The road towards Action's repairable future

Max Olivier Rademakers
MSc Strategic Product Design

TU Delft

The road towards Action's repairable future

Master thesis
Delft University of Technology
Faculty of Industrial Design Engineering
Strategic Product Design

February 2023 – August 2023

Author
Max Olivier Rademakers

Chair
Bas Flipsen
Delft University of Technology
Faculty of Industrial Design Engineering
Department of Sustainable Design Engineering (SDE)

Mentor
Sander Mulder
Delft University of Technology
Faculty of Industrial Design Engineering
Department of Design, Organisation and Strategy (DOS)

Company mentor
Fabeel Butt, Sustainability manager Action

Preface

It is my great pleasure to present my master thesis that focuses on the road towards Action's repairable future.

This thesis marks the end of 6 great years in Delft at the Delft University of Technology.

I would like to thanks everyone at Action who were super open to me and helped answer all of my countless questions. Everyone was super open to my new ideas and I think we both learned a great deal from each other. A special thanks to everyone in the Sustainability team from Action who welcomed me with open arms and really made me feel part of the team. I would like to thank all the Buyers and Product Techs from Action who took the time to help me with my thesis by sitting down with me and answer all my questions to their best abilities.

Secondly, I would like to thank my supervisors Sander and Bas who always believed in me and gave me the confidence to go on. Your constructive feedback and encouragements really helped me through the process.

Most important are my parents who helped me through my thesis by always supporting me and helping me wherever they could.

And finally, I would like to thank my friends who helped me through the process by listening, brainstorming and distracting me at the right moments.

This thesis showed me the interesting and complex world of large retailers and how they operate. I enjoyed getting to know this new sector and gain experience in this field.

The complexity of circularity was interesting, especially in the at some times somewhat counter intuitive environment of big businesses. This challenge made my project interesting and kept me going. I hope you feel the same while reading my thesis.

Max

Executive summary

Action is working on sustainability in social compliance, materials, packaging and circularity but they still have a long way to go in becoming circular. The European Union is taking steps towards a circular economy with the New Circular Economy Action plan, The Green Deal and the Right to Repair. Countries and companies are taking measures where legislation on the European level is taking too long. Action's geographic expansion is ending and needs to look for new opportunities. This thesis will focus on helping Action to take their responsibility in the cycle of products to make them more circular. This will help Action to stay resilient with upcoming European legislation, by being in compliance with present and foreseeable circularity legislation .This has led to the following research question: How to help Action in becoming Circular to stay resilient with present and foreseeable legislation?

Using the double diamond method the most vulnerable product group and corresponding circularity strategy was selected. The first diamond was used to select a product group to focus on and what strategy should be applied. The focus should be on repairability as it is a starting point for other CE strategies. Repairability requires significantly less resources compared to other strategies. Repairability, reliability and upgradeability are tightly related durability aspects for extending a product's service life. This means that designing for repairability can also benefit reliability. Electrical and electronic equipment is the most vulnerable product group to legislation and is forcing Action to take responsibility after an electrical and/or electronic (commonly referred to as Energy Related Products; ErP) product has been sold. ErP have the biggest potential to reduce CO2 emissions. Therefore, Action should focus on selling repairable ErP as a step towards circularity. Besides the Sustainability team repairability is not common knowledge within Action. The buyer has a lot of power in making decisions but is lacking the knowledge of making decisions in terms of circularity. The problem that needs to be solved is that the buyer is making decisions on purchasing ErP products while lacking repairability knowledge. This is developed in the last diamond of the double diamond method.

To help Action stay resilient with present and foreseeable legislation a repairability index is made which Action can use to quantify the repairability of products. This repairability index is specific for every ErP group and needs to made by Action. This is made possible through an index guide that helps select priority parts and reference values for the repairability index of every specific ErP group. Suppliers can fill in the repairability index using the supplier guide. A repairability index feedback system is used by the buyers to keep track of the repairability of the products they buy and to improve this. The repairability index is accompanied by a future vision which aims that Action has build a vibrant ecosystem through innovative partnerships and collaborations in 2035, where Action works together with its manufacturers, repairers and customers to create a circular future where customers are empowered to repair Action's durable products more easily. Getting here is explained through a roadmap with three horizons.

The repairability index was validated by doing a case study to see if it works and to be used while discussing it with product techs, buyers and a supplier. The future vision was validated by interviewing managers from Action to see if it resonated with them. The repairability index feedback system was validated by buyers.

This thesis helps Action in creating a new standard in the repairability of their products and offers new opportunities for Action's (circular) future during the three horizons as seen below.

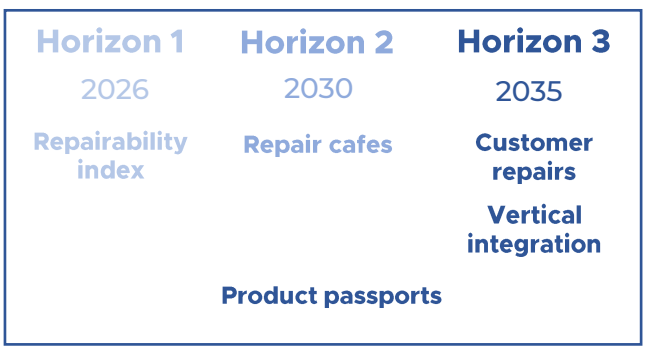


Table of content

13. Appendix

Reading guide

X. Chapter title

Chapter introduction

X.1 Subtitle 1

Subtitle 2

Subtitle 3

Subtitle 4

Subtitle 5

Main body text.

Important insights or key take aways.

Figure or table description

Abbreviations

CE: Circular Economy
CEAP: Circular Economic Action Plan
DC: Distribution Centre
EEC: European Economic Community
ErP: Energy Related Product
FA: Fixed Assortment
FFP: Fit For Purpose
FRI: French Repairability Index
GHG: Green House Gasses
LCA: Life Cycle Assessment
LCC: Life Cycle Costing
PSS: Product Specification Sheet
RRO: Resource Retention Options
RoHS: Restriction of certain Hazardous Substances
SKU: Stock Keeping Unit
WEEE: Waste Electronic and Electrical Equipment

1. Intro

(Facebook, n.d.)

1. Intro

Action is an international discount store-chain owned by different private equity investors under which 3i and Eurofund. The commodities Action sells are low budget non-food products and food with long shelf life. Action's strategy can be seen in Figure 1 and consists of five pillars. Pilar one, two and three are focused on building an international, expendable, simple and efficient operating business model while strengthening Action's value proposition. The value proposition Action offers their customers is an ever-changing variety of products for an affordable price. While doing this Action wants to make sustainability accessible and treasures their people and values.

Figure 1: Action's strategy (Butt, n.d.)

With 6000 different items Action offers a wide variety of products from food to linen to Electrical and Electronic Equipment. Action has divided their products in 14 different categories and aims to have 150-200 new products every week. An overview of all categories can be seen in Table 4. Around 30% of Action's offer in stores is Fixed Assortment, the rest is non fixed and changes regularly. The philosophy of Action is to have a shopping basket full of items for the price of 15 euros.

Action is operating all over Europe with over 2200 stores in over 11 countries and they are expanding. To support all of these stores Action has over 11 distribution centers (DC) throughout Europe. Next to Actions physical stores an experiment is going on in the Netherlands with a webshop. In 2021 a staggering 6.8 billion euro revenue was booked with an EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) of 828 million.

Action is largely owned by 3i which is a venture capitalist and private equity company that is listed on the London Stock Exchange. 3i's strategy is to invest, grow and realize (3i, 2023). Action is vulnerable to European legislation with its operations scattered throughout the continent.

In recent years the European Union issued several Regulations, Directives and adopted several Initiatives to protect the environment. An example is the Ecodesign directive to reduce energy consumption for the production and use of goods (European Parliament & Council of the European Union, 2009).

In 2019 the European Commission presented the Green Deal. This strategy aims at transforming our society and economy, to preserve the environment (European Commission, 2019). For the long term the European Green Deal has the intention to become the first continent which is climate neutral by 2050 (European commission 2019).To implement parts of the green deal at shorter notice the European Commission issued the new Circular Economy Action Plan (new CEAP) recently (European commission, 2020b; European Union, 2020)

The new CEAP is an agenda which sets goals for a Circular Economy (CE) in Europe. In February 2021, the Parliament adopted this new CEAP, but urged the European Commission to develop binding targets for the year 2030, which must be embedded in legislation (European Parliament, 2021). One of the results is the issuing of a proposal for a directive on the right to repair by the European Commission in 2023 (European Parliament 2023). While writing this the EU has accepted a new proposal to increase the repairability of products (Van de Hulsbeek, 2023). The idea is to make repairing products mandatory for retailers when broken items are returned within the warranty period. They even want to oblige manufacturers to offer repairs 5 to 10 years after purchase. Manufacturers are also obliged to inform customers about repair options instead of replacement.

And finally, the EU wants to launch an online repair platform which helps to find people who repair products or sell repaired products combined with an European quality standard (Wigand, 2023).

At national level, the Netherlands has the ambition to become fully circular by 2050 (Ministerie van Infrastructuur en Waterstaat, 2023a). For the near future the government of the Netherlands is implementing the National Circular Economy Programme 2023 - 2030, which defines many goals on circularity (Ministerie van Infrastructuur en Waterstaat, 2023). France is implementing circular legislation by banning the destruction of unsold goods and encouraging repairs through a repairability index (Ellen MacArthur Foundation, 2021).
There is a shift coming towards a circular economy. Where European law is taking long to be implemented, some countries take their responsibility and implement their own national laws. This is important for Action as their sales market is Europe wide. France has for example implemented the French Repairability Index (FRI) which grades products based on their repairability (Ministère de la Transition écologique, 2022). Where European law or national law is sometimes not extensive enough companies are, such as Patagonia or Fairphone. These companies try to take responsibility by selling second hand clothing and creating repairable phones and for instance.

But a CE in itself is fairly complicated and there are many definitions of a CE out there. Kircherr researched CE definitions and found 114 from published and non published resources (2017).

The essence of a CE is "an industrial system that is restorative or regenerative by intention and design." This is done without affecting society and environment in a negative way but rather including them (Ellen MacArthur Foundation 2013; Geissdoerfer et al., 2017; Kircherr 2017). With restorative and regenerative it is meant that materials are restored or regenerated. Circularity is not absolute. A system can be designed from the intention of being circular without for example being 100% regenerative. How circular a system is determines how close a system is to being circular. Sustainability on the other hand aims to benefit the environment, economy, and society. However, CE mainly benefits economic actors (Geissdoerfer et al., 2017). Despite this, it still has positive impacts on the environment and society, including reduced resource depletion and pollution, and added benefits such as fairer taxation and more manual labor.

Action might not be the first company that comes to mind while thinking about circularity. Other companies are already well on their way to become circular such as Fairphone or Patagonia. This does not mean that Action should not become circular. Society would still greatly benefit from Action becoming more circular. Due to Action's volumes a small change can have a massive impact. Action already has a sustainability program in place called the "Action Sustainability Program" (ASP) in which they focus on the 4Ps, guided by the UN Sustainable Development Goals (Product, People, Planet & Partnership). The ASP is divided into four topics: Social compliance, Materials, Packaging and Circularity. The goals of the ASP in time can be seen in Table 1 and will be further explained below.

2022	2023	2024	2025	2030
100% recyclable packaging for all Private Labels	Increase CTI score of every category by 5%	Timber 100% sustainably sourced	25% primary packaging reduction	Full social compliance and transparency mapped to raw material
	Cotton and Cacao 100% sustainably sourced		100% social compliance and transparency of all Action brands	
			100% sustainable cardboard/paper in primary packaging	

Table 1: Timeline of Actions sustainability goals

Social compliance

Action strives for 100% supply chain transparency. The goal for 2025 is to be 100% social compliant and transparent of all Action products excluding A-brands. By 2030 Action wants to have full social compliance and transparency mapped to raw material. Out of Action's 970 producers 814 are located in High-risk countries like China, Bangladesh and Pakistan. Action works together with Impact buying to map all these factories and get transparency throughout the supply chain.

Materials

Action strives to minimize their impact on materials through manufacturing and raw material use. Action wants to source their cotton and cacao by 2023 and timber by 2024 100% sustainable.

Packaging

For packaging Action wants to optimize their approach for packaging waste reduction. Action wants to have 100% recyclable packaging for all Private Labels by 2022, a 25% primary packaging reduction by 2025 and use 100% sustainable cardboard/paper in their primary packaging by 2025.

Circularity

Action wants to minimize its impact through manufacturing and raw material use. Circle Economy is a company that has helped Action with determining the Circular Transition Indicator (CTI) score of the top 50 products in terms of weight and sales of every product category and translating these into Key Performance Indicators (KPI's). The KPI for every category is to increase the CTI score of these products by 5% by the end of 2023. In the future Action wants to broaden the focus of the current top 50 to the top 100 of every category based on weight. The focus has shifted from exclusively fixed assortment products to only excluding In and Out products. Within this top 100 the idea is to look for commonalities among suppliers to tackle multiple products from the top 100 per supplier.

A different kind of strategic risk is the end of the geographical expansion of Action. If Action will continue with its growth rate of 15 new stores per week Europe will be saturated by 2032, or maybe even sooner if they grow faster (further explained in Chapter 9).The need of growth from their investor 3i and saturation of the European market creates the need for new opportunities. Circularity could fill this need for opportunity for Action and their investor 3i.

Action is working on sustainability in social compliance, materials, packaging and circularity but they still have a long way to go in becoming circular. The European Union is taking steps towards a CE with the New Circular Economy Action plan, The Green Deal and the Right to Repair. Countries and companies are taking measures where legislation on the European level is taking too long. Action's geographic expansion is ending and needs to look for new opportunities. This thesis will focus on helping Action to take their responsibility in the cycle of products to make them more circular. This will help Action to stay resilient with upcoming European legislation, by being in compliance with present and foreseeable CE legislation. This leads to the following research question:

How to help Action in becoming Circular to stay resilient with present and foreseeable legislation?

This is done by creating a framework that will enable Action to respond to foreseeable legislation. This framework will help Action in staying resilient in the foreseeable future.

To be able to answer this research question correctly some sub research questions (sRQ) have to be answered. These questions are discussed below. First some basic understanding is needed on how a circular economy can be accomplished. The first sub question is:

sRQ 1. How can a Circular Economy be accomplished?

For change to be successful the right steps in the buying process and people involved have to be known. That is why it is important to analyze Action and discover how they are buying products for their store. The second sub question is:

sRQ 2. How is Action acquiring their inventory?

If it is known how Action is acquiring their inventory the question arises why they are doing it this way. The third sub question is:

sRQ 3. Why is Action acquiring their inventory this way?

Action already has a lot of data on their circularity due to their collaboration with Circle Economy. This raises the question: how is Action measuring circularity? The sub question is:

sRQ 4. How is Action currently measuring circularity?

The research question of this thesis is broad and includes all product categories. To get a more in depth analysis one product category is selected and will be further explored. There is a lot of news on new legislation surrounding circularity. Therefore, the product category is selected based on the foreseeable and present legislation. The sub question is:

sRQ 5. What product category is most vulnerable for foreseeable and present circular legislation ?

With this product category in mind the applicable foreseeable legislation will be further defined. The sub question is:

sRQ 6. What is foreseeable circular legislation that influences the most vulnerable product category?

These questions will help answer the research question which will help Action to take their responsibility in the lifecycle of the product they sell. This keeps Action resilient in the future and helps contribute to a better future for Action, the people and the planet.

2. Approach

2. Approach

As discussed in the previous chapter the goal of this thesis is to create a framework that enables Action to take their responsibility in the lifecycle of products in compliance with present and foreseeable legislation in a circular economy. The approach used in this thesis is the Double Diamond approach. The double diamond consists of the Discover, Define, Develop and Evaluate phase (Design Council, n.d.). The methods used in every phase of the Double Diamond approach will be discussed per phase.

2.1 Discover

In the discovery phase the required knowledge to answer the research question is obtained. This is done through answering the sub questions. This begins with the basic understanding of what the definition of a Circular Economy is and how this can be accomplished. These two questions are answered by doing a literature review.

Action already has a lot of data on their circularity due to their collaboration with Circle Economy. This raises the question: how is Action measuring circularity? This sub research question is answered by doing interviews with Action employees (Confidential Appendix) and a literature review. For the interviews McNamara's eight principles for interview stage preparation and effective research questions have been used. Using probes as suggested by Baumbusch the interviewee can be guided in answering the questions properly (2010).

The scope of the research question includes all product categories. It is more useful for Action to get an in depth analysis of one product category. This selection will be based upon legislation surrounding circularity. The current and foreseeable circular legislation is analyzed by doing a literature review.

If the implementation of the desired framework wants to succeed it has to be made for the right people. By finding out how Action is acquiring products and who is involved, it can be determined who the framework should be made for to be implemented successfully. These questions were answered by doing interviews with Action employees (Confidential Appendix). For the interviews McNamara's eight principles for interview stage preparation and effective research questions have been used. Using probes as suggested by Baumbusch the interviewee can be guided in answering the questions properly (2010). Jones and Van Ael suggested that Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (2022), so this type of analysis is used.

2.2 Define

In the define phase the acquired knowledge of the discovery phase is analyzed and used to formulate the redefined design challenge (Design Council, n.d.). The insights from the interviews and literature review will be used to create maps of the existing situation at Action.

First a process map was made that describes the process of Action buying products to sell them in the store. This map includes the steps taken in the process, stakeholders and the information used to make decisions.

A simplified system map was made according to Meadows system thinking to analyze the driving forces within Action (2008).

To get a better understanding of the key participants within the buying process of Action and their relationships among each other a stakeholder map has been made based on the Actors map from Jones & Van Ael (2022).

The redefined design challenge was used to describe the problem, who is involved, the context, goals and side effects to be avoided. The design challenge is used as a basis in the develop phase.

2.3 Develop

For the development of a suiting solution for the redefined design challenge the scenarios are described in which the identified problem occurs. This gives more context to the problem when buyers are buying products. The most problematic scenarios were used for developing various ideas.

An initial ideation was done using how could we questions. Several were made for every scenario. After conducting the first round of ideation brain writing is used with 4 fellow IDE students to further develop ideas. With brainwriting participants build on each other's ideas to increase the quantity of ideas (Van Boeijen et al., 2014).

The ideas were made more specific and were transformed into concepts. Some concepts naturally dropped as they were not feasible. A handful of concepts were further developed after which a common factor was detected. This common factor was transformed into a concept that is further pursued.

2.4 Evaluate

For the evaluation the future vision, repairability index and feedback of the buyer is evaluated.

The future vision is tested to check whether this vision resonated with employees at Action. Different concepts have been proposed to them to see which ones resonated and which ones did not.

For the future vision employees at Action were asked to read the roadmap towards the future vision in 2035. After they have read this, they were walked through the roadmap to check if there were any questions. Four ideas were proposed that could diversify Action's revenue streams due to the stalling geographic expansion in Europe and upcoming legislation. The concepts were based on the insights and feedback on the products Action sells in the coming future, the concepts were as follows:

1. Set standards in parts and integrate vertically to produce them ourselves.
2. Fully develop products ourselves.
3. Create a product passport system ourselves or with partners
4. Invest in knowledge and solutions for repairability which could be sold to suppliers

The proposed concepts were ideas that all try to put Action on the market in different, more extreme ways. These were chosen to trigger the respondents in thinking outside of the box. The suggested Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (Jones & Van Ael. 2022). For the selection of participants, managers at Action were asked to participate. Preferably managers who are affiliated with sustainability as they have the knowledge regarding circularity and the company.

The repairability index was evaluated to measure the current state of repairability for Action products. This gave Action an indication of what the current state of repairability is and potentially how urgent an repairability index might be.

To get a grip on a framework for Action to become more circular a case study has been crafted for one ErP (Energy Related Product) group, namely the ErP group grills. This ErP group is chosen as it is in the top 5 of most product weight sold. Additionally, a relevant supplier to this ErP group is located in the Netherlands and are open to collaborate and share information. Three grills from Action's assortment are used to fill in the repairability index. For the case study the proposed goal, index outline and goal of Appendix 8 were used. The selection of the priority parts was first tested to be able to fill in the reference value for the criteria.

The repairability index supported by the case study as an example is discussed with buyers, product techs and a supplier to gather feedback from these stakeholders. The Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (Jones & Van Ael. 2022).

The feedback system from Figure 15 was filled in with KPI's and the current score of an ErP group. The buyers were presented a product from this ErP group and were asked to fill in the score in the feedback form. After this feedback was asked from the buyer on how he would use this tool.

The repairability index was in detail discussed with the product techs after which they were asked if they would think suppliers would be able to use the repairability index and if they foresaw any problems.

One of Actions suppliers is visited to gain insights in how a supplier could implement the repairability scoring system and supply more repairable products to Action. By asking how they currently solve circularity problems, what the measure in place are and how they responded to the FRI deeper understanding in their operation is gained.

Figure 2 shows a overview of the process of this thesis using the double diamond approach. The sub research questions, redefine chapter and methods used can be seen in the overview.

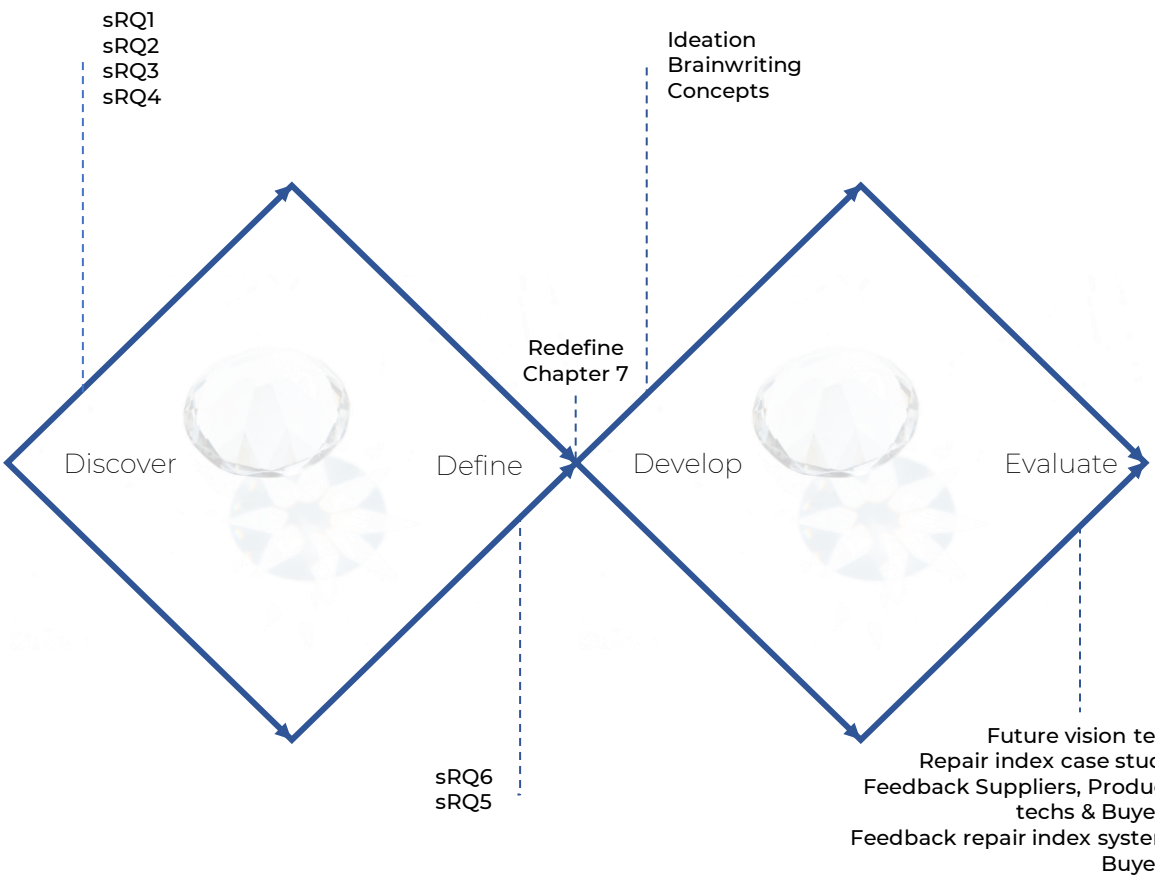


Figure 2: Double diamond process throughout this process

3. Resource flows and Circularity

(Alexandru, 2023)

3. Resource flows and Circularity

Action wants to move towards a circular future and incorporate sustainability into their strategy. This chapter will present a literature review of what a circular future will entail. This is done by looking into what defines a Circular Economy and how this can be applied in practice through resource retention options. The findings are summarized in a conclusion at the end of the chapter and further used in this thesis. This will help answer sRQ 1: How can a Circular Economy be accomplished?

