	TNO IMPACT model, Leesman, Design for Disassembly, Design for material recovery, Recycling, Revive, Remade, Design for happiness and health, Corporate Social Responsibility (CSR), NEN - NPR8313 (in development), Design for managing obsolescence
TOOL	Carrying Capacity, Ecological Footprint, Ecological Management Systems, Ecological Rucksack, Factor X, Global Warming Potential, Life Cycle Analysis, Life Cycle Sustainability Analysis, Material Intensity Per Service Unit, Total Material Flow, Waste hierarchy	Pianoo MVI- criteria tool, InsideInside, SCORA, Circular IQ, Life Cycle Analysis (LCA)

Table 1 | Sustainable product development classification model adapted from Van den Hout.

1.3 THE THREE DIMENSIONS OF SUSTAINABILITY IN RELATION TO THE DEVELOPMENT OF PRODUCTS

This section serves to create a better understanding of the impact of the three dimensions on sustainable product development. Besides that, the three dimensions are linked to the life cycle thinking philosophy and discussed separately. Several identified concepts are used to clarify the dimensions.

The three dimensions society, environment and economy can be directly linked to the goals that are described in the life cycle thinking philosophy:
1. Reducing a product's resource use
2. Reducing a product's emissions to the environment
3. Improving a product's socio-economic performance

1.3.1 Reducing a product's resource use
Starting with the first goal, a way of reducing a product's resource use is by reusing produced goods. This indicates that products, parts or materials are looped back into the product life cycle when they are at the 'end of their use'. As illustrated in figure 4, each loop indicates a different circular strategy for reuse. The loops together are thus a replacement for the disposal stage.
In the PLC of figure 3 different resource states are mentioned: raw materials, materials, parts and products. These resource states can be linked to the different loops and corresponding stages of the PLC. Blomsma et al. (2020) developed a Resource States framework that represents the material entropy linked with the main industrial processes that are taking place. Three different resource states are distinguished: materials (molecules, particles, substances), parts (components, assemblies, sub-assemblies) and products (Blomsma & Tennant, 2020). This is illustrated in figure 4.
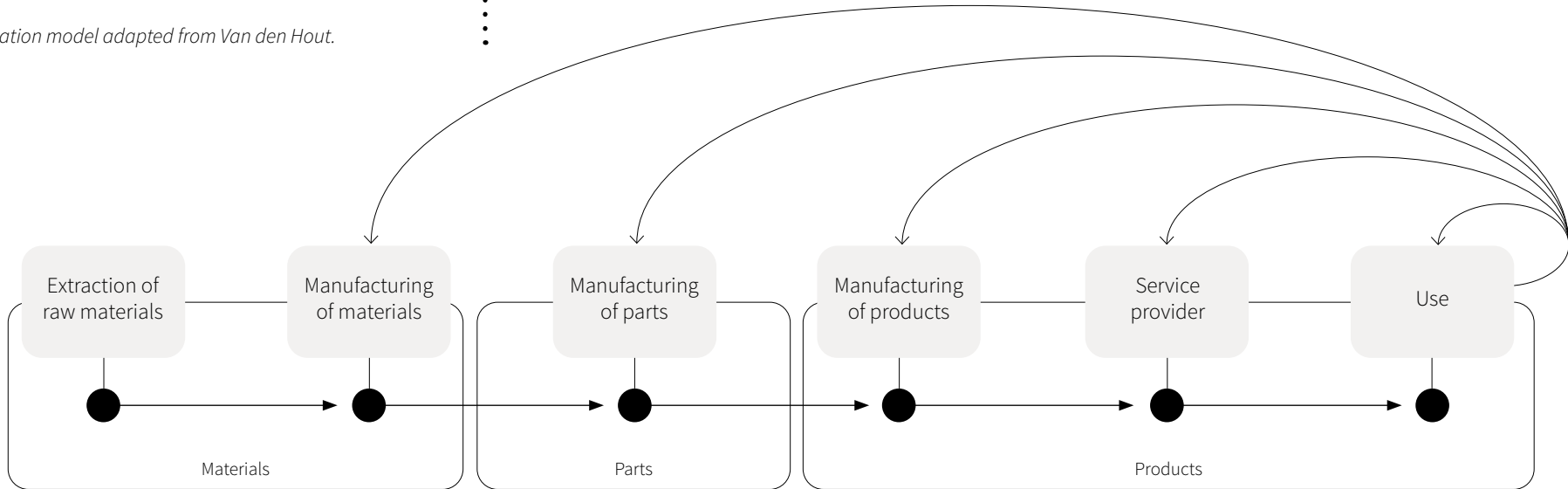

Figure 4 | The product life cycle from a life cycle thinking perspective including the different resource states.

Referring to the loops that flow back, a product's value is kept the highest when the loop is closest to the user. The wider the loop is, the lower the value. This leads to the introduction of a new term: the resource value state. The product state is the highest resource value state, then the part state, thereafter the material state. In addition, a higher resource value state corresponds with higher complexity. This is due to the fact that a product consists of parts that are made out of materials. Section 3.4 Elaborates on the resource value states and the complexity in more detail. From a functional economic perspective, reusing products, parts and materials provide the possibility to deliver the same functionality (economical added value) with effectively fewer resources and waste production.

These insights focus on the product life cycle of a product and how to keep products in the loop at their highest value possible. This addresses a part of the economical aspect of SPD, specifically how resources are used at a continuous high value. Furthermore, minimizing the amount of resources that are distracted from the earth, positively influences the impact on the environment, and thus addresses the environmental aspect of SPD. In addition, when making responsible choices concerning the resources that are mined, for example choosing renewable materials, the natural system can regenerate itself and resource depletion is avoided (EMF, 2019b).

AN INTERPRETATION OF THE CIRCULAR STRATEGY LOOPS
DEEP DIVE

In section 1.3.1 the circular strategy loops are introduced as a way for reducing a product's resource use. However, only the concept of closing the loops is explained and the Resource states framework is mentioned. Therefore, this section serves to give substance to the loops in relation to the different resource value states. First, three literature perspectives on closing the loops are explained. Thereafter these perspectives are combined and summarized.

The butterfly model
One of the most known perspectives that is based on the life cycle thinking philosophy and several other schools of thought including Cradle to Cradle (EMF, 2019a) is the Circular Economy (CE) concept. The Ellen MacArthur Foundation (EMF) is the organization that boosted the Circular Economy concept into a framework for interpreting and realizing sustainable development, specifically aimed at industrial and economic activity. The three principles of CE according to the EMF are 1. Design out waste and pollution; 2. Keep products and materials in use; and 3. Regenerate natural systems.

They created a 'butterfly' model that illustrates these three principles in relation to closing the loops of the technical and biological resource cycle. A simplified version of the butterfly model of the EMF is illustrated in figure 5.
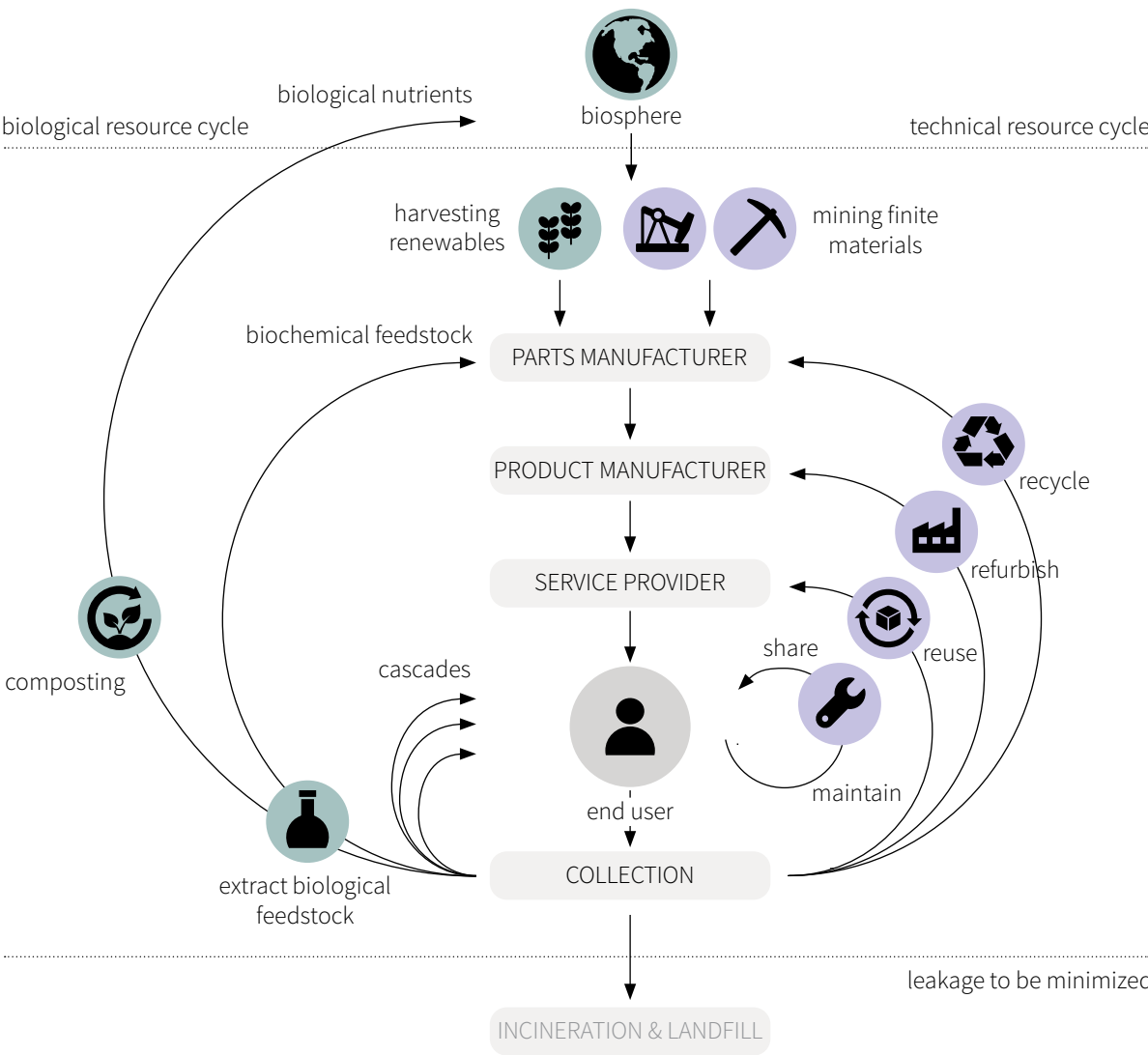
Figure 5 | The Circular Economy butterfly model adapted from the Ellen MacArthur Foundation.

Design for managing obsolescence

A different perspective is established by Den Hollander (2018). He introduces design approaches with the goal to preserve product integrity which he defines as Long use (resisting obsolescence), Extended Use (postponing obsolescence) and Recovery (reversing obsolescence). Within these three categories, several approaches are described (den Hollander, 2018). Preserving product integrity is another way of describing the resource value state of a product. The design approaches that Den Hollander introduces can be directly linked to the different loops. The design approaches of Den Hollander are visualized in figure 6.

Use to use

The two discussed perspectives are framed from a production and business model perspective. Another interpretation is from the user's perspective. This user-centred perspective emphasizes the importance of product exchange, which underscores that products can be transferred in tight loops from one user to another, use to use (Selvefors, Rexfelt, Renström, & Strömberg, 2019). Product exchange can be realized in many different ways depending on what paths of obtainment and riddance are considered possible and desirable by the users involved. A possibility for product exchange is using products as a service (Ahrend, 2020). By offering products as a service, the user can use the product, for example, based on a subscription, but does not become the owner of the product. This is an example of how to increase product utilization. Increasing product utilization also indicates that a product can go through several use cycles before it reaches one of the other loops. Selvefors's perspective is illustrated in figure 7.

<table>
<tr><td colspan="3">DESIGN FOR PRESERVING PRODUCT INTEGRITY</td></tr>
<tr><td>LONG USE</td><td>EXTENDED USE</td><td>RECOVERY</td></tr>
<tr><td>Resisting Obsolescence:
Design approaches for long use</td><td>Postponing Obsolescence:
Design approaches for extended use</td><td>Reversing Obsolescence:
Design approaches for recovery</td></tr>
<tr><td>Designing for Emotional Durability</td><td>Designing for Maintenance</td><td>Designing for Recontextualizing</td></tr>
<tr><td>Designing for Physical Durability</td><td>Designing for Repair</td><td>Designing for Refurbishment</td></tr>
<tr><td></td><td>Designing for Upgrading</td><td>Designing for Remanufacturing</td></tr>
</table>

Figure 6 | Design approaches for preserving product integrity, adapted from Den Hollander, 2018.
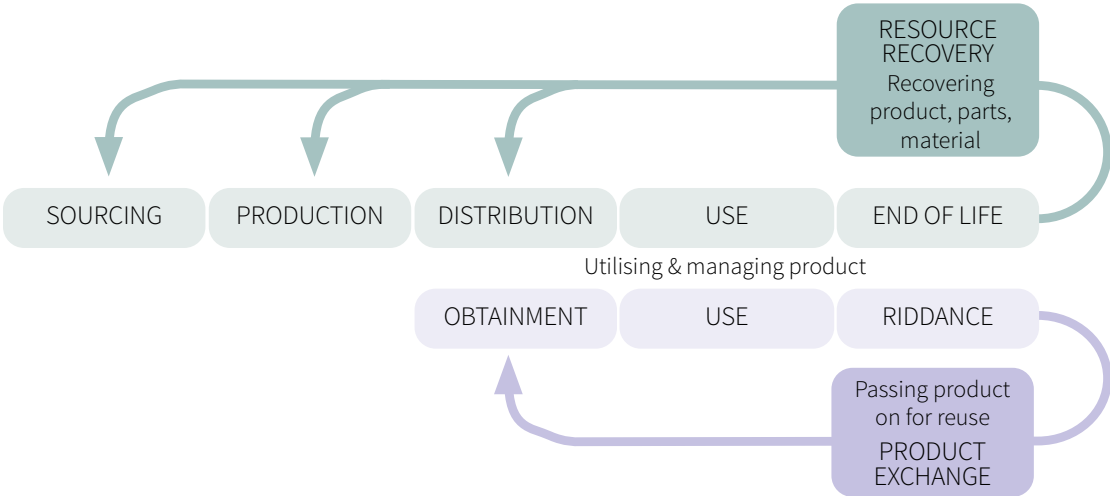
Figure 7 | Use to use, people's consumption processes as a point of departure. Adapted from Selvefors et al., 2019.

Closing the loops in relation to the different resource value states

These interpretations combined lead to the following Figure 8 that summarizes the gained insights and different perspectives from the literature regarding product development. It highlights the life cycle perspective; the categorization of resources into 3 states, materials, parts and products; and the different loops and the related strategies that can be used to retain value. An important insight is the fact that not every strategy is applicable to every situation. It should be applied in a targeted manner dependent on the status and performance of each product.

Figure 8 illustrates that a product, part or material can have multiple 'use cycles' because they are brought back into the PLC. To provide a better understanding of the different 'use cycles' of products, parts and materials, an illustration is created that is shown in figure 9. This illustration is based on the perspective of Den Hollander. For example, at first, a product is used as long as possible, then the product is extended twice, thereafter the product is recovered, again extended and then recycled. In each arc after the first long use arc, materials or parts are added to the product. Furthermore, a part that has been replaced can be used in another product by recovery or recycling. This indicates that the amount of use cycles is not directly important and is also hard to determine because the resource value state can be different within an arc. For example, the recovery loop can contain a product in its first cycle with two parts in its second cycle and a material in its fourth cycle. This emphasizes the fact that closing the loops goes on infinitely. Therefore, when designing a product, the product life cycle of a product (planning for multiple use cycles) should be considered beforehand. Meaning, that the strategies can serve as design guidelines to make it possible to close the loops later on.

Figure 9 | Den Hollanders strategies in time

Figure 8 | Closing the loops in relation to the different resource value states. Interpretation combined from figure 5, 6 and 7.

1.3.2 Reducing a product's emissions to the environment

Continuing with the environmental aspect, it is important to reduce a product's emissions to the environment during all stages of the PLC. Besides, a product's waste should be avoided likewise. The waste aspect is already addressed by closing the loops back into the PLC. However, emissions are not yet discussed. Braungart and McDonough came up with the Cradle to Cradle approach. This approach consists of C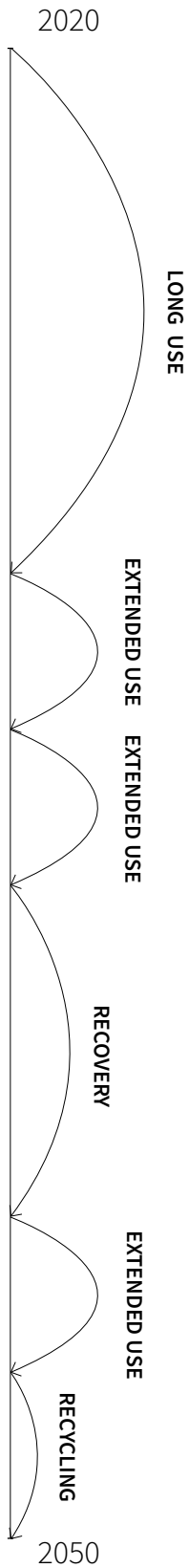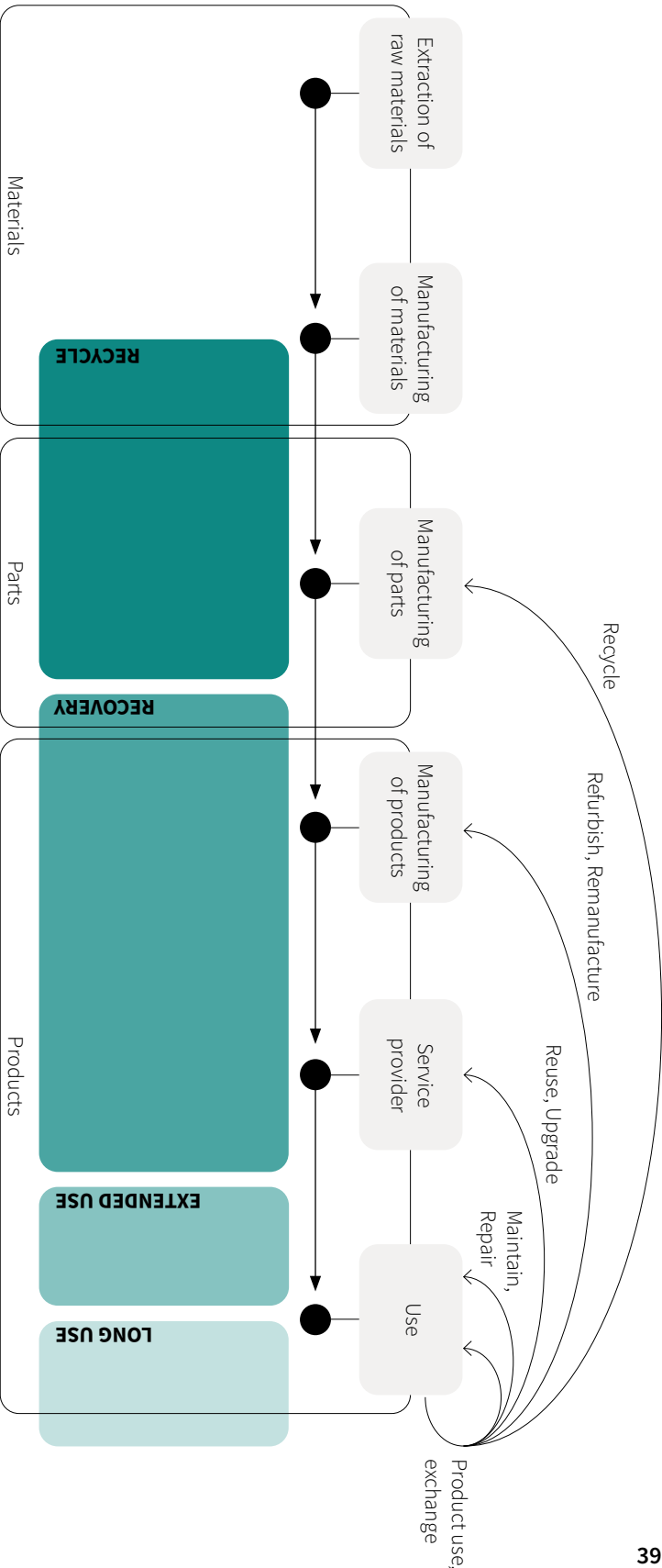radle to Cradle design principles to continuously innovate around the economic, environmental and social issues of human design and use of products and services (McDonough & Braungart, 2002). Two of their principles focus directly on the elimination of emissions and hazardous substances that can end up in the environment: Renewable energy and Carbon Management and Water Stewardship. The first principle helps to ensure that products are manufactured using renewable energy so that the impact of climate-changing greenhouse gases due to the manufacturing of the product is reduced or eliminated. The second principle helps to ensure that water is recognized as a valuable resource, watersheds are protected, and clean water is available.

1.3.3 Improving a product's socio-economic performance

Moving on to improving a product's socio-economic performance. Another principle of the Cradle to Cradle approach is Social Fairness. This principle aims to design business operations that honour all people and natural systems affected whilst manufacturing a product. This addresses the social dimension of SPD. Besides that, the products that are manufactured should preferably contribute to the health and well-being of the users whilst they are being used. This implies that these products should enhance people's physical and mental health and fitness (Kellert & Calabrese, 2015). So, when products contribute to people's lives, they contribute to sustainability. This aspect of the social dimension of SPD will be further discussed in section 2.1 as this is mainly determined by the kind of products that are manufactured.

In the social fairness principle, business operations are mentioned, which indicates the need for an adjusted business organization. This is consistent with the circular strategy loops wherefore similarly a new business approach is needed (de Pádua Pieroni et al., 2018). An upcoming solution is offering 'products as a service'. Users do not become owners of the products. Hence, product manufacturers remain owners of those products. This makes it easier to stay in control over the product life cycle of their produced goods. Staying in control over the product life cycle requires clear documentation of what is happening in the different stages of the PLC. Thereby, transparency is created. However, collaboration and clear communication are needed between the stakeholders in the different stages (Metabolic, Economy, DGBC, SGS, & Foundation, 2018). To actually enable sustainable product development innovation is key (Blomsma et al., 2019). In addition, as sustainable product development is something quite new, innovations should be carefully managed in order to implement them properly.

1.3.4 Implications of the three dimensions regarding sustainable product development

The three dimensions of sustainability are clarified through discussing the three goals of the life cycle thinking philosophy. This results in the following list of implications regarding SPD for product manufacturers like Royal Ahrend:

- Resources must be kept in the loop at their highest possible resource value state.
- The use of (finite) resources must be minimized/avoided and responsible choices must be made regarding material use.
- Waste and pollution must be avoided throughout the whole product life cycle.
- People and natural systems should be honoured whilst manufacturing a product.
- The health and well-being of the users should be supported whilst using a product.
- *Current business models must be reconsidered.*
- *Collaboration and communication between the stakeholders in every life cycle stage are significantly important to be able to gain full transparency.*
- *Transparency should be secured in the development process by clear documentation*
- *Innovation is key to achieving sustainable product development.*

For this thesis, the focus is on the earlier addressed circular strategy loops, avoiding waste and emissions and the well-being of people in relation to product development. This research focusses specifically on product development which results in the fact that Business models, collaboration, transparency and innovation are subjects that are not further discussed (listed in italic). Furthermore, the choices made in the design phase have a major influence on the product life cycle. Thus, a lot is determined already at the beginning of the product development process which allows to make the biggest impact there.

1.4 AN INTERPRETATION OF SUSTAINABLE PRODUCTS FOR ROYAL AHREND

As stated in the introductory chapter, there is a need for establishing and developing a solution that facilitates the integration of sustainability in Royal Ahrend's product development. This solution should be a translation of their design philosophy that includes sustainable design principles with a focus on ecology, circularity and well-being. These three key elements are directly linked to the triple bottom line that is already explained in section 1.1.

Linking the key elements to this interpretation creates a substantiated basis for the further development of the design philosophy. The concepts categorized in Table 1 are taken as a source of inspiration for Royal Ahrend's own definition of the key elements and what they mean in relation to sustainable products. The gained insights of section 1.1, 1.2, 1.3 lead to an interpretation of a sustainable product for Royal Ahrend:

A product that is designed, sourced, developed, manufactured, used and reused with circularity, ecology and well-being in mind.