3.1 Circularity

The three principles that can be used to move to a circular resource flow are shown in the model of Bakker et al. in Figure 3 (2015). Here you can see what happens if a loop is 1. closed (x-axis), 2. slowed down (y-axis) and 3. narrowed down (z-axis). By closing the loop of a linear resource flow the materials are reused. An example of this is recycling materials and turning them into new products. If a linear resource flow is slowed down the resources will be used longer. This will reduce the amount of products being made thus reducing the amount of resources being used. An example of slowing resource flows is by making products repairable. The combination of a closed resource flow and a slowed down resource flow will result in resources being used longer before being reused. The resource flows can also be narrowed down resulting in less material being used. This is mostly beneficial in linear flows where the focus is on efficiency. It is also beneficial in circular flows as no excess material is being used which could influence transportation for example. **The focus in a Circular Economy should be on closing and slowing resource flows as narrowing flows focuses on efficiency and not on circularity.**

A fourth principle is proposed by Geissdoerfer et al. which focuses on use phase extension (2018). The use phase could be intensified by offering software and service solutions instead of products so a form of dematerialisation. Geissdoerfer et al. call these intensifying loops (2018). Intensifying loops could also be seen as a circular business model with the aim of closing, slowing and narrowing loops.

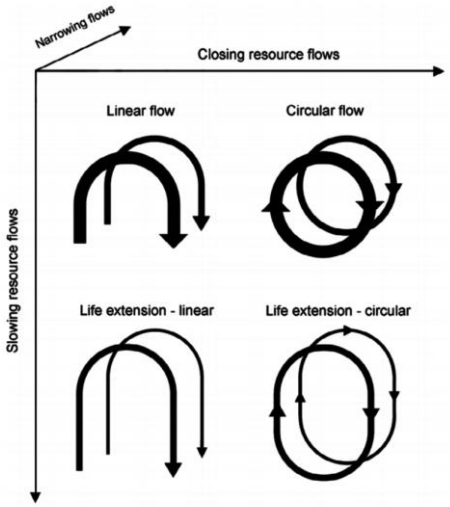


Figure 3: linear and circular flows (Bakker et al., 2015)

As mentioned earlier, a linear flow becomes circular when the loop is closed and the resources are used again, this is called cascading. The concept of cascading has been mentioned in recent publications on CE as a way to maximize the value of materials for as long as possible (Campbell-Johnston et al., 2020). Cascading involves using resources sequentially for different purposes, ideally through multiple reuse phases before resorting to energy extraction or recovery operations. While cascading shares CE's goal of promoting resource efficiency through consecutive resource circulation, it is often mistaken for recycling or downcycling. Supporters of cascading argue that it can lead to greater natural resource efficiency across the entire lifecycle of a material, from extraction to disposal. A simple example of cascading is a wooden product, which then becomes a particle-based product, which then becomes a fiber-based product, which then becomes a bio-based product, which then becomes energy for electricity or heat.

Within CE three archetypes of products are defined which all require different approaches to be circular. The three archetypes of products are products that last, flow and dissipate and can be distinguished by focusing on the use of the product. Products that last are products that are used over an extended period of time (more than one year) such as a fountain pen. Products that flow are products that are used within a short period of time such as food or cleaning detergent. Products that dissipate are products that vanish over time such as lubricants. (Bakker et al., 2014). **If possible, companies should aim at selling products that last as this slows down the resource flow.**

Making the shift towards CE requires differentiation between three different levels in economics according to Valls-Val et al. (2023). These levels are referred to as circles by Geng and Doberstein (2008) and consist out of the micro, meso and macro circles. The micro circle is on a corporate level and could be in the form of waste minimization within a factory for example. The meso circle is on an inter-firm level, a good example is an eco-industrial park where companies can trade byproducts such as excess heat from industrial processes. The macro circle emphasizes social levels such as the development of eco cities and provinces to create a circular society. This is useful when measuring the impact of new CE strategies which will be touched upon later in 'Measuring Circularity'.

To move towards a CE four principles can be used: Narrowing, closing, slowing and cascading flows. The focus should be on closing, slowing and cascading flows as these truly contribute to a CE. Companies should focus on selling products that last as these slow the resource flow. When shifting towards a CE micro, meso and macro impact should be taken into account.

3.2 Resource retention options

Putting the principles of a CE into practice in order for a system to become circular is not easy. Putting the principles of a CE into practice in order for a system to become circular is not easy. Ten ways of retaining resources are described as a way to make a system restorative or regenerative by intention. Two different views are presented and a preferred one is chosen where the focus on certain resource retention options is proposed.

Moving towards a CE requires retaining resources also described as Resource Retention Options (RRO). Morseletto identified ten different RROs (numbered from R0 to R9) for moving toward a CE, see Table 2. The ten options can be divided into three subdivisions; Smarter product use and manufacture, Extend lifespan of products and its parts, Useful applications of materials. **To move towards a CE Morseletto claims that we need to shift more towards R3-7 instead of only focusing on R8 and R9**. RRO R8 and R9 only focus on waste management and resource conservation resulting in products being decomposed for their materials instead of reused in the economy. Therefore, Morseletto suggests that to shift towards a CE one should aim for extending the lifespan of product and its parts (R3-7) by designing better products (R0-2) to delay useful application of materials (R8-9).

A similar research was conducted by Reike et al. who researched different RROs as seen in Table 2 (2017). The RRO Reike et al. proposes are similar except the replacement of Rethink with Re-mine. Morseletto proposes to use Rethink as this is a more relevant strategy and Re-mine has rarely been used in practice (Morseletto 2020). Reike sees rethink as a part of repurpose as she explains that it is a way to reuse discarded goods. Re-mining, according to Reike, is retrieving materials after the landfilling phase by for example mine for valuable resources in old landfills. The model Morseletto (2020) proposes is favorable as this includes rethinking in the way of rethinking products or businesses within a CE and not discarded products as Reike proposed. Secondly, Re-mine can be seen as a form of recycling but then in a later stage. Finally, the model used by Morseletto is used as well by various other authors (Jonker et al., 2022; The Ellen MacArthur Foundation, n.d.). The order within this Table can be used as a rule of

thumb to increasingly achieve circularity (starting at R9 up to R0) (Jonker et al., 2022; Morseletto 2020).

3.3 Conclusion

To accomplish a CE four principles can be used: narrowing, closing, slowing and cascading flows. The focus should be on closing, slowing and cascading flows as these truly contribute to a CE. Companies should focus on selling products that last as these slow the resource flow. When shifting towards a CE micro, meso and macro impact should be taken into account.

Morseletto identified ten different RROS (numbered from R0 to R9) that make it possible to switch to a CE. According to Morseletto we need to shift more towards R3-7 instead of only focusing on R8 and R9 if we want to become circular. The order within the RROs can be used as a rule of thumb to increasingly achieve circularity from high to low (R9 to R0).

Morseletto (2020)	Reike et al. (2017)	#	Morseletto (2020)	Reike et al. (2017)	Morseletto (2020)	Reike et al. (2017)
Smarter product use and manufacture	Client/user choices	R0	Refuse	Refuse	making a product redundant	Refrain from buying
		R1	Rethink	Reduce	making a product use-intensive by sharing for example	Use less, use longer; share the use of products
		R2	Reduce	Re-sell/Re-use	using fewer natural resources by reducing the number of products	Buy 2nd hand, or find buyer for your non-used products
Extend lifespan of products and its parts	Product upgrade	R3	Reuse	Repair	The second or further use (by another user/owner) of a product that is still in good condition	Making the product work again by repairing or replacing deteriorated parts
		R4	Repair	Refurbish	repair and maintenance of defective product so it can be used with its original function	R5 for large complex products
		R5	Refurbish	Remanufacture	restoring an old product and bringing it up to date	Replacement of key modules or components if necessary, decompose, recompose
	Downcycling	R6	Remanufacture	Repurpose	using parts of discarded products in a new product with the same function	New user of a product
		R7	Repurpose	Recycle	the use of discarded products or their parts in the formation of a new product with a different function	Dispose separately; buy and use secondary materials
Useful applications of materials		R8	Recycle	Recover (energy)	processing of materials to obtain the same or lower quality of recycled materials	Buy and use energy (and/or distilled water)
		R9	Recovery	Re-mine	incineration of material with energy recovery	Buy and use secondary materials

Table 2: The 10 different RRO of Morseletto compared to Reike et al.

4. Action

(Berlier, 2023)

4. Action

The organization of Action has to be understood to successfully implement circularity into Action's strategy. In this chapter Action will be analyzed to find out how Action gets their products in the store and who is involved. Secondly, insights are shared that go into why Action is acquiring their inventory this way and how this creates problems for implementing circularity. The conclusion is that the buyer should be helped in making the right decisions in terms of circularity and get feedback on these decisions. Thus, enabling Action to sell more circular products. This chapter will answer sRQ 2: How is Action acquiring the products in their inventory? and sRQ 3. Why is Action acquiring their inventory this way?

4.1 Acquiring inventory

As Action is such a vast company an analysis has been done to map the processes that describes actions process of acquiring products for them to sell. The gathered information is obtained by conducting interviews with various employees of Action (N=13) from different departments (Confidential Appendix). The insights gathered from these interviews are used to create an overview that describes the process of Action acquiring products to sell in their store. The in depth overview is only available in the confidential appendix. Therefore, the buying process will be discussed shortly without too much detail. This process is an interpretation based on the interviews and might vary in reality.

The stakeholders in the buying process are introduced first and can be seen in Figure 4. Every product category has their own team of buyers with one head of buying. The buyers are supported by a quality team existing out of product techs, compliance and the sustainability team. The product techs work for one specific category and test the products. The sustainability team is made up out of packaging specialists, a social compliance analyst and a circular product specialist. The sustainability team and compliance do not belong to one specific category. There are two types of third party importers, Li & Fung and the rest. Li & Fung is an sourcing agent that helps Action with direct import from the far east. The rest, who are also referred to as suppliers, are the importers whom Action buys from. Action buys from many different suppliers domestically but only from Li & Fung as direct import. If a product is from domestic import it means that it is either sourced from a European supplier or European factory. The supplier could import from European factories or from outside of Europe. The buyer often knows what the expertise of their suppliers is and sets out samples at the right supplier. Direct import products are products sourced directly from China, India or Vietnam through Li & Fung. If a product is directly imported it automatically comes in high quantities but for a lower price. Other third parties Action works with are TÜV Rheinland, TÜV SÜD and Intertech who test products for Action as well as product IP who collects and stores product information for Action.

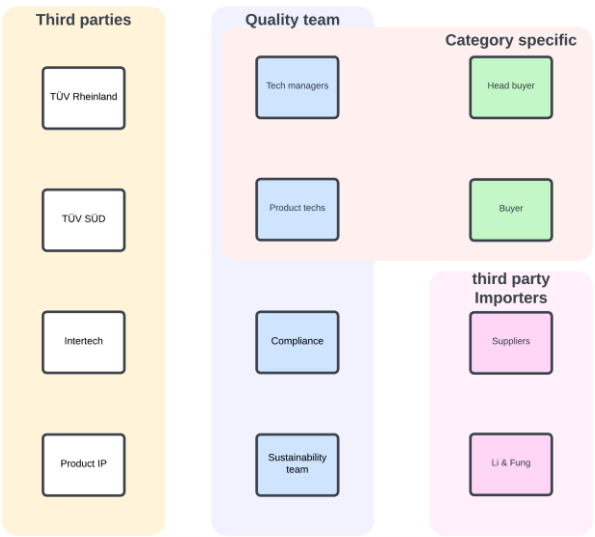


Figure 4: Short introduction to the main stakeholders in the buying process of Action.

The process of acquiring inventory is drawn from the perspective of the products Action buys, these will be explained further. Action brands their products in different ways, they sell White label, Private label and A-Brand products. White label products are products that are

made in order for other companies to rebrand and sell. Private label brands are brands that are owned and sold by Action. A-Brands are products from known brands such as Axe or Red Bull. Products are also sorted on how they are being sold to action, an overview can be seen in Table 3 together with how labels fit into these types of products. Suppliers of Action hold a PSS (Product Specification Sheet) of every type of product they sell to Action. The PSS holds al the information and requirements a product needs to confirm to before Action is able to sell it. An overview of how Action acquires their inventory can be seen in figure 5. The phases will be discussed briefly as the in-depth overview can be seen in the confidential appendix.

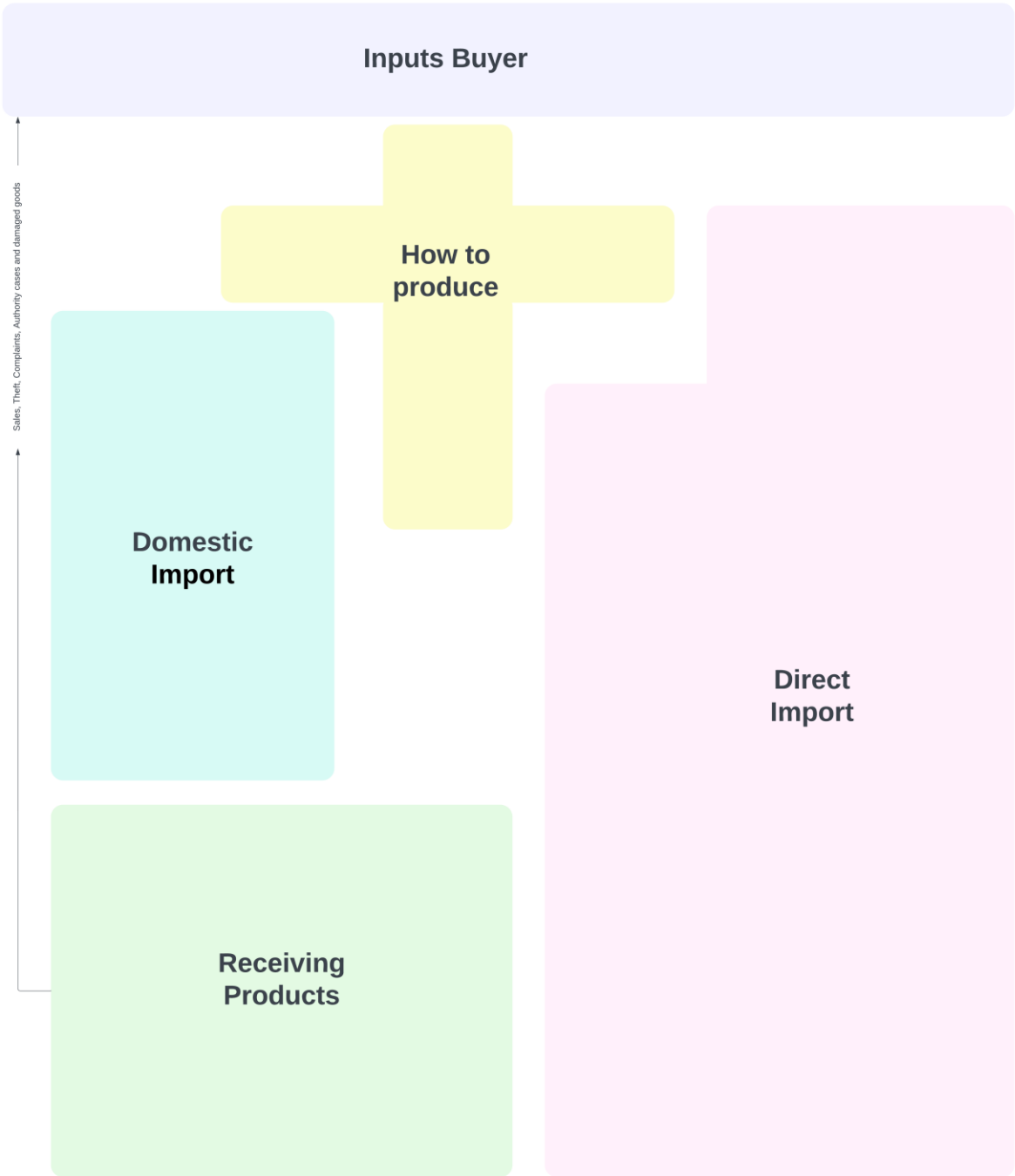


Figure 5: The process of Action acquiring products to sell in their stores

Type of product	Description	Labels
Fixed Unlimited (**FU**)	Product is continuously offered at Action and supply goes automatically. Contracts are renewed every year.	White and private label
Fixed Seasonal (**SE**)	Fixed seasonal products are products that get offered every year.	White, private and A-brand
Fixed Assortment (**FA**)	Product is continuously offered at Action but every reorder has to be done manually.	White, private and A-brand
In and Out (**IO**)	Product is sold for one time and then replaced	White and A-brand

Table 3: Different types of products, their description and what labels are commonly used.

Acquiring products starts with the buyer and the inspiration for selecting products to buy. Three different types of input can be distinguished: Internal, outside and collaborations. Internal input comes from benchmarking of products, outside inputs come from what buyers see around them on social media, assortment of competitors and offers they get from suppliers. The last input for buyers are "collaborations' with A-Brands. Sometimes buyers look for A Brands they can sell such as Dreft or Red Bull.

With the input the buyer has to make a selection on what product to buy and how it is going to be sold and produced. Products from the current assortment can be reflected upon and potentially be reordered. The buyer makes the choices based on the inputs from the data of previous sales, theft, complaints, authority cases and damaged goods. When selecting products the buyer keeps in mind the Fit For Purpose (FFP) of the product. FFP means that the customer understands what the product does and the product actually delivers its promise.

If the buyers decides a product is going to be bought domestically he will request several samples from different suppliers that fit the desired product. The buyer shares his thoughts on the product and some initial specs with the supplier, sometimes a product tech gives advice. The reason for this is to get price and quality checks of the product he has in mind. Then the buyer chooses what sample to pursue in buying and selling at Action. **This decision is made based upon price, quality, sustainability and FFP.** Underlying factors for the buyers are targets based on: number of SKUs, quality, margin, sustainability and availability.

SKU stands for Stock Keeping Unit and is associated with a particular product. These targets will be discussed later in "insights interview". The buyer always makes sure the quality and price are in proportion of all samples. Then he chooses the best price for the FFP and tries to implement some sustainability options. The label for the product is chosen and the supplier can send out a prototype to be reviewed by the buyer and product tech. The product tech tests the product based on safety, legal compliance, fit for purpose and sustainability.

The product tech is not always involved. **The buyer decides if the product is a high risk product or not when he is buying something new.** The quality team has predetermined the risk of general products but the buyer might encounter new products. If the buyer is dealing with a high risk product he will ask for help from the product tech. High risk products are for example products that touch food. This makes the buyer a gatekeeper for the product tech. If he decides to include the product tech he can do this earlier in the process if he thinks this is needed. When the product comes in the product tech reviews the product and if needed asks for help form compliance or the sustainability team. The product tech shares his findings with the buyer after which he decides to change things or not. This can sometimes lead to further negotiations with the supplier to come to a new agreement. The advantage of domestic import is that the importer and not Action is responsible for the product. The domestic importer can also supply Action on demand instead of Action having to store all the products themselves. This comes at a price which is taken into account when making the decision on how to acquire a product.

When a product comes from direct import a similar process occurs as domestically. The buyer keeps a wish list of products he wants to have sourced from direct import. These are often products that have already performed well in terms of quality and sales. Li & Fung goes sourcing for vendors and factories to produce the products from the wish list. The buyer visits Li & Fung and selects the products he wants to buy and often some extra items that are being presented as well. Action works closely together with Li & Fung, TÜV Rheinland, TÜV SÜD and Intertech to ensure quality from direct import. In Hong Kong, a small team of 4 Action employees works closely together with Li & Fung to oversee everything. When Action buys something from direct import Action is the importer which comes with more responsibilities. That is why there are more extensive tests and checks when products are being directly imported. If products are sourced directly the quantities are big which impacts the capacity of Actions warehouses.
Lastly, the items are being received at Action. Domestic products are almost always stored by the supplier and delivered to local Distribution Centers (DC) on demand. Direct import products get divided over the DC's of Action. DC's send products to DC Zwaagdijk to be tested by the sample room and put them in the system. In the sample room the material of the primary packaging of the product is determined and weighed. The same happens for the product and the information is stored to pay taxes over the product's weight. The DC's supply the nearby stores who sell the products to the customers.

The conducted interviews helped create the overview of the process of Action acquiring products. During these interviews the reason and motivation for certain actions and decisions were asked as well to understand why it is happening the way it is happening. This is discussed in the next section "Insights interviews".

4.2 Insights interviews

The insights of the interviews and the way action works are further analyzed to pinpoint why the buying process is working the way it does. This will be done by looking into driving forces within Action, targets for the stakeholders, Suppliers & relationships within Action. This is all summarized in the conclusion.

Driving forces

Within Action there are three driving forces in the buying process: Fit For Purpose (FFP), price and quality. FFP describes if the product delivers its promise for the amount it costs in terms of quality and function. The buyer thinks of a product he wants to sell which fulfills a certain purpose and collects products with different quality price ratios. He then decides the best price that would work for this purpose and the associated quality. These steps are quite subjective which makes it hard to measure and quantify. Action is trying to add circularity to these three driving forces by measuring the CTI score of every category and bind targets to this. This means that currently buyers select products based on FFP, quality price ratio and circularity in that order.

The forces within Action are mapped in a simplified system in Figure 6 according to Meadows system thinking (2008). To read this one stock, for example "Customer perspective", should be taken as a starting point. The arrows leaving from this stock tell you what would happen to other stocks if the stock you are starting at were to increase. This means that if Customer perspective were to go up Sales would go up as well.

Action is expanding, increasing their sales, stores, DC's and order quantity. This will result in lower product costs which Action chooses to incorporate in the product price while handling a similar margin. This means if Action wants to make the same profit on an item with the same margin but at a lower price they have to sell more products. **This is a reinforcing loop within Actions business model** as long as they can continue to grow and sell more products.

The reinforcing price loop can be seen in Figure 6, next to the price loop the product quality check and circularity. The buyer (red) decides how to balance the product price, product circularity and product quality. He gets feedback from the quality team (green) in the form of a product quality check and circularity improvements. The buyer makes his decisions based on what he thinks is right and his targets (Meadows, 2008).