Circularity: Keep products, parts and materials in use at a continuous high value.
Ecology: Products should positively contribute to the environment and ecosystem.
Well-being: Products should contribute to the health and well-being of people.

This interpretation is used as a basis for the theoretical framework of the solution. However, this interpretation is yet another perspective on how to develop sustainable products. With the changing customer demand in mind, and the number of different interpretations and definitions that can be found in literature, more changes will probably appear in the future. This indicates that the solution preferably should be flexible, so adaptation to changes is easily possible later on. Furthermore, this perspective contributes to the development of a universal way of integrating sustainability in product development. Royal Ahrend can act as a thought leader by being an expert in the field and sharing their perspective with others. In the future, this can lead to an unambiguous method for rating products based on sustainability. As a follow-up, section 2.2.5 will focus on the broader context of the design philosophy project.

CHAPTER 2

What aspects regarding the current situation of Royal Ahrend are important to consider for the development of sustainable products?

This chapter describes the current status of the furniture industry: Royal Ahrend's competitors and the developments within the industry. This improves the understanding of the broader context in which Royal Ahrend is positioned. Furthermore, by elaborating on the corporate context, the current design and development processes of Royal Ahrend are discussed. This is necessary to connect the solution to Royal Ahrend's specific context. The chapter is concluded with a summary of the important aspects regarding the development of sustainable products, and the specification of a research focus within the organization.

2.1 THE FURNITURE INDUSTRY AND THE CURRENT DEVELOPMENTS WITHIN THE INDUSTRY

In this section competitors of Royal Ahrend are analysed and current developments within the furniture industry are discussed. 2.1.1 and 2.1.2 together illustrate the broader context wherein Royal Ahrend is positioned.

2.1.1 Competitors

Royal Ahrend is an international leader when it comes to producing office furniture. However, they are not the only leader in this industry. The top 20 office furniture producers (including Royal Ahrend) in Europe is analysed to gain insight in their way of working, story, strategy, values and sustainability vision. This analysis is conducted to investigate how competitors handle sustainability in their product development. The whole furniture industry is facing the same challenges, and everyone is looking for useful solutions. Therefore, analysing competitors can provide interesting insights and inspiration. Furthermore, Royal Ahrend can determine how to distinguish themselves from other furniture producers. An overview of the top 5 is shown in Table 2. From each furniture producer information is collected regarding the type of products they produce, the country of origin, their sub-brands, their general story and values, their Corporate Social Responsibility reports and the relevant certificates and standards. Next to that, their sustainability strategies are analysed by looking at the clarity of the goals, the progress overview, reference to the Sustainable Development Goals of the UN and the presence of their own solution or concept for integrating sustainability in product development. The complete competitor analysis can be found in appendix B.

All competitors describe their sustainability strategies by addressing several related themes. The sustainability themes addressed in these strategies are gathered in a word web that serves as a frame of reference for the further development of the solution. This word web is depicted in appendix C. Some relevant insights gained are:
- All of the furniture producers refer to several standards, certificates and labels to substantiate and validate their sustainability vision. This addresses the wide variety of available standards, certificates and labels that are related to the sustainability of materials, products, organisations, companies and buildings. In addition, this shows the need for validation (preferably by an external party or organization).
- Several competitors try to distinguish themselves with their own frameworks. What can be noticed is that every company interprets sustainability in their own way. This makes it hard to compare these frameworks on their functionality and added value.

POSITION	COMPANY	COUNTRY
1	Kinnarps Holding AB	SE
2	Steelcase SA	US
3	Vitra Holding AG	CH
4	Nowy Styl SP.ZO.O	PL
5	Royal Ahrend	NL

Table 2 | Top 5 office furniture producers in Europe, Q1 of 2018 (based on sales in million euros in Europe).

2.1.2 Changes within the furniture industry

Possible future changes regarding the customer demand and regulations and policies are addressed in the introductory chapter. Subsequent to these changes, the furniture industry is expected to change as well. Some transformations are already occurring.
- The building industry is incorporating the well-being aspect of sustainable development. The WELL Building Institute offers the WELL building standard. A rating system that is focused on the ways that buildings, and everything in them, can improve comfort, drive better choices, and generally enhance health and wellness (IWBI, 2019a). Furniture is part of the interior and therefore these well-being aspects should also be considered in the furniture industry.
- Corresponding to the need for validation, an interesting insight is gained from the competitor analysis. The number of certificates, standards and labels is expected to increase. Furthermore, the NEN (Nederlandse Norm) is working on a new guideline for definitions and measuring methods of circular office- and educational environments, the NPR 8313 (Nederlandse Praktijk Richtlijn). Royal Ahrend is part of the team that is working on the development of this guideline.
- In line with the aforementioned well-being aspect, measuring workplace experience has become more important. Leesman measures employee experience via the Leesman Index, a global business intelligence tool that captures employee feedback on how effectively the workplace supports them and their work (Leesman, 2017). The index provides critical insights regarding these subjects.

- Office environments are changing as the wishes, requirements and needs of employees are constantly changing. Therefore, the urge for modular and flexible working environments is increasing and the furniture industry is responding to this urge by developing new kinds of products. An example is the Ahrend Flexbox that is pictured in figure 10. This flexbox is an acoustic space-in-space solution that can serve as a phone booth, concentration workspace or meeting room (RA, 2020a).

This section indicates the need for the incorporation of the social aspect of sustainable development. Royal Ahrend is already collaborating with the International WELL Building Institute and Leesman to research the possibilities of including well-being in their product development. Some examples are given in section 2.2.6. However, well-being can be further expanded when incorporating this into the solution.

Figure 10 | The Ahrend flexbox, the Silent Call, retrieved from Royal ahrend.

THE NEW WORK REALITY DUE TO COVID-19
DEEP DIVE

Due to COVID-19, employees are currently required to work from home because in the office environment does not guarantee the safety of 1.5 meters distance between people (RIVM, 2020). This situation illustrates a clear example of office environments that are constantly changing (unexpectedly). At some point, people will start to go back to their offices which requires a change in the way offices are currently organized. To prevent more infections, it is necessary to take some measures regarding the 1.5 meters distance, safe distribution of people, and changes in the field of routing and hygiene. This new work reality can be captured in four trends that are listed in table 3 (Ahrend, 2020b). Royal Ahrend is already working on several solutions that match with the trends and allow people to get back to the office safely. The solutions are presented in table 3. The changed situation creates opportunities to rethink the way working environments are currently organised. With everyone that is currently working from home, meeting online, why not keep working from home more often in the future? This is also beneficial for the environment because fewer people will travel to their offices which causes a decrease in emissions. Additionally, the well-being aspect of sustainable products has taken on a different meaning due to the changes that need to be made regarding the working environment (signage, social distancing app) and the workplace (personal space, hygiene). This may cause a change in the way buildings are organised in the future (more flexible, less workplace availability).

NEW WORK REALITY TRENDS	SOLUTIONS	
THE OFFICE AS A SOCIAL HUB An office is a social hub where employees like to go to meet, to encounter, to collaborate and be coached and trained.		Workspace nudging and signage, Social distancing app
PERSONAL SPACE Personal space, safety and hygiene will have a lasting influence on the layout of offices.		Ahrend Clear collection, Gispen PEXX, Ahrend concentration corner, Gispen HUGG
WORKING FROM HOME MORE FREQUENT AND MORE FOCUSSED The workplace at home is an integral part of the new working environment and thus its status will be different than before.		Workplace at home: a healthy and ergonomically responsible workplace at home
LESS TRAVELLING, MORE VIDEOCONFERENCING Business travelling will often take place virtually from the office, supported by the implantation of isolated workspaces and lounges with business class facilities and technical solutions such as Teams.		Video conference and flexible workspaces: Ahrend flexbox, silence collection, Gispen MOXX collection

Table 3 | New work reality trends and solutions as defined and developed by Royal Ahrend.

2.2 ROYAL AHREND'S CORPORATE CONTEXT

This section serves to elaborate on the corporate context of Royal Ahrend. A clear understanding of the current way of designing and developing products is presented. At first, the organizational structure is explained, then the brand identities of Gispen and Ahrend are clarified. Thereafter, the product development process is described by elaborating on the design and development departments, the collection strategy roadmap and the product life cycle. Furthermore, the broader context of the design philosophy project is explained by elaborating on the CSR strategy. Finally, current sustainability-related practices are highlighted.

2.2.1 Royal Ahrend's organizational structure

This section serves to provide a clear understanding of Royal Ahrend's organizational structure, so a research focus within the organization can later be specified. In the introductory chapter the company profile of Royal Ahrend is already described in short and the brands Ahrend and Gispen are introduced. An overview of Royal Ahrend's leading brands' portfolio is given in figure 11. Royal Ahrend has production locations in the Netherlands, Czech Republic, Russia and China which enables manufacturing close to their customers and creates flexibility in meeting specific requirements of their clients (RA, 2018b).

Figure 11 | Royal Ahrend's brand portfolio.

Within the Netherlands Culemborg and Sint-Oedenrode are the main production locations for furniture of Gispen and Ahrend. As both brands produce office furniture, collaboration and communication are two crucial elements while managing the brand identities and positioning the brands in the market with their own sustainable products. This requires a transparent and coherent organizational structure. A simplified version of this structure is illustrated in figure 12. Referring to figure 12, the marketing department is where new ideas are created, so this is where the product development process starts. To gain a better understanding of how this works in practice, the brands and the marketing department are discussed more extensively in the following sections.
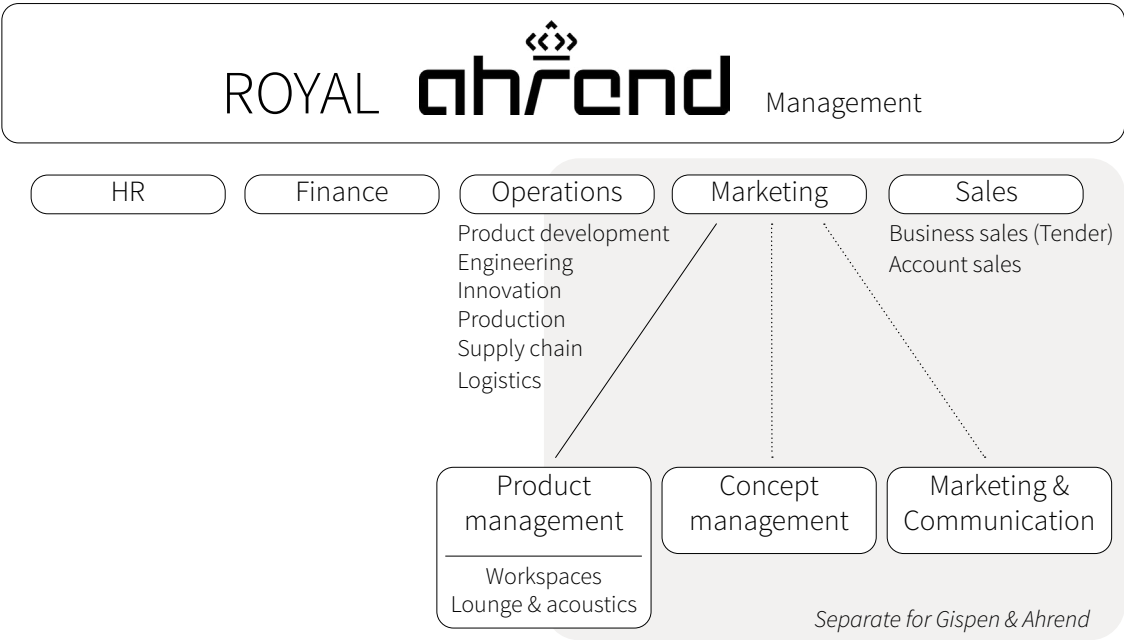
Figure 12 | Simplified version of the organizational structure of Royal Ahrend.

2.2.1 Royal Ahrend's organizational structure

As illustrated in figure 12, the marketing department is split into three sub-departments: Marketing and Communication, Concept Management and Product Management[3]. The first two sub-departments work separately for both brands and are discussed in this section. The Marketing and Communication team is responsible for setting up and implementing the marketing communication strategy and the translation of this into an effective diversity of marketing tools. Think of advertising campaigns, events, PR, promotions, online (content) and social media. Concept Management is the link between Marketing and Communication and Product Management. Their responsibility is to creatively translate the brand-specific strategy and brand identity to inspiring and distinctive marketing tools and product development and communication. For example, photoshoots, a digital product brochure or an exhibition stand.

For both of the sub-departments, the distinction between the two brands, strategy and brand identity, needs to be remarkably clear. To describe and visualize this distinction, the brand identity prism as defined by Jean-Noël Kapferer is used (Kapferer, 2008). The brand identity prisms for Ahrend and Gispen can be found in figure 13a and 13b.

[3]Retrieved from Tessa Bouwman, head of Marketing. Internal document: Meet Marketing.

BRAND IDENTITY PRISM AHREND

Internalisation

Sender — Receiver

Personality · Physique · Culture · Relationship · Reflection · Self-image

Leader
Professional
Reliable
Sophisticated
Proud

Innovation
Vitality
Sustainable
Determination
Adaptive

I'm sustainable
I'm reliable
I'm timeless
I'm international
I'm proud

Functional
Timeless
Modern
Vitalising
Sleek

'Less is more' - Friso Kramer
Creating vitalising workspaces
Transparent & direct

Dutch heritage
Global
Sustainable
Vitalising workspaces
Classic

Externalisation

Figure 13a | Brand identity prism Ahrend. The prism is validated by Tessa Bouwman, head of Marketing, Royal Ahrend.

BRAND IDENTITY PRISM GISPEN

Figure 13b | Brand identity prism Gispen. The prism is validated by Tessa Bouwman, head of Marketing, Royal Ahrend.

Externalisation

Sender / Receiver

Physique:
Modern
Playful
Robust
Sustainable design
Influencing people positively
Stimulating others to be responsible

Relationship:
Down to Earth
Caring
Responsible
Circular
Sustainable

Gispen

Reflection

Personality:
Challenger
Flexible
Creative
Optimistic
Approachable
Connecting
Proud

Culture:
Circular
Sustainable
Design
Innovative

Self-image:
I'm circular
I'm design
I'm sustainable
I'm functional
I'm cheeky

Internalisation

2.2.3 The design and development process

The third marketing sub-department, the product management team, is responsible for the realization of an optimal product portfolio for the product categories 'Workspaces' and 'Lounge & Acoustics'. Each category has its own team. Several subcategories exist within these two main categories, this is depicted in figure 14. Besides that, several new ideas and developments are coming from the innovation department. Innovation is part of the operations department and focusses on several subjects regarding product development, new materials, production technologies, sustainability and the working environment as depicted in figure 14.

WORKSPACES	LOUNGE & ACOUSTICS	INNOVATION
Desking	Soft Seating	Vitalising workspaces
Seating	Privacy & Acoustics	CE materials
Meeting		Closing the loops
Storage		Knowledge sharing
ECM & ACC		
(electrification, cable management & accessories)		
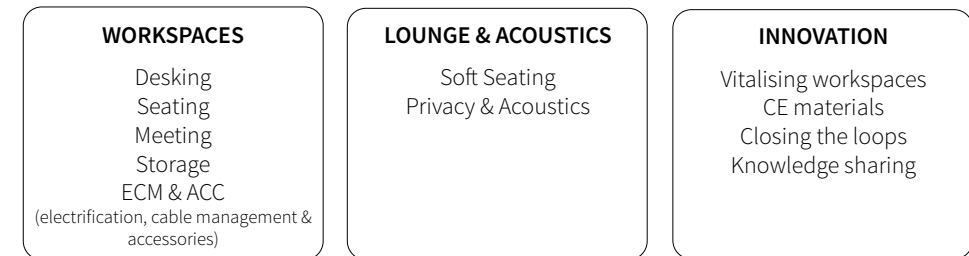
Figure 14 | Product categories as described by Royal Ahrend.

The collection strategy and the corresponding roadmap are the starting point for all product developments wherein analysis, positioning, pricing, developments (technical, design, sustainable), (technical) product communication and training are all of importance. Every year, a new collection strategy is determined for each brand. The collection strategy for the upcoming year is based on multiple analyses, trends, reviews, feedback and evaluations. The final result is a product board that includes ideas for new to be developed products and further developments that will be the focus of that year. These ideas are prioritized within the product board and then converted to product briefings.

The whole process of determining the collection strategy is captured in the corresponding roadmap. This roadmap is visualized in figure 15. This visualization is an extensive version, including some of the follow-up steps. The product management team is responsible for the steps in the grey area.

The other steps are considered as follow-up steps. The product board with all the developments, that is the result of the steps within the grey area, eventually becomes a part of the product portfolio.

What can be noticed in this roadmap is the distinction between further development and new product development. A further development idea is defined as: *An idea that is a follow-up or an adjustment of an already designed and existing product that is part of the current product portfolio. The follow-up*

or adjustment idea originates from Trends, Reviews, Evaluations or Portfolio analyses.

A new product development idea is defined as: *An idea that is completely new and has no direct link to the current product portfolio. The new idea originates from market analyses (needs/trends), technology scans (innovations), product assessments or Sales (missing a specific product or feature that customers demand).*

The different new development ideas are finally transferred to the product development department within operations. This is done in the shape of a design briefing. The design briefing describes the following aspects: Cause, goal, target group and market, product description, prognosis, cost structure, feasibility, product requirements and wishes, standards, fulfilment, distribution requirements, planning and approach, development time and costs, appendixes (the design, mood board, product positioning). In appendix D an example of such a design briefing can be found.

The product development department continues with the design briefing by further developing the idea with the requirements from the design briefing in mind. This leads to a technical list of requirements (measurements, configurations, safety, materials and more), a production proposal and further on a prototype and pilot run.

What can be noticed, is that both product management and product development have a big influence on product developments. However, their tasks are completely different. Summarizing, product management is responsible for the final product and strategically positioning the product. Product development is responsible for the technical details and making the product production ready.
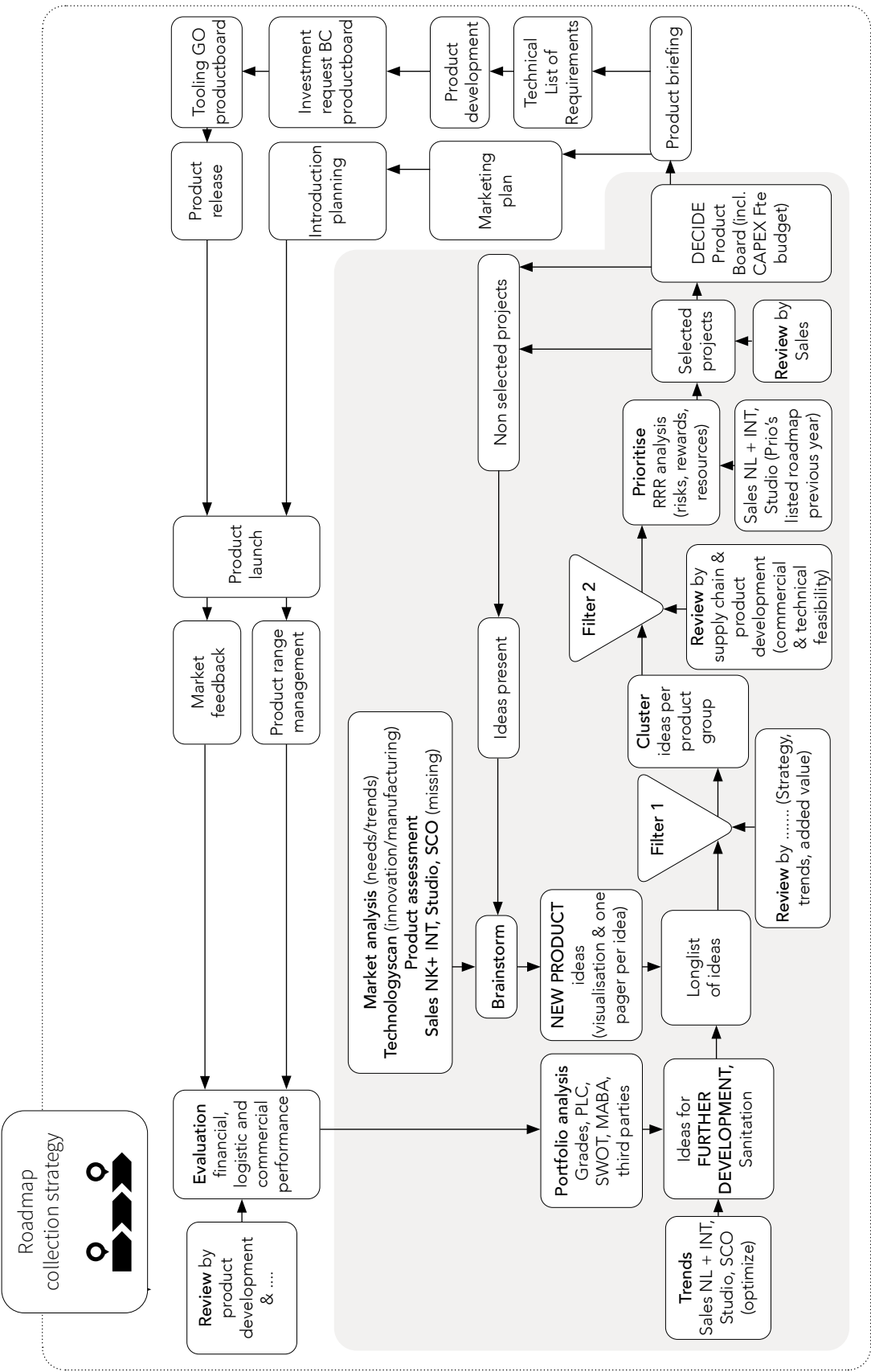
Figure 15 | The collection strategy roadmap.

2.2.4 The product life cycle

In figure 16 the product life cycle of furniture from Royal Ahrend is illustrated. In each stage, the specific stakeholders are named, and some main activities are mentioned. The different resource value states as described in section 1.3.1, are pictured as an extra stage, end of use, that represents the loops that flow back into the PLC. The stakeholders mentioned in figure 16 are direct stakeholders that collaborate to make the development of Royal Ahrend furniture possible. Royal Ahrend itself is a stakeholder in four of the seven defined stages.
This indicates that the way of working throughout this product life cycle is mainly determined by the operational management of Royal Ahrend. This, in combination with managing the end of use stage, is called extended product responsibility.

Producers pay for the cost of collecting, transporting, recycling and responsibly reusing of the products, parts and materials at the end of their use cycle[4]. A solution that makes this aspect more specific is Furniture as a service (RA, 2020b). This solution is already applied by Royal Ahrend and makes it possible to lease office furniture. Customers pay a fixed amount per month and get an up-to-date and flexible vitalizing work environment in return.

*Royal Ahrend = service provider: product developer, manufacturer, distributor & sometimes parts producer
**Customer = facilitator of use

STAKEHOLDERS	Raw material miner	Material supplier	Parts supplier, *Royal Ahrend (operations - production)	*Royal Ahrend (Marketing - product management) (Operations - product development, engineering, production, supply chain)	*Royal Ahrend (Operations - logistics)	**Customer, user	End of use partner, *Royal Ahrend (Operations & Management)
	Extraction of raw materials	Manufacturing of materials	Manufacturing of parts	Manufacturing of products	Service provider	Use	End of use
	Materials		Parts		Products		Materials, parts, products
ACTIVITIES	Mining resources	Collecting/sorting resource streams, converting (mined) resource into a ready-for-production material	Producing parts from ready-for-production material	Creating new product ideas and concepts, development of the ideas and concepts, engineering, production, assembly	Selling products, distribution of products, packaging & transportation	Facilitating use, use of products	Managing the end of use of the products (for example, furniture as a service)

Figure 16 | The product life cycle of Royal Ahrend

[4]Information retrieved from Royal Ahrend. Internal document: CSR strategy 2025.

2.2.5 The CSR strategy 2025

Royal Ahrend is working on a Corporate Social Responsibility Strategy (CSR) 2025[4] that is currently realized by the execution of several projects. The CSR strategy is developed to give the sustainability of products a substantiated place next to subjects like commercial and technical feasibility. To clarify the broader context of the design philosophy project, the purpose, vision, strategy and main goals of the CSR strategy as described by Royal Ahrend are shown in figure 17.