This price has to give good value for the customer which is translated into good quality. The product tech gives feedback on the quality of products and sometimes suggests more circular alternatives in material use for example. If the product tech gives feedback to the buyer, **he decides what to use and what not to use.** The product tech comes into place when the buyer thinks he is dealing with a high risk product. **This makes the buyer a sort of gatekeeper** when he thinks he needs a quality check. As the product tech and buyer share the same goals it rarely happens that a buyer decides to sell products that the product tech does not agree with, as long as he is involved.

Circularity is something that comes last for some of the interviewed buyers as they are focused on acquiring qualitative products for a good price. Buyers want to throw in circularity at the end of negotiations and act as if circularity is a sort of standard without wanting to spend money on it. Some buyers said to be able to spend maybe 5 or 10% on a product to make it more circular but this depends on the price.

Buyers select products based on FFP, quality price ratio and circularity in that order. Within Actions business model there is a reinforcing loop that makes the products cheaper as long as Action is growing. The Buyer has a lot of power in the buying process and decides when to involve the product tech and what advice to use.

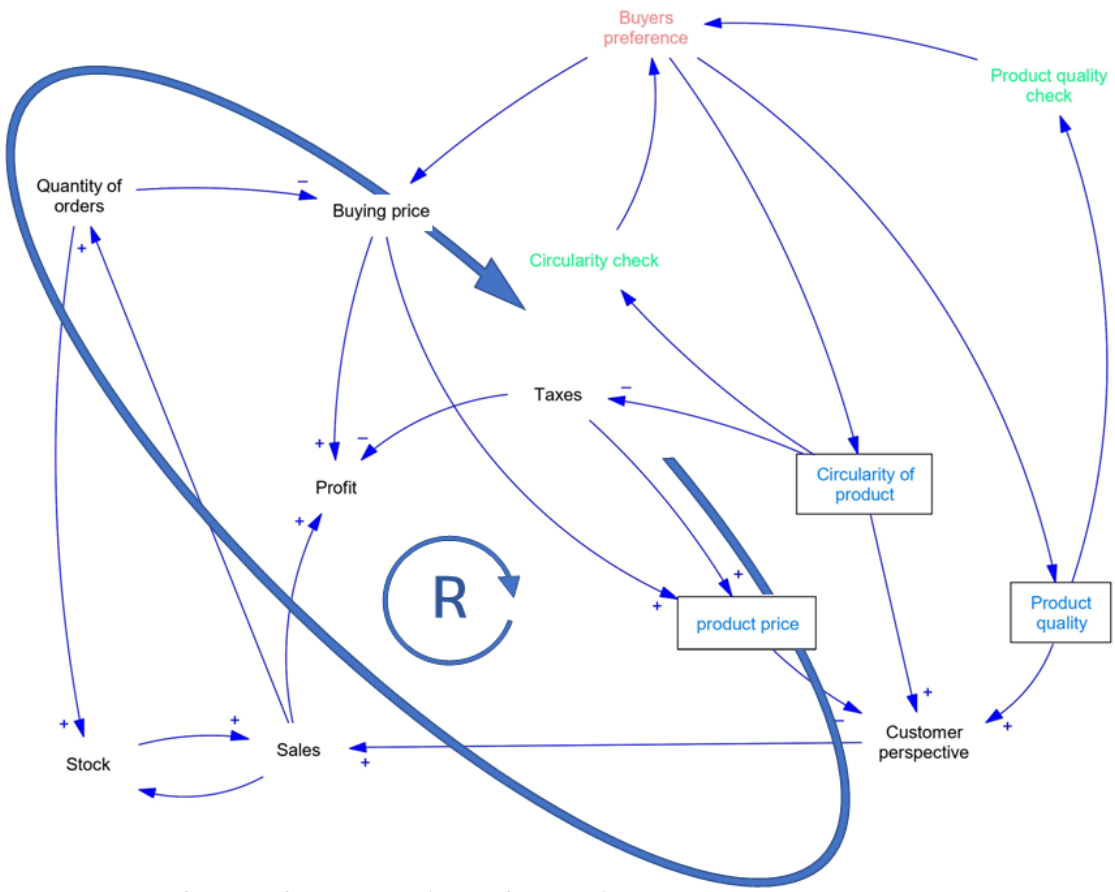


Figure 6: Driving forces of Action with reinforcing loop R

Targets

Buyers have different targets based on SKU's, quality, margin, circularity and availability which they share with the product tech. These are described below.

Buyers have a fixed amount of SKUs in their assortment and they have to make sure all the spots within their category are filled. The commercial planner helps to plan this. Quality is measured in damaged goods, theft, returns and complaints. Action tries to handle a fixed margin on all their products which the buyers have to maintain. For circularity this is to increase the CTI score of every category by 5%. Availability of the SKUs which are influenced by products actually make it to the store so they can be sold.

Buyers have addressed that they can reach their targets as they can see what choices impact these targets. **However, they found this to be hard for circularity as they did not know how their choices influenced the circularity of the product and category in general. If Action wants to become Circular the targets in price and circularity must be implemented accordingly.**

Suppliers

Action works with domestic suppliers and Li & Fung who supply the products. Action has a lot of leverage with Li & Fung as Action is a big client that orders in large amounts. This allows Action to design products the way they want as they are produced solely for Action. With domestic suppliers Action has a lot of leverage because of the quantity as well but changes are typically slower due to the nature of domestic import. With direct import Action is focussing on importing simple products that carry little risk. If Action imports products directly, they are responsible for these products. As Action currently does not have the inhouse expertise on some more high risk products, these are avoided and bought domestically. High risk products are different for every buyer but some examples include most Electronic products (except for some cables), products that are in contact with food and children toys that include small parts.

Relationships

To get a better understanding of the key participants within the buying process of Action and their relationships a stakeholder map has been made based on the Actors map from Jones & Van Ael (2022) (Figure 7).

The stakeholders are mapped based on their circularity knowledge (X-Axis) and power within the system (Y-Axis), the connections between the stakeholders show their relationship. The type of relationship differs as seen in the legenda, as well as the strength of the relationship defined by the weight of the lines. The stakeholders from Action consist of Tech managers, Product techs, Buyers, Head buyers, Sustainability team and the Director of commerce. Some simplifications have been applied such as the exclusion of junior buyers etc. The internal stakeholders from Action have relationships to different suppliers and Li & Fung where the products are being bought from.

The suppliers generally do not have a lot of knowledge as they sometimes only resell the products. This differs per supplier but it is common that the product tech knows more about the technical aspects of a product than its supplier. For Li & Fung this knowledge is a bit lower as they do not have to conform to EU legislation. Action has to point out the EU regulations to Li & Fung before the products can go to Europe.

In the buying process the buyer makes all the decisions in regard to FFP, price, quality and circularity as seen in Figure 5 and 6. **The buyer has a lot of power in making decisions but is lacking the knowledge of making circularity decisions.**

The knowledge lies at the sustainability team who have less power. The current circularity decisions are on a level of reducing materials but the knowledge to take the next step in circularity is missing for product techs, tech managers and buyers. Therefore, **the buyer should be supported in making the right decisions enabling Action to sell circular products.**

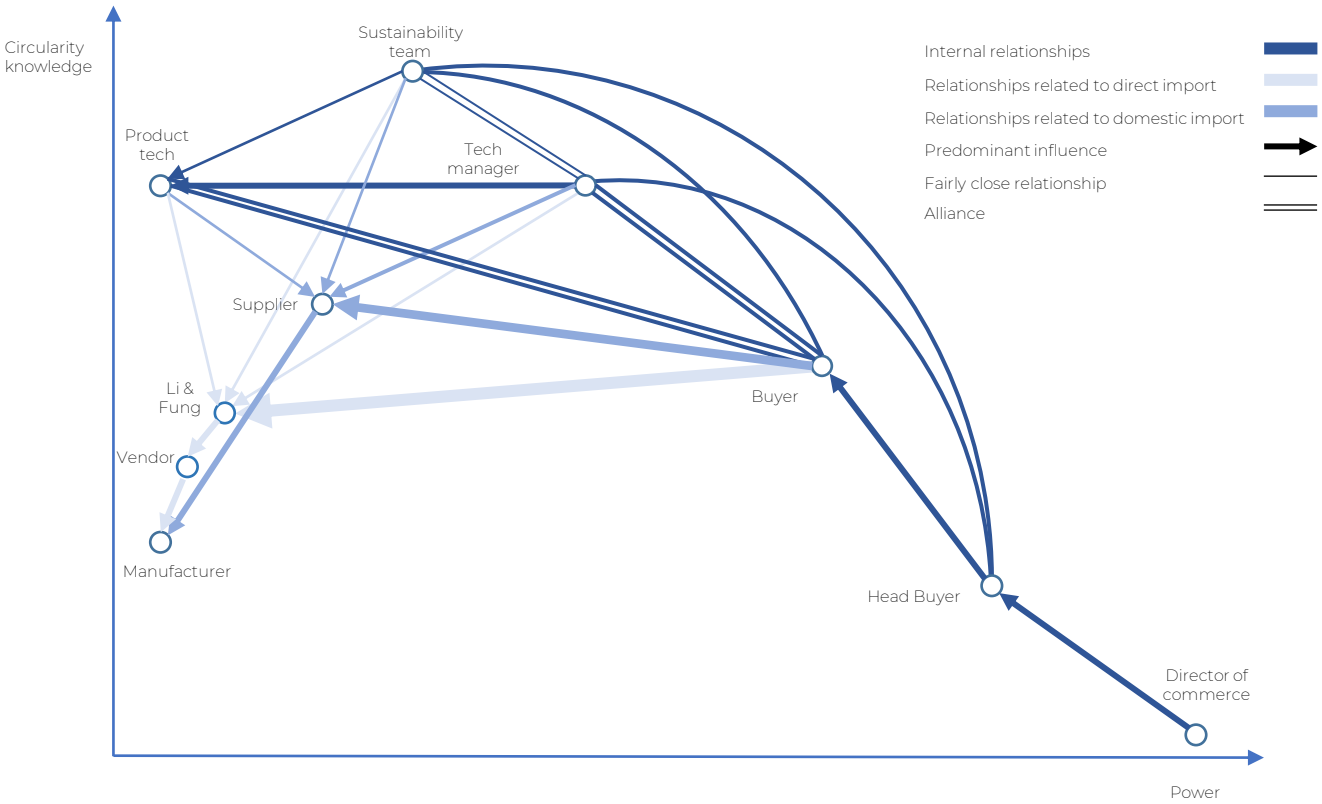


Figure 7: The stakeholders are mapped based on their power in the buying process versus circularity knowledge.

4.3 Conclusion

Buyers select products based on FFP, quality price ratio and circularity in that order. Within Actions business model there is a reinforcing loop that makes the products cheaper as long as Action is growing. The Buyer has a lot of power in the buying process and decides when to involve the product tech and what advice to actually use.

Circularity targets are hard for buyers as they do not know how their choices influence the circularity of the product and category. If Action wants to sell circular products the targets in price and circularity must be implemented accordingly.

Besides the sustainability team circularity is not common knowledge. The buyer has a lot of power in making decisions but is lacking the knowledge of making decisions in terms of circularity. Therefore, the buyer should be helped in making the right decisions and get feedback on these decisions. Thus, enabling Action to sell circular products

5. Measuring circularity

(Longas, 2019)

5. Measuring circularity

Before improving circularity the current status has to be measured to be able to tell a difference. In this chapter a short introduction into measuring circularity is presented. Next to this the current circularity state of Action as measured by an external consultancy firm called Circle Economy is presented. From the measurements of Circle Economy and insights of Morseletto a conclusion is drawn to focus on the end of life phase to increase Action's circularity. With this information sRQ 4 can be answered which covers how Action is currently measuring circularity.

Measuring Circularity within an organization is quite hard as described by Valls-Val et al. who analyzed seven different qualitative CE tools (2023). The EU is working on a CE monitoring framework as well to track the EU's process in circularity (European Parliament, 2022).

Action has worked together with the company Circle Economy to identify circularity gaps in their value chain and propose solutions at hotspots. A more in depth scan of every product category has been made using the Circular Transition Indicator score (CTI) to identify product category specific problems.

Due to the scale and diversity of products within Action, Circle Economy made a company level analysis and a product category level analysis. Circle Economy measures the circularity of a company by measuring the input and output of materials. When focussing on the input of materials the percentage of non-virgin or regenerative materials is measured. For the output the percentage of material that is not being landfilled, incinerated or prevented from further usage or reentry into natural nutrients is measured. The opposite to the circularity metric is the circularity gap. The circularity gap is the inverse of the circularity metric describing the percentage a company or hotspot or product etc. is removed from reaching a 100% circularity metric score. As this metric is only focussing on material flows and not on what types of materials, mode of transport, etc. it should be seen as indicative. The circularity metric can help identify hotspots where a company should focus on. These measurements resulted in Action scoring 7% on the circularity metric leaving a 93% circularity gap. The 7% came from the percentage of virgin resources that were being reclaimed and reused. The overall advice from Circle Economy within the scope of products was to reduce the use of virgin materials which could result in an increase of 58% on their circularity metric. The second advice was to focus on the end of life phase which could result in an increase of 9% on their circularity metric.

The Product category scan was done using the Circular Transition Indicator score (CTI) on every individual category. The CTI score tool is developed by an organization called WBCSD (World Business Council For Sustainable Development) together with 30 other companies and aims to help businesses measure their circularity (WBCSD, 2021). The CTI framework is designed to be an additional sustainability framework to the ones already being in place (WBCSD, 2022). The CTI framework works by analyzing the material flows through a company and the companies ability to minimize resource extraction and waste materials. This is done through looking at the inflow of materials, recovery potential (design for disassembly, repairability, recyclability, etc.) and the actual recovery. Within the CTI score system four topics can be analyzed within a company with each topic having different indicators. Companies choose what indicators are the most useful to them but always start with material circularity. An overview of the four topics can be seen in Table 4, the bold indicators are the indicators Circle Economy measured for Action. A detailed overview of the metrics used and how these were used by Circle Economy can be seen in Table 5. The limitations of these measurements are the lack of capturing upstream and downstream material consumption. The method does include the end of life stage by averaging the recycling rates per material type and country but excludes other RRO.

The circular value (CTI revenue) is measured to introduce financial KPIs linked to the circularity gap making it easier to monitor the value chain. This however can be impacted by other factors like total sales growth, questioning the usability of this metric with Action's rapid growth in mind. The measurements are based on the 50 most relevant products of each category. Product relevance is calculated as a weighted average of the revenue generated by the product and volume shares of the fixed assortment (FA); a calculation example is included in Appendix 2 (Circle Economy, 2020) Unpublished internal company document.

The results of the CTI scan on the 14 categories can be seen in Table 6. In this Table the findings of the CTI circularity scan and CTI revenue are projected alongside the types of product within a category. Circle Economy proposed different scenarios on improving each category and the ones with the highest effect on the CTI circularity metric are shown in the Table. The type of product had an influence on which scenario had the highest impact and this is why it was included in the Table. The results of the new scenario are marked bold.

For Food and drink and Decoration the highest impact scenarios are to recycle primary packaging and use circular synthetic fibers due to the amount of products that dissipate in these categories. In the product categories where the predominant type of product is a product that lasts the impact scenarios are all the same. Here the highest impact would be achieved if all the waste of the product would be recycled. This is the opposite of the findings of the company wide scan as focusing on end of life would only result in a 9% increase in circularity. What could explain the difference is that the company wide scan takes into account the total upstream materials used, unlike the CTI score. As the CTI scores are more in depth, these are the preferred measurements to refer to.

Based on the CTI scores of the categories, Action should **focus on recycling waste for products that last** to increase the circularity of the company and have the highest impact. The focus should be with a "higher" RRO (R3-7) as suggested by Morseletto to actually close the loop. If one would solely focus on decreasing the circularity gap one would naturally go for cascading to decrease the use of virgin materials. But this does not change the system as a CE is about creating a system that is restorative or regenerative by intention and design. In this scenario Action would deplete less resources but is not closing the loop.

Close the loop	Optimize the loop	Value the loop	Impact of the loop
% material circularity % water circularity % renewable energy	% critical material % recovery type actual lifetime Onsite water circulation	circular material productivity **CTI revenue**	GHG impact

Table 4: The four topics from CTI scan and the selected indicators in bold

Currently the target for the CTI score is to increase the score with 5% by the end of the year. In practice this meant that a lot of improvements on packaging have been made to increase categories CTI score, based on the interviews from Chapter 4. The CTI score based on materials can be lowered more but there comes a point that the optimum has been reached. This would be a moment to expand the circularity program and focus on other RRO. Action still has a lot of steps to take to be able to implement other RRO strategies. **Besides the sustainability team, other RRO strategies are not really known by employees at Action's corporate office.**

Conclusion

Measuring circularity in a system is hard and comparing it among other systems is even harder. Action has made a beginning using the CTI tool to indicate hotspots where they should focus. Based on the CTI scores of the different categories, Action should focus on recycling waste to increase the circularity of the company and have the highest impact. The focus should be with a "higher" RRO (R3-7) as suggested by Morseletto to actually close the loop.

Metric	Benefit	Disadvantage	Description	Calculation	Data collected
Circular inflow (close the loop and part of material circularity)	Key component of the headline metric under the CTI framework; trace the cycled material input performance of Action suppliers.	**No upstream material consumption considered.**	Inflow that is: · Renewable inflow (bio-based sources that are sustainably grown and sourced) used at a rate in line with natural cycles of renewability OR · Non-virgin (e.g recovered or recycled)	% non-virgin content + % renewable content	●Article number ●Description ●Net weight ●Material type ●Material weight ●Material sustainability type ●Weight sustainably sourced part 1/2/3 Packaging ●Net weight ●Material type ●Material weight ●Material sustainability type Weight sustainably sourced part 1/2/3
Circular outflow (close the loop and part of material circularity)	Key component of the headline metric under the CTI framework; trace the end-of-life cycling performance.	**Focus on the direct material consumed and recycled;** no downstream material consumption considered; data analysis highly depends on supplier estimation.	For the CTI outflow, we deviated from the CTI methodology because we could not access potential and actual recovery rates of Action's products. Instead, we used average **recycling rates per material type and per country of sales** and used this to calculate the circular outflow.	weighted averaged of material weight * average recycling rate, for each material.	●Article number ●Description ●Net weight Sales ●Per product category Per country Publicly available data ●Recycling rates per material ●Recycling rates per country
Circularity score (close the loop and part of material circularity)	Key headline metric to measure circularity; more intuitively and directly demonstrate the circular performance of Action products.	Focus on the direct material consumed and cycled; no upstream material consumption considered.	The weighted average of the % circular inflow and % circular outflow for a given product (group or portfolio), business unit or company.	weighted average between % circular inflow and % circular outflow.	Circular inflow and outflow
CTI Revenue (value the loop)	Relevant as it connects the circularity gap or CTI metric to revenue and therefore **introduces a financial KPI; calculated per product**, easier to monitor the value chain in detail.	Focus on the direct material consumed and cycled; Not merely related to the circularity but **can also be impacted by other factors like total sales growth.**	The revenue generated by a product (group or portfolio), business unit or company multiplied by its % circularity	((% circular inflow + % circular outflow) / 2) * revenue	Revenue generated per product

Table 5: Metrics used by Circle Economy for the analysis of Action's product categories

Category	Products that:	CTI inflow	CTI outflow	CTI circularity score	Highest impact scenario
Food and drink	Last: 0% Flow: 0% Dissipate: 100%	4,6%	94,3% **+2,8%**	49,4% **+1,4%**	Recycling primary packaging input
Pets	Last: 24% Flow: 34% Dissipate: 42%	8,1%	97% **+48,7%**	28,2% **+24,3%**	Recycle waste of products that last and flow
Personal care	Last: 8% Flow: 40% Dissipate: 52%	12,9%	9,6% **+39,4%**	11,3% **+19,7%**	Recycle waste of products that last and flow
Laundry and cleaning	Last: 0% Flow: 30% Dissipate: 70%	40,2%	31,6% **+26,1%**	35,9% **+13%**	Recycle waste of products that last and flow
Clothing	Last: 93% Flow: 7% Dissipate: 0%	47%	69,9% +**28,5%**	58,4% **+14,2%**	Recycle waste of products that last and flow
Sports	Last: 77% Flow: 2% Dissipate: 22%	59,6%	58,6% **+19,7%**	59,1% **+9,9%**	Recycle waste of products that last and flow
Stationary and hobby	Last: 32% Flow: 68% Dissipate: 0%	69,1%	65,5% **+33,4%**	67,3 **+16,7%**	Recycle waste of products that last and flow
Decoration	Last: 50% Flow: 0% Dissipate: 50%	25,1% **+11,4%**	43%	39,7% **+5,7%**	Circular synthetic fiber input
Toys & entertainment	Last: 41% Flow: 58% Dissipate: 2%	25%	50,5% **+46,1%**	37,7% **+23,1%**	Recycle waste of products that last and flow
Linen	Last: 92% Flow: 5% Dissipate: 3%	52,7%	63% **+35,6%**	57,8% **+17,8%**	Recycle waste of products that last and flow
Household	Last: 90% Flow: 5% Dissipate: 5%	33,9%	37,9% **+57,9%**	35,9% **+29%**	Recycle waste of products that last and flow
DIY	Last: 77% Flow: 14% Dissipate: 9%	22%	35,8% **+54,6**	28,9% **+27,3%**	Recycle waste of products that last and flow
Multimedia	Last: 85% Flow: 5% Dissipate: 10%	45%	50,5% **+35,4%**	47,9% **+17,7%**	Recycle waste of products that last and flow
Garden & outdoor	Last: 85% Flow: 5% Dissipate: 10%	23,5%	37,9% **+58,6%**	30,7% **+31,3%**	Recycle waste of products that last and flow

Table 6: Outcomes of the CT scan of every category and proposed scenario to improve this in bold (Circle Economy, 2020). Unpublished internal company document.

6. Legislation and Initiatives

(Bolovtsova, 2020)

6. Legislation and initiatives

The European Union is trying to make their economy more circular. Action should act to this accordingly to stay resilient. This chapter will shortly discuss European legislation and policy initiatives to get a basic understanding of the context of implementing a more Circular Economy. EU legislation and policy initiatives on three priority product groups (Textiles, Plastic and Electronics) will be further discussed, to select the product category that has the most impact for Actions operation. After the selection of the high impact product category "Electronics" specific legislation and initiatives are discussed for this category. This leads to a focus on repairability for Electrical and Electronic equipment. This chapter will help answer sRQ 5: What product category is most vulnerable for foreseeable and present circular legislation? And sRQ 6: What is foreseeable circular legislation that influences this product category?

6.1 European and national policies

In European law there is a distinction between "Regulations" and "Directives". Regulations are binding laws for all member states of the EU. A Directive is a legislative document that defines goals that member states must achieve. The member states must translate the Directives into their own national law. Furthermore there are "Decisions", which are laws only applicable to an individual member state, and "Recommendations" which are not binding documents and do not have any legal consequences. Finally there is the instrument called "Opinion", this instrument enables the EU to make a statement without any legal consequences (European Union, n.d.). Member states can act on recommendations and opinions on a voluntary basis.

The European Committee often starts the process of policy making by issuing an initiative. The initiatives can be seen as a recommendation, which are formulated in strategies or agenda's. They entail non-binding goals. These goals can be further specified by targets, which can form the basis for future Directives or Regulations.

In recent years the European Union issued several Regulations, Directives and adopted several Initiatives to protect the environment. An example is the Ecodesign directive to reduce energy consumption for the production and use of goods (European Parliament & Council of the European Union, 2009).

In many cases the implementation of the requirements, which are set in a Regulation or Directive, will be supported by European Standards. These are developed as an initiative of the EU. For instance, the CENELEC organization produces standards on electrotechnical matters (Hughes, 2017).

In 2019 the European Commission presented the Green Deal. This strategy aims at transforming our society and economy, to preserve the environment (European Commission, 2019). For the long term the European Green Deal has the intention to become the first continent which is climate neutral by 2050 (European commission 2019).To implement parts of the green deal at shorter notice the European Commission issued in 2020 the new Circular Economy Action Plan (new CEAP) (European commission, 2020b) (European Union, 2020). The new CEAP is an agenda", which sets goals for a CE in Europe. In February 2021, the Parliament adopted this new CEAP, but urged the European Commission to develop binding targets for the year 2030, which must be embedded in legislation (European Parliament, 2021). One of the results is the issuing of a proposal for a directive on the right to repair by the European Commission in 2023 (European Parliament 2023).

At national level, the Netherlands has the ambition to become fully circular by 2050 (Ministerie van Infrastructuur en Waterstaat, 2023 a). For the near future the government of the Netherlands is implementing the National Circular Economy Programme 2023-2030, which defines many goals on circularity (Ministerie van Infrastructuur en Waterstaat, 2023).

The new Circular Economy Action Plan (CEAP), which is a part of the European Green deal, has identified several initiatives to protect the environment. This plan is partly supported by binding Directives of earlier dates. In the nearby future new binding directives are foreseen. Standards are developed to make targets more comprehensible. Also at national level (the Netherlands) there are several initiatives for implementing CE.

6.2 Resource intensive product groups

In the new CEAP the EU has identified several resource intensive product groups: electronic equipment, ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients. These product groups were given priority because they have a high environmental impact and much circularity potential.

The new CEAP broadens the group of electronics by mentioning that the waste of Electrical and Electronic Equipment is growing fastly and only 40% is recycled. Therefore some measures in the new CEAP have the Electrical and Electronic Equipment in scope. Furthermore two EU Directives on Waste Electrical and Electronic Equipment (WEEE) are supportive of achieving some of the new CEAP goals (European parliament & Council of the European Union, 2012) (European parliament & Council of the European Union, 2018). Finally also the National Circular Economy Programme 2023-2030 of the Netherlands has a priority focus on Electrical and Electronic Equipment. Therefore in the following the product group Electrical and Electronic Equipment (EEE) is used instead of electronics.

If the new CEAP list of resource intensive product groups is compared with the 14 product categories of Action (Table 6), a few categories stand out. The group's textiles, plastics and electrical and electronic equipment are the most represented within Actions product assortment. The future of legislation or initiatives within these three groups is further analyzed. The goal is to identify the product group that is most vulnerable to coming legislation or initiatives. This group will have the focus in this thesis and will be pursued as an example.

6.3 Most vulnerable product group

Appendix 3 gives an overview of legislation and initiatives, which are relevant for the resource intensive sectors plastics, textiles and electrical and electronic equipment. The results are visualized in Figure 8. All the presented legislation and initiatives were color coded according to their potential impact to Action's current operations per sector (yellow/low impact, orange/medium impact and red/high impact). Furthermore the figure shows legislation and initiatives which are product group specific and which have a general nature.

As can be seen by the color coding, the legislation and initiatives for plastics and textiles have the lowest impact for Action. This is due to their nature.
For plastics the focus is on reducing pollution (e.g. reduce single use of plastics, reduce microplastics, and use bio-based plastics) and improve recycling (e.g. biodegradable plastics). These directives and initiatives will probably impact the industry the same as all customers of suppliers. Customers of suppliers will start demanding different types of plastics which will put the pressure on changing on the supplier and not on customers like Action. Nevertheless, the reduction of plastic and a shift to renewable resources and improving recycling is still needed within Action. But in terms of initiatives this does not have the biggest impact. Therefore, this group is not pursued.

Textiles have some initiatives coming which mainly focuses on reusing textiles, including recycled or sustainably sourced material in the fabric and recycling textile after use. These rules might pose a small impact in the near future if suppliers are not able to supply these fabrics within the time frame for a reasonable price. This might cause Action to already start working towards this solution together with suppliers to be ahead of these new rules. But Action is not going to be held responsible for the items after they are sold which minimizes the impact in the future.Therefore, this group is also not pursued.

Figure 8 shows that there are many directives and initiatives in the product group Electrical and Electronic equipment. Some of these will have a serious impact on the activities of Action (color coded red). For example: “the right to repair”, “to provide the consumers with reliable and relevant information on product durability and reparability, availability of repair services, spare parts and repair manuals, and software updates and upgrades", and “devices must be designed for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling”. These initiatives are **forcing Action to take responsibility for what they sell even after it has been sold.** This will have a big impact on how Action is currently operating with their ever changing inventory. Furthermore, according to the new CEAP Electrical and Electronic equipment is the fastest growing stream of waste (Ministerie van Infrastructuur en Waterstraat, 2023) and expected to double by 2045 (Parajulyetal et al., 2019). Also less than 40% of this waste is recycled in the EU. In the Netherlands e-waste has the biggest potential of reducing overall CO2 emissions by 5,52 Mtons according to Ministerie van Infrastructuur en Waterstaat (2023). And lastly, e-waste may potentially contain hazardous substances and/or toxic additives (Vanessa Forti et al., 2020).

Therefore Electrical and Electronic equipment is the most vulnerable product group in terms of present and upcoming legislation. In this legislation Action is being forced to take responsibility for what sells even after it has been sold. Additionally, Electrical and Electronic equipment is the fastest growing waste stream, has the biggest potential to reduce CO2 emissions and contains hazardous substances.

The product groups textiles, plastics and electrical and electronic equipment are the most represented within Actions product assortment in terms of resource intensive groups. The present and future of legislation within these three sectors is plotted in Figure 8. Electrical and Electronic equipment is the most vulnerable sector to (foreseeable) legislation, and is forcing Action to take responsibility after an electrical or electronic product has been sold. Action should focus on this group to stay resilient.

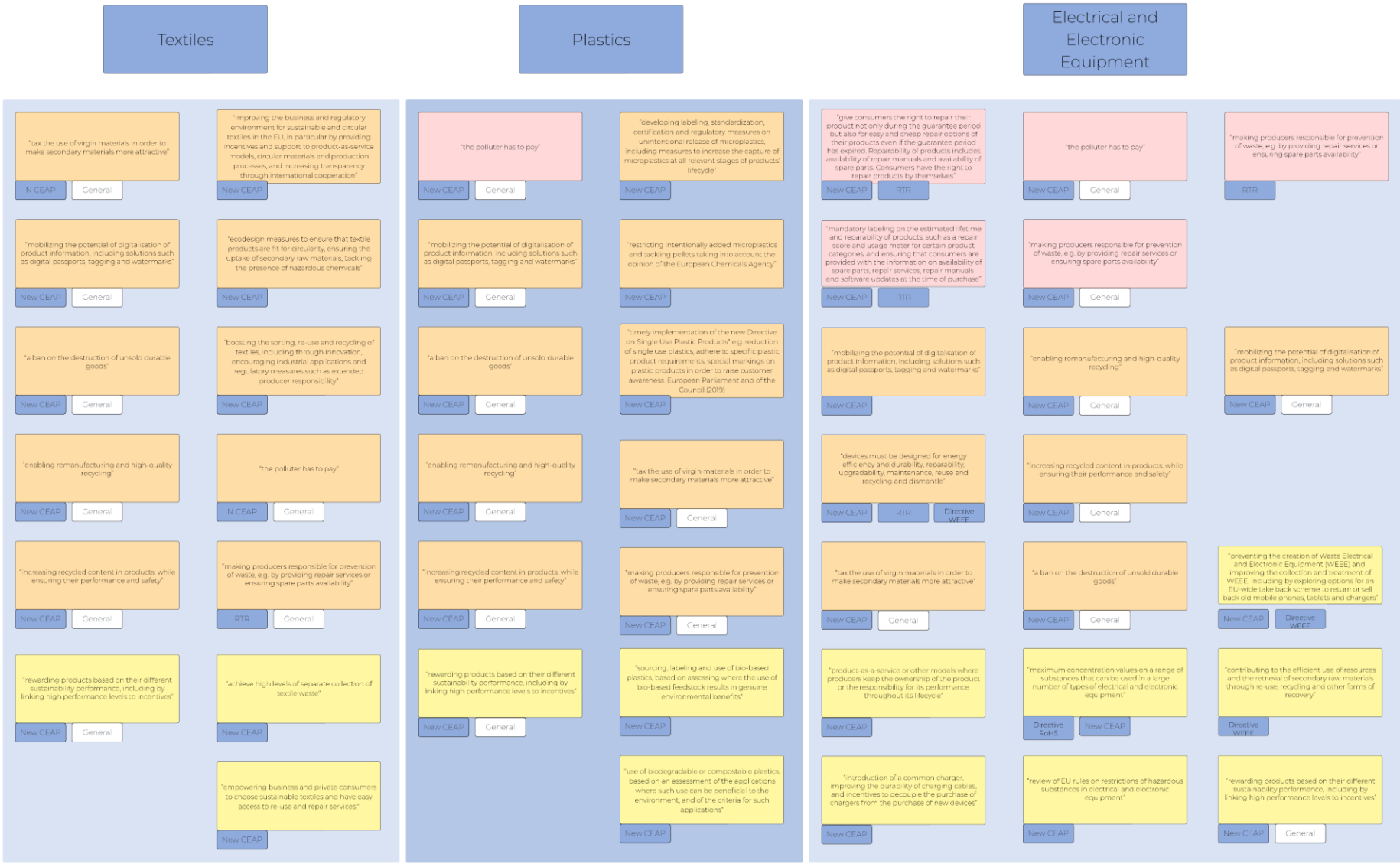


Figure 8 : impact of initiatives on the different product categories of Action

Electrical and Electronic Equipment

As the focus for Action is the product group Electrical and Electronic equipment, it should be defined what this equipment entails. This product group will be abbreviated as ErP which stands for Energy Related Product which is commonly used in literature. Within this product group many ways of improving circularity are possible. The discussed directives and initiatives give guidance in how the EU wants to increase circularity in this sector.
First of all, ErP waste (E-waste) is defined by a set of criteria (European Union, 2014). If the product meets criterion 1 and one of criteria 2 - 5, the product is in scope of WEEE, although there are some exceptions but Action would never sell these. The criteria are as follows.
1. "The product is designed for use with a voltage rating not exceeding 1000 V for alternating current and for 1500 V for direct current.
2. The product is dependent on electric currents or electromagnetic fields to work properly.
3. The product is for the generation of such currents.
4. The product is for the transfer of such currents.
5. The product is for the measurement of such currents".
This definition of E-waste can be used to define ErP as this was the former functional state before E-waste.

Circularity of electrical and electronic equipment

The previously discussed initiatives and directives on electrical and electronic equipment are now summarized and categorized using the subdivisions of the RRO of Morseletto. The references in the following categorization are as follows:

- New CEAP: New Circular Economy Action Plan (European commission, 2020b).
- RTR : Right To Repair initiative of European Commission, supported by the proposal for a directive on common rules promoting the repair of goods as issued by the European commission (European Parliament 2023)
- ROHS: Directive for "The Restriction of certain Hazardous Substances (European Parliament & Council of the European Union, 2011)
- Directive WEEE: the Directives on Waste Electrical and Electronic Equipment (European parliament & Council of the European Union, 2012), (European parliament & Council of the European Union, 2018).

Smarter product use and manufacture (R0-R2)

- "Maximum concentration values on a range of substances that can be used in a large number of types of electrical and electronic equipment" (RoHS).
- "Review of EU rules on restrictions of hazardous substances in electrical and electronic equipment" (new CEAP).
- "Introduction of a common charger, improving the durability of charging cables, and incentives to decouple the purchase of chargers from the purchase of new devices" (new CEAP).
- "Product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle" (new CEAP).
- "Polluter has to pay" (new CEAP).

Extend lifespan of products and its parts (R3-R7)

- "Give consumers the right to repair their product not only during the guarantee period but also for easy and cheap repair options of their products even if the guarantee period has expired. Repairability of products includes availability of repair manuals and availability of spare parts. Consumers have the right to repair products by themselves"(new CEAP; RTR).
- "Devices must be designed for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling and dismantle" (new CEAP, RTR, Directive WEEE).

- "Mandatory labeling on the estimated lifetime and reparability of products, such as a repair score and usage meter for certain product categories, and ensuring that consumers are provided with the information on availability of spare parts, repair services and software updates at the time of purchase" (new CEAP, RTR).
- "Making producers responsible for prevention of waste, e.g. by providing repair services or ensuring spare parts availability" (new CEAP)
- "mobilizing the potential of digitalisation of product information, including solutions such as digital passports, tagging and watermarks" (new CEAP).
- "Making producers responsible for prevention of waste, e.g. by providing repair services or ensuring spare parts availability; the polluter has to pay" (RTR).
- "Enabling remanufacturing and high-quality recycling" (new CEAP)

Useful applications of material and energy (R8-9)

- "Preventing the creation of Waste Electrical and Electronic Equipment (WEEE) and improving the collection and treatment of WEEE, including by exploring options for an EU-wide take back scheme to return or sell back old mobile phones, Tablets and chargers" (new CEAP, WEEE directive).
- "Contributing to the efficient use of resources and the retrieval of secondary raw materials through re-use, recycling and other forms of recovery" (Directive WEEE).
- "Increasing recycled content in products, while ensuring their performance and safety" (new CEAP)
- "Tax the use of virgin materials in order to make secondary materials more attractive" (new CEAP)
- "A ban on destruction of unsold durable products" (new CEAP).
- "Rewarding products based on their different sustainability performance, including by linking high performance levels to incentives" (new CEAP)

In the overview of current initiatives and directives all Morselettos sub categories are represented. Currently Action is focussing on useful applications of material and energy but should make the next step and start looking into ways to extend the lifespan of products and its parts as mentioned in Chapter 5. This could also be done with smarter product use and manufacturing as this contributes to the same goal and is a higher level of RRO. But in this segment there is little high impact legislation for Action. The challenge for Action in ErP products lies in extending the lifespan of products and its parts. A lot of (foreseeable) legislation within the extending the lifespan part is focused or contributes to repairability. Repairability itself is a starting point for other CE strategies such as remanufacturing and refurbishing. But Repairability requires significantly less resources compared to other strategies (Ruiz-Pastor & Mesa, 2023). Repairability, reliability and upgradeability are tightly related durability aspects for extending a product's service life. This means that designing for repairability can also benefit reliability (Cordella et al., 2019).
Therefore, from a legislation point of view it makes sense to focus on repair as a lot of initiatives and directives focus on repairability which makes it a good starting point. Repair is defined as repair and maintenance of defective product so it can be used with its original function (Morseletto 2020).

The increased responsibility for the distributor of ErP is mainly going to focus on repairability. Therefore, in this thesis Repair for ErP will be further explored as most initiatives of the EU are focused on repairability.

6.4 Conclusion

The new Circular Economy Action Plan (new CEAP), which is a part of the European Green deal, has identified several initiatives to protect the environment. This plan is partly supported by binding Directives and Regulations on this matter of earlier date. New binding legislation is foreseen. Standards are developed to make targets more comprehensible.

The product groups textiles, plastics and ErP are the most represented within Actions product assortment in terms of resource intensive products. The future of legislation within these three categories is plotted in Figure 8. ErP is the most vulnerable product group to legislation and is forcing Action to take responsibility after ErP has been sold. Action should focus on these products to stay resilient.

The increased responsibility for the distributor of the product group ErP is mainly going to focus on repairability. Additionally, repairability is a starting point for other CE strategies in which it shares several characteristics. Therefore, in this thesis repair for ErP will be further explored as most initiatives of the EU are focused on repairability.

7. Redefine design challenge

(King, 2018)

7. Redefine design challenge

This chapter will discuss how the findings from the previous chapters come together as a problem definition underlying the research question. This problem definition will be used to redefine the design challenge. Followed is a categorization of ErP with the products Action sells and a selection of one product group for the case study.

7.1 Solution space

The redefinition of the design challenge is used to describe the problem, who is involved, the context, goals and side effects to be avoided. This gives a direction of the solution space in which the solution will be designed.

Besides the Sustainability team repairability is not common knowledge. The buyer has a lot of power in making decisions but is lacking the knowledge of making decisions in terms of circularity. This is concluded from the insights of the conduct interviews (N=13) which have been analyzed using the process map of Figure 5, System map of Figure 6 (Meadows, 2008) and Actors map of Figure 7 (Jones & Van Ael, 2022).

Therefore, the buyer should be supported in making the right decisions, enabling Action to sell more circular products.

Electrical and electronic equipment is the most vulnerable product group to legislation and is forcing Action to take responsibility after an electrical and/or electronic product has been sold (new CEAP, RTR, Directive WEEE). Additionally, Electrical and Electronic equipment is the fastest growing waste stream (Awasthi et al., 2019) and expected to double by 2045 (Parajulyetal et al., 2019), has the biggest potential to reduce CO2 emissions (Ministerie van Infrastructuur en Waterstaat, 2023) and contains hazardous substances (Vanessa Forti et al., 2020).

The focus of legislation lies in durability, repairability, upgradeability, maintenance, reuse and recycle (new CEAP; RTR; WEEE). There is also specific legislation for repairability like Right to Repair. Repairability itself is a starting point for other CE strategies like the previously mentioned ones. But repairability requires significantly less resources compared to other strategies (Ruiz-Pastor & Mesa, 2023). Repairability, reliability and upgradeability are tightly related durability aspects for extending a product's service life. This means that designing for repairability can also benefit reliability (Cordella et al., 2019).

Therefore, Action should focus on selling repairable ErP as a step towards circularity. The problem that needs to be solved: the buyer is making decisions on purchasing ErP products while lacking repairability knowledge. This leads to the following design challenge:

Finding a solution that helps the buyer in making decisions on purchasing repairable ErP products.

The people involved in this process are the buyer, the sustainability team, product techs, suppliers and tech managers, see Figure 4.

Buyers select products based on FFP, quality price ratio and circularity in that order. This currently means that there is little budget for circular improvements. Buyers have a lot of power in the buying process and decide when to involve the product tech and what advice to actually use. This means that the buyer acts as a gatekeeper but should know when to, as it were, open the gates. Buying products from domestic or direct import does not influence the rules applied in terms of repairability. Action could rethink their import strategy if it is easier to import repairable products domestic or directly. Buyers need to be able to make decisions quickly to be able to supply Action with enough stock.

Action works with domestic suppliers and Li & Fung who supply the products. Action has a lot of leverage with Li & Fung as Action is a big client that orders in vast amounts. This allows Action to design products the way they want produced solely for Action. With domestic suppliers Action has a lot of leverage because of the quantity but changes are typically slower due to the nature of domestic import. Most ErP are currently from domestic import due to the risk involved when importing directly. As the same rules apply for domestic and direct import in terms of repairability no distinction is being made.

The goal for Action in order to stay resilient is to change the assortment of ErP to more repairable products. It is also important to make repairability measurable to be able to set an entry level on which can be improved. This helps with tracking repairability and with seeing the impact of change on a product level. Therefore, repairability should be measurable on a product level.

What needs to be avoided is limiting the flexibility in decision making of the buying process. Actions success formula is based on making snap decisions and offering products in the store quickly which results in the varying assortment.

This design challenge contributes to creating a framework that enables Action to take their responsibility in the lifecycle of products in compliance with present and foreseeable legislation in a circular economy.

8. Ideation

8. Ideation

This chapter will put the design challenge into different scenarios which are used to ideate. The ideation is briefly described together with the outcome of the ideation session which is further discussed in the next chapter.

8.1 Scenarios

To put the design challenge into context several scenarios were created in which the described problem occurs. These were made together with buyers and shown in Table 7. In this table the five scenarios are described in which a buyer is making a purchase including where this happens and who is involved in which step in the process. Buyers have indicated that time is of upmost essence during sales meetings with suppliers. There are only two scenarios where buyers actually make purchases in sales meetings with suppliers under time pressure. The other purchases are being done from the office and have more flexibility timewise e.g. to carry out tests.

8.2 Ideation

With the scenarios in mind several "How could We" questions were phrased as a brainstorming technique to come up with solutions. The questions used were:

- How could repairability be tested?
- How could a repairability test be done during a sales meeting?
- How could you check for repairability before a sales meeting?
- How could you buy repairable products?

These how could we questions were used to do brain writing were multiple people join in coming up with solutions. The participants were Amine Allai, Thomas Lubbers, Wolf König and Mees Peeters. The outcome of the brainstorm were several ideas that were applicable on some of the buying scenarios but not all of them. Combining the ideas formed concepts which combined could solve many of the scenarios partly but not entirely. The scenarios in Table 7 are describing the current situation but this can of course be changed. The limiting factor in the scenarios are time as this is according to the buyers of the essence. Scenarios were described where in 30 minutes products were assessed in terms of quality and a deal was made. By developing concepts in four alternative scenarios with different amounts of time the ideal scenario could be chosen. The four scenarios were;

i: There is a short moment to assess the repairability of a product (20-30 minutes),
ii: A longer period of time is available and decisions can be made later,
iii: A decision has to be made on the spot within minutes,
iv: The choice is irrelevant in terms of repairability.
An overview of this process can be seen in Figure 9.

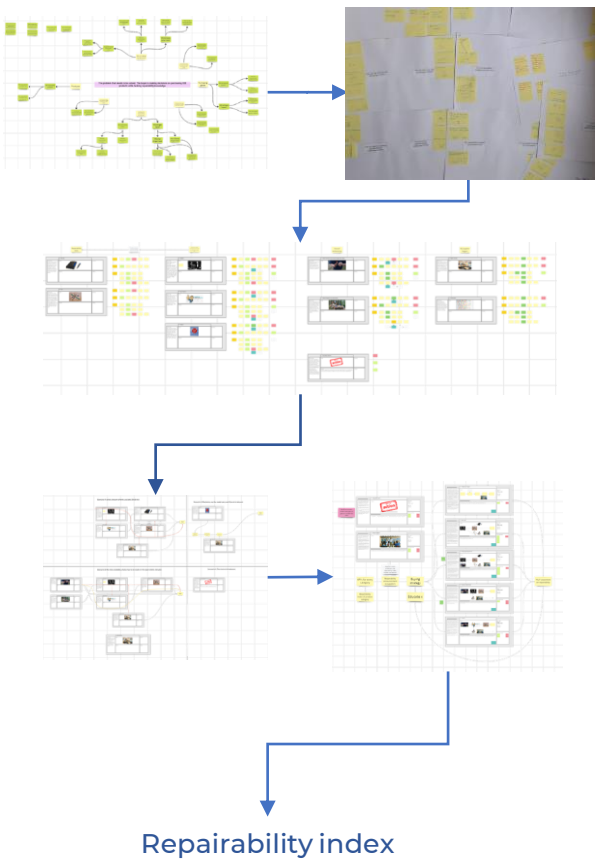


Figure 9: Overview of the ideation process

	Scenario	Steps				
Direct Import	1. The buyer is visiting the country of manufacturing	Upfront a wish list is created of what products to buy and send to supplier	Wishlist is shared with the supplier beforehand	On location buyer selects samples to fulfill wishlist and buys extra (non-wishlist) items	A deal is made with agreements on quality (PSS)	Product techs check quality after the deal and propose changes if needed at location
	Who:	Buyer	Buyer	Buyer	Buyer	Product Tech
Re-Orders	2. A Re-Order is being made (from the office)	Check current product upon reordering	Think of improvements of the product	Communicate preferred changes with suppliers.	Check and asses improved product	Complete the re-order
	Who:	Product tech & Buyer	Product tech & Buyer	Buyer	Product tech & Buyer	Buyer
Domestic	3. Supplier proposes a product by sending it (digitally/physically to the office)	The buyer receive a product from a supplier	The product gets assessed to see if it has potential	If needed adjustments are proposed	Supplier shares the price including adjustments if needed	Product gets bought for that price or is being turned down
	Who:	Buyer	Product tech & Buyer	Product tech & Buyer	Supplier	Buyer
	4. Requesting from supplier based on existing product (from the office)	An existing product is being send to a supplier with the request to create something similar for an certain price	The supplier gets back to the buyer by sending a sample product	The product gets assessed and if needed adjustments are proposed and price is further negotiated	If the product is approved a deal is made and the product is ordered	
	Who:	Product tech & Buyer	Supplier	Product tech & Buyer	Buyer	
	5. Buyer is visiting a supplier for a specific product	Buyer lets the supplier know what products he wants	Buyer visits the supplier and the products are presented together with extra products	Buyer selects the product he wants to buy on the spot possibly including products he did not intent to buy at first	A deal is made with agreements on quality (PSS)	Product techs check quality after the deal and propose changes if needed at the office
	Who:	Buyer	Buyer	Buyer	Buyer	Product tech & Buyer

Table 7: Buying scenarios

A part in every concept was that suppliers have to be informed about the changes Action will be making in what the requirements will be for the products that will be bought. If products would all be tested on the spot without suppliers knowing what the new standards were, every product would be rejected. Therefore suppliers need to be updated on what Action is looking for in products they are buying. This way suppliers know what standards their products have to meet to be able to be sold to Action. A repairability index would score products based on criteria selected by Action. This makes clear what the standards for Action are and what they are looking for in a product. The concepts mainly varied in how to deal with products that would not have been scored on this repairability index by the supplier in different scenarios. These concepts could still be

picked up in a later state by Action if the repairability index would not prove to be sufficient enough.