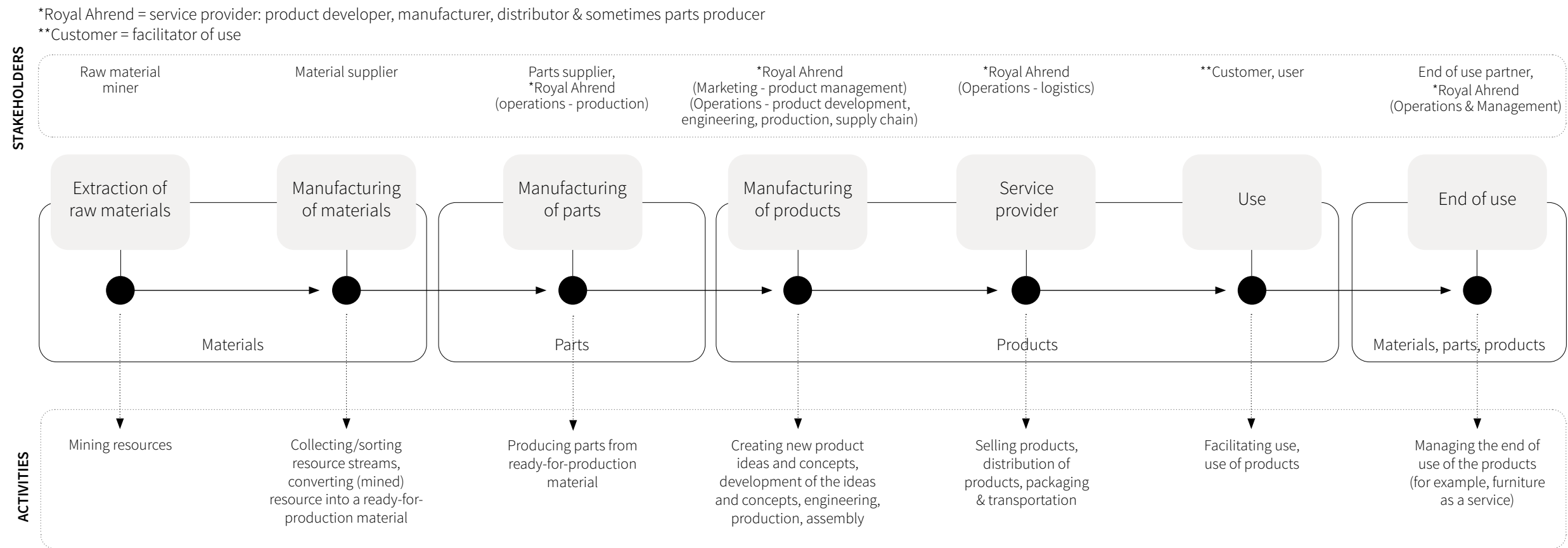The overall goals that are set should be reached in 2025 by executing several projects. The projects are subdivided into four main themes: Vitalizing Workspaces, Sustainable Products, Resource Preservation and Environmental Integrity. An overview of the projects under each theme is given in figure 17. Each theme has its own goal and ambition stage. Every project is described by a definition, the key elements, a goal, the why: evidence for importance, the benefits, the milestones, the metrics, the resources and the responsible persons (the project team). Important to mention is that all the projects and themes are interrelated and should together contribute to the achievement of the overall goals.

[4]Information retrieved from Royal Ahrend. Internal document: CSR strategy 2025.

ROYAL AHREND CSR STRATEGY 2025
STRATEGY SUMMARY

PURPOSE   Vitalising workspaces to increase customer performance and employee experience.

VISION   We believe in vitalising workspaces by designing sustainable products for multiple lifecycles. Produced in environmental and social friendly production facilities.

STRATEGY   Honoring our heritage by complementing and aligning our overall strategy with a robust sustainability strategy, thus setting a new standard in vitalising workspaces.

Reduce product environmental footprint by 25%

80% of our value chain engaged

Marketleader in Furniture as a Service

Reduce emissions by 50%

Positive impact factory

Leading social entrepreneurship in the industry

One Royal Ahrend - market leader in Benelux, top 3 in Europe, top 5 in Global Accounts segment in creating and offering inspiring work environments that excel in sustainability, design and flexibility to contribute to well-being and performance of employees

VITALISING WORKSPACES *Ambition: stage 5*	SUSTAINABLE PRODUCTS *Ambition: stage 4*	RESOURCE PRESERVATION *Ambition: stage 4*	ENVIRONMENTAL INTEGRITY *Ambition: stage 4*
Well-being	Design Philosophy	Closing the Loops	Emissions
Diversity & Inclusion	Insight in Impact	Commercial Models	Waste
	Innovation	Sales Channels	Water
	Value Chain Responsibility		

Leadership

Culture

Governance

Figure 17 | Strategy summary, Royal Ahrend CSR 2025[6].

2.2.6 Royal Ahrend and Sustainability

Stated in the problem definition in the introductory chapter and in chapter 1, Royal Ahrend is already applying some concepts to increase sustainability in product development. Yet, this results in several unconnected sustainability-related practices. However, these practices are relevant to include in the process towards a valuable solution. Therefore, an overview is created in figure 18 that highlights some of these practices.

One of the practices in figure 18 is the Gispen Circular Design Framework. The framework is discussed more extensively to provide a better understanding of this framework specifically and because it is still in use by Gispen.
In 2015, Gispen has developed a circular design framework in collaboration with TNO that makes circular design and its resulting products measurable (Granholm, Grösser, & Reyes-Lecuona, 2017) (Gispen, 2015). The framework has been developed to provide guidelines for the design process and (product) developments for the future, but also for the comparison of products. This is achieved by assessing the underlying requirements. Each product receives a number of points on a circular ladder based on forty-seven statements divided into seven themes. In figure 19 a short description of the seven themes in the framework is shown.
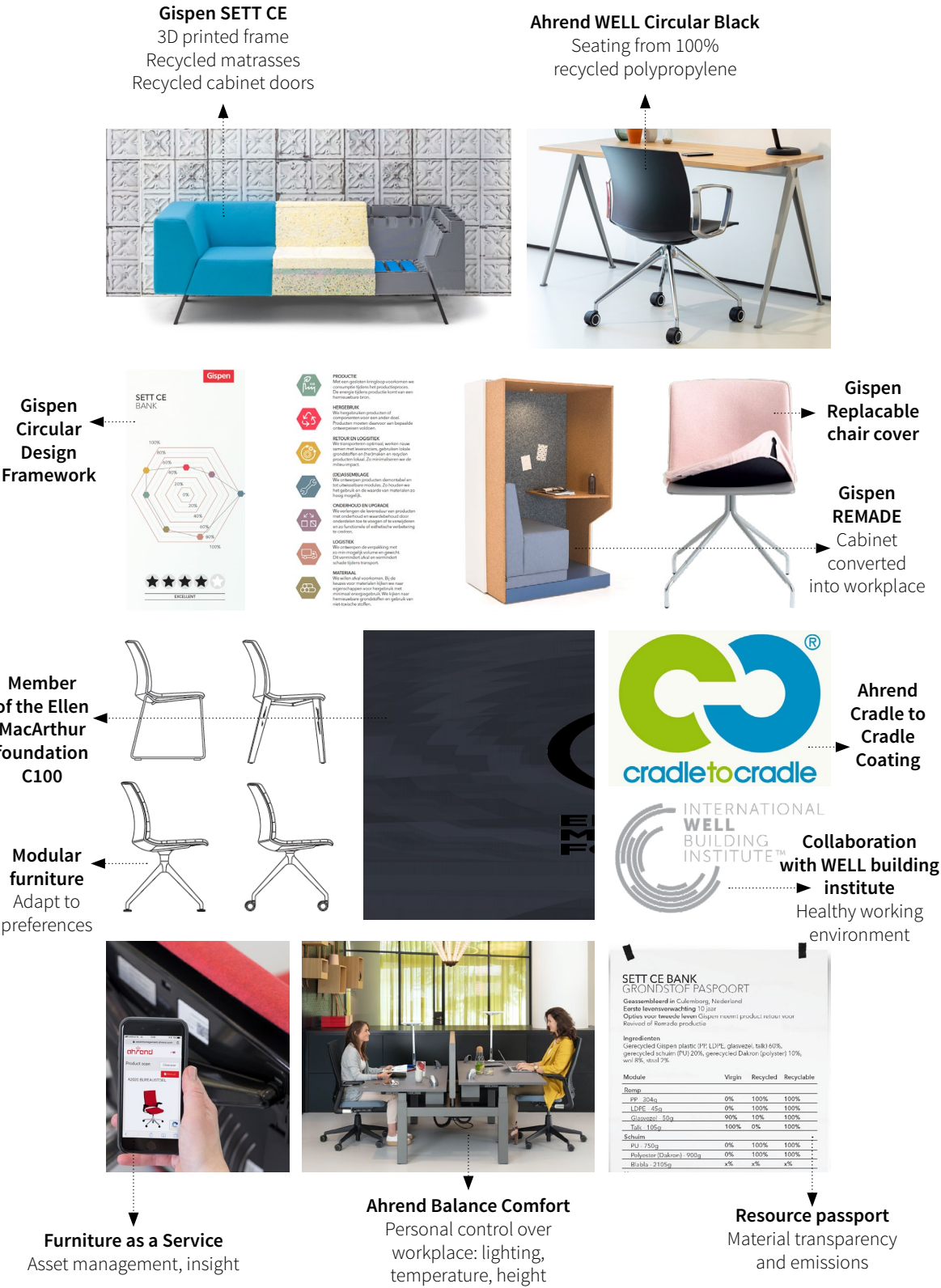
Figure 18 | Royal Ahrend and sustainability, example projects.

As mentioned, the framework was developed in 2015. Due to developments over time regarding sustainable product development, the framework has become outdated. Furthermore, some remarks can be made regarding the current state of the framework:

- Judging own products, the framework is not objective.
- The framework is multi interpretable therefore non-reliable. A different result is reached when the framework is filled in by someone with a different background or function.
- Time to fill in the framework is +- 1 hour. This is considered as time-consuming in relation to the result that comes out of the framework.
- The framework cannot be used for all products and product lines.
- There is a double theme: logistics and (reversed) logistics.
- The statements can only be answered with a harsh YES or NO, there is no nuance.
- Currently, the framework is not applicable for both brands as it is specifically focussed on the brand Gispen.
- The focus of the themes and statements is not in line with the new strategy and can be sharpened.

However, some highlights should be addressed as well. The framework is extensive, seven themes are addressed. In addition, the framework functions well as a communication and marketing tool to compare products. The remarks and highlights are useful input for the development of the solution.

Figure 19 | The seven themes of the Gispen circular design framework.

(DIS)ASSEMBLY
Ease of disassembly is taken into account during the design of complex products and interchangeable modules, parts and components. This way, the materials are used efficiently and retain their value.

MATERIALS
We strive to prevent waste production. We select our materials upon their suitability for reuse and level of energy consumption. We also use renewable resources and non-toxic substances.

LOGISTICS
During the design process we already take a product's packaging into consideration to reduce its volume, weight and waste. This method is good for the environment and reduces transportation damages.

MAINTENANCE AND UPGRADES
We extend the life of products by means of (un)planned regular maintenance but also take care of value retention by adding or removing components to improve a product's functionality or design.

REUSE
Products, parts or components that have come to the end of their lifecycles are given a new purpose. Products do need to meet certain design requirements to be viable for reuse.

(REVERSED) LOGISTICS
Our transportation methods are optimised, we work closely together with our suppliers, use either acquired or mined local resources and manufacture/refurbish and recycle our products locally. This all results in a minimum strain on the environment.

MANUFACTURING PROCESS
The closed loop prevents waste production during the manufacturing process. The energy supplied during this process comes from a renewable source.

2.3 SPECIFICATION OF A RESEARCH FOCUS AND LISTING SOLUTION REQUIREMENTS

2.3.1 Specification of a research focus

In the introductory chapter the scope of this research was already limited to the design philosophy project specifically focused on the brands Ahrend and Gispen in the Netherlands. This section serves to further define the research scope based on the insights that are gained in chapter 1 and 2. Hereby a research focus within the organization is determined.

From chapter 1, the definition of sustainable products as defined in section 1.4 is taken as a basis for the theoretical framework of the solution. Furthermore, an interpretation of the life cycle thinking philosophy combined from different literature perspectives is established. Moreover, section 1.2 addresses the lack of solutions that focus on integrating sustainability at the beginning of the product development process.

From chapter 2.1, a frame of reference regarding sustainability-related themes is created out of the sustainability strategies of competitors. In addition, several insights are gained:
- The whole industry is still searching for ways to incorporate sustainability, but there is no unambiguous way. This leads to own interpretations of sustainability;
- Companies are trying to take responsibility for their actions by referring to standards, certificates etc., which shows that there is a need for validation;
- From the transformations that are currently occurring within the furniture industry, the importance of the well-being aspect in the working environment is addressed.

From chapter 2.2, the importance of distinguishing the brands within the solution is made clear. Moreover, a specific focus on the start of product development has led to a clear understanding of the product management department, the product life cycle of products from Royal Ahrend, the collection strategy roadmap and the corresponding design briefing. This is relevant to make the solution fit and ready for implementation. Besides that, current sustainability practices and the Gispen framework analysis are taken as inspiration for the further development of the solution.

The choice is made to focus on a solution that is ready for implementation at the start of the product development process, because of the lack of solutions in this area and the wishes and requirements of Royal Ahrend. Furthermore, the impact is bigger when focusing on the start of product development, because in this part of the process a lot of freedom is offered, and nothing is determined yet. This implies that product management and product development are the main internal stakeholders. Several interviews and discussions with the stakeholders were held to be able to specify the needs of both departments regarding sustainability in their field and current tasks. Besides, a clear link should be established between these two departments as the design brief functions as a transfer of the development idea from product management to development.

In the primary research question two parts are addressed: the design philosophy and the translation of this philosophy into a solution. Therefore, at first, the design philosophy is clarified by establishing a theoretical framework that represents the design philosophy. Secondly, the theoretical framework serves as a basis for the development of a support instrument in the form of a toolkit (see chapter 4).

2.3.2 Solution aspects

In this section the solution aspects are listed in figure 20 that need to be considered whilst designing the theoretical framework and corresponding toolkit. First, some general solution aspects are listed. Then, the aspects are separated into aspects for the theoretical framework and for the toolkit. Thereafter the needs and wishes of the stakeholders are listed.

THE SOLUTION SHOULD:

GENERAL
1. include a clear description of the goal of the solution and what can be achieved with it.
2. be reliable and structured, independent of who is using the solution.
3. focus on the start of the product development process
4. be flexible by means of changes over time that have big impact on sustainable product development.

THEORETICAL FRAMEWORK
5. contain a clear distinction between the three key elements ecology, circularity and well-being.
6. contain strategies that are substantiated.
7. be complete and include relevant aspects of sustainable product development.
8. connect to the higher goals of the CSR strategy 2025 of Royal Ahrend.

TOOLKIT
9. contain a manageable amount of information.
10. facilitate storing of information and knowledge.
11. include a link to the different resource value states by making the solution applicable for each resource state.
12. facilitate a possible distinction between the two brands Gispen and Ahrend.
13. Include a measuring component to specify certain strategies.
14. connect to the (changing) customer demand.
15. contain a minimum level for each key element and ambition levels towards 2025.
16. include legislation and certification.
17. include a clear link between the two stakeholders:
    a. Transfer of the idea from product management to development.
    b. Communication and feedback during the development process.
18. give guidance and support regarding sustainability during the deisng and development process.

Figure 20 | Solution aspects, needs and wishes.

PRODUCT MANAGEMENT

NEEDS
19. Get inspired by current sustainable product development practices (market trends etc., but also from own products and projects).
20. Gain knowledge regarding the possibilities of sustainability in the design process, insight in the impact of specific choices.
21. Being able to set ambitions regarding sustainability in development ideas.
22. A way to incorporate sustainability in the strategic approach of a development idea.

WISHES
23. A way to map the customer demand in the area of sustainability.
24. A way to communicate the sustainability of products towards customers.
25. Being able to compare products based on sustainability.

PRODUCT DEVELOPMENT

NEEDS
26. Gain knowledge regarding the possibilities of sustainability in the development process, insight in the impact of specific choices.
27. Receiving a design briefing that specifies the sustainability aspects of the development idea.
28. Access to a database with a standard set of materials to choose from (providing information about the materials: certification, environmental impact, approved by Royal Ahrend).
29. Being able to create product passports.
30. Being able to measure product sustainability.
31. Being able to track materials, parts and products.

CHAPTER 3

What are the characteristics of a theoretical
framework for the development of sustainable
products for Royal Ahrend?

This chapter describes the process towards the
development of a theoretical framework that
represents the design philosophy. First, the
definition of a sustainable product for Royal Ahrend
is elaborated on. Thereafter, the steps towards a
strategy-indicator framework are explained. Each
impact area is discussed, and the strategies are
explained. Finally, a sidestep is taken towards product
complexity and what this means for applying the
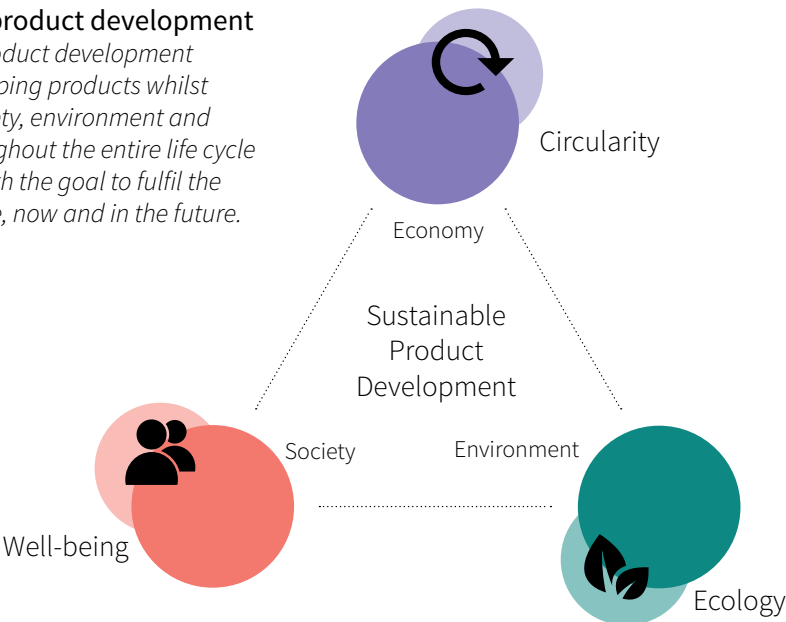strategies.

3.1 SUSTAINABLE PRODUCTS FOR ROYAL AHREND

This section serves to elaborate on Royal Ahrend's definition of sustainable products as it is defined in section 1.5. Figure 21 repeats the definition of sustainable product development and sustainable products for Royal Ahrend and visualises how the three key elements relate to each other. Incorporating Royal Ahrend's definition of sustainable products into the theoretical framework and solution eliminates the variety of internal interpretation and creates possibilities to clearly distinguish the brand identities regarding sustainability.

Mapping the key elements in a triangle shows that they interrelate. Furthermore, choices that are made regarding one of the key elements, influence the other two key elements directly.

Each key element has a certain impact on the sustainability of a product. Therefore, throughout the remaining parts of this thesis report, the key elements are called impact areas.

Sustainable product development
Sustainable product development is about developing products whilst balancing society, environment and economy throughout the entire life cycle of a product with the goal to fulfil the needs of people, now and in the future.

Sustainable product
A product that is designed, sourced, developed, manufactured, used and reused with circularity, ecology and well-being in mind.
-   Circularity: Keep products, parts and materials in use at a continuous high value.
-   Ecology: Products should positively contribute to the environment and ecosystem.
-   Well-being: Products should contribute to the health and well-being of people.

Figure 21 | Sustainable products and sustainable product development for Royal Ahrend

3.2 DEVELOPING A THEORETICAL FRAMEWORK

As said Royal Ahrend's definition of sustainable products serves as a basis for the theoretical framework. From the solution requirements listed in section 2.3.2, the theoretical framework should contain a clear distinction between the impact areas and contain clear goals and substantiated strategies. These strategies together should include all relevant aspects of sustainable product development.

3.2.1 The goal of the theoretical framework
The overall goal of the theoretical framework is to create a substantiated representation of the design philosophy that is understandable and structured and can be translated into concrete, supporting and functional tools.
The framework contributes to the integration of sustainability in product development by providing a clear understanding of sustainable product development and its impact areas. It contains strategies that serve as guidelines for the development process and can be applied to find and create sustainable solutions for product development on multiple levels. The multiple levels refer to material, process, part, connection, sub-assembly and product sustainability. Section 3.4 elaborates on these levels in more detail.

3.2.2 Strategy-indicator framework
It is chosen to give substance to the theoretical framework in the shape of a strategy-indicator framework. The United Nations is using such a framework for the Sustainable Development Goals and the related targets (UN, 2018a). Furthermore, the companies Circle Economy, Metabolic, DGBC, SGS Search and Redevco together developed a framework for circular buildings that is based on this same approach (Metabolic et al., 2018). This circular building framework serves as inspiration for the framework to be developed.

Strategies provide an understanding of how to achieve a certain goal (in this case the goals of the impact areas) by describing a plan of action on how to get to that goal. Indicators help to measure the success of achieving the goals. They are tools for communication, evaluation and decision making that can take a quantitative as well as a qualitative form depending on the purpose of the indicators (Gallopin, 1997). In addition, indicators simplify; can be used as tools for planning like guiding and prioritizing future activities; and can be a helpful basis for analysing and reporting status (Linser, 1999). Throughout the remaining parts of this thesis, an indicator is defined as: A way to communicate, demonstrate or measure if and how a sub-strategy is put into practice.

For this thesis, the impact areas will be expanded by developing strategies and corresponding sub-strategies for each impact area. Furthermore, some general strategies are mentioned that complete the set of aspects that are relevant for the development of sustainable products. Hence, the indicators are not part

of this. Creating a theoretical framework without specific indicators makes the framework applicable in a broader sense because the type of product is not specified yet. However, for Royal Ahrend, several possible indicators are mentioned in section 3.3 to improve the understanding and applicability of the sub-strategies and find relevant solutions for office furniture specifically. Additionally, in chapter 4 a link is established towards the indicators and tools.

3.2.3 Steps to take towards a strategy-indicator framework

Figure 22 illustrates an overview of the steps that are taken towards the strategies and sub-strategies of the framework. Appendix E provides more details regarding the results of each step.

1.   The first step in establishing the framework is to expand the three impact areas Well-being, Circularity and Ecology. A frame of reference regarding sustainability-related themes was created in section 2.1.2. These themes are subdivided over the three impact areas. In addition to the frame of reference, insights and perspectives from literature research, the Gispen framework and current practices are considered for the development of the strategies.

2.   The first set of strategy themes is established as a result of expanding the impact areas.

3.   The first set of strategy themes is discussed with several stakeholders.

4.   After multiple iterations, related to stakeholder input and finding connections and relations between the strategies a final set of strategy themes was determined as a basis for the strategy-indicator framework. Figure 23 illustrates the relations between the strategy themes in the sustainability triangle. This clearly indicates that choosing to focus on one strategy in a specific impact area, automatically influences the possibilities in the other impact areas. This shows that sustainable product development is very complex and there is not one specific right choice to make.

5.   From this basis, the strategies are defined with corresponding sub-strategies and possible indicators as explained in section 3.3.
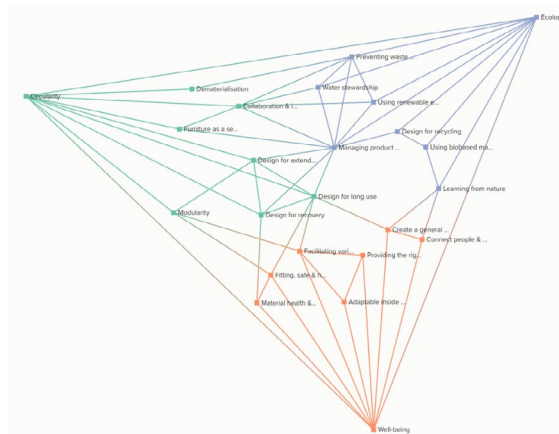

Figure 23 | Illustrating the relations between the strategy themes in the sustainability triangle.
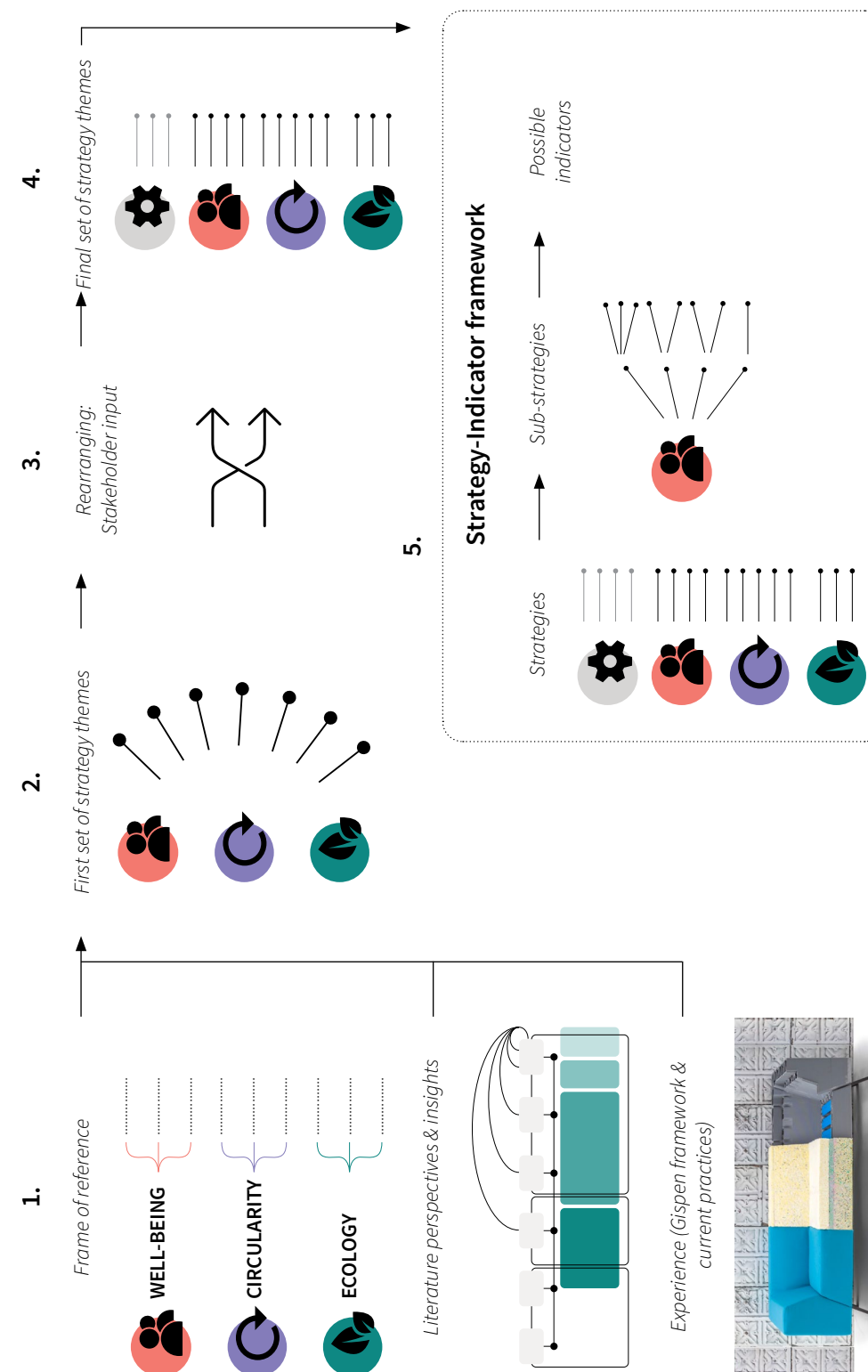

Figure 22 | Steps towards the strategy-indicator framework.

3.3 DEFINING AND FORMULATING DESIGN STRATEGIES FOR EACH IMPACT AREA.

From the final set of strategy themes, the strategies and their sub-strategies are established. Figure 24 provides an overview of the strategies and sub-strategies. Appendix F provides a full overview of the strategies and sub-strategies including their descriptions. Each impact area and their main strategies are described in the following sections. In addition, for each strategy, several possible indicators are mentioned. Firstly, general strategies are explained that enable sustainable product at its full potential when applying them besides the impact area strategies. Then, each impact area is discussed by elaborating on the strategies and explaining their relevance for the development of sustainable products.

3.3.1 General strategies for sustainable product development

In section 1.3.4 a list of implications regarding SPD for product manufacturers like Royal Ahrend is created. Some of the listed implications are chosen not to further discuss because the research focusses on product development specifically. However, these implications are of significant relevance in order to develop sustainable products. Therefore, in the strategy framework they are mentioned as general strategies but are not further specified into sub-strategies and only serve to illustrate the broader context to make sustainable product development possible. The four general strategies are related to other projects of the CSR strategy that are mentioned in figure 17: Insight in impact, Value chain responsibility, Commercial models, Innovation. To provide a better understanding of the general strategies, an explanation is given for each strategy.

G1. Collaborate to create joint value and transparency: Enabling sustainable product development is directly related to the product life cycle of the product. Section 1.1.2 explains that in each PLC component different stakeholders are involved. SPD requires that all stakeholders take responsibility for the industrial processes that they are related to. Therefore, collaboration is necessary which leads to value for all stakeholders (Metabolic et al., 2018). Furthermore, by collaborating, transferring information is facilitated and this promotes transparency.

G2. Incorporate digital technology: Online platforms and new technologies can offer possibilities for collaboration and safe transfer of supply chain information (Metabolic et al., 2018). Distributed Ledger Technology is an example of such a technology that can support safe data transfer between relevant stakeholders in the supply chain (WEF, 2019). To illustrate this example, a material passport can be created with accurate and verified information about the product, its parts and materials without the need of a central party that stores this information. As the information is constantly synchronized, transparency is preserved.

IMPACT AREA	STRATEGY	SUB-STRATEGY
GENERAL	G1. Collaborate to create joint value and transparency	
	G2. Incorporate digital technology	
	G3. Rethink the business model	
	G4. Keep innovating	
WELL-BEING	W1. Design for good habitat	W1.1 Biophilic design W1.2 Create a general appearance that contributes W1.3 Facilitate various working environments
	W2. Design for adaptability	W2.1 Providing the right features & technology W2.2 Adaptable inside environment
	W3. Design for diversity	W3.1 Adaptable & fitting furniture W3.2 Comply with ergonomic regulations
	W4. Consider social fairness	W4.1 Use (fairtrade) certified materials
CIRCULARITY	C1. Design for long use	C1.1 Design for physical durability C1.2 Design for emotional durability
	C2. Design for extended use & recovery	C2.1 Design for maintenance and repair C2.2 Design for upgrading and refurbishing C2.3 Design for remanufacturing C2.4 Design for recontextualizing C2.5 Design for update and changing needs
	C3. Design for recycling	C3.1 Use pure materials C3.2 Materials must be separatable C3.3 Recyclability
	C4. Design for natural regeneration	C4.1 Use recycled materials C4.2 Use renewable materials
	C5. Healthy material selection	C5.1 Avoid the banned list of materials C5.2 Use materials with a minimum environmental impact
ECOLOGY	E1. Use renewable energy	E1.1 Minize the amount of embodied energy E1.2 Renewable production
	E2. Manage the water	E2.1 Minimize the amount of embodied water E2.2 Water availability E2.3 Clean water
	E3. Design out waste and pollution	E3.1 Produce without waste and emissions

Figure 24 | Impact areas, strategies and sub-strategies.

G3. Rethink the business model: as mentioned in chapter 1, a different way of approaching product design requires a different business model (de Pádua Pieroni et al., 2018; EMF, 2019b; Metabolic et al., 2018). Extended responsibility and products as a service are examples that fit within that different approach. By offering products as a service, the responsibility for the products is for the manufacturer and not the user. This causes more control over closing the loops back into the product life cycle and offers new possibilities like selling, for example, 'refurbished' products or leasing products.

G4. Keep innovating: Sustainability is a continuously developing subject that can be interpreted in multiple ways. To be able to keep up with the changes, and, as a thought leader, be the first to make those changes, innovation is essential (Blomsma et al., 2019). Possible innovations can be specifically about developing new materials but can also mean a new tracking tool for products that can give information about the product after scanning a QR-code.

3.3.2 Impact area | Well-being
The goal of the impact area Well-being is to design products that contribute to the health and well-being of people. The strategies within this impact area focus on the well-being of the user during the use of the product and on the well-being of employees during sourcing, developing and producing. During the use of the product, the well-being of the users can be influenced on three levels: through the working environment, through the workplace and through the furniture itself. These three levels are established to make this aspect of sustainability understandable and applicable. The fourth strategy, Social fairness, is focussed on the well-being of employees during sourcing, developing and producing the materials, parts and products.

W1. Design for good habitat (the working environment): The focus of this strategy is on creating a good habitat for the user by enhancing their physical and mental health and fitness. The related sub-strategies are facilitating various working environments, a contributing general appearance and biophilic design. Biophilic design aims to satisfy peoples' need for contact with nature which positively influences their mental health, productivity and well-being (Kellert & Calabrese, 2015). Facilitating a variety of working environments serves to fit the needs of people. Additionally, it ensures a flexible infrastructure that can be adapted to possible changes (IWBI, 2019b; Leesman, 2017). Possible indicators can be the use of natural colours and shapes or the multifunctionality of a product.

W2. Design for adaptability (the workplace): This strategy focuses on the workplace that can be adapted to the preferences of people. Related sub-strategies focus on providing the right features and technology that people find important and to allow people to adapt their workspace to personal preferences (IWBI, 2019b; Leesman, 2017). Examples of personal preferences are related to the temperature of the workplace, ventilation and amount of light. Possible indicators can be the availability of lighting control or sockets.

W3. Design for diversity (the furniture): The focus of this strategy is on designing products that can be adjusted to personal preferences and comply with ergonomic regulations. These two parts relate to the two sub-strategies. Ergonomic standards are generally determined by organisations such as the Arbo unie and must be fulfilled. Furthermore, this contributes to the experience of comfort. Adjusted to personal preferences implies that, for example, a desk, should contain the possibility to adjust the desktop in height. Possible indicators are the availability of height adjustment control or Arbo standard certificates.

W4. Consider social fairness: This strategy focusses on the well-being of people throughout the life cycle before a product arrives at the use phase. The sub-strategy focusses on Fairtrade certified materials which indicates that materials should be responsibly sourced without for example child labour or excessive work time (McDonough & Braungart, 2002). This also applies to the manufacturing of parts and products. Possible indicators can be Fairtrade certification for materials or production locations, social hotspot database: choose places for production with better standards, employee experience assessments.

3.3.3 Impact area | Circularity
In section 1.3.1, circular strategy loops are introduced as a way to reduce a product's resource use. Furthermore, these loops are substantiated and linked to the different resource value states and product life cycle components. The goal of the circularity impact area is to keep products, parts and materials in use at a continuous high value. The circular strategy loops already offer possiblities to keep products, parts and materials in use. High value implies that the resource value state should preferably be the product state, with the aim to keep products in use as long as possible. The strategies that are illustrated in figure 8, indicate that they are applied after the use of the product and that they are dependent on the status and performance of a product at the end of its use. However, when using these same strategies during the design process, closing the loops is already enabled. Thus, before the product is designed, several use cycles of the product are already considered instead of just one cycle. Therefore, the following three strategies are established. Design for long use and Design for extended use & recovery focus on the product and part resource value states. Design for recycling focusses on the material resource value state.

C1. Design for long use: The focus of this strategy is on designing products that can be used for a long time. Thus, making the first cycle of the product as long as possible. The two corresponding sub-strategies are design for physical durability and design for emotional durability. Physical durability is about a product that remains able to fulfil all physical functions for which it was designed. Emotional durability is about a product remaining wanted. Both sub-strategies are related to product replacement that needs to be avoided.

C2. Design for extended use & recovery: This strategy is focussed on extending the product's use cycle or giving a part a new use cycle by designing products that are, for example, easy to maintain, repair and remanufacture. These examples are each illustrating a sub-strategy in addition to the other sub-strategies mentioned in figure 24. A key indicator for these strategies is modularity. Modularity means to enforce conformance of assembly configurations to standards based on modular units with standard sizes, shapes, and interface locations (Moss & Dekker, 1985). This allows for easy (dis)assembly to, for example, replace a specific part. Other indicators can be standardisation, interchangeability, keying, accessibility, and identification (den Hollander, 2018).

C3. Design for recycling: This strategy is focussed on the material resource value state which indicates that it should be possible to separate a product into pure materials that can then be used for new parts or products (Blomsma et al., 2019). The material is processed in order to obtain the same or comparable quality (Allwood, Ashby, Gutowski, & Worrell, 2011). The related sub-strategies focus on ensuring that the materials can be used again when the product is at the end of its use (material output). For example, using pure materials means avoid mixing of materials like certain composites. Indicators can be preventing the use of additives or coatings or preventing blending plastics or mixed composites.

Two more strategies are important in addition to the three strategies that are discussed. Both of these strategies focus on the material resource value state. However, as design for recycling is focussed on the material output, these two strategies are focussed on the material input in relation to the environment.

C4. Design for natural regeneration: The focus of this strategy is on avoiding resource depletion (EMF, 2019b). The two sub-strategies illustrate two sides of this strategy. Using recycled materials means that there is no need to extract virgin resources from the earth because materials that are already extracted are looped to be continuously used. Using renewable materials means that once virgin resources are extracted, it should be resources that renew themselves within 10 years. Possible indicators can be specific certifications for wood or other materials, or the percentage of recycled content of a part or product.

PRODUCT REPLACEMENT
DEEP DIVE

Product replacement can have all kinds of causes. These causes can be intrinsic (product property changes: wear, defects, decay) or extrinsic (product context changes: fashion trends, new technology, new user needs) (Haug, 2017). To avoid such replacements, Haug, 2017, created a framework for intrinsic and extrinsic durability and resilience. For intrinsic durability and resilience, he considered appearance and function. For extrinsic durability and resilience, he considers several dimensions like timelessness, exclusivity and evolution. Table 4 provides an overview of the potential means that can avoid product replacement. These means can be used as indicators for the design for long use strategies.

INTRINSIC MEANS

		APPEARANCE	FUNCTION
DURABILITY	Decay resistance	A desk with a scratch-resistant surface.	
	Maintenance resistance	Easily understandable instructions for how to maintain a woollen sofa.	A desk that is easy to clean.
	Positive decay features	A leather sofa that develops appreciated patina.	An armchair that adapts to the user's body over time.
	Repair quality		An officechair with a warranty that covers malfunctions.
RESILIENCE	Replacement quality	A chair with an easily replaceable seat cover.	
	Upgrade quality	A chair where the chair base can be replaced with a more exclusive base.	A desk that allows replacement of the desktop with a heated desktop.
	Extension quality	A chair that may be fitted with a cover.	
	Reconfiguration quality	A sofa with cushions that can be reorganised to even out wear.	

EXTRINSIC MEANS

DIMENSION	MEANS	EXAMPLES
TIMELESSNESS	Long-lasting fashions/styles	Designing furniture in fashion-neutral colours.
	Inherent aestetic focus	Designing furniture using gestalt principles.
EXCLUSIVITY	Limited editions	Offering limited editions of a chair.
	Luxury	Using exclusive materials and manufacturing methods for a desk.
EMOTIONAL	Having 'personality'	
	Stimulating curiosity	Designing a table lamp that produces fictional associations.
	Increasing sensorial variety	Designing a table to highlight look, feel and sound (rather than focusing on exclusively visual appearance).
DESIGN PROCESS	User-center design	Using extensive user studies for designing a chair.
	User involvement in design	
	Purchase personalisation	Allowing for the personal configuration of chair elements.
USE SERVICE	Sharing products	
	Consumer communities	
	Product advice	Providing buyers with usage information
	Making social connections	

Table 4 | Intrinsic and extrinsic means to be used as potential indicators. Adapted from Haug, 2017.

C5. Healthy material selection: This strategy focusses on the toxicity or hazardousness of materials that should be avoided in order to preserve the health and safety of people and the environment. One of the sub-strategies is to avoid all materials that are on the banned list of materials as specified in the Cradle to Cradle certification (institute, 2020). Indicators for healthy material selection can be the environmental properties of the material or a material health assessment score.

3.3.4 Impact area | Ecology
The goal of the Ecology impact area is to design products that positively contribute to the environment and ecosystem. The strategies within this impact area focus on the resources that are needed to manufacture materials parts and products. Material as a resource is already considered in the circularity impact area. This impact area focusses on the 'external' resources like energy and water, and avoiding waste and pollution that can be a result of manufacturing. The strategies are based on the cradle to cradle principles that were already highlighted in section 1.3.2 (McDonough & Braungart, 2002).

E1. Use renewable energy: This strategy is focused on using renewable energy during sourcing, developing and producing materials, parts and products. Renewable energy means energy from the sun, wind, water or biomass. The sub-strategies indicate two sides, using renewable energy during manufacturing and minimizing the amount of embodied energy. With embodied energy is the amount of energy that is used to produce a material, part or product. Possible indicators can be using processing methods that are energy neutral or an energy positive factory.

E2. Manage the water: The focus of this strategy is to manage the water by minimizing the amount of water that is used to produce a product, the availability of water in the area of production and the availability of clean water. For clean water, it is important that no chemicals are used that can end up in the water as a result of making the product. Indicators can be to use specific materials or processing methods with less water use.

E3. Design out waste and pollution: this strategy is focused on avoiding waste and pollution during sourcing, developing and producing materials, parts and products. With waste is meant rest energy like heat, contaminated water or by-products. With pollution is meant emissions to the environment like CO_2 or other harmful substances. Possible indicators can be CO_2 neutral factories, energy efficiency of processes, or industrial symbiosis. industrial symbiosis means that waste could be a possible resource for another industry (Blomsma, 2018).

3.3.5 Strategy relations
To improve the understanding of the strategy framework the main strategies of each impact area and their relations with the product life cycle (simplified version) are illustrated in figure 25. The general strategies apply on all stages and are illustrated to show the relation between the general strategies and the impact areas. The circularity impact area has an impact on all three stages of the PLC: 1. Mining and manufacturing, 2. Use and 3. End of use. Ecology is mainly focussed on the first stage and well-being on both stage 1 and 2. The essence is that the impact area strategies have the most impact in the stages to which they are linked. Besides that, there is an overlap in impact areas over the different stages, indicating that the impact areas and the related strategies interrelate. Thus, when choosing a specific strategy, other strategies are influenced, possibly positively or negatively. This appoints the aspect of balancing society, environment and economy when talking about sustainable product development. Furthermore, as mentioned before, strategies should be applied in a targeted manner depending on the product or one of the other resource value states.

G1. Collaborate to create joint value and transparency
G2. Incorporate digital technology
G3. Rethink the business model
G4. Keep innovating

C1. Design for long use
C2. Design for extended use & recovery
C3. Design for recycling
C4. Design for natural regeneration
C5. Healthy material selection

W1. Design for good habitat
W2. Design for adaptability
W3. Design for diversity
W4. Consider social fairness

E1. Use renewable energy
E2. Manage the water
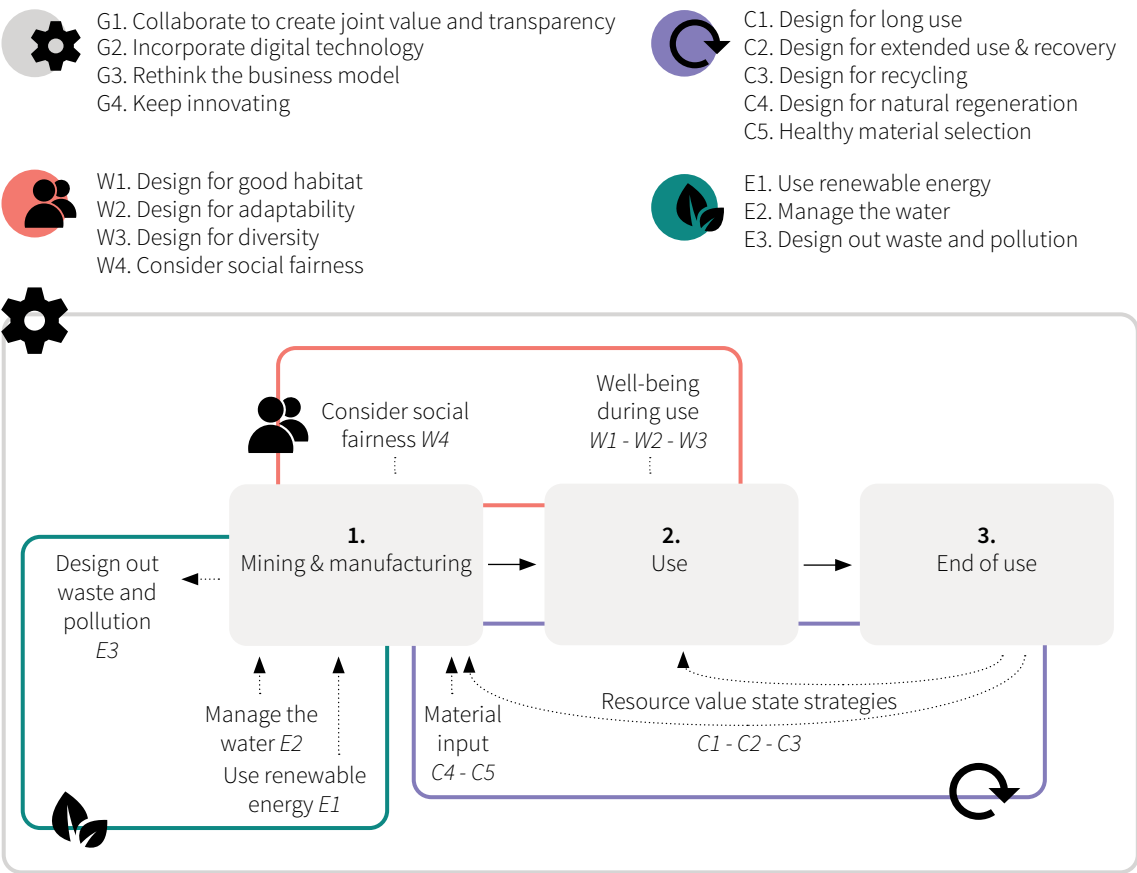E3. Design out waste and pollution

Figure 25 | Strategies in relation to the product life cycle (simplified version of the PLC).

3.4 VALUE DESIGNING AND PRODUCT COMPLEXITY

In section 3.3 the strategies are extensively discussed and mentioned throughout section 3.3 are the different resource value states. This section elaborates on the statement that strategies should be applied in a targeted manner depending on the product or one of the other resource value states. A link is established between the resource value states, product complexity, value designing and the framework strategies.

3.4.1 Product complexity

In section 1.3.1 the term resource value state was introduced. This term is based on the Resource States framework from Blomsma et al. (2020). Shortly summarizing 1.3.1, a higher resource value state corresponds with higher complexity. Figure 26 serves to clarify this complexity. In this figure, an additional state is added, the sub-assembly state. This state is added to clarify the product complexity because a product often consists of several sub-assemblies. Furthermore, sub-assemblies improve the configurability of a product. For example, the same chair can have different kinds of chair bases. The chair base, in this case, is the sub-assembly. Figure 27 illustrates this example.
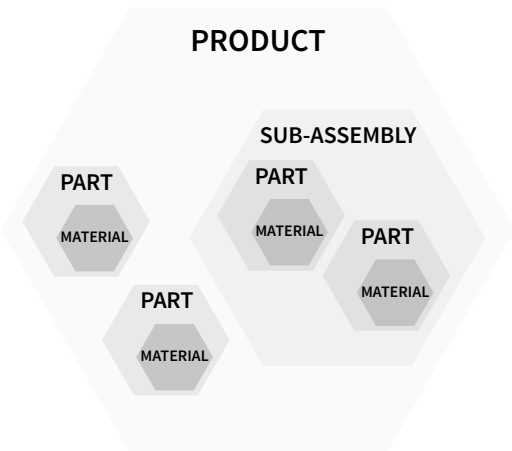
Figure 26 | Product complexity explained.
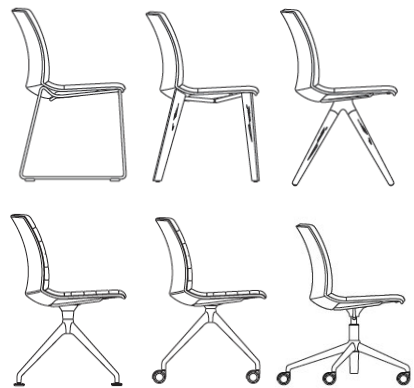
Figure 27 | Easy configuration by sub-assemblies like a chair base.