Currently all the products Action buys have to meet certain standards which are described in the PSS. The PSS is already shared with suppliers to make sure the products that are offered meet the standards Action demands. Things like FSC graded paper in packaging is integrated in the PSS which makes it a standard and not a choice for the buyer. If the PSS can be extended to include requirements for repairability the offered products should be more repairable. The requirements on repairability could be in the form of a repairability score such as the French Repairability Index giving every product a rating on how repairable it actually is. If KPI's were to be set on this rating buyers could select based on the ratings and the KPI of their category. This leaves the buyer with the task of buying products that tick the repairability boxes with the right quality for the right price.

8.3 Conclusion

The most critical scenarios are described in which the problem of buying products without the proper repairability knowledge occurs. These scenarios were used to ideate using "how could we" questions. These initial ideas were put into scenarios and the most fruitful ones were further developed as solutions. A part of every solution was the repairability index and need to update the supplier. This is further developed in the following chapter.

9. Solution

(Lusina, 2020)

9. Solution

This chapter will go through the future vision which will help Action stay resilient and gives the repairability index direction. This future vision is further explained using a roadmap that will explain how to get to the future vision. The roadmap explains this through three horizons and discusses the risks involved. The repairability index will be shortly introduced by explaining the overall system of a repairability index in general, one created specifically for Action, the feedback for the buyers, the repairability index for suppliers and the KPI's.

9.1 Future vision

The repairability index on itself would be able to help Action in buying more repairable products. But it has to be part of a encompassing strategy for Action to stay resilient in a circular future. This will also help in creating the repairability index. A future vision is created which paves a circular future for Action with new opportunities to mitigate risk. The future vision is based on Action's future, Action's risk approach EU legislation and EU industry vision. Based on Action's approach to risk the EU industry vision is used in the future vision opposed to trend research.

Action

Action has several goals in terms of circularity as mentioned earlier and seen in Table 1. But Actions business model is growth, this can clearly be seen in Figure 1. Pilar one, two and three (Strengthen our unique customer value proposition, Drive international geographic expansion and Build a simple, efficient and scalable operating model) are focussed on expanding Action's operations internationally. Currently, Action is taking over Europe and is solidifying its positions in every country by opening stores and DC's. This is beneficial as all the EU member states have similar rules, governance, currency, infrastructure, etc. But, the EU and its number of countries has its limits and there will be a moment when the European market is saturated. There are rumours of Action expanding to other continents. If Action will continue with its growth rate of 15 new stores per week Europe will be saturated by 2032. In this scenario the whole of Europe would have the same saturation of the amount of stores per inhabitant as the Netherlands. The Netherlands is more or less saturated in the amount of physical stores which serves as a gauge for the rest of Europe (Action, 2021). The population growth of the EU and the possible upscaling of the amount of stores being opened is left out of scope but could potentially cancel each other out (Appendix 10 for detailed calculation).

Action collaborates with its suppliers to foster a sustainable supply chain and ensure a resilient business environment. Action's Product pillar aims to enhance transparency in the supplier relationships and promote stronger collaboration. This collaboration drives innovation in terms of circularity, responsible sourcing, and packaging (Action, 2023).

Risk approach Action

To achieve international expansion, Action takes calculated risks while prioritizing the interests of stakeholders. Action approaches risk cautiously, ensuring value for customers through quality products at affordable prices. Safety, transparency, and responsible production are paramount. As Action expands into more European markets and source products globally, they have to comply with a growing number of laws and regulations. Action is committed to compliance and preventing non-compliance incidents. Action has an infrastructure for timely awareness of changes in regulation and legislation to act accordingly (Action, 2020).

Action is largely owned by 3i which is a venture capitalist and private equity company that is listed on the London Stock Exchange. 3i's strategy is to invest, grow and realize (3i, 2023). Action has proven its business model and is successfully expanding through the whole of Europe. There is going to be a moment in Action's future where the European market is going to be saturated and

strategic decisions have to be made. As mentioned earlier next steps could be to expand towards the UK or the United States to further test the business case. Other investments in diversifying revenue streams are possible such as vertical integration to stay resilient when the European market is saturated. The question is what 3i's strategy is going to be: invest, grow or realize?

EU Circularity legislation

The EU plans to enhance its efforts, together with national authorities, to enforce the sustainability requirements for products sold in the EU market. This includes conducting coordinated inspections and implementing market surveillance actions to ensure the effective and efficient implementation of the new sustainable product framework. Additionally, the EU aims to create a shared European Dataspace for Smart Circular Applications that will contain valuable information about value chains and product details (new CEAP).

Circularity measures

The EU is exploring the idea of implementing mandatory measures to enhance the circularity of both goods and services. This includes considering requirements related to environmental and social aspects throughout the entire value chain, from production to end-of-life, while taking into account the rules of the World Trade Organization (WTO). For example, ensuring the accessibility of certain products and services, in addition to promoting social inclusion, can also have the positive outcome of increasing the durability and reusability of those products (new CEAP).

Right to Repair

Furthermore, the Commission will strive to establish the "right to repair" and explore the possibility of introducing broader material rights for consumers. These material rights could encompass aspects such as ensuring the availability of spare parts, facilitating access to repair services, and, specifically for ICT and electronics, enabling access to upgrading services. This goes together with standardization based on the on-going assessment of existing standardization at European and international levels (new CEAP).

Producer responsibility

The EU will also enhance the implementation of the recently adopted requirements for extended producer responsibility schemes, provide incentives and encourage sharing of information and good practices in waste recycling (new CEAP). All this shall serve the objective to significantly reduce total waste generation and halve the amount of residual (non-recycled) municipal waste by 2030. The final goal is the European continent to be climate neutral by 2050 - European green deal (European commission 2019)

Product passport

To promote sustainability and circularity, it is crucial to share key product information among economic actors. This collaboration accelerates the transition to a circular economy by enhancing material and energy efficiency, extending product lifetimes, and optimizing design, manufacturing, usage, and end-of-life handling. It also creates new business opportunities, helps consumers make sustainable choices, and enables authorities to verify compliance with legal obligations (Digital Product Passport, 2023).

CSRD guidelines

Starting from 5th January 2023, the Corporate Sustainability Reporting Directive (CSRD) has come into effect. This directive aims to modernize and strengthen the regulations regarding the social and environmental information that companies are required to disclose. It expands the scope of reporting to include a broader range of large companies and listed SMEs (Corporate Sustainability Reporting, n.d.). This will be applicable for Action starting in 2025 (Action, 2023).

EU industry vision

In 2020 the EU has set out a vision of Europe for 2030 that aims at transitioning towards climate neutrality and digital leadership. The European industrial strategy aims to ensure that European industry can lead the way as we enter this new age (European commission, 2020b). Some of the for Action relevant ideas are shared below.

Standardization

A strong and efficient system for standardization and certification is crucial for the single market. These systems enhance market size and ensure legal certainty. It is essential to develop new standards, technical regulations, and increase EU involvement in international standardization bodies to enhance the competitiveness of industries.

Greener choices for customers

The Action Plan incorporates initiatives to empower consumers in the circular economy. It aims to provide consumers with reliable and pertinent information to make choices in favor of reusable, durable, and repairable products. The Commission will explore ways to enhance consumer rights and protection, including the introduction of a "right to repair" for consumers. Moreover, public authorities, including EU institutions, are encouraged to lead by example through environmentally-friendly procurement practices. By prioritizing green procurement, they can drive the transition towards sustainable consumption and production. The Commission intends to propose additional legislation and guidance on green public purchasing.

Skilling and reskilling

Skills play a crucial role in the twin transitions (green & digital transition) and the opportunities they present for individuals. The shift to a low-carbon economy is projected to generate over 1 million jobs by 2030, while there is currently a demand for 1 million digital technology experts in Europe. However, 70% of companies are experiencing investment delays due to a shortage of skilled individuals. To compete globally for talent, Europe must increase its investment in skills and make lifelong learning a reality. This requires collaborative efforts from industry, Member states, social partners, and stakeholders through a new "Pact for Skills." The Pact will focus on sectors with high growth potential or undergoing significant changes and aim to facilitate upskilling and reskilling, as well as mobilize public and private investment in the workforce. The European Education Area will also support these endeavors.

Digitalization

Digitalization plays a crucial role for small and medium-sized enterprises (SMEs), and therefore, relevant platforms are collaborating to provide collective assistance to SMEs within their ecosystems. This support includes enabling SMEs to embrace data-driven business models and implementing effective measures against cyber threats. In the year 2023, the Digital Europe Programme aims to allocate EUR 310 million towards European Digital Innovation Hubs, which will offer local support to SMEs in their digital transformation endeavors and facilitate access to technology testing. Additionally, in 2021, the European Innovation Council plans to allocate EUR 1.1 billion in grants and equity funding, primarily benefiting startups and innovative SMEs (European Commission, 2021).

Future vision

The input from Action's view on its foreseeable future, their risk approach, EU circularity legislation and EU industry vision is distilled into a future vision:

"Through innovative partnerships and collaborations, Action has built a vibrant ecosystem in 2035, where Action works together with its manufacturers, repairers and customers to create a circular future where customers are empowered to repair Action's durable products more easily."

This Future vision is further explained through a roadmap that describes the future vision and the steps that lead up to this future vision making it possible.

9.2 Roadmap

The roadmap describes how Action's future vision will be established. This is done by describing different steps called horizons which all contribute to Action's future vision in 2035. Lastly, the risks in this roadmap are pointed out and discussed. The roadmap can be seen in Figure 10.

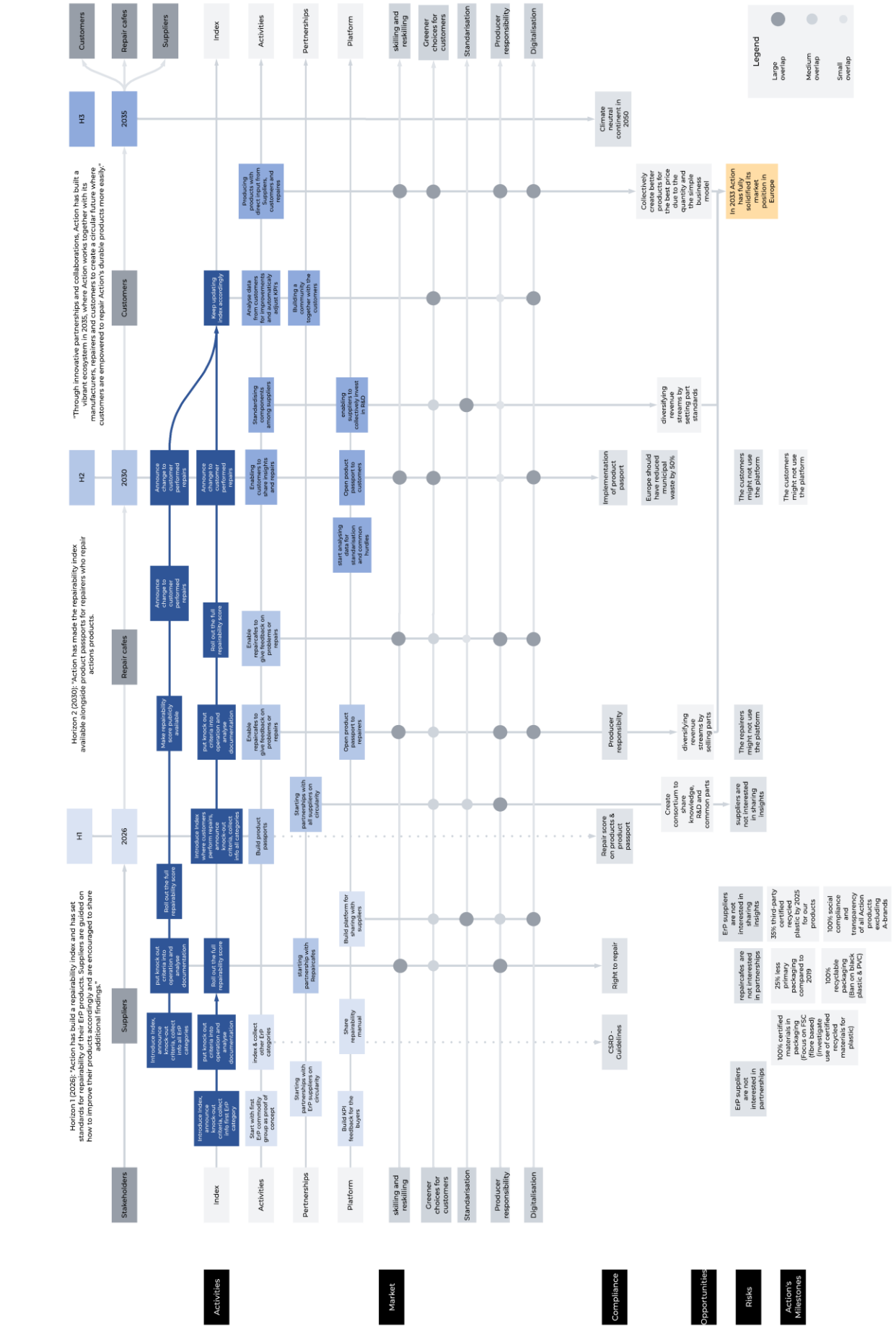


Figure 10 : Roadmap towards future vision of 2035

Horizon 1 (2026): “Action has built a repairability index and has set standards for repairability of their ErP products. Suppliers are guided on how to improve their products accordingly and are encouraged to share additional findings.”

In this first horizon Action has made an repairability index to measure the repairability for all their ErP products and has set KPI’s to improve the repairability of these products. This is done by going through three stages to give manufacturers the time to adapt. The index will first be announced introducing knock-out criteria and initial data will be requested on disassembly time, disassembly steps, fasteners and tools. The second step is to put the knock-out criteria into action and use the initial data to set standards and KPI’s. These standards and KPI’s are then shared with suppliers to adjust accordingly. The third step is to enforce the knock-out criteria and KPI’s to enable Action in selling more repairable products. This could potentially help Action to comply with CSRD Guidelines.

Action is going to demand improvements on disassembly steps or fasteners which might be difficult improvements for some suppliers. A manual is shared with suppliers which can help them with suggestions on how to improve products to score better on these criteria. It is not the role for Action to redesign every product but rather to set high standards and propose solutions to suppliers on how to improve. It will become possible for suppliers to share these findings and add them to the manual.

The repairability score of every category is monitored real time with new products being added. Buyers can now easily see what the impact of a product is on their repairability KPI and make an informed decision. It could be that the EU will implement their own repairability index. Action’s repairability index will be based on the European standards which will mitigate the impact of this happening. The idea is that the system is able to implement new findings, standards or legislation which is easily accessible to all stakeholders to be able to align them accordingly. New findings and standards could be added to the manual on how to improve a product’s score. New legislation could be used as new criteria for the repairability index.

In the next horizon a collaboration with repair cafes is envisioned, to lay the foundations for this collaboration an early partnership is supposed. Repair Cafes can guarantee a reliable, safe and environmentally friendly repair sometimes opposed to customer repairs (Bakker, z.d. ; Cordella et al., 2019). This can be in the form of supporting the repair cafes with tools, materials or access to repair manuals. An example of this is a garden manufacturer called Hartman that started to supply repair cafes with maintenance kits and spare parts. This is done through a collaboration with repair cafés Europe wide (“Levensduur Verlengen Samen Met Repair Café," n.d.). This could potentially help Action to comply with the right to repair by making their products repairable for repair cafes. If Action is obliged to make manuals, spare parts, etc. available to the public the score could be adjusted accordingly.

The second horizon will start after the first horizon is finished and will be explained next.

Horizon 2 (2030): “Action has made the repairability index available alongside product passports for repairers who repair Action’s products.”

In horizon two the remaining categories will be indexed and will go through the same three phases as described in horizon one but with the focus on customer repair. Partnerships will be made with other suppliers to be able to continue to develop better products and share knowledge between suppliers. The repairability Index will become available in store to customers to help them make better decisions. This will first begin with ErP and will be followed by the other categories. To prepare for horizon three the announcement will be made that products from ErP will become repairable for customers themselves and that criteria will be adjusted accordingly.

The repair cafes will be granted access to manuals, ordering spare parts and other information. This enables the repairers to easily order spare parts and possess the needed information to replace these parts. To easily find the right information products will have product passports which hold information about their repairability score, spare parts and manuals. This information will be accessible to repairers through the Action website. Repairers can also upload repairs they have conducted on products to give Action valuable data on how to improve their products. This could also include general feedback on improvements and be encouraged with rewards. Repairers have the ability to add a repair instruction if this is not included in the manual, similarly to the iFixit website. These instructions will be available to all repairers and visible in the product passport and could be promoted with a reward as well. This gives Action the ability to learn from products and potentially adjust their criteria.

Action sells relatively cheap products and customers are currently not willing to spend more than 30% of the purchase price on a repair (Cordella et al., 2019). This makes it very hard for Action to offer repairs for the prices products are currently being sold for. Supporting and collaborating could possibly be an outcome for cheaper products in the view of legislation. This extended responsibility is something that fuels collaboration between stakeholders as well, such as manufacturers, retailers and repair service providers (Dao et al., 2021). Selling products for a low price is not bad perse as a lot of people depend on low prices due to their financial situation, in 2021 21,7% of Europeans were at risk of poverty (Eurostat, 2022).

The third horizon will start after the second horizon is finished and will be explained next.

Horizon 2 (2030): “Action has made the repairability index available alongside product passports for repairers who repair Action’s products.”

In horizon three everything should come together. If all products have a product passport similar parts could be detected. Manufacturers or suppliers of these products can be linked together to standardize components used in their products. Manufacturers sharing similar repair problems detected by repairers could be linked as well and invest in R&D together on how to fix this. This will help in making spare parts cheaper and enables the suppliers to share the burden of spare parts. Here could potentially lie an extra opportunity for Action. If Action would vertically integrate by producing these standard components themselves they would be able to diversify their revenue streams. Action could profit from suppliers selling products with Action’s standard components to the competition. This could be interesting if Action is unable to further grow in Europe as mentioned in “Risk”. This opportunity is however left out of scope as it would not fit Action’s current strategy.

Product passports are available for every product and customers are encouraged to repair their own products. Due to skilling and reskilling customers are more aware and more capable of repairability. More available manuals and repairing information possibly impacts the future purchases of repairable products (Ruiz-Pastor & Mesa, 2023). The foundation of reviews and repairs has already been made by repairers and customers can join in. Customers will be able to share their repairs or feedback to help other people. Action can use this data to improve their products in terms of quality and wishes from their customers more accurately (Cordella et al., 2019). With the introduction of standardized components Action's assortment will be reduced in the number of SKU's. The element of surprise of what new products are available could be maintained to a certain level by using modular design where the base of lights for example are the same but the cover differs. This appears to the customer as a new product but is the same product "under the hood". Action's USP shifts from a varying assortment for a low price to qualitative durable products for a low price, this makes sustainability truly accessible as mentioned in the strategy in Figure 1. Durability is to be interpreted as the possibility to lengthen the service life of a product with repairs (NEN, 2020a). Data will be a game changer for Action as it gives insights into reliability and could avoid premature failures (Ruiz-Pastor & Mesa, 2023 ; Cordella et al., 2019). This builds a community around Action and their products which will help brand loyalty and improve customer satisfaction, gaining more customers (Dao et al., 2021). This will solidify Action's position in a circular and repairable future.

During the horizons some decisions have been made that might involve certain risks. These risks are further explained next.

Risks

A risk in horizon one and two is that the supplier or repair cafe are not interested in partnerships or collaborations. The suppliers might lose a large customer if they do not partner or collaborate, so this risk is manageable. The repair cafes might need some convincing, giving them access to materials, tools and service manuals will probably help. It could also help to give them rewards for repairing products from Action. If retailers were to be forced by legislation to offer repairs for consumers the demand for repairers would explode. A transitional phase could be funding existing repair cafes to repair Action's products. Other options could be to collectively open repair shops with other retailers who will suffer the same faith.

It could also happen that the right to repair will focus on giving customers control over their products and access to spare parts and manuals. In this case Action has the information and parts to supply customers but the B2C side of things have to be moved forward.

Perhaps a bigger risk is the willingness of suppliers sharing their insights in circularity. This can contain sensitive, perhaps even classified information. Information could also be traded of some sort with other suppliers.

The risk of repairs and customers not using the platform would have consequences for horizon two and three. This risk could be mitigated by involving the customer and repairer early in the development process and listening to their needs and thinking of possible rewards as well.

9.3 Repairability index

The repairability index is essential for Action's transition towards a circular future. The repairability index will be explained by briefly introducing the system and the required building blocks. The building blocks will be further discussed describing the repairability index in general, the repairability index specifically for Action, the feedback for the buyers, the repairability index for supplier and the KPI's.

The system

The design challenge is solving the problem of the buyer making decisions on purchasing ErP products while lacking knowledge in repairability. The real problem occurs in two scenarios where buyers have to decide quickly on what products to buy. The buyer knows what products he is going to buy upfront but there are always extra items presented that could be interesting. This happens at a location outside of the office with limited resources and limited time which makes it hard for a buyer to take repairability into account when making the purchase. If the repairability of a product is known the buyer can take this into account in making a decision on a product.

Suppliers often focus on ErP groups of products or even commodity groups they sell. This enables them to have specific in depth knowledge about their ErP group and have experts working for them. If Action wants to buy a product of a certain ErP group they know what suppliers to reach out to to who are experienced with this ErP group. Action has been working with the majority of their suppliers for a long time. The suppliers know what type of products Action would like to buy and what their requirements are. The standards Action requires from their products is listed in the PSS. These standards have to be created and updated for repairability by the product techs.