3.4.2 Value designing

When reaching sustainability in the different resource states, a sustainable product is created. However, the different resource states need to be connected to create a complete and functioning product. Thus, this indicates that some kind of connection is needed between parts and between sub-assemblies. Furthermore, to be able to create parts out of a material, the material needs to be processed. So, to create a sustainable product, not only the resource value states need to be considered, also the processes and connection methods need to be configured in a sustainable way. Figure 28 illustrates the four resource value states and connectors.

Using this complexity as a basis for product development enables to reach sustainable products on different levels. To be able to address this way of thinking throughout the remaining parts of this thesis, a new term is introduced: value designing. Value designing implies that product development is applicable on different levels, meaning that a product development idea can be a complete product, but also a specific part or connection method over a range of products or product categories. Figure 29 illustrates the different value design levels in relation to the product categories of Royal Ahrend and shows several examples for each level. Process and connection developments are always related to two resource value states as they are the link between two states.
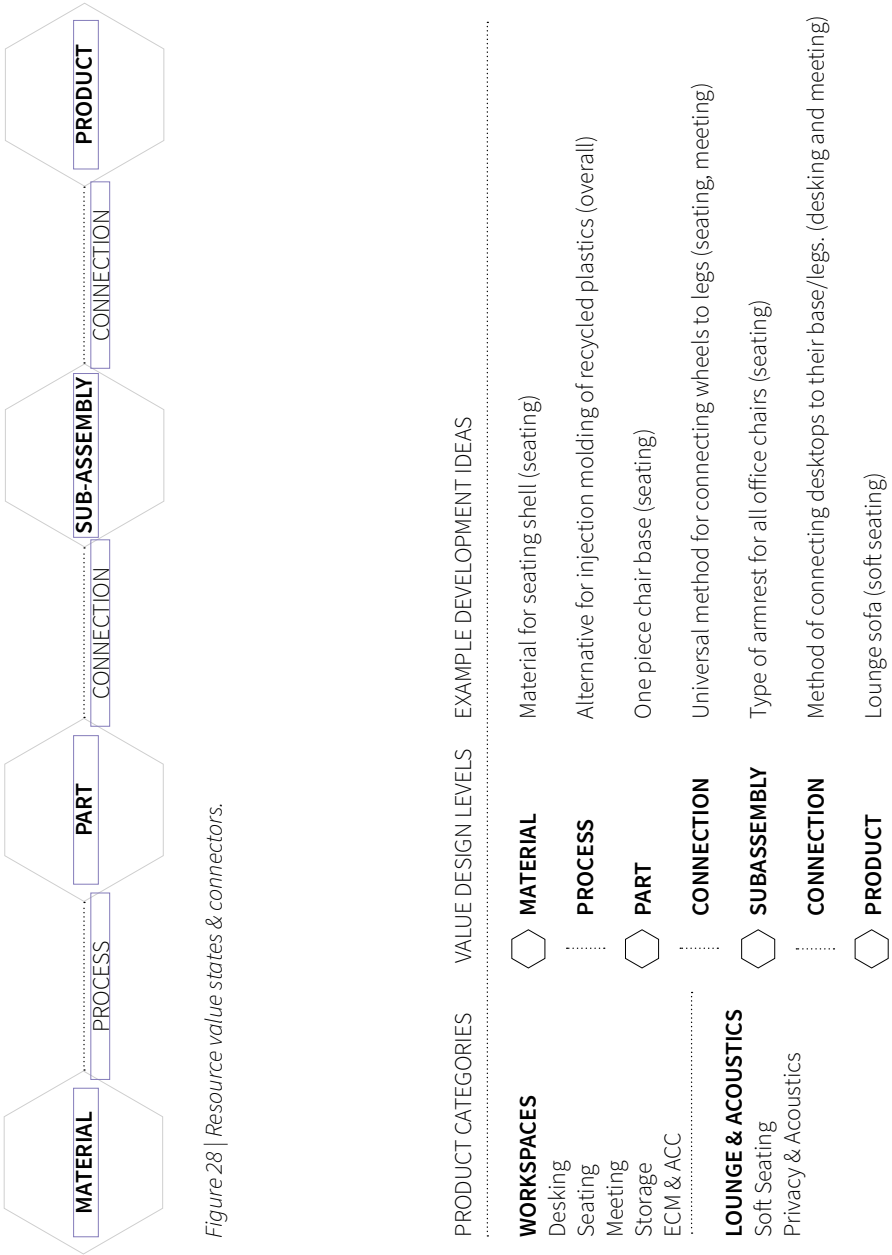
Figure 28 | Resource value states & connectors.

Figure 29 | Value designing.

3.4.3 Value designing in a strategy-indicator framework

Having introduced the concept of value designing, a link must be established between value designing and the framework strategies. Value designing indicates that development ideas can be applied on different levels. Thus, the framework strategies are applied on a specific level or several levels together. As each strategy consists of sub-strategies and indicators, this can imply that not all strategies, sub-strategies or indicators are relevant on each value design level. Figure 30 illustrates the application of the strategies on each value design level. In this figure, the general strategies are not pictured as they are not the focus of this thesis and apply overall as illustrated in figure 25. Appendix F indicates on which value design levels each strategy can be applied.
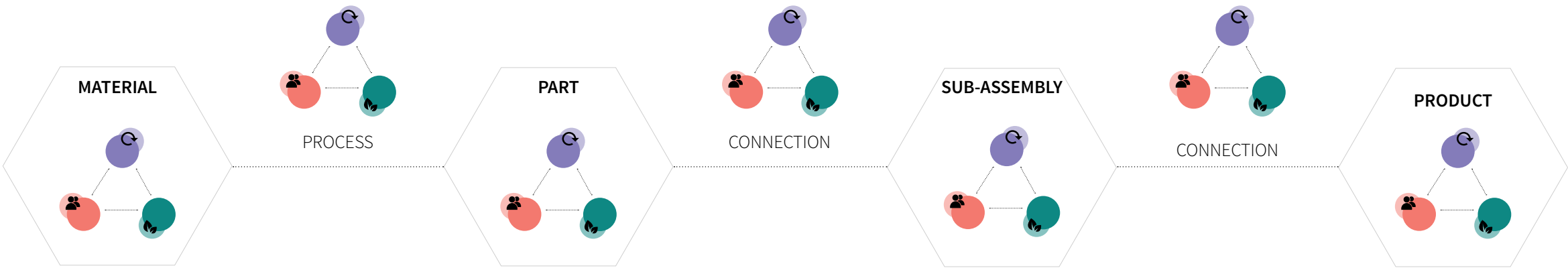
Figure 30 | Strategy application on the value design levels.

CHAPTER 4

How can the theoretical framework be translated
into a concrete, functional and supporting toolkit?

This chapter describes how the framework is translated towards a concrete, functional and supporting toolkit. First, the goal of the toolkit is described, then the three main aspects of the toolkit are explained: the application categories; the link between product management and product development; and the resulting tools. Thereafter, the overall solution is summarized.

4.1 THE GOAL OF THE TOOLKIT

The overall goal of the toolkit is to offer tools that enable users to apply the strategy framework in a structured way. The tools should be concrete, functional and supporting for the users at the start of the design and development process.

In section 2.3.2, figure 20, several solution aspects are listed that need to be considered to achieve the full potential of the toolkit. Additionally, the needs and wishes of the stakeholders are mentioned. For Royal Ahrend specifically, the toolkit serves to bridge the gap between product management and product development. This also indicates that the toolkit should contain tools for both product management and product development. Figure 31 serves to illustrate the goal of the toolkit by mentioning the three main aspects that need to be considered. Each aspect is addressed in the following sections.
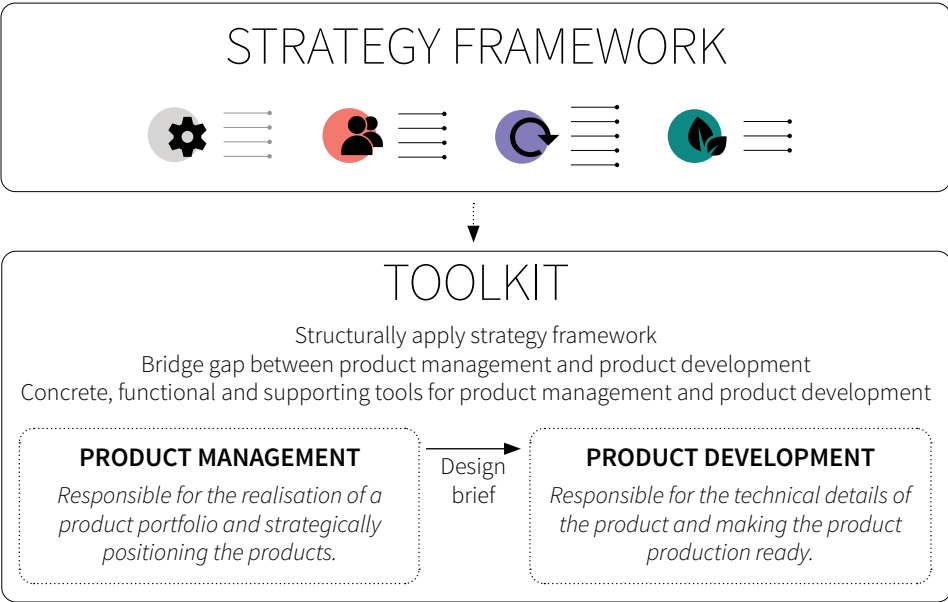
Figure 31 | The goal of the toolkit.

4.2 STRUCTURED APPLICATION OF THE STRATEGY FRAMEWORK

The strategy framework contains strategies and sub-strategies that enable sustainable product development. In section 3.3, several possible indicators are identified that improve the understanding and applicability of the strategies. These indicators can be used to communicate, demonstrate or measure if and how a sub-strategy is put into practice. They simplify the complexity of a strategy by addressing a specific aspect or interpretation of that sub-strategy. Thus, the sub-strategy is split into different kinds of indicators. In section 3.3.5 the impact areas are mapped in relation to the product life cycle. This mapping indicates that strategies in different impact areas are related but the emphasis is

on different parts of the product life cycle. The different kinds of indicators and strategies that are applied in different parts of the product life cycle address the overall complexity of sustainable product development. To make this complexity understandable and to enable the application of the strategies, a clear approach is needed so the strategies can be applied in a structured manner. Therefore, four different application categories are established that serve to classify the different kinds of indicators. Figure 32 illustrates these four application categories.

The categories are based on multiple solution aspects as listed section 2.3.2. They represent the aspects 10 (storing information), 13 (include a measuring component), 16 (include legislation and certification) and 19 (product management need for inspiration). Categorizing the indicators into these four categories enables to capture both quantitative (provable) and qualitative (imaginable) aspects of sustainable product development. For example, the strategies within the Well-being impact area are hard to translate into a measurable indicator. Hence, they can be captured in another shape as an inspiring indicator. Addressing both quantitative and qualitative aspects increases the value of the whole solution as most concepts for sustainable product development focus on only the quantitative side as indicated in section 1.2. Furthermore, by establishing these categories, supporting tools can be created that specifically focus on aspects within one of the categories. Appendix F indicates through which categories the framework sub-strategies can be applied. Most sub-strategies are applied through several categories. Each application category is described.
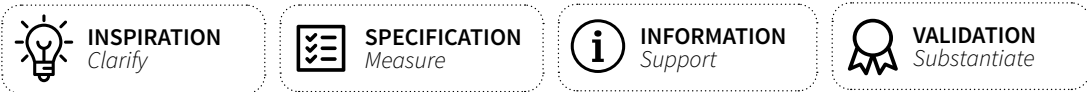
Figure 32 | The application categories.

4.2.1 Inspiration
This application category serves to include the qualitative aspect of sustainable product development. The category implies that qualitative sub-strategies can be clarified through visualised indicators. These visualisations serve as inspiration for further development of an idea. Possible sources of inspiration are:
- Previous sustainability-related practices: take outstanding or very successful sustainable products or practices as inspiration.
- Current market developments and innovations: take current sustainability-related developments and innovations as inspiration.
Inspiration is valuable for designers at the start of the process because this can support them in creating new ideas. These sources of inspiration can also serve to educate employees about the possibilities of sustainability in product development.

4.2.2 Specification
This application category serves to include the quantitative aspect of sustainable product development. The category implies that quantitative sub-strategies can be made measurable by SMART indicators (Doran, 1981). SMART stands for Specific, Measurable, Assignable, Realistic, and Time-related. Specification is needed to clarify the aspects for which a specific value needs to be determined. This results in clear requirements that serve as a base for further development.

4.2.3 Information
This application category serves to support the quantitative aspect of sustainable product development. The category implies that sub-strategies can be supported by informative indicators. These indicators relate to securing information for example by:
- Creating product passports
- Executing assessments (material health assessment, LCA)
- Creating product manuals
- Tracking products, parts and materials

Information is needed to be able to manage sustainable product development. It is an important step towards transparency regarding the product life cycle of a product. Furthermore, having information secured and available allows for clear communication towards for example customers about the sustainability of products.

4.2.4 Validation
This application category serves to include the need for validating information throughout the product life cycle. The category implies that sub-strategies can be substantiated by validation indicators through connecting with external verified organisations or conforming to widely known standards. Examples are:
- Organisation certificates (ISO 14001 environmental management system)
- Material certificates for responsible sourcing (FSC, PEFC)
- External knowledge databases (regarding materials, C2C banned list of materials)

Validation is needed to substantiate the quantitative aspect of sustainable product development.

4.3 BRIDGING THE GAP BETWEEN PRODUCT MANAGEMENT AND PRODUCT DEVELOPMENT

An aspect of the solution is to bridge the gap between product management and product development. Currently, the design brief serves to fill this gap by extensively describing the development idea like the example in appendix D. The design brief is a result of the collection strategy roadmap that is described in section 2.2.3. The need of product development about receiving a clear and specified design briefing (solution aspect 27) addresses the current unclarity or incompleteness of the briefing. This is because throughout the roadmap, not enough information is gathered to make the design briefing specific enough regarding the sustainability aspects. Therefore, in the current roadmap process pictured in figure 33, several aspects are highlighted that can be improved regarding sustainability. The first one addresses the amount and type of development ideas that are listed (1).

Referring back to section 3.4.2, value designing offers possibilities to make a change regarding the list of development ideas. By listing different ideas based on the value design levels, strategically positioning (C2C) each development idea is simplified because each level corresponds with a different strategic approach. Figure 34 illustrates how this can look in a future situation. The other two aspects in the collection strategy roadmap (3, 4) are both very dependent on the first two aspects and are therefore not further illustrated. The roadmap is the responsibility of product management, thus the set-up of figure 34 can be used as a tool to support product management in listing different product developments on the roadmap and determining the product board each year. Support is given by indicating the different kinds of developments that need to be considered.

Figure 33 | The current collection strategy roadmap with improvement possibilities.

Flowchart (Figure 33):

Roadmap collection strategy

1 List and type of development ideas
2 Strategy review (sustainable positioning)
3 Sustainable feasibility & prioritizing
4 Product briefing

- **Review by** product development & ....
- **Trends** Sales NL + INT, Studio, SCO (optimize)
- Ideas for **FURTHER DEVELOPMENT**, Sanitation
- **Portfolio analysis** Grades, PLC, SWOT, MABA, third parties
- **Evaluation** financial, logistic and commercial performance
- Longlist of ideas
- **NEW PRODUCT** ideas (visualisation & one pager per idea)
- Brainstorm
- **Market analysis** (needs/trends) **Technologyscan** (innovation/manufacturing) **Product assessment** Sales NK+ INT, Studio, SCO (missing)
- **Review** by .... (Strategy, trends, added value)
- Filter 1
- **Cluster** ideas per product group
- Ideas present
- **Review by** supply chain & product development (commercial & technical feasibility)
- Filter 2
- **Prioritise** RRR analysis (risks, rewards, resources)
- Sales NL + INT, Studio (Prio's listed roadmap previous year)
- Non selected projects
- **Review by** Sales
- Selected projects
- **DECIDE** Product Board (incl. CAPEX Fte budget)
- Product briefing
- Product range management
- Market feedback
- Product launch
- Product release
- Marketing plan
- Introduction planning
- Technical List of Requirements
- Product development
- Investment request BC productboard
- Tooling GO productboard

1 2 3 4

MARKETING PRODUCTS

PRODUCTS

Telling the story & strengthen vision
- Conforming to customer demand (partly)
- Focus on a specific product
- Specific focus on an Impact Area
- Focus on design
- Higher prices
- Smaller amounts

Roadmap
- 1? product development per year per brand
- Developing from innovation & trend-setting

MID CATEGORY PRODUCTS

PARTS, CONNECTIONS, SUB-ASSEMBLIES

Answering the broader customer demand & match the needs of each target group
- In every product category enough representation
- Focus on platform development (parts, connections or subassemblies over a product category)
- Sustainability and price on average

Roadmap
- 4? product (collection) developments per year
- Development from research/benchmark/customer demand/tender

BASIC PRODUCTS

MATERIALS, PROCESSES

Making the difference
- Low cost price
- High amounts

Roadmap
- 2? material/process developments per year
- Cost price and sustainability go hand in hand
- Material development over the whole collection

- 4? budget product developments per year
- Cost price is leading
- Sustainability benchmark

Figure 34 | Future strategically positioning of development ideas based on value designing.

DISTINGUISHING THE BRANDS USING THE VALUE DESIGNING CONCEPT
DEEP DIVE

In chapter 2, section 2.2.2 the brand identities of both Gispen and Ahrend are clarified through brand identity prisms. One of the solution aspects is to be able to distinguish the brands in development ideas (aspect 12). Figure 34 already indicates that 'marketing products' should be developed specifically for a brand. Figure 35 illustrates how Ahrend and Gispen distinguish themselves regarding the impact areas. Therefore, for 'marketing products' this difference can be used to position the product with a focus on one of the impact areas (dependent on the brand).

For the 'mid category' and 'basic' products, distinguishing the brands is harder because the developments are focussed on a whole category or collection. Therefore, for the mid category products, the developments can be distinguished based on the difference in look and feel of the brands (colours, shapes). The basic products are the same for both brands and do not need to be tailored towards a specific brand.
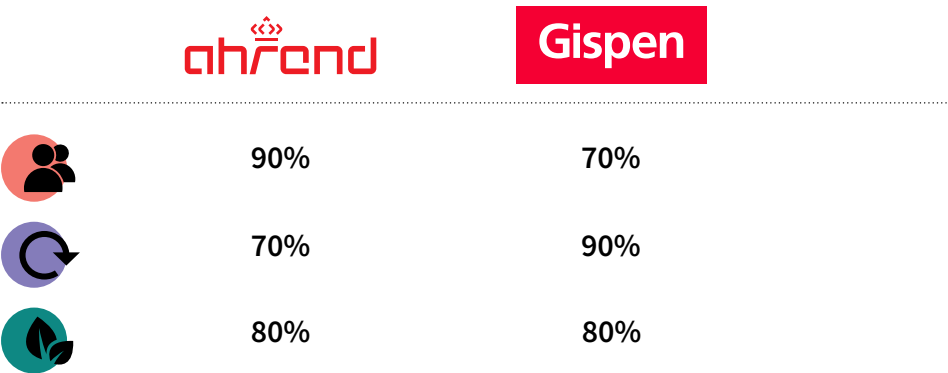
	Ahrend	Gispen
(people)	90%	70%
(circular)	70%	90%
(sustainability)	80%	80%

Figure 35 | Brand distinguishing in relation to the impact areas.

4.4 CONCRETE, FUNCTIONAL AND SUPPORTING TOOLS FOR PRODUCT MANAGEMENT AND PRODUCT DEVELOPMENT

As explained in chapter 2, the departments that are related to the development of products are product management and product development. Through interviews and discussions with both departments, the needs of both have become clear. The needs are listed in figure 20. A summary is given in figure 36.

The needs serve as a starting point for the development of tools that support Royal Ahrend in developing more sustainable products. The combination of the needs, the other toolkit related solution aspects and the established application categories, lead to a set of dedicated tools for product development and product

management. Figure 37 provides an overview of the tools. Each tool is shortly described in appendix G.

PRODUCT MANAGEMENT
Responsible for the realisation of a product portfolio and strategically positioning the products.

NEEDS
19. Gain sustainability knowledge and insight in the impact of choices
20. Determine the sustainabilitiy ambition of an idea
21. Incorporate sustainability in the strategic approach of an idea
22. Get inspiration from current developments

WISHES
23. Map the customer demand regarding sustainability
24. Communicate the sustainability of products towards customers
25. Compare products based on sustainability

Design brief → Communication & feedback

PRODUCT DEVELOPMENT
Responsible for the technical details of the product and making the product production ready.

NEEDS
26. Gain sustainability knowledge and insight in the impact of choices
27. Receive design briefing with specified sustainability requirements
28. Having material information available
29. Create product passports
30. Measure product sustainability: assessments
31. Track materials, parts and products

Figure 36 | The needs and wishes of product management and product development.

INSPIRATION PLATFORM

Innovations
RA successes
Working environment

DATA MANAGEMENT

Assessments
Product passports & manuals

EXTERNAL NETWORK & TOOLS

Collaboration partners
Supplier code of conduct
C2C banned list of materials

STRATEGY FRAMEWORK

Explanation of strategies
& sub-strategies
Education: possibilities + impact

CERTIFICATION & STANDARDS

Material certification
Standards (ergonomic,
organisation)

RA MATERIAL DATABASE

Standard set of Royal Ahrend
materials

ASSET MANAGEMENT

Furniture management system

STRATEGIC APPROACH

Indicator specification
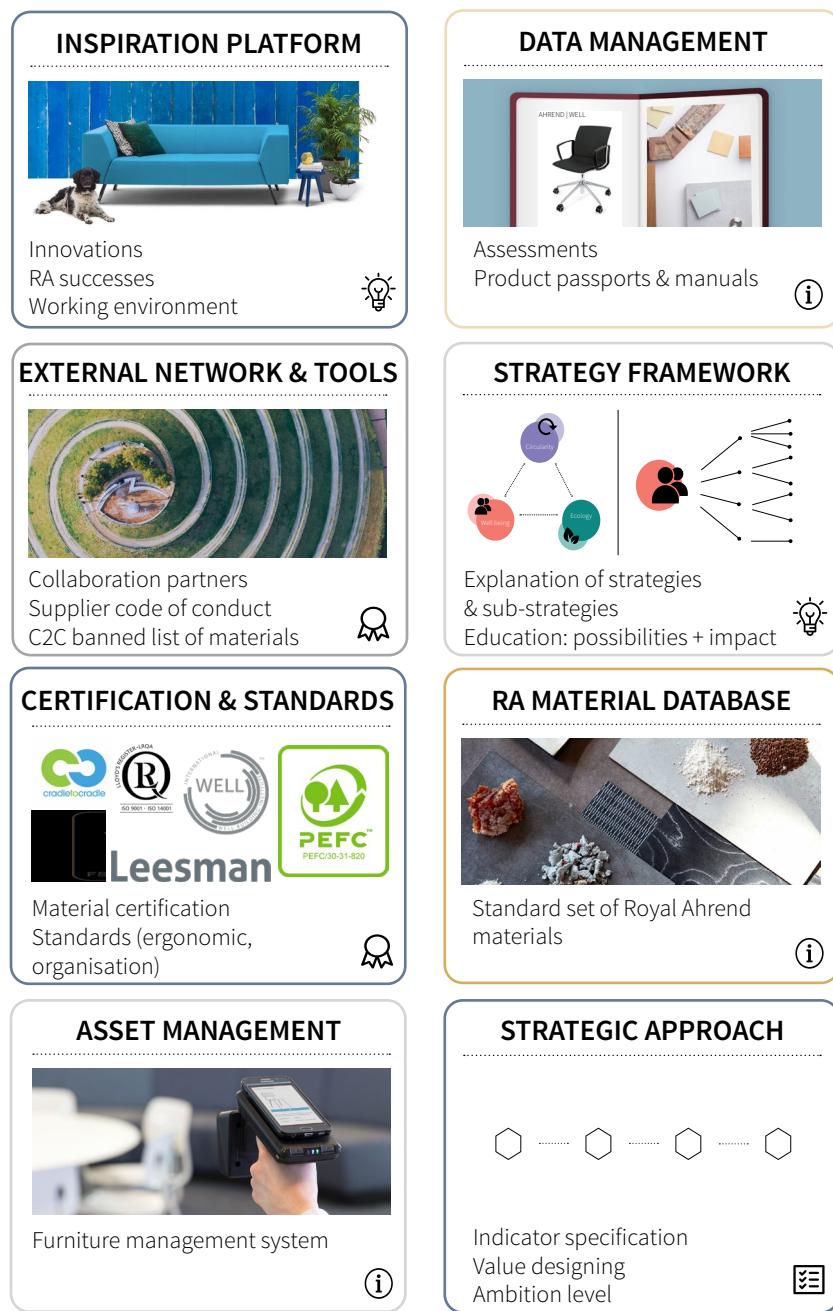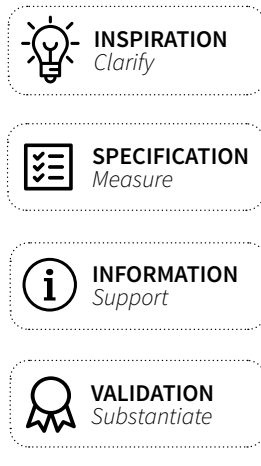Value designing
Ambition level

Figure 37 | The toolkit.

Within this set of tools, the wishes are not yet considered. However, additional tools can be added to the toolkit depending on the situation or knowledge gaps of the organization or company. For example, a sustainable packaging standard, a sustainability communication tool, or a standard LCA assessment method can be added to the toolkit.

APPLICATION CATEGORIES

INSPIRATION
Clarify

SPECIFICATION
Measure

INFORMATION
Support

VALIDATION
Substantiate

USERS

PRODUCT
MANAGEMENT
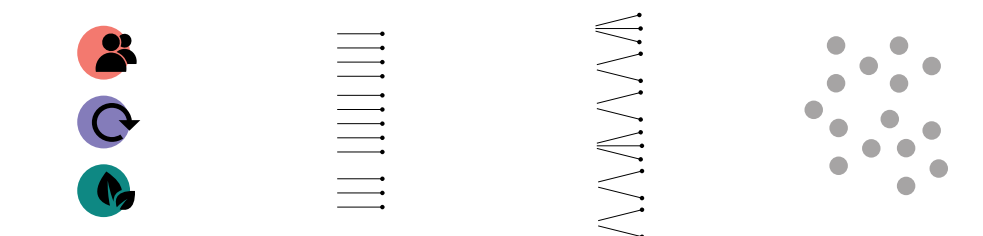
PRODUCT
DEVELOPMENT

SUPPORT
BOTH

The toolkit offers both product management and product development supporting tools to integrate and improve sustainability in product development. Using the tools leads to a better understanding of the possibilities regarding sustainability because they are specifically focussed on an aspect within one of the application categories. This automatically improves the design brief regarding completeness and clarity as both departments will have more knowledge about sustainability in product development. Additionally, addressing solution aspect 17, clear communication and feedback between the two departments are essential to create a clear link between both departments.

4.5 THE OVERALL SOLUTION

Throughout chapter 3 and 4 the strategy framework and the toolkit are described. Figure 38 provides an overview of all the important solution elements. Some parts of the solution can be applied generally, and some should be tailored to the specific organisation or company. Both the indicators and the dedicated tools are dependent on the situation of the organisation or company. Therefore, for each specific situation, these indicators need to be determined. Furthermore, some of the tools need to be adapted to fit the situation. The concept of value designing has been integrated as one of the tools and is an important aspect for applying the framework strategies.

STRATEGY FRAMEWORK

IMPACT AREAS .... STRATEGIES .... SUB-STRATEGIES .... INDICATORS

TOOLKIT

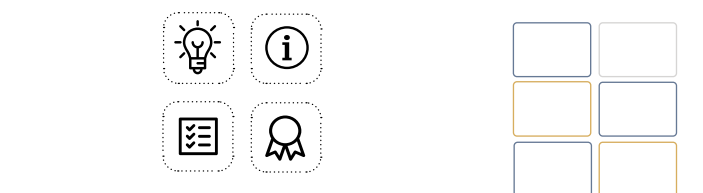........ APPLICATION CATEGORIES .... DEDICATED TOOLS

Figure 38 | The overall solution.

CHAPTER 5

How can the theoretical framework together with the corresponding toolkit be integrated in the product development process of Royal Ahrend?

This chapter describes the aspects that need to be considered to be able to implement the solution. Thereafter, discussions with experts in the field of product development, design and the circular economy are summarized by pinpointing the relevant outcomes of the discussions.

5.1 IMPLEMENTING THE SOLUTION

The overall solution presents a toolkit that supports product management and product development in applying the framework strategies at the start of the design and development process. The process towards this solution has led to valuable insights regarding other aspects that need to change first before application and implementation is possible. The following insights are gained that directly relate to the start of product design and development:

- The current collection strategy process might not be ideal for integrating sustainability at its full potential because it is very detailed and often not executed like it is supposed to be.
- Focussing on the development of fully sustainable products is hard and requires an extensive organisational change. Therefore, space must be made for other kinds of developments (referring to value designing).
- It is more valuable to focus on specific projects and fewer projects each year instead of a full list that will never be achieved within a year. Furthermore, the focus can be on improving what is already in the product portfolio.
- Improving the current portfolio requires to assess the whole portfolio and pinpoint where the biggest impact can be made.

Besides these other aspects that need to be considered, the implementation of the solution requires designating responsibilities. As the toolkit is meant to be used by both product management and product development, the responsibilities should be divided over both departments. However, product management is responsible for the realisation of the product portfolio, thus they should have the overall responsibility once the solution is in use.

An online platform is needed to facilitate access to the tools. Furthermore, each tool should be developed and integrated in the platform. Employees should be educated and informed about the strategy framework and toolkit to be able to apply the strategies and use the tools. In practice, related to Royal Ahrend's current situation, the online platform can be integrated as a function on their current intranet platform. This platform allows for easy accessibility for all employees. Employees can get additional rights for the parts or tools that are relevant for their expertise. Royal Ahrend already organises so called 'insight outs'. Such an insight out can be used for educational purposes and additional sustainability trainings can be organised.

To facilitate both the creation of an online platform and educational programme for employees, investment is needed that covers the costs of the technical development and invested time of employees or external parties that need to be hired to realise the solution. A project plan needs to be written including the just mentioned aspects, structured planning, and the responsibilities of the people in the project team.

FUTURE SCENARIO: USE OF THE FRAMEWORK AND TOOLS
DEEP DIVE

To illustrate the future use of the framework and the tools, an example situation is sketched.

For the coming year, the collection strategy needs to be determined. The inspiration tool can be used to get inspiration from earlier successes or innovations that are currently investigated by the innovation department. Then, new development ideas and further development ideas are listed. The value designing tool can be used to strategically position the ideas. This tool also offers a frame regarding the amount of development ideas to be chosen for the coming year. Furthermore, it describes the sustainability ambition level of the development ideas. Based on this ambition level and the strategic positioning of the development idea, several strategies are chosen to help realise this ambition. The amount of chosen strategies can depend on the brand, ambition level, or strategic focus of the idea. Then, for each development idea, a design brief needs to be created. This design brief contains the current aspects as described in Appendix C with an additional section regarding sustainability. In this section the ambition level, strategies and relevant certifications are described. For the certifications the certifications and standards tool can be used. This tool contains an overview of the certifications and standards per type of product, product category and material group. Regarding the strategies, indicators are described that make the strategy applicable for a specific development idea. Finally, possibilities for collaboration are described by addressing specific suppliers or partners.

The described steps so far are executed by product management. Once the design briefing is complete, it is transferred to product development. They are responsible for the realisation of the development idea as described design brief. For specific material choices they are supported by the material database that can be filtered based on specific material groups, products or product categories. Furthermore, it indicates which materials are certified. The data management tool allows for easily saving the choices that are made during the development process. This can be linked to a 3D model of the development idea. This provides a data set with information regarding the materials, the amount of materials, the production methods and more. Having this data available makes it easy to execute assessments like a Life Cycle Assessment and product passports can be created. Finally, the product passport information can be saved in the asset management tool. This tool can be used to manage the products while they are being used. Once a product arrives at the end of its use, information is available that allows to take back the product and close the loops.

5.2 EXPERT DISCUSSIONS

The completeness, usability and applicability of the solution for the development of more sustainable products are assessed by discussing the solution with experts in the field of product development, design, and the circular economy. Three sessions are organized:
- Peter van de Water – External designer of Royal Ahrend (Designed the SETT CE sofa)
- Joost van der Made – Innovation manager of the Nederlandse Spoorwegen (NS)
- Anna Queralt – Engagement manager and circular design expert at the Ellen MacArthur Foundation

Each session is summarized by describing the relevant outcomes of the discussions.

5.2.1 Peter van de Water – Peter van de Water furniture and product design
9th of June 2020 (Peter van de Water, Laura de Ridder, Sarah Schiffer (concept manager Gispen))

Peter van de Water is a designer that has been hired by Royal Ahrend as an external designer several times. Peter is working on the development of sustainable products and has designed the Gispen SETT CE couch that is awarded with a Dutch Design Award. This couch is produced out of 95% recycled materials and one of the key elements is the base, 3D printed out of recycled cabinet doors. The couch is pictured in figure 39.

Figure 39 | The Gispen SETT CE couch designed by Peter van de Water.

During the session, the framework set-up and the value designing concept are discussed. The following outcomes are relevant to mention:
- **The solution aspects:** The longer the list of requirements for a framework, the harder it is to create a valuable solution because the number of variables increases as the complexity of the solution is higher. In this way, opposites are created which makes it hard to make choices in the development process.
- **Opportunism:** A lot can be achieved when being opportunistic. It is better to set high ambitions because it triggers to think different and create possibilities for change. Furthermore, opportunism can be used to convince customers to set their ambition higher as well.
- **Incorporate successes:** Successes that are already achieved can be used as inspiration for other projects and products. For example, the design aspects of the SETT CE couch can be applied for other products. Research on the possibilities is already executed and thus requires a minimum amount of effort to apply on different products. Subsequently, other lounge furniture can be designed with the use of recycled matrasses or 3D printed frames.
- **Collaboration is key:** When wanting to achieve more sustainable product development, collaboration is a key element. Through collaboration, partners or suppliers with relevant knowledge and expertise can help to look for new opportunities. This saves time and a collaboration network is created.
- **Value designing:** The biggest impact can be made regarding the products that are produced in high volumes. Therefore, the product volume should be considered when analysing the current portfolio. For example, replacing a specific material with a sustainable variant will have a big impact when this is done for a product like an office chair that is sold more often than a lounge set.
- **Standardizing parts and connection methods:** Standardizing parts and connection methods over a range of products or product categories can cause a limitation in design freedom.

5.2.2 Joost van der Made – NS
9th of June 2020 (Joost van der Made, Laura de Ridder, Sarah Schiffer)

Joost van der Made is concept and innovation manager of the Nederlandse Spoorwegen (NS). NS is currently reorganising to bring the innovation department towards the centre of the organization. Joost has been working on the 'train of the future' concept in collaboration with Gispen and architectural firm Mecanoo.

During the session, the framework set-up and the value designing concept are discussed. The following outcomes are relevant to mention:
- **Marketing to enable sustainable development:** By using a product like the SETT CE couch as a marketing instrument to show the possibilities of sustainability in product development, sustainability is made attractive.
- **Asking the right questions:** Royal Ahrend is responsible for asking the right questions towards their suppliers. They do not have the resources to achieve sustainable products on their own. Therefore, asking the right questions will trigger suppliers in making changes to their processes and ways of working.
- **Setting a baseline:** A baseline regarding sustainability in product development is required to build upon. Therefore, the current way of working needs to be assessed. Once this is clear, the baseline can be expanded towards the desired situation.
- **Setting up a material database:** A material database offers support for both the designers and engineers to make specific material choices. It maps the characteristics of the materials and might lead to new opportunities.

Figure 40 | The concept of the 'train of the future' from NS in collaboration with Mecanoo and Gispen.

5.2.3 Anna Queralt – Ellen MacArthur Foundation
11th of June 2020 (Anna Queralt, Laura de Ridder)

Anna Queralt is engagement manager and circular design expert at the Ellen MacArthur Foundation. The Ellen MacArthur Foundation is leading as an expert organisation regarding the circular economy and circular design. Anna herself has a background in construction architecture and engineering for sustainable cities. Her master research was related to the development of sustainable furniture.

During the session, the solution was presented including the steps and research towards the solution. The following outcomes are relevant to mention:
- **A substantiated solution:** The way the research is conducted clearly shows how all the important elements connect and how this leads to the research outcome. Because of this, a substantiated solution is presented that offers several interesting new perspectives on the design of sustainable products.
- **The difference in needs of designers and engineers:** In the solution there are two main stakeholders: product management (designers) and product development (engineers). Creating a solution that supports both stakeholders requires to clearly distinguish the different needs of both stakeholders. In this thesis the considered needs are specifically focused on Royal Ahrend's situation. Therefore, for general applicability, it would be relevant to research the differences in needs of a bigger group of designers and engineers.
- **Well-being as impact area:** Already a lot is known regarding the circularity and ecology impact areas, well-being is a surprising new addition to the field. Both the well-being during the use of the product and well-being during sourcing and manufacturing are addressed. Especially well-being during the use of the product offers possibilities for further research to be able to better secure this aspect in product development.
- **State of the art:** Analysing the current situation is key to be able to make a change.

5.2.4 Further development of the solution
The expert discussions address several interesting aspects that need to be considered for the further development of the solution. The completeness of the solution is confirmed by all three experts, however, the complexity of the solution does require dedication and commitment to be able to actually use the solution. Additionally, well-being as impact area offers a new perspective that makes this solution distinctive from other frameworks and tools. The usability and applicability of the solution requires additional work. Aspects that need to be further looked in to are: analysing the current situation (consider sustainability successes that are already achieved) and determining a baseline; clearly identify the needs of product development and product management and, furthermore, the needs from other departments and stakeholders. Finally, these insights need to be incorporated in the project plan as described in section 5.1.

CONCLUSION

Answering the primary research question

This thesis has started to further develop the design philosophy, a project as described in the CSR 2025 of Royal Ahrend. Therefore, the primary research question to be answered was:

How can the design philosophy (as described in the CSR 2025 of Royal Ahrend) be translated into a solution that facilitates the integration of sustainability in the product development of Royal Ahrend?

This question has been addressed by five secondary research questions that are answered in the previous chapters. The findings from these chapters lead to the conclusion of this thesis.

What are sustainable products and how can sustainable products be developed?

This first question is answered in chapter 1 by addressing the broader context of the assignment and explaining sustainable development. An explanation of the product life cycle, different literature perspectives, and elaboration on the life cycle thinking philosophy have led to a meaningful interpretation of sustainable products for Royal Ahrend. Having one clear interpretation eliminates the internal ambiguity and this interpretation can serve as a basis for the further development of the solution. Additionally, through identifying and analysing existing concepts for the development of sustainable products, the lack of solutions that focus on integrating sustainability at the beginning of the product development process has become clear. Furthermore, the term resource value state is introduced. The different resource value states are key in the development of sustainable products as they illustrate the complexity of a product by addressing specific parts of this complexity. They are directly linked to the concept of closing the loops. These insights are valuable for the three key elements of sustainable product development because they might provide a basis for the, to be developed, strategies.

What aspects regarding the current situation of Royal Ahrend are important to consider for the development of sustainable products?

The second question is answered in chapter 2 by describing the current status of the furniture industry and the corporate context of Royal Ahrend. Analysing competitors and the developments in the industry led to several interesting insights. These insights address the urge of companies to validate their practices and the fact that everyone is trying to distinguish themselves with their own frameworks and interpretations. Additionally, the well-being aspect of sustainable development is becoming more important, and the urge for modular and flexible working environments to fulfil the changing needs of customers is increasing. Elaborating on the corporate context of Royal Ahrend gave insights in the current way of working, the differences between the two brands and current sustainability-related practices. These insights led to the choice to focus on the start of the product development process because this part of the process offers the most freedom and thus huge impact can be made here. The findings from both chapter 1 and 2 are converted into a list of solution aspects as a basis for the development of the framework and toolkit. The list consists of general, framework and toolkit aspects, and the needs and wishes of product management and product development incorporated.

What are the characteristics of a theoretical framework for the development of sustainable products for Royal Ahrend?

The third question is answered in chapter 3 by describing the steps that need to be taken towards the development of a strategy-indicator framework. A complete framework is presented by describing each impact area and its related strategies and sub-strategies. Besides, several indicators are mentioned that serve to communicate, demonstrate or measure how a sub-strategy can be put into practice. The extensiveness of the framework, the substantiated strategies and the positioning of the three impact areas are characteristics of this framework. Another characteristic is the link between the strategies and the different resource value states that can be used for the application of the strategies. This concept is called value designing which implies that product development is applicable on different levels. In addition, mapping the relations between the strategies by linking them to the product life cycle emphasises the fact that the strategies should be applied in a targeted manner depending on the product and the resource value state.

How can the theoretical framework be translated into a concrete, functional and supporting toolkit?

The fourth question is answered in chapter 4 by describing the three main aspects of the toolkit: the application categories; the link between product management and product development; and the resulting tools. The goal of the toolkit is to offer tools that enable users to apply the strategy framework in a structured way. Therefore, application categories are introduced. The application categories serve to categorise the indicators and capture the complexity of sustainable product development by securing both quantitative and qualitative aspects. Furthermore, supporting tools can be created that specifically focus on aspects within one of the categories. A set of tools is presented that offers both product management and product development guidance and support to integrate and improve sustainability in product development. Using the tools leads to a better understanding of the possibilities regarding sustainability because they are specifically focussed on an aspect within one of the application categories. The concept of value designing is highlighted as a tool to be used for the strategic positioning of development ideas and a way to distinguish the brands is presented. Finally, the overall solution is summarized to explain the general applicability of the solution. Both the indicators and the tools need to be determined and tailored for each specific situation and are dependent on the organisation or type of product.

How can the theoretical framework together with the corresponding toolkit be integrated in the product development process of Royal Ahrend?

The fifth question is answered in chapter 5 by formulating steps that need to be taken for the implementation of the framework and corresponding toolkit. A list of aspects that need to be considered before implementation is possible is presented. This addresses the complexity of sustainability in product development and the organisational changes that need to occur to allow for implementation. Furthermore, the solution is assessed on its completeness, usability and applicability by discussing the solution with experts in the field of product development, design and the circular economy. These discussions led to interesting insights like the need for collaboration, learning from own successes and assessing the current portfolio. These insights are valuable input for the further development of the solution. Additionally, all experts could relate to value designing as a concept for reaching more sustainable product development and were enthusiastic about this approach.

Finally, the primary research question 'How can the design philosophy (as described in the CSR 2025 of Royal Ahre*nd) be translated into a solution that facilitates the integration of sustainability in the product development of Royal Ahrend?'* can be answered by summarizing the findings of the secondary research questions.

The research method 'Research Through Design' is used to answer the primary research question. This method helped to understand the relevant problems and solutions through extensively analysing the current situation of Royal Ahrend and researching literature perspectives.

A substantiated strategy framework is developed that serves as a basis for sustainable product development. The framework is a clear translation of the design philosophy as described by Royal Ahrend in their CSR strategy for 2025 by elaborating on the three key elements Circularity, Ecology and Well-being. The created toolkit supports product management and product development at the beginning of the design and development process in structurally applying the strategy framework through the use of application categories and dedicated tools. Value designing is introduced as a concept that can be used to reach more sustainable products at different levels and to offer support in strategically positioning development ideas. The overall solution is generally applicable; however, the indicators and tools need to be determined or tailored for each specific situation.

The solution adds to the development of the field by offering new perspectives on sustainable product development and the incorporation of both quantitative and qualitative aspects. Besides, it is relevant for the furniture industry as everyone is searching for solutions to integrate sustainability and to take responsibility for the product life cycle of the products they produce.

DISCUSSION

Discussing the outcomes

The conclusions drawn are open to multiple interpretations. Having used 'Research Through Design' as a research method allows pinpointing several points of discussion that specify some of the possible interpretations.

This thesis is focused on finding a specific solution for Royal Ahrend and offers yet another perspective on the development of sustainable products. Nonetheless, the creation of this solution has value for the industry as it serves as an example and shows what needs to be done and considered to achieve more sustainable product development. With Royal Ahrend being a thought leader, they show that it is possible to make a change. Being a thought leader does not imply having the best ideas but being able the find the right solutions for specific challenges. The gained insights can also serve as valuable input for the development of the NEN 8313 (definitions and measurement methods for circular office and learning environments) where Royal Ahrend is a part of. This is a step towards a general approach regarding sustainability for the whole industry.

One of the distinctive aspects of the solution is the incorporation of both quantitative and qualitative aspects. Especially the Well-being impact area is specified through strategies that are based on qualitative indicators. In many current concepts and frameworks, the qualitative aspects are often not considered as they are not measurable and determined by people's emotions. Thus, the solution offers a new perspective by incorporating this non-measurable side of sustainable product development. However, a critical point can be that these qualitative aspects are still open for interpretation which indicates that the discussion still exists. Besides that, sustainability is not one dimensional, pinpointing that multiple choices can lead to a more sustainable product. Achieving more sustainable product development is furthermore dependent on the situation, the organization, and the product itself.

Following on these dependencies, this thesis is specifically focused on the start of product development, the design process and part of the development process (technical details). However, the context of product development is much broader. According to Du Preez et al., 2009, the product development process is influenced by four factors: the organization (size, type, structure, design capacity), the product (complexity, the level within system hierarchy, type), the project (size, type, constraints, complexity, novelty), and the personnel (team size, level of expertise, design capability). Several aspects are addressed within the solution, like product complexity and organizational structure. Nonetheless, other not yet addressed aspects need to be considered as influencing factors (du Preez, Lutters, & Nieberding, 2009). An example of such an influencing aspect is the product category. The strategy framework consists of an extensive set of strategies that can be applied to achieve more sustainable products. It can be that not all strategies are applicable for this product category. Additionally, strategies do sometimes contradict with each other because all three impact areas are related. Specific choices need to be made to find the most optimal solution for a specific situation, regarding a specific product and the other contextual influences. A constant trade-off is needed between all the

relevant aspects. The aspects need to be prioritized based on what you want to achieve regarding the three impact areas. Being able to make these choices requires knowledge and insight into the impact of the choices that are made.

Sustainability is a subject that will keep evolving and changing, Additionally, new insights will lead to new developments in the field. Coming up with new frameworks and toolkits when there is a new development in the field, requires too much work. Therefore, the solution's adaptability to change is an important aspect. This adaptability is illustrated through the following examples. The material database tool with a standard set of allowed materials does not implicate that this set cannot change. For example, when innovation comes up with a sustainable alternative for a material in the set, this material can be added to the set and possibly the least sustainable material can be removed from this set. Another example relates to the indicators. Adding nuances to the indicators makes it easy to link the indicators to specific ambition stages. When external changes arise, there is a possibility to build towards even higher ambition stages to connect to these changes.

The fact that sustainability is a subject that will keep evolving and changing also influences the solution implementation process. The implementation steps that are described in Chapter 5 are focussed on implementing the solution based on the current situation of Royal Ahrend, thus based on the way the company is currently organised. However, the constant developments change the situation and thus the steps that need to be taken for implementation will change similarly. This is also due to the wide scope of the solution and framework. Almost during the whole product development process, attention and support is needed to be able to integrate sustainability in product development. This is illustrated by the wide variety of tools. Integrating sustainability is not something that can be easily added to current processes. It requires integration in the current processes and working methods and bigger organisational changes might be needed on top of that. Furthermore, it requires commitment to change and the time to make the changes possible.

Finally, although achieving sustainable product development is very complex, constantly changing and difficult to grasp, it also offers possibilities to use this strategically. Chapter 4 already illustrates examples to use the concept of value designing to strategically position development ideas and to distinguish the brands based on a focus on one of the impact areas. These examples are focused on branding. However, there are more strategic possibilities regarding life cycle planning and business models (furniture as a service). Therefore, sustainable product development is very versatile regarding the benefits that can be gained. The outcomes of this research can be seen as a diving board towards a more mature way of handling sustainability.

RECOMMENDATIONS

Further development of the solution

This thesis has been conducted from a specific scope and solution direction. The result offers Royal Ahrend the possibility to create more sustainable products, but the research results can be further improved upon and be supplemented beyond the scope of this thesis. Therefore, some recommendations for further development are discussed that relate to the implementation and further development of the toolkit and to the commitment to designing and developing more sustainable products.