If the repairability index is included in the PSS the suppliers can change their products accordingly. If the supplier measures the repairability of their products and communicates this in the buying process the buyer can make an informed decision. The buyer should be motivated to buy these repairable products through KPI's on the ErP groups he buys. By keeping track of the repairability score of every product that is purchased a score per ErP group can be determined. If a buyer wants to buy a product he should be able to see what the impact of this purchase is on his KPI to be able to manipulate this. This could stimulate the buyer to buy more repairable products to hit his repairability KPI. This could further be stimulated by bonuses and penalties.

The implementation of the repairability index requires several building blocks to be successful.
i) A repairability index that enables Action to measure repairability
ii) A feedback system for buyers to see the impact of their purchases
iii) A guide for suppliers to measure repairability of their products (Appendix 7)
iv) A guide for product techs on how to develop a ErP group specific repairability index (Appendix 8).
v) KPI's to stimulate buyers in purchasing repairable products.

These building blocks will be further discussed in the following paragraphs.

Repairability index

The repairability index is explained in two segments. The first segment describes indexes, goals, criteria and priority parts in general. In this segment ErP groups are described which are needed to make the repairability index for different groups of products. The second part will discuss the chosen index for Action with its goal, criteria and method of choosing priority parts.

Indexes in general

Before a repairability index for Action is made the currently available indexes are discussed. To further define a suitable index the goal of an index is discussed which is used to select the appropriate criteria. To be able to fill in the criteria a method has to be used to select priority parts.

For the repairability index for Action the 45554 standard (NEN, 2020a) is used as a guideline. In the 45554 standard a non exhaustive list of product and support related criteria are presented in regard to repairability. The relevance of the criteria can be determined for each product group. The criteria are divided into two sets of criteria groups; product related criteria and support related criteria. Informative examples are given in the 45554 standard according to the proposed criteria. Two methods with similar criteria were taken into account and divided between product related criteria and support related criteria. The first method is the French Repairability Index (FRI) (Ministère de la Transition écologique, 2022), as this method is already being used and assessed by Halte à l'Obsolescence Programmée (HOP) (HOP, 2022). This data of what went well and what went wrong can be used to learn from past mistakes in the FRI. The second method used is developed by the Joint Research Centre (JRC) (Cordella et al., 2019) which gives more elaborate criteria that can be used as product or support related criteria. The criteria of JRC and FRI are mapped to see commonalities in the criteria as seen in Appendix 5. The most suitable criteria with the goal of increasing repairability can be chosen for every ErP group.

The index each criteria can weigh in on the total score in different ways. In the FRI all criteria weigh equal but the sub criteria within a criterium may differ. All the sub criteria can score between a 1 and 10 as seen in Figure 11. In total 100 points can be scored which are divided by ten which results in a final score. In the 45554 example the weight of a priority part is multiplied by the score on a certain criteria, this criteria is multiplied by its weight. The score of the priority parts are added together with the score on the product level criteria and its weight. An example of the calculation can be seen in Table 8.

Correlations should be taken into account, if a spare part for example is not available the price becomes irrelevant. This is done in JRC, a similar distribution is used but some criteria have knock out criteria. If a specific set of predetermined knock out criteria is not met the rest of the criteria are discarded and the product is not eligible for repair. This is done for fundamental aspects to repair such as documentation or product identification. To be able to create a suiting index the goal of the index has to be clear, this is discussed in the next section.

Criteria	Sub-criteria	Score of sub criterion /10	Weighting factor of sub criterion	Score of criterion /20	Total criteria scores /100
CRITERION 1 : DOCUMENTATION	1.1 Availability of the technical documentation and other documentation related to user and maintenance instructions	0	2	0	0
CRITERION 2 : DISASSEMBLY, ACCESSIBILITY, TOOLS, FASTENERS	2.1 Ease of disassembly parts from List 2*	0	1	0	
	2.2 Necessary tools (List 2)	0	0,5		
	2.3 Fasteners characteristics parts from List 1** and List 2	0	0,5		
CRITERION 3 : AVAILABILITY OF SPARE PARTS	3.1 Availability over time parts from List 2	0	1	0	
	3.2 Availability over time parts from List 1	0	0,5		
	3.3 Delivery time parts from List 2	0	0,3		
	3.4 Delivery time parts from List 1	0	0,2		
CRITERION 4 : PRICE OF SPARE PARTS	4. Ratio between price of parts from list 2 to the price of the product	0	2	0	
CRITERION 5 : SPECIFIC CRITERION	5.1 Free remote assistance	0	2	0	
			Reparability index on 10		0

Figure 11: Example of the FRI (Ministère de la Transition écologique, 2022),

Score = Σ(Wpp × Σ(Wi, pp × Si, pp)) + ΣWj × Sj
Wpp is the overall weight of the priority part pp
Wi is the weighting factor of criterion i assessed at priority part level
Si is the score of criterion i assessed at priority part level
Wj is the weighting factor of criterion j assessed at product level
Sj is the score of criterion j assessed at product level

Table 8: 45554 standard calculation of repairability score

Goal

It is important to have a goal in mind for the repairability index to be able to build a suiting index and choose the right criteria. This includes the context the repairability score will be used in. Things that have to be considered are: Who is going to do the repair, What products are going to be compared in the index, For whom is the index to be intended, What differences are you expecting to find between products, etc.

Criteria

JRC proposes three conditions for criteria which will guarantee the outcome will be equal for every stakeholder, the criteria must:

i. Be measurable and enforceable in an objective way (i.e. not interpretable in different ways depending on who is doing the evaluation);
ii. Stimulate an active market for repair/upgrade (being the aim to favor product options and scenarios that can result in an easier repair operation), without undermining the product safety
iii. Be adaptable to reflect specificities of groups/ types of products.

These conditions together with the goal have to be taken into account when selecting criteria. A list of example criteria from the FRI and JRC method can be used to pick and choose relevant criteria as seen in Appendix 5.

Priority parts

Not all parts are equally relevant for the ability to repair a product, some parts have priority. These parts are called priority parts and are prone to being replaced/repaired.

In the FRI method the priority parts are determined for every type of product, this is not further explained. The priority parts are divided in list 1 and 2 and have a different weight in the index. List 1 contains less important parts and is made up of a maximum of 10 parts. List 2 parts are considered to be more important/vulnerable and are made up out of 3 to 5 parts in total. In the 45554 standard priority parts are selected by testing all parts of a product according to the EN45552 standard (NEN, 2020b). In the 45552 standard the approach as seen in Figure 12 is proposed. For the goal of repairability only reliability is important as this describes the "probability that a product functions as required under given conditions, including maintenance, for a given duration without limiting event." (NEN, 2020b). Before a reliability analysis can be performed the assessment of reliability and durability must be conducted. This begins with a functional analysis which exposes the failure modes, failure mechanisms, failure sites and failure frequencies. This is followed by an analysis of the environment and conditions in which a product is operating. Additional information can help such as field data, regulations or user experiences. This is further tested in the reliability assessment to determine the exact failure rates.

JRC proposes to select the priority parts based on functional importance and if it is likely to fail. This is basically the same as a functional and reliability analysis. There are three levels in part importance; primary, secondary and tertiary functions. For example the primary function of a washing machine is to clean, rinse and spin clothes. The secondary function are aspects that enable, supplement or enhance this primary function such as a display on a washing machine. Tertiary functions are not important for priority parts. Drawing a product and its parts could help in visualizing the parts that are present in a product.

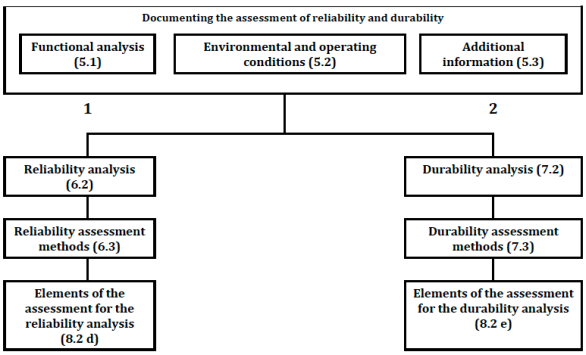


Figure 12: 45552 standard' approach on selecting priority parts

Products that have been on the market can give the best insights into what parts might fail (Cordella et al., 2019). There are several ways of obtaining information about parts that are vulnerable to failing such as risk assessments, repair monitor, spare parts supply, etc. According to JRC sources for this kind of information can be manufacturers of products and parts, repairers, reuse and remanufacture organizations, consumer testing organizations, insurance companies, researchers and regulators. The actual depth of broken parts is to be considered as well as replacing an electric motor might not be necessary if only the brushes are worn. The economic and

environmental considerations of parts is left out of scope as this does not influence the repairability of a product.

Product groups

Action uses Product categories who all cover pieces of ErP. The product categories are made up out of commodity groups which are product groups who share more resemblance. Think of household electronics as a commodity group. But this group contains kettles, grills, mixers, etc. These do not share a lot of similar priority parts which makes them incomparable. The ErP are rearranged into ErP groups that share commonalities in terms of function and probable priority parts. A group of ErP groups are collected in a commodity group similar to what is happening now. Some specifications or rearrangements have been made in terms of commodity groups. A list with all commodity groups (gray) and ErP groups can be seen in Appendix 4. In this list the average price and the weight of the products without packaging in Mtons can be seen.

Index Action

The requirements for a repairability index which were discussed previously are used to create a general repairability index for Action's products. First the goal is discussed which is used to select criteria. This is used to create the index outline and select priority parts. Finally, the general guide for setting up a guide for every ErP group is discussed.

Goal

The goal for the repairability index in horizon 1 of Action's roadmap is to measure the repairability of a product category. This is used as a baseline from which targets can be developed which are translated into tangible KPI's for the buyers. The score is used B2B between Action and suppliers. For horizon 1 the goal is to start with focussing on repairing products at repair cafes to ensure a reliable, safe and environmentally friendly repair (Bakker, z.d.). As Action introduces 150 new products each week efficiency has to be taken into account. This will help determining the criteria and how these should be measured between the ones suggested by JRC, FRI, HOP and 45554.

With this focus in mind the appropriate criteria are selected.

Criteria selection

For the product related criteria the FRI covers the ease of disassembly, fasteners' characteristics and necessary tools for disassembly. This is similar to what JRC proposes but here the disassembly time and "safety, skills and working environment" is suggested as well. The safety, skills and working environment can be discarded as this is not expected to differ for products within Action's product categories. The repairs would be performed in repair cafes making this more controlled and therefore redundant.

The disassembly time is taken into account as this gives perspective to the ease of disassembly. The ease of disassembly and disassembly depth only take into account the amount of steps but not the time it takes. It could happen that it would take only three steps to remove a priority part but that the time needed is exceeding the removal of a part which takes 6 steps to remove. This could be because of hard to access connectors, connectors that are hard to remove due to the force needed or low visibility. This could be displayed in a disassembly map highlighting these anomalies (De Fazio et al., 2021). This is something the supplier could do to pinpoint what increases his disassembly time. As this tool offers a solution to the problem of the ease of disassembly and disassembly time it is not taken into account as a criteria. The selected product related criteria are:

Ease of disassembly (FRI)/Disassembly depth sequence (JRC)
Fasteners characteristics (FRI)/Fasteners (JRC)
Necessary tools for disassembly (FRI)/Tools (JRC)
Disassembly time (JRC)

For the support related criteria several criteria are proposed by the FRI and JRC. For these criteria it is important to keep in mind that the products Action sells are quite simple and cheap with the goal of making them repairable. In this context the criteria

(i) Data transfer and detection,
(ii) Password reset and restoration of factory settings,
(iii) Software and firmware and,
(iv) Diagnosis support and interface can be left out of scope.

Additionally, criteria i,ii and iii add to the ability of the product to be reused which is out of scope for the repairability index as mentioned in the 45554 standard. The criterium that is selected is the documentation as this holds the information to successfully complete an repair. Trouble shooting which is a part of diagnosis support can be taken into account for documentation. The spare parts play an important role in repairability as well. FRI uses the availability over time, delivery time and price of spare parts. JRC mentions the availability and delivery time as well but focuses on the communication of the price and not relative to the price of the original product. Additionally, the JRC introduces if the used interface is standard or proprietary. With horizon one in mind the availability, delivery time, price relative to the price of the product, and target group is important. The communication of the price is expected to be accordingly and left out of scope. Lastly, Cordella mentions commercial guarantees offered by the retailer and its commitment to repair. all products come from the same retailer and a approach towards repairability is in place making this criteria irrelevant.The selected support criteria are:

Documentation (FRI)/Type and availability of information (JRC)
Spare parts:
- Availability (FRI)
- Deliverytime (FRI)
- Price relative to the price of the original product (FRI)

The 45554 standard mentions return options of products in regard to repairability. As this index is for products sold to the customer by the same company this is not included in the index as this should not differ per product. Additionally, Cordella mentioned that it is hard to predict if return models actually help repairability of products. It could potentially keep products from going to repairers as replacement could be cheaper for the original manufacturer.

Index outline

The index outline is something that is not really a problem for B2B as full transparency can be demanded for every priority part. This makes the overall score and its weight less interesting as the individual indicators hold more information about the product. KPI's can be adjusted to these specific indicators which makes it possible to control these even better. The knockout criteria as proposed by Cordella can help set a basic standard for repairability which can be improved if these conditions have been met. These knockout criteria will be further specified for each applicable criteria.

Priority parts

Not many analyses have been made on the type of small cheap appliances Action sells. This makes it hard to collect data such as failure rates or reliability analysis. To keep it simple but effective for Action to appoint priority parts the system of the FRI is used. The FRI used list 1 and list 2 who both contain parts. list 2 is made up of 3 to 5 parts that most frequently break and list 1 is made up of a maximum of 10 parts that must be in good condition for the product to properly operate. Input from stakeholders and experts is important as well and parts proposed by them should be considered accordingly. If more data is available on failure rates the guidelines of JRC could be applied to the list. Parts in list 2 would then need to have a failure rate of over 10% and parts in list 1 a failure rate of over 3%. The available information on the type of products Action sells can be deducted from:

- Repair monitor
- Available spare parts
- Customer returns
- Literature regarding the relevant product
- Inspecting physical products

A simple way of determining priority parts is described in Table 9 as not for every product category sufficient information is available. If this is done with more products the outcome might be more accurate

1. Draw product/ make it visual
2. Determine primary and secondary functions of product
3. Draw/take pictures and visually inspect parts on the product that contribute to these functions
4. Make first selection of priority parts
5. Collect information and check for extra priority parts
6. Divide priority parts between list 1 and list 2

Table 9: Workflow of determining priority parts

New groups

If the repairability index is introduced in a new ErP group the index guide as seen in Appendix 7 will guide Action employees on how to do this. It will go through setting the goal, selecting criteria, the index and selecting priority parts.

Criteria

The selected criteria will be discussed in detail explaining how they work and what is taken into account. This is concluded with how the repairability index could be changed over time in the different horizons. These criteria form the basics for the repairability index for every ErP group. Lastly, the reference values are discussed and how these can be determined.

Disassembly

For the disassembly it is important to keep in mind the goal of the index. If Action wants to sell more repairable products it should define its standards clearly towards the suppliers. As it makes more sense to demand higher standards from the suppliers than to redesign products from suppliers. Therefore, the knock-out criteria are introduced after which the suppliers have time to adjust their products. The data such as disassembly maps will be used to determine what the average amount of steps are to access primary parts among other criteria. This data is used to measure the current state of products and develop goals and KPI's. When this is concluded it is shared with the suppliers after which they can upgrade their products accordingly.

For the disassembly, a workflow could be proposed to rate the criteria accordingly. First the product should be fully disassembled while this is being filmed similarly to the hotspot mapping method (Flipsen et al., 2020). When the product is fully disassembled all parts should be named to use in the disassembly map. With all these parts the disassembly map can be created. The technique used for making the disassembly map follows the Disassembly Map from De Fazio et al. (2021). For the disassembly map a list of predetermined parts should be determined to make the disassembly maps as similar as possible between suppliers and grills. Aditionately, the fasteners and tools used should be displayed the same. The variety of tools and fasteners and their abbreviations is as follows:

Type of fastener:
1. Removable and reusable = R&R
2. Neither removable nor reusable = NRNR
3. Not applicable = NA

Type of tools:
1. No tool or basic tool = NT
2. Other commercially available tools and tools that are supplied with the product or spare part = OT
3. Proprietary tools = PT
4. Not feasible = NF

If a fastener is removed with a tool the needed time should be added in the end as well. This makes it easy to quickly determine disassembly times later on. An example can be seen in Figure 13 where a removable and reusable connector is used which can be removed using no or basic tools in 89 seconds. If any connector is different than R&R or tool used other than NT the color should be changed. This makes it easy to point out what makes a part less removable.

Figure 13: Removable and reusable fastener, removable with basic or no tools in 89 seconds.

The most critical scenarios are described in which the problem of buying products without the proper repairability knowledge occurs. These scenarios were used to ideate using "how could we" questions. These initial ideas were put into scenarios and the most fruitful ones were further developed as solutions. A part of every solution was the repairability index and need to update the supplier. This is further developed in the following chapter.

Disassembly depth

The disassembly sequences to priority parts can be read through the disassembly map. With this information the disassembly steps can be determined for each specific priority part. The number of steps to get to the priority part is determined by counting the removed parts similar to the Disassembly Map from De Fazio et al. (2021). If the number of steps needed to remove the priority part is the same as the reference number of steps the appointed score is 5. If fewer steps are used the score can go up to a maximum of a 10 and if more are needed it goes down to a minimum of 0. If a part scores zero it does not make the product unrepairable, just harder to disassemble. Therefore, it is not a knock-out criteria. The formula used to determine the score can be seen below:

S1,i = DDref-DDi+5
S1,i = Disassembly depth score (between 0 and 10)
DDi = Number of steps to remove priority part
DDref = The reference number of steps for a specific priority part in a specific product group

Extra weight should be given to priority parts of list 2 as these have to be repaired more frequently and would benefit more from being better accessible. If parts are not present in a product the reference value can be given. If a disassembly takes two times as many steps or more it is marked as an outlier. An example scoring is seen in Table 10.

Disassembly depth part:	**DDref**	**DDi**	**S1,i**	**Weight**
Motor	5	4	6	2
Battery	4	2	7	1
Total score	(S1,Motor*2+S 1,Battery*1)/3			6,3

Table 10: Example scoring of disassembly depth

Fasteners

fasteners are hardware devices that hold two or more parts together through mechanical or magnetic connections (Cordella et al., 2019). Documenting the type of fasteners used to hold a priority part in place contributes to a product's repairability. Three types of fastener groups are distinguished by the JRC, 45554 and Bracquené et al. (2018). Fasteners can be; A) removable and reusable, B) removable but not reusable and C) neither removable nor reusable. Fasteners will have the following scores: A = 2, B = 1 and C = 0. The score will be weighted according to which list they belong to. Parts from list 2 will weigh double and parts from list 1 will weigh singular.

A removable and reusable fastener is a fastener that can be reused after disassembly. Removable but not reusable fasteners are fasteners that can be removed without causing damage or leaving residue which could hinder reassembly. This includes single use fastenings that are supplied with new parts. This opposes 45554, Cordella and Braquene but if extra parts are needed to make a fastener work again it would be non reusable by definition. Neither removable nor reusable fasteners are fasteners that are not reusable when disassembling a product. This includes glued, welded or soldered parts as removing these parts without damage is considered to be difficult (HOP, 2022). When different fasteners have to be removed to access a part the least removable fastener is selected, this is the

weakest link in the chain. Connectors are also considered to be fasteners (NEN, 2020a). An example can be seen in Table 11. The formula used to determine the score can be seen below:

S1,i = ((Score parts list 2 * 2)+(Score parts list 1))/((# Parts list 2 * 2 * 2) + (# Parts list 1 * 2))* 10

If a part is not in the product, it is left out of scope and is not taken into the calculation as this "bonus" was already added to the disassembly depth. If a part is non removable it is highlighted as a non removable part in the final score.

Priority part	Type of fasteners	Score	Weight
Motor	Removable and reusable	2	2
Battery	Neither removable nor reusable	0	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		6,7

Table 11: Example of scoring of fasteners

Necessary tools for disassembly

The tools needed for disassembly work similarly to fasteners. A score is given for every priority part of list 1 and 2 and according to the type of tools used during the disassembly. Within tools four types of tool groups are distinguished ; A) The use of no tool or basic tools, B) Other commercially available tools and tools that are supplied with the product or spare part, C) Proprietary tools and D) not feasible . This list has been adopted from the 45554 standard except for the supplied tools. Tools that are supplied with the product or spare part might not always be available making it an extra hurdle. Therefore, these tools score one point lower as opposed to the 45554 standard. The product specific tool group from the 45554 standard has merged with group B to keep the scoring simple, this is proposed as an option by the JRC as well. Group A consists of tools as listed in Appendix 6. Group B consists of other commercially available tools. Group C consists of tools which are not commercially available for purchase. If a part is non removable it is located in group D.

The tools will have the following scores: A = 3, B = 2, C = 1 and D = 0. The score will be weighted according to which list they belong to. Parts from list 2 will weigh double and parts from list 1 will weigh singular. An example can be seen in Table 12. The calculation can be seen below:

S1,i = ((Score parts list 2 * 2)+(Score parts list 1))/((# Parts list 2 * 2 * 3) + (# Parts list 1 * 3))* 10

If a part is not in the product it is left out of scope and is not taken into the calculation as this "bonus" was already added to the disassembly depth. If a part is non removable with any tool it is highlighted as a non removable part in the final score.

Priority part	Type of tool needed	Score	Weight
Motor	Group A	3	2
Battery	Group C	1	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		7,8

Table 12:Example of scoring of necessary tools for disassembly

Disassembly time

The disassembly time for reaching priority parts holds information of the difficulty of disassembly. If the disassembly steps towards a priority part in a certain product take more time it suggests that the disassembly is not easy (De Fazio et al., 2021). What this problem is and how to solve this is up to the supplier although several suggestions are provided. The disassembly time is measured per priority part by adding the time needed for all the disassembly steps needed to remove the part. This can be done using the recording of the disassembly and the disassembly map.

S1,i = ((1-(DDi/DDref))*5)+5

S1,i = Disassembly time score (between 0 and 10)
DDi = Time needed to remove a priority part
DDref = The reference time needed for a specific priority part in a specific product group

The maximum time has been set at double the reference disassembly time and will be highlighted from that point onward as an outlier. This gives a head up that something is wrong with that part. If a part is not present the reference value can be filled in. If a part is non removable double the reference value should be filled in.

Spare parts

The criteria of the spare parts and their availability, delivery time and price are discussed in the following paragraphs.

Availability

Spare parts should at least be available during the entire lifetime of the product. According to JRC this is 5 to 10 years for smalls appliances (eg. hair-dryers, kettles, coffee machines, grills). This goes in from the moment the last product is placed on the market. Users are generally less willing to pay for repairing a product if it is nearing its end of life limit (Cordella et al., 2019). Action should agree the availability upfront with suppliers. Three groups are distinguished; A) Priority parts are available up to 5 years, B) Priority parts are available after 6 to 9 years and C) Priority parts are available for more than 10 years. Group A is the minimum time parts from list 2 need to be available making it a knock-out criteria. If a part is less than 5 years available it will be a knockout. Parts from list 2 will weigh double and parts from list 1 will weigh singular. The groups will have the following scores: A = 1, B = 2 and C = 3. An example scoring is seen in Table 13. If a part is not in the product it is left out of scope and is not taken into the calculation as this "bonus" was already added to the disassembly depth.

Priority part	Minimal time available	Score	Weight
Motor	10 years	3	2
Battery	10 years	1	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		7,8

Table 13: Example of scoring of availability of spare parts

Delivery time

According to Cordella the spare parts have to be available within 15 working days. Spare parts could be available for pick up at the Action store, sent to the repairer or be sent to the customer. It has to be further analyzed which is more efficient in terms of costs as these have an effect in the choice of customers to repair a product or not (Cordella et al., 2019). What does matter is the delivery time, the delivery time of 15 days (B) is taken as an average. Delivery time for parts can be over (A) or under this 15 days (C) which will have the following scores: A = 1, B = 2 and C = 3. An example scoring is seen in Table 14. Parts from list 2 will weigh double and parts from list 1 will weigh singular.

Priority part	Delivery time	Score	Weight
Motor	15 days	3	2
Battery	less than 15 days	1	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		7,8

Table 14: Example of scoring of delivery time of spare parts

Price relative to the price of the original product

The price of spare parts cant be too high as this would make repairs less favourable. The maximum price customers are willing to pay for repairing electronics is around 30% of the retail price (Cordella et al., 2019). Using this as the baseline a scoring system for the price of spare parts is used which is adapted from the FRI. The lower the price, the higher the score. If a spare part costs more than 30% of the retail price the score will be a zero. The scoring is presented in Table 16 and an example of a filled in score can be seen in table 15.

Priority part	Price ratio	Score	Weight
Motor	0,24	30	2
Battery	0,11	95	1
Total score	**(Σ(Priority part score * Weight) / total weight) /10**		5,2

Table 15: Example of scoring of the price of spare parts

ratio	0,1	0,11	0,12	0,13	0,14	0,15	0,16	0,17	0,18	0,19	0,20	0,21	0,22	0,23	0,24	0,25	0,26	0,27	0,28	0,29	0,30
Score	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0

Table 16: Price scoring of spare parts

Documentation and availability of information

For the documentation the most appropriate documents from the FRI and JRC have been selected which enable repairers to repair Action's products. Action will hold and distribute the information from suppliers to ensure its availability over time. This also allows for updates, technical bulletins and future improvements, known repairs, etc. The documents have to be available for the entire lifespan of the product. Small household appliances have an estimated lifespan between 5 and 10 years (Cordella et al., 2019). This means the documents have to be available for at least 10 years. The requirements of the documents come from various sources which were applicable for that criteria (Bracquené et al., 2018 ; HOP, 2022). The score that can be obtained ranges from 1 to 3, the minimum score that needs to be scored is 1 for every document. This is the minimum documentation needed for products to be repairable. If one of the documents is missing or does not meet the requirements as described in the "1 points" the whole document's criteria scores a zero. The amount of accumulated points determines the score. The scoring of the documents criteria can be seen in Table 17.

Next horizons

The repairability index can change overtime if the outcome does not fit the goal of the index. As the horizons change over time so does the goal over time, the index should be adapted accordingly. Some suggestions for horizon 1 and 2 are proposed.

Horizon 2

If the repairability index were to be made publicly available some reconsiderations have to be made. For the repairability score itself it could be determined if one grade would work better or the three different grades of disassembly, spare parts and documentation. Several ways of scoring products are discussed by HOP. Additionally, customers want to see how scores are established and this should be accessible to customers according to HOP. In horizon 2 customers will still have their products repaired by repairers which is the same target group to whom the information, spare parts, etc should be available. Action could start with collecting data on what interfaces are being used to be able to standardize. Currently no product specific criteria have been taken into account. If these were to be needed the index should be changed accordingly. The index is a live document that can change according to legislation, new standards or feedback.

Horizon 3

If customers perform repairs adequate information should be available to do so. Think of self repair instructions, safety instructions and things like warranty for the customer (Cordella et al., 2019). If repairing products is available for customers directly the target group has shifted. It should be taken into account how accessible repairs are for customers by allowing them access to manuals and giving them the opportunity to order spare parts. Customers are actively sharing their experiences, hurdles and improvements that could be added as criteria or as ideas on how to improve on criteria. Standardization should be added to the criteria as well as this is added in horizon 3. And lastly the repairability score should be checked with customers to check whether it covers their experiences in reality (HOP).

Document	1 points	2 points	3 points
The unequivocal identification of the product (type of product, trademark, trade name, model, and possibly, serial number)	Removable label (Bracquené et al., 2018)	Non Removable label (Bracquené et al., 2018)	
Diagnostic fault and error codes	Available if applicable		
List of necessary repair and test equipment	Available	Avoid scoring double on the same criteria	Further discussed in the "tools" criteria under disassembly
Technical manual of instructions for repair	1. safety measures 2. (check)list of identified root causes for common failures/misuses (Bracquené et al., 2018)	- safety measures- basic fault diagnostic advice: (check)list of identified root causes for common failures*- test method to check working condition of key functional parts*- limited list of error codes and required repair actions, if applicable (Bracquené et al., 2018)	- safety measures- fault diagnostic advice: (check)list of identified root causes for common failures* and troubleshooting tree - test method to check working condition of priority part- complete list of error codes and required repair actions, if applicable - fault detection software , if applicable (Bracquené et al., 2018)
A disassembly map or exploded view	Disassembly map including how to remove list 2 and 1 parts. (Bracquené et al., 2018)	Disassembly video for entire product (HOP, 2022)	
Electronic boards diagrams (internals of the product)	available with component specification (HOP, 2022)		
Total score:	all points combined		

Table 17: Scoring system used for documentation

Reference values

The mentioned criteria need to have a reference value on which they are measured against. This touches upon the KPI's as it depends on what your KPI's are as well. For this reason the reference values are further discussed in the KPI section of this chapter.

With the current index the design of products can differ in the disassembly depth and disassembly time. The levels for the type of fasteners and tools used as well as documentation, parts availability, parts delivery time and parts price are the same for every product. The disassembly depth and disassembly time can be changed by setting the right reference values to which the products will be designed.

Feedback for the buyers

A system for the buyers is created to give them insights in the repairability of products. The general scoring template and ErP group score are explained and how buyers could use this when buying products

The buyers have to know what the score on a product they want to buy is. If the score is known the buyer can check what would happen if he were to buy an X amount of products in regard to his KPI. An example of a filled in scoring template can be seen in Figure 14 where the score of a grill is presented. Not only the score is displayed but outliers and non removable parts are highlighted as well. This gives the buyer a heads up to further ask about these outliers or non removable parts. This could be an early warning sign for him to get in touch with his product tech first or to stall the deal.

If the product complies the buyer could check what the impact of this product would be on the overall score of this ErP group. This can be seen in Figure 15 where the current score of his ErP group and KPI is displayed. The score of the potential grill he would like to buy is filled in in the new product column. This shows the buyer what the impact of the new product is on his KPI and how far removed he is from reaching his KPI with the quantity he filled in. This gives the buyer control over his KPI and a better bargaining position without needing additional specific knowledge.

Repairability score:		
Disassembly depth part average:	Outlier	0
Fastners used:	Non removable part	0
Tools needed:		10
Disassembly time average:	Outlier	3,8
Dissasembly score		**3,5**
Availability:		6,7
Delivery time:		6,7
Parts price:		0
Parts		**0**
Documentation	Knock-out	**6**

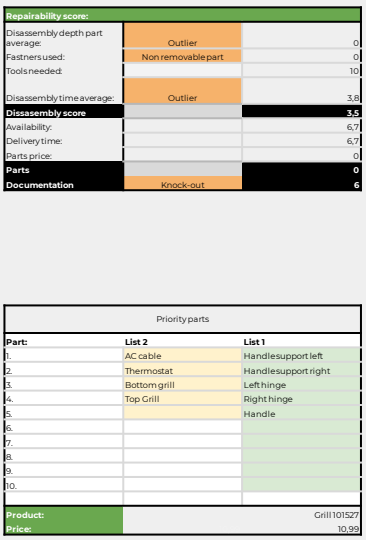
Figure 14: Filled in repairability score

Repairability score:	**Current score:**	**New product**	**New score**	**KPI**	**% removed from KPI**
Disassembly depth part average:	5,2	8	6,6	5	-32%
Fastners used:	5,7	4	4,9	10	51%
Tools needed:	9,8	5	7,4	10	26%
Disassembly depth part average:	2,4	7	4,7	5	6%
Dissasembly score	5,8	**7**	6,4	7,5	15%
Availability:	0	5	2,5	6,7	63%
Delivery time:	0	7	3,5	6,7	48%
Parts price:	0	5	2,5	5	50%
Parts	6,8	**7**	6,9	6,7	-3%
Documentation	5	**5**	5	6	17%
Amount:	150000	150000			

Figure 15: ErP group score example

Repairability index for suppliers

The suppliers have to be able to use a repairability index for its implementation to be successful. A manual is written on how to fill in the score as seen in Appendix 7. This goes through all the criteria the suppliers have to assess and fill in to get a repairability score. The score framework will be added to the PSS and the manual on the repairability index will be added to the general suppliers manual. This gives the supplier clear boundaries on how to grade their products. The output of a filled in repairability index can be seen in Figure 16.



Repairability score:		
Disassembly depth part average:	Outlier	0
Fastners used:	Non removable part	0
Tools needed:		10
Disassembly time average:	Outlier	3,8
Dissasembly score		**3,5**
Availability:		6,7
Delivery time:		6,7
Parts price:		0
Parts		**0**
Documentation	Knock-out	**6**

Priority parts		
Part:	**List 2**	**List 1**
1.	AC cable	Handlesupport left
2.	Thermostat	Handlesupport right
3.	Bottom grill	Left hinge
4.	Top Grill	Right hinge
5.		Handle
6.		
7.		
8.		
9.		
10.		
Product:		Grill 101527
Price:		10,99

Figure 16: Output of a filled in repairability index

KPI's

Currently, the KPI's on sustainability are to increase the CTI score with 5% within the end of the year. What is not taken into consideration is the potential a ErP group has to change. Some groups could easily increase their score by 20% while others hardly manage to reach the 5%.

For determining the KPI's a product used for reference values is selected. In this example the product is made out of reusable fasteners which are removable with proprietary tools for good repairability. The product has the same disassembly depth and disassembly time as the reference levels. The spare parts are available between 5 and 10 years similar to the products life time and are delivered in 15 days (Cordella et al., 2019). The minimal required documents are available for this product. The parts price depends on the price of the product and its spare parts would score a 5 when they cost 20% of the original price. For the delivery and availability this product scores a 6,7 if it is available for 6 to 9 years and delivered in 15 days. The overall score can be seen in Table 18.

Repairability score:		
Disassembly depth part average:		5
Fastners used:		10
Tools needed:		10
Disassembly time average:		5
Dissasembly score		**7,5**
Availability:		6,7
Delivery time:		6,7
Parts price:		5
Parts		**6,1**
Documentation		**6**

Table 18: Scoring of product used for reference values.

The score of this product is the minimum score of a product and makes sure the product is easy to disassemble and that parts and documentation are available. The KPI for buyers should be this score as these are the minimal requirements for repair. To incentivize buyers bonuses could be given to buyers who reach these scores. By measuring this over a period of a year the improvements can be compared. Extra bonuses could be given to buyers who go beyond the given KPI. The KPI can also be updated by updating the reference value or increasing the minimal score for the other criteria.

10. Validation

10. Validation

For the validation of the proposed system several forms of validation will be performed. The future vision, repairability index and feedback provided through an interactive repairability index calculation sheet will be tested. Additional feedback will be gathered from one of the suppliers of the selected ErP group on the repairability index.

10.1 Future vision

The future vision was tested to check whether this vision resonated with employees at Action. Different concepts have been proposed to them to see which ones resonated and which ones did not.

Method

For the future vision employees at Action were asked to read the roadmap towards the future vision in 2035. After they have read this they were walked through the roadmap to check if there were any questions. Four ideas were proposed that could diversify Action's revenue streams due to the ending expansion in Europe and upcoming legislation. The concepts were based on the insights and feedback on the products Action sells in the coming future, the concepts were as follows:

1. Set standards in parts and integrate vertically to produce them ourselves.
2. Fully develop products ourselves.
3. Create a product passport system ourselves or with partners.
4. Invest on knowledge and solutions for repairability which could be sold to suppliers.

The proposed concepts were ideas that all try to put Action on the market in different, more extreme ways. These were chosen to trigger the respondents in thinking outside of the box. The by Jones & Van Ael suggested Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (2022). For the selection of participants, three managers at Action were asked to participate. Preferably managers who are affiliated with sustainability as they have the knowledge regarding circularity and the company. The managers were all from the quality or susaintability department of Action. The responses of the participants were paraphrased to show the highlights of the interview. Some participants started with feedback concerning the roadmap before going into the four concepts which was insightful as well and included in their response.

Interviews

The responses of the participants are discussed per participant in the following paragraphs.

Sustainability manager at Action - Sustainability department

Horizon 3 might be a bit too complex for Action, "where Action has built a vibrant ecosystem" is not Action's core business. We would rather implement proven concepts or join renounced parties to mitigate risk and stick to our core. Currently the focus is on growth as this has been proven to work for us. Our philosophy is to keep things simple which enables us to run an efficient business, that's why we want to avoid selling services or additional concepts.

1.Setting standards in parts towards our suppliers might be something that I could potentially envision in the future. To keep it simple this could be done by making exclusive deals with factories rather than producing parts ourselves. This helps with uniformity among products in for example batteries or electrical motors which would benefit repairability.

2. We would rather not change our buying process as producing products ourselves slows this significantly. Additionally we would have to acquire a lot of knowledge before being able to do this.

3. We would not join with competitive suppliers and create solutions together from scratch as this has not been done before and increases complexity. Joining a consortium of some sort with a clear

vision might be considered as this would most likely be proven to work.

4. Action would not offer services to help suppliers with repairability or other sustainability measures ourselves. We would rather refer them to Intertek who could help suppliers with making products more repairable according to a repairability index.

Direct Import Quality & Sustainability Manager at Action - Quality department

1. I think this could be very interesting for Action and our suppliers. It would allow us to source a higher number of parts from one factory which gives us more control over quality as well. This will result in a price reduction for Action and more control in the supply chain.

2. I do not think producing products ourselves is in the core business of Action. This defeats the purpose of being adaptive and agile. This would rather be something for a company like Hema.

3. I think an online system to store our data regarding products is very interesting and is something we should pursue. But developing this is not up to us but should be done by a 3rd party. Usually, we look into solutions that are already available or used by other players in the market.

4. Many of our internal learnings are already being shared among suppliers. I don't think we should sell this expertise, but we can trade this through the people who work for us.

In general, I think we need to reduce our SKU's and have to think about what a customer wants. We can make this decision for our customers in our buying process. Selling less SKU's would also benefit standardization.

Head of Product Quality & Sustainability at Action - Quality department

We were already thinking about what the possibilities or opportunities were within circularity. Next to the things that are mandatory we are doing extra things like our cotton commitment. But we want to take this to the next step and look for something that could really make a strategic difference such as circularity. Action wants to do this to be able to decouple economic growth from consumerism and contribute to sustainable consumerism through circularity. This would include bring back schemes, reselling and reusing and partnering with different organizations.

1. This would make sense as IKEA is doing something similar with their spare parts. It is not a way of working for us but it could be a 10 year initiative with the right sourcing commitments and communication towards suppliers.

2. I could see ourselves develop some products, but not on the level of IKEA. Considering scope 3 emissions and the footprint of the product sold it would be good to understand our products better to design for this.

3. We are going to have to do something for this but no collaboration. We would break it up in chunks and implement it slowly.

4. We would certainly be proactive towards circularity and expand our knowledge. But selling this would not fit Action as we collaborate with our suppliers. We would share our findings and best practices with suppliers free of charge to be able to continuously improve our product offering.

Conclusion

Currently the focus for Action is on growth and keeping the business model simple. Some interviewees point out that in the the future circularity could help in creating new strategic opportunities.

The first concept resonated with every interviewee as it could stimulate uniformity amongst products, gives more control over the supply chain and lower prices. The second concept did not resonate as it would require too much knowledge and limits adaptiveness and agility, for a small number of products it could be imaginable in the future. The third concept did not resonate either as Action rather invests in proven concepts and would want to avoid making the

business model more complex. The fourth concept also did not resonate as Action already shares information with suppliers to be able to sell better products.

The first concept of vertical integration resonated the best with the interviewees as it could be done without making the business model more complex and less adaptive and agile. It offers opportunity for standardization, better quality and lower prices. This concept is currently selected in the future vision and is suitable for Action's future vision.

10.2 Creating an index for a ErP group

The proposed repairability index would make it possible for Action to measure the repairability of every ErP group. This is tested by a case study of developing and filling in an repairability index for an ErP group. Creating a repairability index consists of determining the goal, index outline criteria and priority parts. Lastly the reference data for the selected criteria have to be chosen. When the repairability index is ready it is filled in for a selection of products. The goal of the case study is to test the proposed repairability index and to use the results in further conversations with buyers and product techs.

Method

For the case study the proposed goal, index outline and goal of Appendix 8 are used. The goal, criteria and index will be discussed after which selection of the priority parts will be done to be able to fill in the criteria. The ErP group grills are used for this case study. This ErP group is chosen as it is in the top 5 of ErP groups with the most weight being sold (Appendix 4). Additionally, a relevant supplier to this ErP group is located in the Netherlands which is open to collaborate and share information. Three grills from Action's assortment are used to fill in the repairability index. A picture of the set up used while filming the disassembling can be seen in Figure 17 and 18.

Figure 17: Set up for filming a disassembly

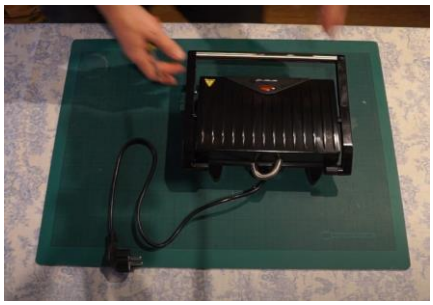


Figure 18: View from the camera from Figure 17

Goal

The goal for the repairability index in horizon 1 of Action's roadmap is to measure the repairability of a product category. This is used as a baseline from which targets can be developed which are translated into tangible KPI's for the buyers. The score is used B2B between Action and suppliers. As Action introduces 150 new products each week efficiency has to be taken into account. The goal of measuring repairability is to enable the repair of a product and make it accessible through ease of disassembly.

Criteria

The proposed criteria from Appendix 8 are adapted to get a understanding if the product is repairable and how easy this is. The ability to repair is covered via the types of fasteners used, tools needed, availability of spare parts, delivery time of spare parts, the price of spare parts and the documentation. The ease of disassembly is covered by the disassembly time and number of disassembly steps. These criteria should cover everything, other criteria are not expected to give extra usable or significantly different information between the grills.

Index

As no extra criteria are used the proposed index from Appendix 8 is used without making adjustments. This means that if a product complies it will have the score as seen in Table 19. In this example the product is made out of reusable fasteners which are removable with proprietary tools. The product has the same disassembly depth and disassembly time as the set levels. The spare parts are available between 5 and 10 years similar to the product's life time and are delivered in 15 days (Cordella et al., 2019). The minimal

required documents are available for this product. The price depends on the price of the product and its spare parts and can or can not comply.

Repairability score:		
Disassembly depth part average:		5
Fastners used:		10
Tools needed:		10
Disassembly time average:		5
Dissasembly score		**7,5**
Availability:		6,7
Delivery time:		6,7
Parts price:		...
Parts		**6,1**
Documentation		**6**

Table 19: Score of a product that complies with the minimal requirements

Priority parts

For determining the priority parts for an ErP group a workflow is proposed. For this case study three grills of Action's assortment have been selected to gather information (Figure 19). These three grills were randomly selected from the current available assortment.

The first step is to make the product visual, three stock photos from Action have been used as seen in Figure 20. The second step is to take apart the products and map all parts as seen in Figure 20 The list with parts of all products is combined in one parts list. Not all parts are present in every product. The list can be seen below:

Figure 20: Products dismantled and labeled. Tristar, Alpina and Emerio from top to bottom

Figure 19: Tristar, Alpina and Emerio contact grill in sequential order.

Parts list of the Tristar, Alpina and Emerico grills:

1. Top grill
2. Bottom grill
3. Cable
4. Top Cover
5. Handle
6. Spring release
7. Spring release cover
8. Left hinge
9. Right hinge
10. Cable cover
11. Indicator light
12. Top Heating element
13. Thermostat
14. Bottom heating element
15. Bottom cover
16. Top insulation
17. Left handle support
18. Right handle support
19. Locking mechanism
20. Protective cover
21. Cable tree
22. Weight
23. AC Outlet
24. Heating element place holders
25. Light cover
26. Light holder

The third step is to determine primary and secondary functions of the product. The fourth step is to draw/take pictures and visually inspect parts on the product that contribute to these functions. This can be seen in Table 21.

The fifth step is to make a first selection of priority parts. From the disassembly the hinges look vulnerable. This would hinder the primary function making it an important part. The heating element is essential for heating objects and is an important part as well. The thermostat keeps the temperature of the grill within limits. The grill can not function without it making it an important part. The parts enabling the secondary functions are not really important to the general functionality of the product. For now the parts 12,14,8,9 and 13 are selected as priority parts.

The sixth step is to collect information about potential priority parts from literature and practice. For the data from literature the repair monitor, customer returns from Action,

The data from the repair monitor (Repair Monitor, unpublished), available spare parts from the selected grills and comparable A-brand grills has been used to identify priority parts. The repair monitor collects data from repair cafes all over the world. The data contains what type of product is repaired, the problem and the found defect. In total 133 repairs were monitored for the grill in the repair monitor. These repairs have been mapped according to the nature of the defect and can be seen in Appendix 9. The results can be seen in Table 20. There is a clear top three in the Table visible including the thermostat, element and cable which are part 13,12, 14 and 23

Problems:	Amount of repairs:	Percentage
Housing	9	6,77%
Thermostat	26	19,55%
Element	22	16,54%
Cable	37	27,82%
Unknown	16	12,03%
Fuse	6	4,51%
Lamps	2	1,50%
Shortcut	6	4,51%
Loose connections	9	6,77%
Total	133	

Table 20: Data from repair monitor (Repair Monitor, unpublished)

Alpina, Emerio and Tristar do not supply spare parts for their contact grills. Only Tristar offers some spare accessories such as leakage trays for grease. Available spare parts from the suppliers could therefore not be taken into account. Additionally Action has little to no data why customers return products.

To compare the availability of spare parts an A-brand grill has been selected to determine what are considered priority parts by A-brands based on the availability. The selected grill is the Tefal Inicio GC241D panini grill as is it shares the most similarities with the previous selected grills and is from an renowned A-brand. Tefal refers to four websites for spare parts of their products which are parts.nl, onderdelen.nl, handyman.nl and beekman.nl (Tefal, personal

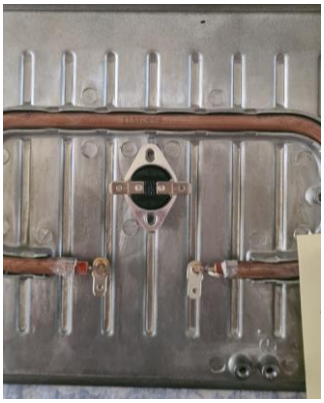
Primary functions	Parts	pictures
Heat objects from two sides	12,14,8,9	  
Control the temperature	13	 
Secondary functions		
Lock the two sides	19	 
Open grill 180°	6,7	 

Table 21: Step 3 and 4 of selecting priority parts.

business model more complex. The fourth concept also did not resonate as Action already shares information with suppliers to be able to sell better products.

communication, June 27, 2023). Handyman does not sell any spare parts (Handyman, n.d.), but the other three websites all sell part 17,18 and 13 respectively (Beekman B.V., n.d. ; Onderdelen.nl, n.d. ; PartsNL, n.d.)