Commit to change

Before the solution can be implemented and applied, the whole organisation should get used to the unambiguous interpretation of sustainable products and what this implies for the organisation itself. The different departments and the managing board should bear sustainability and should have the same mindset regarding achieving more sustainable product development. Getting used to this interpretation of sustainable products takes time and requires knowledge and training to understand the possibilities and to be able to apply the framework strategies. Additionally, when sustainability is in the mindset of the employees, distinguishing the two brands is made easier because clarity is gained regarding the impact of specific sustainability-related choices. Specific choices can then be made that fit the brand identities.

Clearly frame the expectations

To be able to convince own employees to bear sustainability in the work they execute, the expectations need to be clear. Meaning that a basis ambition level should be determined regarding what Royal Ahrend wants to achieve in the field of sustainable product development. Furthermore, several ambition stages need to be formulated that build up to finally achieving the main goals of the CSR strategy 2025. By setting goals in several stages, it becomes clear what needs to be done on the short, mid and long term. However, the further away, the harder and more complicated it is to picture what can be expected. To illustrate this, the customer demand is expected to keep changing as are regulations and governmental policies. A clear example of such a change is the new work reality due to COVID-19. This was an unexpected change and a complete shift towards products to support this new work reality is taking place. Though, sustainability becomes subordinate. Therefore, even though strictly pinpointing to goals is unrealistic, ambition stages provide an expectation guideline for employees to ensure that sustainability becomes a standard aspect within their way of working.

Relating to the bigger picture

Mentioned in the strategy-indicator framework are four general strategies that enable sustainable product development in addition to the strategies related to the three impact areas. As the focus of this thesis was on the impact areas, these strategies were not further specified into sub-strategies. However, when wanting to achieve more sustainable product development, these strategies are key enablers. Each general strategy is related to another project in the CSR strategy of Royal Ahrend. The general strategies indicate that sustainable product development is not a subject on its own. It requires collaboration, transparency, digital technology, innovation and new business models. Through collaboration with suppliers and other organisations, much more can be achieved because more specific knowledge is available, and the right people are brought together.

This offers possibilities for new sustainable solutions. To be able to achieve more sustainable product development, securing information is one of the most important aspects. Storing information serves as substantiation for developments in the future. For example, previous experiences and projects and can be used as input for new developments. Furthermore, storing information contributes to gaining transparency. When knowing what you produce, what materials are put in a product and where they come from, it is easier, later on, to close the loops when products are taken back. Taking back products requires a different kind of business model that is framed around the concept of furniture as a service. Digital technology can be used to support furniture as a service as a business model and offers possibilities for easy collaboration and safe transfer of supply chain information. Finally, innovation is a key enabler as sustainability is a continuously developing subject. Summarizing, the general framework strategies need to be expanded towards sub-strategies and be incorporated throughout the organisation.

Sustainability versus technical and commercial feasibility

Mentioned before are technical and commercial feasibility. Integrating sustainability in product development requires considerations regarding marketability (commercial feasibility) and manufacturability (technical feasibility). Often, sustainable products are experienced as more expensive as it requires different manufacturing processes that are not optimized which leads to more manhours and thus higher prices. However, referring to the concept of value designing, when a new development idea focusses on a specific connection method or part, the costs can be charged over multiple products or a product range. This applies, for example, when a specific connection method (like a method for attaching wheels to the chair base) is standardised for all office chairs. So, by scaling up the development idea over a product range, the charges per product are lower and the influence on the marketability is limited. Furthermore, the investment costs for a new manufacturing process to make this new connection method possible can be divided over multiple products as well. Despite the concept of value designing, the trade-off between marketability, manufacturability and sustainability will always exist and should always be considered.

Further development of the solution

In chapter 5, several aspects were listed that relate to the further development of the solution for Royal Ahrend. Three of these aspects are highlighted as the main steps to take towards achieving more sustainable product development for Royal Ahrend.

- **Assessing the current product portfolio:** The first step to take is to analyse the current product portfolio. By analysing the portfolio, the possible improvements can be mapped, and this allows to pinpoint where the biggest impact can be made. Analysing the current portfolio requires the availability of the sustainability basis ambition level to assess if a product already aligns with this basis.
- **Determining specific indicators for Royal Ahrend:** To make the sub-strategies specifically applicable for Royal Ahrend, indicators need to be determined that are an interpretation of the sub-strategies for Royal Ahrend. Furthermore, the indicators need to be linked to the application categories.
- **Developing the tools and a platform to access the tools:** The development of the tools and a way to access the tools is what requires the most additional work. The tools need to be further devised by gathering a group of people with specific knowledge that can deliver additional input. Furthermore, conversations with the stakeholders need to take place to deepen their needs regarding the specific tools. Also, the technical development of an online platform and the tools should be mapped. Finally, a way should be found to integrate the platform with the existing systems and tools that are used throughout the organisation.

Besides these aspects, achieving the development of more sustainable products requires a huge organisational shift and investment to be able to create the toolkit and educate and inform employees about the use of the toolkit.

Manage the assets

This thesis is focussed on the start of the design and development process and therefore only considers new to be developed products or product improvements. However, this does not include the products that are already designed and in use. These products are often not designed with the intention to be used as long as possible or to be used in a different configuration later on. Therefore, the solution can be extended by broadening the focus towards managing the furniture that is already in use. This indicates that innovation is not only key for new developments but can also be used to find possibilities regarding the reuse of furniture that is not designed to be reused. As an addition to the toolkit, an analysis method can be designed that offers a way to determine if a product, its parts or its materials can be reused. This requires an active attitude regarding reversed logistics and thus actively tacking back

furniture. Furthermore, when implementing new business models like furniture as a service, possibilities arise to offer and sell reused products. Gispen is already practicing this by offering 'Revived' and 'Remade' products. This can be extended over the different brands.

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APPENDICES

Supporting to the report

The cause of global concerns: environmental issues

This section serves to address the environmental issues that are the cause of
concerns on multiple levels. This section focusses on the global concerns. The
biggest and most often mentioned concern is climate change: a long-term shift
in global or regional climate patterns (NGS, 2019). Climate change can refer to
specific complications like the greenhouse effect, global warming, biosphere
integrity, ocean acidification and more. In short, complications that all have
serious consequences for the earth system (Steffen et al., 2015). Therefore,
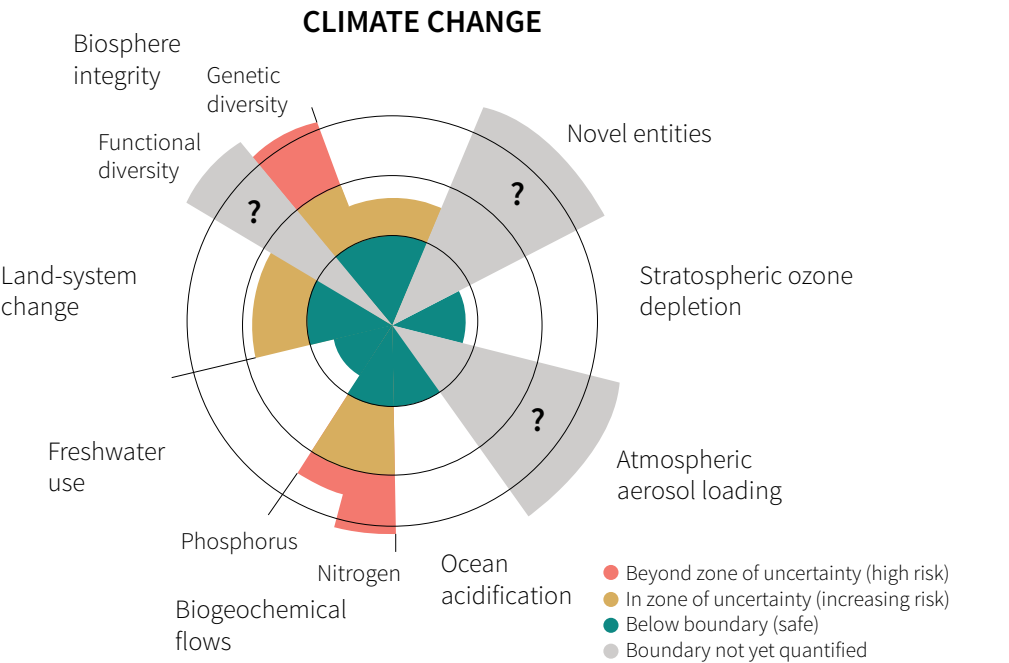prevention of these consequences must become a priority on global level.

Figure A1 | The nine planetary boundaries, adapted from the Stockholm Resilience Centre.

Planetary boundaries

To be able to summarise these threats and guide human development on a
changing planet, the Stockholm Resilience Centre composed a framework of
nine planetary boundaries in 2009. This framework defines a safe operating
space for humanity based on the intrinsic biophysical processes that regulate
the stability of the earth system (Steffen et al., 2015). This is the space wherein
humanity must navigate to be able to keep using the resources of planet earth
in a sustainable way. As can be seen in figure A1, some of the boundaries are
already crossed and some are almost exceeded. To Illustrate an example, by
unconscious handling of the resources of the earth, a serious resource shortage
has become reality as pictured in figure A2 (Murphy, 2008).

Sustainable Development Goals

At the 21st Climate Conference in December 2015, the Paris Agreement was
reached to combat climate change and to accelerate and intensify the actions
and investments needed for a sustainable future (UN, 2019). This is the first-
ever universal, legally binding global climate change agreement, that sets
out a global framework to avoid dangerous climate change by limiting global
warming to well below 2C° and pursuing efforts to limit it to 1,5C°. It also aims
to strengthen countries' ability to deal with the impacts of climate change and
support them in their efforts (EC, 2019). As a reaction on the addressed issues
and the need for change, the United Nations has set up seventeen Sustainable
Development Goals (SDG's). An explanation regarding the SDG's can be found in
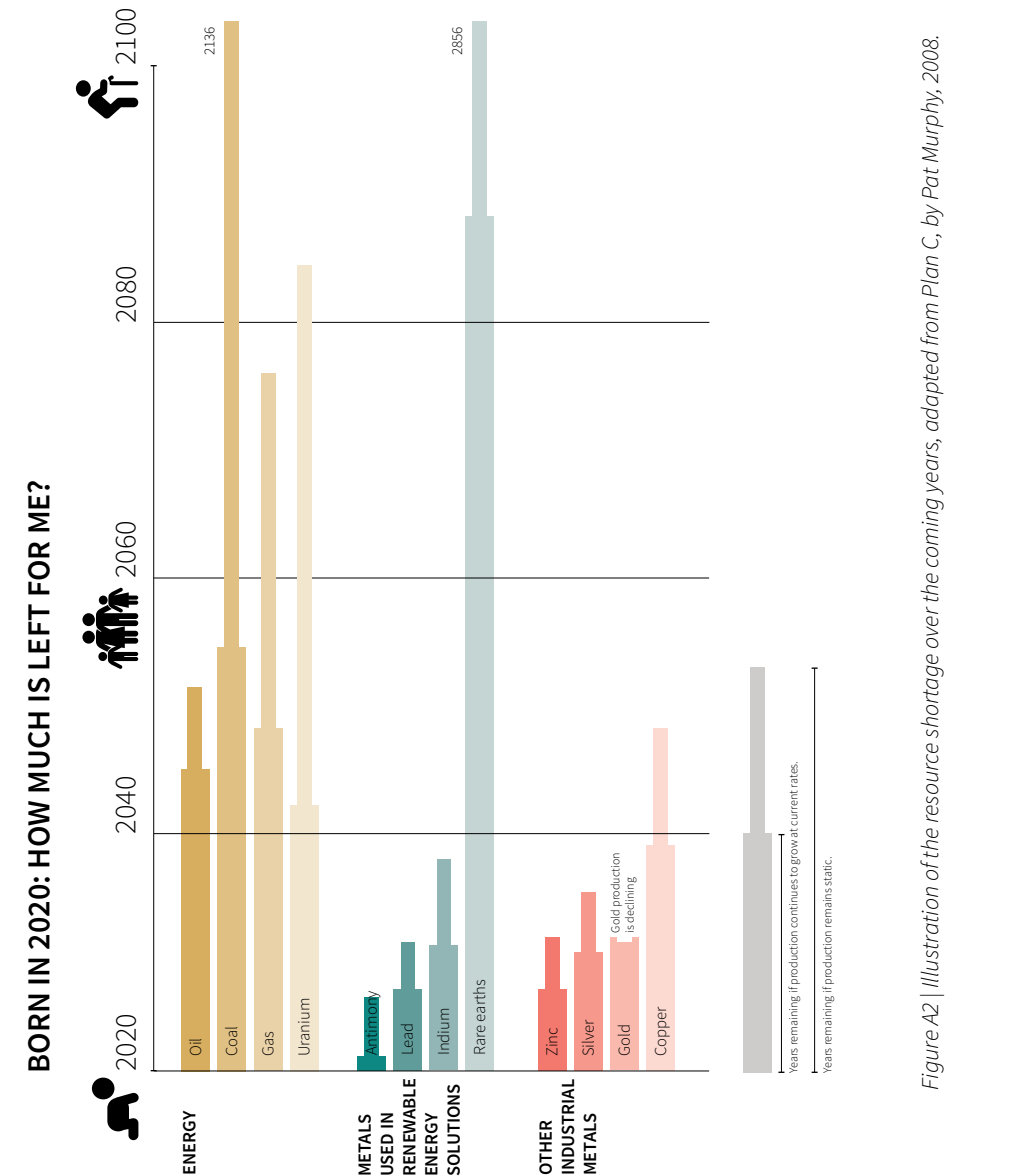section 1.1.

Figure A2 | Illustration of the resource shortage over the coming years, adapted from Plan C, by Pat Murphy, 2008.

The top 20 office furniture producers (including Royal Ahrend) in Europe is analysed to gain insight in their way of working, story, strategy, values and sustainability vision. This analysis is conducted to investigate how competitors handle sustainability in their product development. On the following pages the analysis can be found for the top 4 to give an impression of the values and goals of other companies in the furniture industry. The top 4 are the companies in the list that are listed above Royal Ahrend itself. The outcomes of this analysis are summarized:

Sustainable development goals
- Almost all of the furniture producers relate to the sustainable development goals of the UN.

Certificates, standards & labels
- Almost all of the furniture producers meet ISO 14001, ISO 9001 (and ISO 26000)
- Common certificates, standards and labels are: Blauer engel, Nordic Swan, OEKO-TEX, FSC, PEFC, Greenguard, Cradle to cradle, BIFMA level, Möbelfakta, SCS indoor advantage, EU ecolabel, LEED

Sustainability vision
- Every company describes a philosophy, some goals, focus points or beliefs.
- Kinnarps, König +Neurath, Flokk, Wilkhahn, Bene, Sedus Stoll, Dauphin and Herman Miller define clear targets for a specific year.
- Wilkhahn and Sedus Stoll both present a clear progress overview of these targets.

Own sustainability framework
- Can be considered as framework:
  - Royal Ahrend: Gispen CE design framework
  - Kinnarps: the better effect index
- Only explicit statements:
  - Flokk: principles for sustainable design: 5 circular design criteria & 3 focus areas
  - Dauphin: goals for environmental improvement
  - Martela: product environmental card
  - VDB groep: Drenthea eco tool

NUMBER	COMPANY NAME	COUNTRY
1	Kinnarps Holding AB	Sweden
2	Steelcase SA	United States
3	Vitra Holding AG	Switzerland
4	Nowy Styl SP.ZO.O	Poland
5	Royal Ahrend	The Netherlands
6	Haworth INC	United States
7	USM Holding AG	Switzerland
8	Sedus Stoll AG	Germany
9	König + Neurath A	Germany
10	Flokk holding AS	Norway
11	Interstuhl	Germany
12	Lienhard Office Group - Lista	Switzerland
13	Bene GMBH	Austria
14	Dauphin Office Interiors	Germany
15	Senator International	United Kingdom
16	Martela OYJ	Finland
17	VDB Groep B.V.	The Netherlands
18	EFG Holding AB	Sweden
19	Herman Miller	United Kingdom
20	Wilkhahn group	Germany

Table B1 | The top 20 office furniture producers in Europe based on sales according to Office Republic, 2018.

COMPANY & SUB-BRANDS	SUSTAINABILITY GOALS / VISION	SUSTAINABILITY TOOL	CERTIFICATES/LABELS	VALUES
Kinnarps Holding AB (SE) (Kinnarps, Materia, Skandiform, NC Nordicm, Care, Drabert, MartinStoll)	The better effect areas, targets to be reached by 2020: - Raw materials & resources - Climate - Pure materials - Social responsibility - Reuse - Ergonomics Linked to the SDG's.	The Better effect Index: kinnarps group's own sustainability index and the market's first comprehensive tool for sustainable interior design choices. Based on the 6 effect areas	ISO 14001, ISO 9001, FSC chain of custody, OHSAS 18001, PEFC chain of custody, Acoustic facts, ce labelling, eu ecolabel, FSC, FSC CW, GS (geprüfte sicherheit), Möbelfrakta, NF environment, NF office excellence certifié, OEKO-TEX, PEFC, quality office	7 fundamental parts of our DNA: 1. full service 2. innovative solutions 3. Ergonomy 4. sustainability 5. Quality 6. beautiful design 7. expertise
Steelcase SA (US) (Steelcase, Coalesse, Turnstone)	Steelcase strives to bring value to all our stakeholders: customers, employees, shareholders, partners, communities and the environment. We do this by: - Designing products and solutions to benefit people - Consulting with customers to help meet sustainability goals - Collaborating with key partners to further the science and practice of sustainability - Operating in a socially responsible way - Increasing expectations of our supply chain partners - Reporting global metrics	No tool, but promises + progress framework: - Customers - Partners - Communities - Employees - Environment	AFNOR NF Environment certification program, BIFMA level, Blue Angel, China environmental label, CDP, E1, EU ecolabel, NF environnement, CE100, Civic 50, Cradle to Cradle Certified TM Products Program, Eco-Management and Audit Scheme (EMAS), FCS Chain of Custody, Global Reporting Initiative, ISO 14001, ISO 26000, LEED, OEKO-TEX, OHSAS 18001, PEFC, RE100, SCS Indoor Advantage, World 50, U.S. EPA Green Power Partnership, UN Global Compact	Our seven core values ground us and push us to do more and be better every day. At Steelcase we: - Act with integrity - Tell the truth - Keep commitments - Treat people with dignity and respect - Promote positive relationships - Protect the environment - Excel
Vitra Holding AG (CH)	Sustainbility principles: - Responsibility - Longetivity - People - Ambition - Culture	No tool, but focus areas: - design & product development - choice of materials - manufacturing - waste management - packaging & transport - maintenance - reuse - end-of-life	ISO 14001, ISO 9001, Blue angel (der blauer engel), greenguard gold, GS seal, FSC, PEFC, Ecovadis, occupational safety	Creating innovative products and concepts with great designers is Vitra's essence. Today, in combining technical and conceptual expertise with the creativity of contemporary designers, Vitra seeks to continue pushing the boundaries of the design discipline. A family business for eighty years, Vitra believes in lasting relationships with customers, employees and designers, durable products, sustainable growth and the power of good design.
Nowy Styl SP.ZO.O (PL) (Nowy Styl, BN office solution, Grammer office, Sitag, Forum seating, Stylis, Rhode&Grahl, Majencia)	We are engaged in achieving four of the UN Sustainable Development Goals for the year 2030: - Good health and well-being - Decent work and economic growth - Innovation and infrastructure - Responsible consumption and production	No tool, but focus areas: Sustainable manufacturing: gas purification, sewage treatment, energy efficiency, wood waste recycling, eco-materials, plastic recycling Product live cycle: Raw materials, furniture transportation, responsible supply chain, human-friendly solutions. 6 loops of circularity	ISO 14001, FSC, EU ecolabel (flower label)	values: ambition, humility, honesty, tolerance

Table B2 | The analysis of the top 4 office furniture producers.

DESIGN
- Health & safety
- Esthetics
- Comfort
- Sustainability
- Production
- Image
- Price
  - Market segments
  - Profit
- Functionality
- Quality
  - Strength
- Ergonomics
  - Regulations

WASTE MANAGEMENT
- 0% waste
- Recycling
- Closing loops
- End of life
- Processing
- Reuse
  - Keeping the circle small
  - Design requirements
  - Different levels
    - Product
    - Component
    - Material

SDG'S
- 3. Good health and well-being
- 4. Quality education
- 8. Decent work and economic growth
- 11. Sustainable cities and communitites
- 12. Responsible consumption and production
- 13. Climate action
- 15. Life on land

CLIMATE
- Renewable energy
- Biodiversity
- Footprint reduction
- Certificates
- Environment
- Energy usage
- Reduction of CO_2 emission
- Transparency
  - Measuring
- Transport
  - Packaging
  - Return
  - Suppliers
  - Processing waste
  - Industrial symbiosis
- Production
  - 0% waste

MATERIAL
- Less material
- Raw materials & resources
  - 0% virgin materials
- Transparency/information (LCA)
  - Material passport
- Durability
- Pure materials
- Packaging
- Certificates

WELL-BEING
- Social responsibility
  - Relationships
  - Value to all stakeholders
  - Community
  - Culture
  - Collaboration
- Health
- Employees/users
  - Working conditions
  - Satisfaction
- Safety
- Ergonomics
  - Healthy workplace

PRODUCTS
- Manufacturability
  - Production
  - Value chain
  - Limits (material)
  - Construction
- Maintenance & upgrade
  - Product lifespan
  - Ease of replacement
  - Cleaning
- Longetivity
- Product life cycle
  - Product life cycle planning
- Life extension
- (dis)assembly
- Design
  - Timeless designs
  - Reason of replacement
  - Minimalistic
  - Details, hidden technology
- Innovative
- Less components
- Modularity
  - Adjustable to wishes
  - Interchangeable
  - Max amount of components
  - Product variety/family
  - Multifunctional

Figure C1 | Word web as frame of reference for the further development of the solution.

136   137

Aanleiding
Wat is de aanleiding? Is er een nieuwe trend of een gat in de markt of wordt een bepaalde doelstelling niet gehaald of wordt een andere strategie toegepast etc.?

Doel
Wat is de bijdrage aan de missie, positionering en de merkwaarde? Wat is het doel van het resultaat? Is het om waarde te maximaliseren door het behalen van bepaalde doelstelling(en) (OGSM) zoals: schaalvoordelen, vergroten marktaandeel, omzetvergroting, margeverbetering, etc.? Of is het om bij te dragen aan innovativiteit of aan totaal platform of supply chain synergie? Of is het om publiciteit te genereren?

Doelgroep + afzetmarkten
Profit, non-profit, overheid, onderwijs, zorg, IKAM. Geografische afzetgebieden.

Productomschrijving
Welke behoefte van de doelgroep vult het in? Kenmerken en voordelen product/concept (USP's).

Prognose
Omzet- en volumeprognose voor 1, 3 en 5 jaar.

Kostprijsstructuur
Kostprijs A (circa 10 procent nauwkeurig), SPP en marketing factor. Indien van toepassing rekening houden met royalties. Subsidie RDA, WBSO etc. meenemen indien van toepassing. Kosten octrooi-aanvraag, certificeringen etc.

Haalbaarheid
Business case.

Producteisen en –wensen
 - Design: tijdloos, strak en functioneel
 - Constructie: modulair opgebouwd (smart building blocks), synergie met andere producten
 - Akoestisch: indien van toepassing, te voldoen aan…
 - Duurzaamheid: conform standaard C2C uitgangspunten
 - Eventueel gewenst octrooieerbaarheid
 - Design for assembly of design for installation

Normen
Het moet voldoen aan de norm(en) als NPR, EN, ANSI/BIFMA (sterkte en emissie), C2C, WELL, LCA, MVO, arbo wetgeving. De norm specifiek beschrijven.

Uitvoering (die voldoen aan de betreffende afzetmarkten)
 - Configuraties: varianten (eventueel voor gedefinieerde configuraties) (bestelmodel of losse bestelnummers)
 - Modellen: typen
 - Afmetingen: hoogte, breedte, diepte
 - Materialisatie: fast movers vs. slow movers m.b.t. en bladen, stoffen, kleurstellingen, etc.
 - Bekabeling en elektrificatie: indien van toepassing

Distributie-eisen
Verpakking, export, flatpack, etc. Indien van toepassing.

Planning/aanpak
I.o.m. Projectleider: projectteam samenstelling, datum kick-off, bestelbaar en leverbaar.
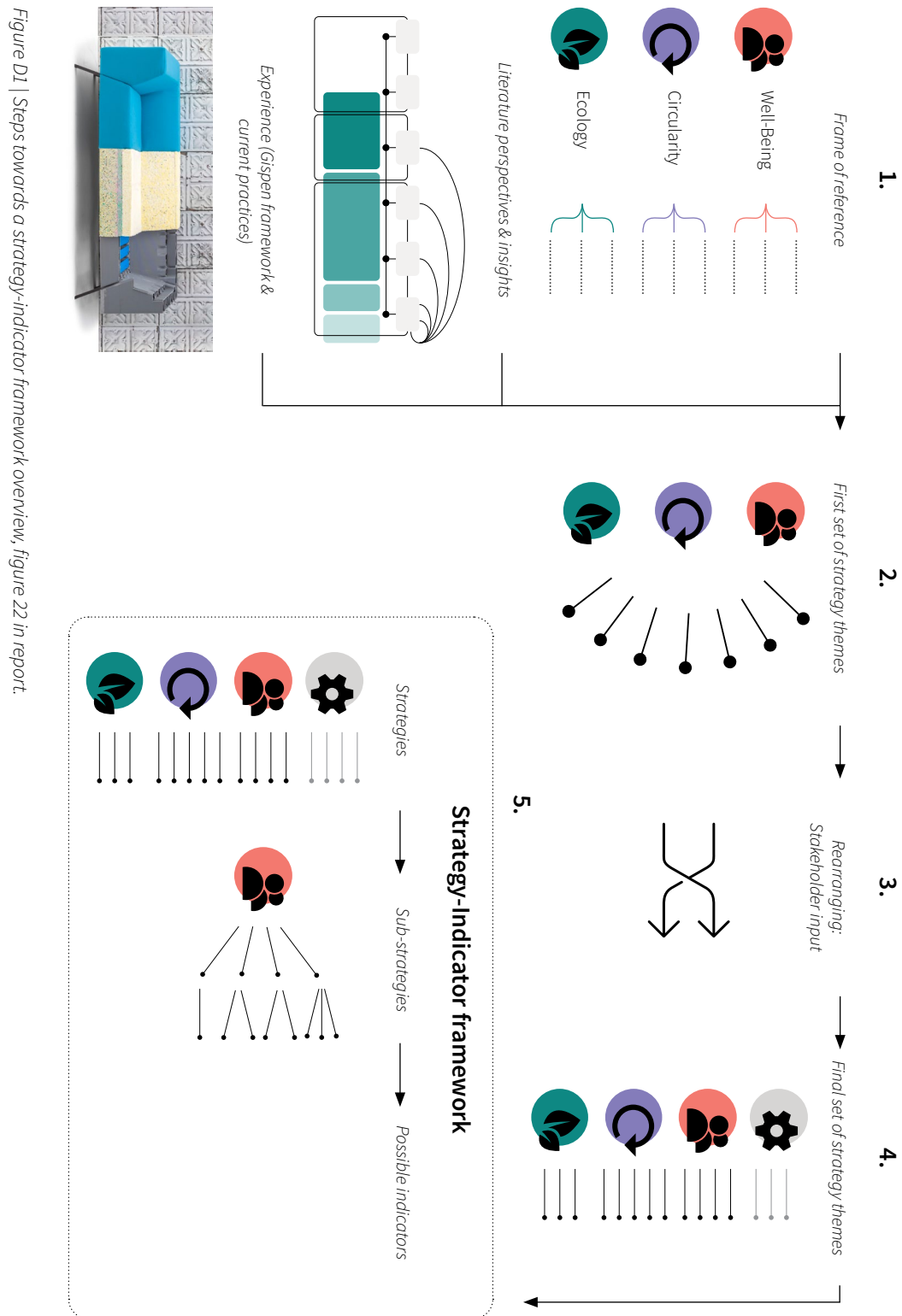
Ontwikkelingstijd en –kosten
I.o.m. Projectleider.

Bijlagen (optioneel)
 - Ontwerp van designer
 - Productpositionering: Prijs-Design
 - Benchmark
 - Moodboard

Overview of the steps.

Figure D1 | Steps towards a strategy-indicator framework overview, figure 22 in report.

1. Expanding the impact areas

The first step in establishing the framework is to expand the three impact areas Well-being, Circularity and Ecology. A frame of reference regarding sustainability-related themes was created in section 2.1.2. These themes are subdivided over the three impact areas. In addition to the frame of reference, insights and perspectives from literature research, the Gispen framework and current practices are considered for the development of the strategies.

Figure D2 | Expanded impact areas.

2. First set of strategy themes

The first set of strategy themes is established as a result of expanding the impact areas.

Strategies for product design for well-being
- Facilitate various working environments
- Adaptable inside environment
- Material health & safety
- Fitting, safe & healthy furniture
- Providing the right services, features & technology
- Create a general appearance that contributes
- Connect people & nature

Strategies for circular product design
- Design for long use
- Design for extended use
- Design for recovery
- Furniture as a service
- Dematerialisation
- Modularity
- Collaboration & innovation

Strategies for ecological product design
- Learning from nature
- Preventing waste & emissions
- Using renewable energy
- Water stewardship
- Design for recycling
- Managing product impact
- Using biobased materials

Figure D3 | First set of strategy themes.

3. Rearranging: stakeholder input & connections

The first set of strategy themes is discussed with several stakeholders and the strategies are mapped to find relations and connections between the strategy themes (note that the colours are switched, circularity is green and ecology is purple here).
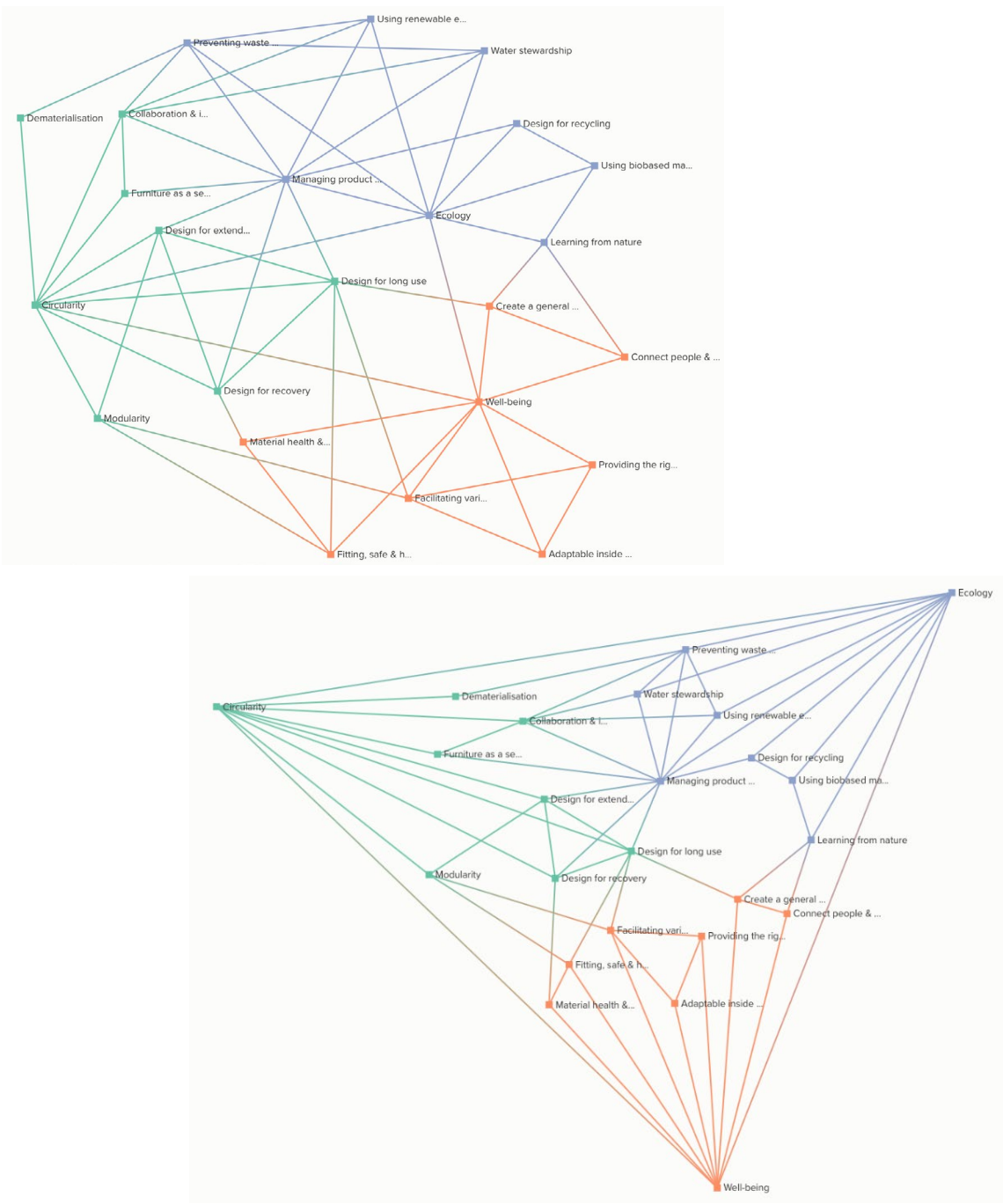

Figure D4a & D4b | Mapping the relations and connections between the strategy themes.

4. Final set of strategy themes

After multiple iterations, a final set of strategy themes was determined as a basis for the strategy-indicator framework. Next to the three impact areas, a general set of strategies is determined.
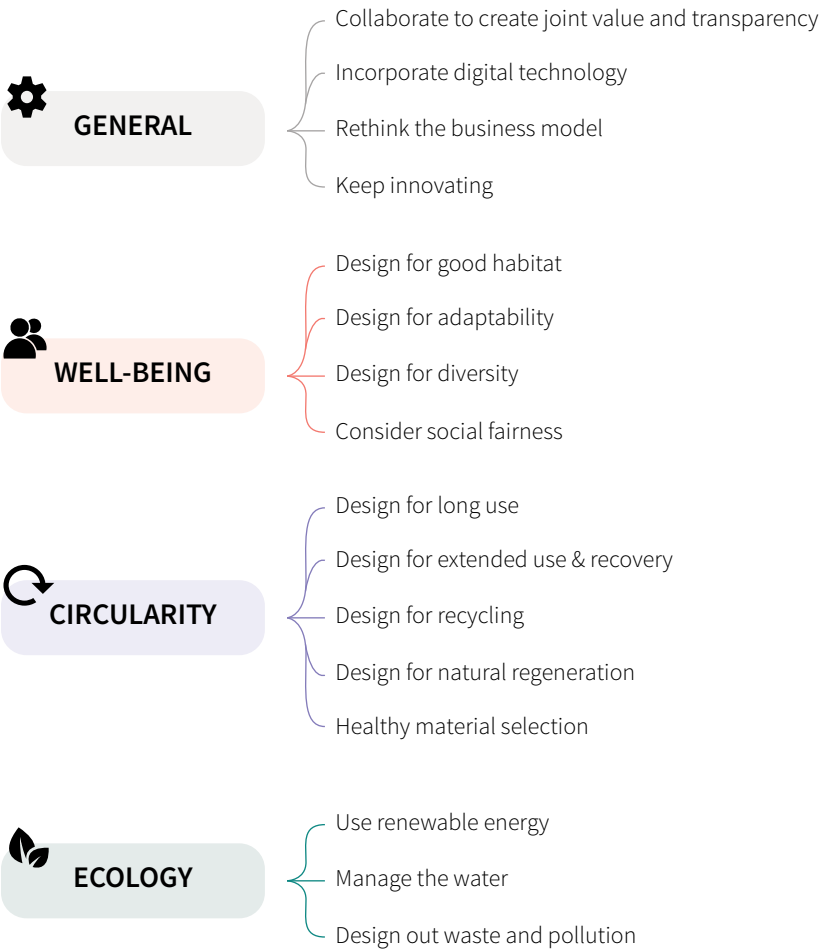

GENERAL
- Collaborate to create joint value and transparency
- Incorporate digital technology
- Rethink the business model
- Keep innovating

WELL-BEING
- Design for good habitat
- Design for adaptability
- Design for diversity
- Consider social fairness

CIRCULARITY
- Design for long use
- Design for extended use & recovery
- Design for recycling
- Design for natural regeneration
- Healthy material selection

ECOLOGY
- Use renewable energy
- Manage the water
- Design out waste and pollution

Figure D5 | Final set of strategy themes.

IMPACT AREA   STRATEGY + DESCRIPTION

GENERAL
Strategies that illustrate the broader context to make sustainable product development possible.

G1. Collaborate to create joint value and transparency

Work together throughout the supply chain, internally within organizations, with the different stakeholders in the supply chain and within the industry to increase transparency and create joint value.

G2. Incorporate digital technology

Track and optimize resource use and strengthen connections between supply chain stakeholders through digital, online platforms and technologies that provide insights.

G3. Rethink the business model

Consider opportunities to create greater value and align incentives that build on the interaction between products and services.

G4. Keep innovating

Enabling sustainable product development by researching, designing and developing new production techniques, materials, interfaces and connections.

Table F1 | General framework strategies.

IMPACT AREA	STRATEGY + DESCRIPTION	SUB-STRATEGY	DESCRIPTION	INDICATORS (3.3)	VALUE DESIGN (3.4)	APPLICATION CATEGORIES (4.2)
WELL-BEING Design products that contribute to the health & well-being of people.	**W1. Design for good habitat** Creating good habitat for people in their environment and thereby enhancing people's physical and mental health and fitness. Good habitat means productive environments where people function to their optimal potential. (Kellert & Calabrese, 2015)	W1.1 Biophilic design	Satisfying the need for contact with nature, because people possess an inborn need for contact with nature essential to their phusial and mental health, productivity and well-being. (Kellert & Calabrese, 2015)	Use natural colours and shapes, product multifunctionality	Product, subassembly, part, material, connection	Inspiration
		W1.2 Create a general appearance that contributes	The product contributes to the engagement and community feeling of users in the environment. (WELL, 2019)	Use natural colours and shapes, product multifunctionality	Product	Inspiration
		W1.3 Facilitate various working environments	Give people the opportunity to choose between various working environments/ settings that best fit their needs. This is called activity based working which, among other benefits, ensures a flexible physical infrastructure that can better adapt to business change and healthier, more engaged and motivated employees. (Leesman, 2017) (WELL, 2019)	Use natural colours and shapes, product multifunctionality	Product	Inspiration
	W2. Design for adaptability Design workplaces that can be adapted to the preferences of people by facilitating possibilities to adapt.	W2.1 Providing the right features & technology	Ensuring the availability of the right features and technology that people find important and that satisfy their needs concerning their working place. (Leesman, 2017) (WELL, 2019)	availability of lighting control, availability of sockets	Product	Inspiration, specification
		W2.2 Adaptable inside environment	Give people the opportunity to adjust their working place to personal preferences. (Leesman, 2017) (WELL, 2019)	availability of lighting control, availability of sockets	Product	Inspiration, specification
	W3. Design for diversity Design products that can be adjusted to personal preferences and that comply with ergonomic regulations.	W3.1 Adaptable & fitting furniture	Designing and arranging products so that the users and products interact most efficiently and safely.	availability of height adjustment control, Arbo certificates	product, subassembly, part, material, connection	Specification
		W3.2 Comply with ergonomic regulations	Design products that comply with ergonomic regulations (activity based).	availability of height adjustment control, Arbo certificates	product, subassembly	Specification, validation
	W4. Consider social fairness Design products that are responsibly sourced, developed and produced.	W4.1 Use (fairtrade) certified materials	Design products that contain materials that are certified (C2C: no child labor, forced labor, excessive worktime, provision of living wage, worker health & safety etc.).	fairtrade certification, production locations with better standards, employee experience asessments	product, subassembly, part, material	Specification, validation, information

Table F2 | Well-being framework strategies.

IMPACT AREA	STRATEGY + DESCRIPTION	SUB-STRATEGY	DESCRIPTION	INDICATORS (3.3)	VALUE DESIGN (3.4)	APPLICATION CATEGORIES (4.2)
CIRCULARITY Keep products, parts and materials in use at continuous high value.	**C1. Design for long use** Design products that are intended to be used for a long time. Prolonging the product's use cycle by making the first use cycle of the product as long as possible.	C1.1 Design for physical durability	Designing into a product a potential for withstanding wear, stress, and environmental degradation and remaining able to fulfil all physical functions for which it was designed over a long period of time (den Hollander, 2018).	Product replacement means (Haug, 2017)	Product, subassembly, part, material, connection	Specification
		C1.2 Design for emotional durability	Designing into a product a potential for remaining wanted over a long period of time (den Hollander, 2018).	Product replacement means (Haug, 2017)	Product , connection	Inspiration, specification
	C2. Design for extended use & recovery Design products that are easy to maintain, repair, upgrade, refurbish, remanufacture, re-contextualize or can be adapted to changing needs. Extending the product's use cycle or giving a part a new use cycle. Modularity is a key factor.	C2.1 Design for maintenance and repair	Designing into a product a potential to undergo and facilitate the performance of inspection and/or servicing tasks at regular intervals, to retain a product's functional capabilities and/or cosmetic condition (den Hollander, 2018).	Modularity, standardisation, interchangability, keying, accessibility, identification (den Hollander, 2018)	Product, subassembly, part, connection	Specification, information
		C2.2 Design for upgrading and refurbishing	Designing into a product a potential to undergo interventions that can turn a(n) (obsolete) product into a product with a satisfactory working and/or cosmetic condition. (den Hollander, 2018).	Modularity, standardisation, interchangability, keying, accessibility, identification (den Hollander, 2018)	Product, subassembly, part, connection	Specification, information
		C2.3 Design for remanufacturing	Designing into a product a potential to undergo and facilitate a series of industrial processes in a factory environment, whereby (obsolete) products are disassembled into parts, and recombines those parts – generally originating from different used products – with as few as possible new parts, to manufacture new products of a similar type and specification, that result in a new product. (den Hollander, 2018).	Modularity, standardisation, interchangability, keying, accessibility, identification (den Hollander, 2018)	Product, subassembly, part, connection	Specification, information
		C2.4 Design for recontextualizing	Designing into a product a potential to facilitate the use of a(n) (obsolete) product (or its constituent parts), without any remedial action, in a different context than it was used in as it became obsolete. (den Hollander, 2018).	Modularity, standardisation, interchangability, keying, accessibility, identification (den Hollander, 2018)	Product	Specification, information
		C2.5 Design for update and changing needs	Designing into a product a potential to update the product or adapt the product to the users changing needs as time passes (Foundation, 2017).	Modularity, standardisation, interchangability, keying, accessibility, identification (den Hollander, 2018).	Product, subassembly, part, connection	Specification, information

Table F3 | Circularity framework strategies.

IMPACT AREA	STRATEGY + DESCRIPTION	SUB-STRATEGY	DESCRIPTION	INDICATORS (3.3)	VALUE DESIGN (3.4)	APPLICATION CATEGORIES (4.2)
CIRCULARITY Keep products, parts and materials in use at continuous high value.	C3. Design for recycling Design products that consist of materials that are pure. Giving the material a new use cycle by separating products into purely recovered materials that can be used as input for new parts or products.	C3.1 Use pure materials	Design products that contain pure materials. Meaning that materials are not mixed unless its mixed shape can be used and reused infinitely.	Preventing additives and coatings, prevent blending plastics, prevent mixed composites	Product, subassembly, part, material	Specification, information
		C3.2 Materials must be separatable	Design products that can be separated back to purely recovered materials.	Preventing additives and coatings, prevent blending plastics, prevent mixed composites	Product, subassembly, part, material, connection	Specification, information
		C3.3 Recyclability	Design products that contain materials that can be recycled without loosing quality.	Preventing additives and coatings, prevent blending plastics, prevent mixed composites	Product, subassembly, part, material	Specification, information
	C4. Design for natural regeneration Design products that postitively contribute to the regeneration of the natural system.	C4.1 Use recycled materials	Design products that contain recyled materials.	Material certifications, percentage of recycled content	Product, subassembly, part, material	Specification, information
		C4.2 Use renewable materials	Design products that contain materials that renews itself within 10 years after mining the material.	Material certifications, percentage of recycled content	Product, subassembly, part, material	Specification, validation
	C5. Healthy material selection Design products that consist of materials that are not toxic or hazardous.	C5.1 Avoid the banned list of materials	The product does not contain materials that are on the banned list of materials (C2C banned list).	Banned list, environmental properties, material health assessment score	Product, subassembly, part, material	Specification, validation
		C5.2 Use materials with a minimum environmental impact	Design products that contain materials that have a minimum impact on the environment.	Banned list, environmental properties, material health assessment score	Product, subassembly, part, material	Specification, information

Table F3 | Circularity framework strategies.

IMPACT AREA	STRATEGY + DESCRIPTION	SUB-STRATEGY	DESCRIPTION	INDICATORS (3.3)	VALUE DESIGN (3.4)	APPLICATION CATEGORIES (4.2)
ECOLOGY Design products that positively contribute to the environment and ecosystem.	**E1. Use renewable energy** Design products that are sourced, developed and produced with the use of renewable energy in the most efficient way possible (preferably energy positive).	E1.1 Minize the amount of embodied energy	Design products with the intention to minimize the amount of embodied energy, the amount of energy that is used to produce the product.	Energy neutral processing methods, energy positive factory	Product, subassembly, part, material, connection, process	Specification
		E1.2 Renewable production	The production of the product must be done with the use of renewable energy.	Energy neutral processing methods, energy positive factory	Product, subassembly, part, material, connection, process	Specification
	E2. Manage the water Design products that are sourced, developed and produced with the least amount of water possible and without polluting the water with hazardous chemicals.	E2.1 Minimize the amount of embodied water	Design products with the intention to minimize the amount embodied water, the amount of water that is used to produce the product.	Using specific materials or processing methods with less water use	Product, subassembly, part, material, connection, process	Specification
		E2.2 Water availability	The product does not cause issues regarding water in the area of production.	Using specific materials or processing methods with less water use	Product, subassembly, part, material, connection, process	Specification, validation
		E2.3 Clean water	The production of the product does not involve the use of chemicals that can end up in the water as a result of making the product.	Using specific materials or processing methods with less water use	Product, subassembly, part, material, connection, process	Specification, information
	E3. Design out waste and pollution Design products that are sourced, developed and produced in such way that no (harmful) emissions are expelled and no (hazardous) waste is created in the process.	E3.1 Produce without waste and emissions	During the production of the product no waste is created and no emissions are expelled.	CO_2 neutral factory, energy efficiency of processes, industrial symbiosis	Product, subassembly, part, material, connection, process	Specification, information

Table F4 | Ecology framework strategies.

INSPIRATION PLATFORM

Innovations
RA successes
working environment

Including the qualitative aspect of sustainable product development, to be used as inspiration.
- RA Innovation: current sustainability innovations to use in product development
- RA successes: successful sustainability related projects or projects to take as example
- The working environment: biophilic design, buildings

DATA MANAGEMENT

Assessments
Product passports & manuals

Managing product sustainability information
- Creating product passports for every new to be developed product (or parts, sub-assemblies).
- Gather sustainability data by assessing products: life cycle assessment (LCA, CircularIQ), material health assessment (C2C)

ASSET MANAGEMENT

Furniture management system

Status tracking of materials, parts, sub-assemblies and products
- Furniture management system with accurate and up to date information of the products
- Assessing the status of materials, parts, sub-assemblies and products
- Executing maintenance
- Related to furniture as a service

STRATEGY FRAMEWORK

Explanation of strategies & sub-strategies
Education: possibilities + impact

Explanation of strategies and sub-strategies
- Basis of sustainable product development
- Learn about the possibilities and impact of the different strategies

STRATEGIC APPROACH

Indicator specification
Value designing
Ambition level

Determining the strategic positioning of product developments regarding sustainability
- Value designing: development ideas on different value design levels
- Determine the ambition level of the development idea
- Select indicators based on the value design level and ambition

RA MATERIAL DATABASE

Standard set of Royal Ahrend materials

Managing material sustainability information
- Creating and managing a database with materials that can be used.
- Specific set of materials for Royal Ahrend, specific certifications/suppliers

CERTIFICATION & STANDARDS

Material certification
Standards (ergonomic, organisation)

Conforming to relevant standards and use certified materials
- Relevant ergonomic norms (NPR), organsiation norms (ISO)
- Compliance with MVI NL and EU criteria regarding materials
- Responsible sourcing (FSC, PEFC)

EXTERNAL NETWORK & TOOLS

Collaboration partners
Supplier code of conduct
C2C banned list of materials

Collaborating and connecting with external organisations or partners
- Learn from and challenge each other
- Find relevant knowledge partners to improve products
- Compliance to the C2C banned list of materials
- Ellen MacArthur Foundation CE100

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