Next to the websites provided by Tefal Fixpart.nl and Onderdelenplanet.nl sell various parts as well. These spare parts are not offered on sites which are promoted by the original brand but are offered on third party sites. But according to these sites the parts are from the original equipment manufacturer (OEM).

The parts included part number 2, 4, 5, 13, 15, 17, 18, 21 and 23 respectively (FixPart, n.d. ; Onderdelenplanet.nl, n.d.). These parts are all claimed to be “original products” and produced by the mother company of Tefal. Some parts were previously mentioned and some were less relevant such as the topcover. The only mentionable part for this grill is the extra available bottom grill and handle. The grills were being sold as one part where the grill and heating element are sold as one. Preferable these are separate available to reduce unnecessary replacement. The handle makes sense to sell as a spare part if the handle supports are being sold as spare parts as well.

For the Emirio, Alpina and Tristar grill no spare parts were to be found online. Tristar is contacted through Action to share the failure rates of the parts of their products to be able to distinct priority parts in list 1 and 2. However, Tristar could not provide this information.

The parts that came forward in step 5 and 6 are listed in Table 22 and highlighted where they were mentioned. This is used to choose and divide the priority parts between list 2 and 1. For list 2 the AC cable, thermostat, bottom and top grill have been selected. These have been selected as they contribute to the primary function, break often according to the repair monitor and are already available for similar grills. For list 1 the handle supports, hinges and the handle are selected. These

Step 5	Step 6		
First physical exam	Repair monitor	Available spare parts officially	Available spare parts unofficially
Top heating element (12)	16,5%		/ In combination with grill
Bottom heating element (14)			/ In combination with grill
Left hinge (8)			
Right hinge (9)			
Thermostat (13)	19,6%	X	X
	AC cable (23) 27,8%		X
		Handle support (17&18)	X
			Handle (5)
			Bottom Grill (1)
			Top Grill (2)

Table 22: Identified parts throughout step 5 and 6

parts are probably less prone to breaking as they are not mentioned by the repair cafes. For the A-brand the handle supports are available through their available website but this could be due to being able to offer them easily and not because of demand.

The grill and heating element are currently not separable in any of the Action or comparable A-brand grills. Models do exist where this is possible but this is also seen as an extra functionality. Therefore, the Grills are selected as priority parts assuming the heating element is irreversibly attached to it. In a later stadium this could be further discussed with suppliers to move towards fully removable heating elements. The final list of priority parts can be seen in Table 23.

List 2	List 1
1. AC Cable (23)	5. Handle support left (17)
2. Thermostat (13)	6. Handle support right (18)
3. Bottom grill (2)	7. Left hinge (8)
4. Top grill (1)	8. Right hinge (9)
	9. Handle (5)

Table 23: List 1 & 2 priority parts

Reference values

The values for the ability to repair a product are the same for every product. The ease of disassembly is covered by the disassembly depth and time. By setting reference values for the disassembly depth and time Action can influence the desired ease of disassembly of the product they buy.

If a product complies with the set ease of disassembly reference level it will score a 5 out of 10 which could be considered as a pass. For the reference value an example is chosen that leaves room for improvements. This encourages manufacturers to go beyond the score of 5 and actually improve their products. For the disassembly steps and time the best product of the current inventory in terms of disassembly depth and time of Action is selected as reference value. The first selection is based on the number of removable priority parts. If parts are non removable their disassembly time can not be taken into account. From the remaining products the total disassembly time of the priority parts are added together to get the total disassembly time of the priority parts. From the remaining products the one with the lowest disassembly time is chosen to be the reference value. The Alpina grill is the easiest to disassemble as can be seen in Table 25. This grill is chosen as reference value for the disassembly depth and time.
The disassembly depth and time which are used as reference value for every part can be seen in Table 24.
The repairability score of the Alpina, Emerio and Tristar grill have been filled in as seen in Figure 21,22 & 23.

Part	Disassembly depth	Disassembly time
1. AC Cable	2	21
2. Thermostat	1	93
3. Bottom grill	4	28
4. Top grill	1	134
5. Left handle support	1	64
6. Right handle support	1	56
7. Left hinge	1	26
8. Right hinge	1	29
9. Handle	3	136

Table 24: Reference disassembly depth and disassembly time values.

Repairability score:		Alpina Grill
Disassembly depth part average:		5
Fastners used:	Non removable part	8,3
Tools needed:		10
Disassembly time average:		5
Dissasembly score		**7,1**
Availability:		0
Delivery time:		0
Parts price:		0
Parts		**0**
Documentation		**1**

Figure 21: repairability score of the Alpina grill

Repairability score:		Emerio Grill
Disassembly depth part average:		5,2
Fastners used:	Non removable part	8,3
Tools needed:		9,5
Disassembly time average:	Outlier	2,1
Dissasembly score		**6,3**
Availability:		0
Delivery time:		0
Parts price:		0
Parts		**0**
Documentation		**1**

Figure 22: repairability score of the Emerio grill

Repairability score:		Tristar Grill
Disassembly depth part average:		5,5
Fastners used:	Non removable part	3,8
Tools needed:	Non removable part	3,8
Disassembly time average:	Outlier	1,8
Dissasembly score		**3,7**
Availability:		0
Delivery time:		0
Parts price:		0
Parts		**0**
Documentation		**1**

Figure 23: repairability score of the Tristar grill

Model:	Alpina			Tristar			Emerio		
Part:	Dis?	#	Time	Dis?	#	Time	Dis?	#	Time
1	X	2	21	X	2	13	X	2	43
2		1	93	X	1	48		1	113
3		4	28	X	1	15		3	57
4		1	134	X	1	39		1	185
5		1	64		1	59		1	113
6		1	56		1	57		1	104
7		1	26		1	35		1	29
8		1	29		1	29		1	28
9		2	136		2	131		2	233
Total time:	1	14	587	4	11	426	1	13	908

Table 25: Possibility of disassembly, disassembly steps and disassembly time per part and product

Conclusion and recommendations

It was possible to fill in the repairability index and select priority parts and determine reference values. But selecting priority parts might be bias as there is critical info missing on failure rates. By doing a visual inspection, checking the repair monitor and available parts a reasonable selection could be made. This selection could always be improved or update if more information is available.

The values of the reference value could be more precise by disassembling a product multiple times and determining the average. It would be better to do this with new products every time as the person who disassembles and reassembles the product influences the tightness of the fasteners used which influences the disassembly time.

If a part is non removable it is not possible to fill in the disassembly time. The Tristar grill had some non removable connections which were spot welded together. The connection could have been cut and the time could be measured. But it would be non logical if this enables a part to score lower on the disassembly time. Therefore, as a penalty the disassembly time for these parts were counted as the maximum disassembly time which is twice the disassembly time of the reference value. The scoring of the Tristar Grill on the disassembly time with the non removable parts can be seen in Table 26. This was not covered in the guide of Appendix 7 & 8 and is added.

The heating element was not separatable in any of the grills. The focus moved to the grill instead of the heating element to be able to fill in reference values.

	Disassembly time:	DDref:	DDi	S1,i
List 2	AC cable	21	42	0
	Thermostat	93	186	0
	Bottom grill	28	56	0
	Top Grill	134	268	0
List 1	Handle support left	64	59	5,390625
	Handle support right	56	57	4,910714286
	Left hinge	26	35	3,269230769
	Right hinge	29	29	5
	Handle	136	131	5,183823529
Total score:				1,8

Table 26 Scoring of Tristar grill on the disassembly time

10.3 Stakeholders

The repairability index is to be tested with the most relevant stakeholders which are the buyers, product techs and suppliers. The system of giving feedback to the buyers on the repairability of products is to be tested. The goal is to see if the tool would help the buyer in making informed decisions in purchasing repairable products. Product techs are asked how they would foresee the implementation of the repairability index and if they could create repairability indexes. A supplier is asked how he would adapt to creating more repairable products if this is being demanded by Action.

Method

The method will be discussed per interviewed stakeholder in the next paragraphs.

Buyers

The feedback template from Figure 15 will be filled in with KPI's and the current score of an ErP group. The buyers will briefly be explained on how a repairability score would work for them. After they understand the repairability index and feedback system they are asked how this would influence the way they buy new products and how they would use this tool. The by Jones & Van Ael suggested Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (2022). For the interviewees buyers from departments who buy ErP products were selected.

Product techs

The product techs will briefly be explained on how a repairability score would work for them. After they understand the repairability index they are asked how they would think suppliers would be able to use the repairability index and if they foresee any problems. They are also asked if they are able to fill in the repairability index and how this went with other similar changes. The by Jones & Van Ael suggested Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (2022). For the interviewees product techs from departments who buy ErP products were selected.

Suppliers

One of Action's suppliers is visited to gain insights in how a supplier could implement the repairability scoring system and supply more repairable products to Action. By asking how they currently solve circularity problems, what the measures in place are and how they responded to the FRI when it was introduced, deeper understanding in their operation is gained. The by Jones & Van Ael suggested Causal Layered Analysis is used to get to from events and trends to underlying causes, paradigms and metaphors (2022). The selected supplier is a supplier from one of the grills to be able to share relevant information and examples of their and competitors products.

Results

The results of the interviews are summarized and paraphrased per interviewed stakeholders

Buyers

The results of the interviewed buyer are presented per buyer.

1. Head of Buying at Action

I think the repairability index is very interesting but it is a bit too much for buyers to be taken into account. The buyers already have so much things to take into account when buying products. Adding a repairability score would not help the buyers in buying products easily. Buyers' main purpose is to buy product for the best price and not all the extra things around it. This is something the sustainability team is for who could help us in these matters.

2. Assistant buyer at Action

I have the feeling the repairability is going to be affecting the quality of the product. If less screws are used the product would be less qualitative but more repairable for example. However, this goes for price as well.

I think suppliers might fill in the repairability score more to their liking instead of what the product should actually score, maybe this is something that can be done/checked by an external

party to ensure the scoring. This way repairability could be benchmarked compared to other suppliers or products.

For the repairability index feedback, I don not think we are going to adjust the amount of products we are going to be buying. When I buy a product I buy it based on how much I think I can sell, not based on my KPI's. I think it is more binary, we would only want products that have a certain repairability which shifts every now and then. This should be Action's new standard, why would we even want to sell fewer products if we know it can be done better. Therefore, you don not need all the specific numbers, just if it complies and maybe how much would be sufficient.

I think showing different suppliers what the repairability scores are and how they could improve would greatly help as they want to be better than other suppliers. For the trustworthiness of suppliers something like a supplier score card could be used.

3. Head of Buying at Action

I think the repairability score could be hard to fill in for some suppliers if every product in their assortment has to be graded. We only buy a few products and this could be a waste of their time. If products do not yet exist it could be extra hard to grade them. But I think sharing these parameters could help in the developing phase. This could be extra hard for fixtures, work lights, headphones, speakers and power tools as we buy these according to our specifics and not of the shelve.

I think the buyers should not be bothered with the repairability index as this should be the standard. So suppliers would have to make sure all the products that are presented to the buyer comply. If this is not the case the product tech should sort this out with the supplier. If I buy something I will bring this up in the quality meeting where the product tech can point out things in the score I could potentially further discuss with the supplier. I think if we would implement this system of standards that 80-85% would comply in a certain amount of time.

I think we should begin with fixed assortment items as we buy these items more frequently which gives us space to improve the product. Many of our speakers we buy only once which makes it harder to improve.

Conclusions

All the buyers stress that it is too much info for the buyer to take into account and that buyers should stick to buying. Some say it has to be the new standard so that every product already complies. This would mean the buyers would not have to think about the repairability of products. But due to the central role buyers play in the buying possess they have to have some knowledge in repairability if this is being incorporated in Action's strategy. Otherwise it would not be possible to incentivize buyers and indirectly manufacturers to acquire more repairable products. If the feedback system of the repairability index was explained step by step it was already better understandable for buyers, maybe it was mere an information overload for the buyers.

Additionally they point out that suppliers could fill in the score more favorable, have trouble grading all products and that it could be difficult for supplies to develop products within the given limits. Filling in scores favorable could be tackled with the supplier score cards as proposed by one of the buyers.. Additionally, Action is a too big of a customer to mislead and risk losing their business for suppliers. The extra given guidelines to supplies could help suppliers in making more suitable products for Action. Difficulty in grading all the products is taken into account for interviewing the supplier.

Product techs

The highlights of the interview per product tech is presented.

1. Product tech at Action

The suppliers will going to have to fill in repairability indexes as it is already happening in France for example with the FRI. It will be easier for big suppliers to make this shift and fill in a repairability index, smaller suppliers might have some more trouble with filling these in. I think it is an good idea to add the explanation on how to fill it in to the supplier manual and explain it to suppliers. Smaller suppliers often do not read the entire supplier manual where bigger ones are. The manual is quite big as it is made out of roughly 90 pages which are not all applicable to every product suppliers offer. We try to guide the suppliers through the chapters by pointing out which chapters are applicable to them.

Currently I do not check every product for quality and I do not think we would have to with a repairability index. We would have to do this for private label and direct import but checking all products would take too much time.

For repairability I think it is good to already start collecting information for when it is going to be fully implemented. I think presenting this to our biggest suppliers would help them in showing where we as Action want to move towards in the future. The best way to start with the repairability index is by choosing one supplier and piloting this and then introduce it to the rest of the suppliers.

2. Technical manager at Action

I think this repairability index would greatly help us in buying more repairable products for Action. This is something we can easily demand from suppliers as they can ask their manufacturers to give the info to them. It would maybe cost a day of work but spread out over the quantity we buy this is neglectable. This would also enable us to compare between different suppliers.

I would not test every product but if it would take 30 minutes I could select some products also based on the supplier. It might make more sense for me to check several unrelated products from different suppliers to see how accurate their findings are. But I trust them to fill this in correctly. For private label and direct import I would check every product.

I think including this in the supplier manual makes sense as suppliers check for the changes compared to the previous year. If this is something that is new it will be picked up by the supplier.

3. Product tech at Action

I think only specialists should be able to repair high voltage products such as grills to ensure safety. Therefore, the information about the product should not be available to consumers. If the data were to be collected it could be connected to Product IP.

I think we should start with private label as we have the most influence on these types of products. We do not have the same focus on white labels for example. If a product is not private label some factories might not even share details of the product with us.

If you want something from the suppliers you have to ask and maybe pressure them a little to do so. Currently we also have to pressure them to supply us with the needed documents for certain products. Certain suppliers care a lot and some just do not care unfortunately.

If the suppliers have to fill in the repairability index they will mostlikely let their factory do this. An explanation or manual could help them with filling in this index as they will probably ask a lot of questions.

Conclusions

According to the product techs it should be doable for suppliers, especially lager ones, to implement the repairbaility score and demand this from suppliers. They would all start with big suppliers and private label and direct import as these have large quantities and thus more inhouse capabilities. Private label and direct import is interesting as this is Action's responsibility to do so. The product techs agree on needing a manual that clearly lays out how the repairability

index should be used for the suppliers and/or manufacturers similarly to the current supplier manual.
Some product techs pointed out that they would not cross reference all products but maybe some of certain suppliers to check their accuracy. They would however check all direct import or private label products because of the previous mentioned reason regarding responsibility.

A risk which was mentioned is factories being unwilling to share information regarding their products. It was pointed that out that perhaps the suppliers should be a little pressured to give the needed documents.

It was also mentioned that making repair possible for customers could be dangerous. This is covered in the future vision which was not shared with product techs as it would take too long. Therefore, this could be neglected as it is taken into account.

Supplier

The highlights of the interview with the supplier is presented, the name of the supplier is left out.

We are currently taking their first steps in terms of repairability. We see how relevant it is for the future and we want our BSCI score be at level B instead of C for example (The BSCI score is the compliance rate of a factory; A: between 86% and 100% compliant, B: between 71% and 85% compliance, C: between 51% and 70% compliance. (Amfori, 2018)). We also try to change our products to reduce packaging. We changed the stand of one of our heaters for example to be removable and save packaging. Changes in products cost a lot of money though as we often need to have them recertified which could cost up to 6000 euros for one product.

We currently offer spare parts on some of our more expensive products. These are for example jars in blenders or lids for example. If we were to offer more spare parts we would start with those kind of items for our customers. These are the quick wins and could help customers to use the products longer. But we would not want our customers to use our products for 25 years.

We would not see customers repair their products themselves. This would legally be difficult if we would offer spare parts and something were to happen with a customer. We would rather offer spare parts like the accessories that currently come with some of our products. It would also be difficult to handle logistically. For spare parts we would like to stay in charge of quality and offer them ourselves. Currently we do not offer repairs on the products we sell to Action as they are too cheap and it is not economically feasible.

For the FRI we had to create some documents for the vacuum cleaners we sell in France. We asked our manufacturer to create these for us but they were in Chinese. If Action were to request this we could simply ask our manufacturer to do the same for the products we sell for Action.

Conclusions

All the buyers stress that it is too much info for the buyer to take into account and that buyers should stick to buying. Some say it has to be the new standard so that every product already complies. This would mean the buyers would not have to think about the repairability of products. But due to the central role buyes play in the buying possess they have to have some knowledge in repairability if this is being incorporated in Action's strategy.

According to the product techs it should be doable for suppliers, especially lager ones, to implement the repairbaility score and demand this from suppliers. The product techs agree on needing a manual that clearly lays out how the repairability index should be used for the suppliers and/or manufacturers similarly to the current supplier manual.

For the supplier filling in the needed documents should not be a problem as they will pass this allong to the manufacturer. The real problem would be the logistics of the spare parts and their willingness in supplying spare parts.

The problems that came forward during conversations with stakeholders are understandable but not unsolvable. The buyers do not want extra tasks and resist, the product techs are worried about safety of costumers and suppliers worry about

their market. These concerns make sense from their perspective but in this changing world they would have to adapt as well.

Concussion from stakeholders

All the buyers stress that the repairability index feedback system is too much info for the buyer to take into account and that buyers should stick to buying. Some say it has to be the new standard so that every product already complies. This would mean the buyers would not have to think about the repairability of products. But due to the central role buyers play in the buying possess they have to have some knowledge in repairability if this is being incorporated in Action's strategy.

According to the product techs it should be doable for suppliers, especially lager ones, to implement the repairability score and demand this from suppliers. The product techs agree on needing a manual that clearly lays out how the repairability index should be used for the suppliers and/or manufacturers similarly to the current supplier manual.

For the supplier filling in the needed documents should not be a problem as they will pass this along to the manufacturer. The real problem would be the logistics of the spare parts and their willingness in supplying spare parts.

The problems that came forward during conversations with stakeholders are understandable but not unsolvable. The buyers do not want extra tasks and resist, the product techs are worried about safety of costumers and suppliers worry about their market. These concerns make sense from their perspective but in this changing world they would have to adapt as well.

10.4 Overall conclusion

For the future vision the first concept of vertical integration resonated the best with the interviewees as it could be done without making the business model more complex and less adaptive and agile. It offers opportunity for standardization, better quality and lower prices.

It was possible to fill in the repairability index and select priority parts and determine reference values. Selecting priority parts might be bias as there is critical info missing on failure rates. Adiotionately, the values of the reference value could be more precise.

In conversations with stakeholders buyers brought up that they do not want extra tasks and resist, the product techs are worried about safety of costumers and suppliers worry about their market. These concerns make sense from their perspective but in this changing world they would have to adapt as well.

11. Conclusion

(*DPG Media Privacy Gate*, n.d.)

11. Conclusion

This chapter will go through the discussion, recommendations, conclusions and ends with a personal reflection.

11.1 Discussion

The outcome of this thesis are three important results. The first one is the focus on the product group that is most vulnerable for current and coming legislation for Action and what circular strategy should be applied. The second result is a future vision for Action towards 2035 in regard to the most vulnerable product group. The final result is a repairability index which helps to determine the repairability of energy related products.

Product group

By looking into present and upcoming legislation which could impact Action's business model the product group ErP was chosen. This product group would potentially have the biggest impact on Action's business model if this legislation is being put to action. This was determined by analyzing European legislation in comparison to what products Action sells. This product group was to be expected to have the biggest impact on the business model. However, European legislation does have uncertainty to use as a focus as many initiatives still have to be voted on by European Parliament and national governments. The right to repair proposal is for example accepted but still has to be adopted by the European Parliament and the Council (Right to Repair: Making Repair Easier for Consumers, 2023).
The outcome of this is unknown and could be stirred in different directions by lobbyists for example. This uncertainty of European legislation would always be present but could have been reduced by talking to insiders or experts to verify this direction. It could be that European law makers are more focused on reducing single use plastics for example. This would mean focusing on ErP groups would have less impact for Action. For further research this direction could be verified by talking to insiders and experts on European law.

The chosen strategy for this product group was repairability as several initiatives focus on this specific strategy. The European commission made an proposal on right to repair for example as discussed earlier. This means the same uncertainty in regard to legislation exists. But, repairability is a starting point for other CE strategies and requires fewer resources (Ruiz-Pastor & Mesa, 2023)(Cordella, 2019). Next to the uncertainty in legislation this outcome was to be expected. This uncertainty could be further reduced by talking to insiders and experts on European law.

Future vision

A future vision for Action was created using the industry vision of the European industry, European initiatives regarding circularity and Action's potential risks and their risk approach. This was used to create a future vision for Action and was tested through three interviews with managers from Action. The idea of integrating vertically and make deals with factories resonated most with interviewees as it did not further implicate Action's business model. Employees at Action can not giveaway Action's future strategy completely making them vulnerable to competitors. This could have resulted in interviewees not sharing all their knowledge in regard to strategy as the interviewer was seen as an outsider. The interviewees were from management positions from within Action. Higher ranking people from within Action such as the director of commerce were not interviewed due to unavailability but could have given more insights. Action is largely owned by 3i who might have a different agenda as Action in terms of strategy, growth and risk. 3i is a private equity group who are listed on the London stock exchange. This gives them other incentives and a more short term vision. It was not possible to interview employees of 3i. Interviewing employees from 3i would have given more insights in 3i's plans for

Action's future. As typically private equity groups focus on risk management in regard to circularity instead of value creation (Zaccone & Pedrini, 2020). Interviewing employees from 3i and higher ranking employees of Action could have given more valuable insights. The risk would still remain that they would not be willing to share everything. Interviewing these employees could strengthen or discard the chosen future direction for Action.

With Action's current business model and prices it would not be possible to offer inhouse repairs as it would be too costly in comparison to the costs of their products. As customers are only willing to spend up to 30% of the original price on repairs (Cordella et al., 2019). Increasing the quality and price significantly is not an option as not everyone can afford this (Eurostat, 2022). Therefore a collaboration is preferred with repair cafes which is already happening with Hartman for example ("Levensduur Verlengen Samen Met Repair Café," n.d.). This should be further discussed with repair cafes to ensure this collaboration. Eventually customers should be able to repair their own products. This depends on legislation as currently the interviewed supplier for example foresaw problems in regard to liability issues. This should be further covered by European or national law to be able to make this transition.

Repairability index

The future vision starts with a repairability index which is created as an excel tool to be filled in by the supplier. A guide is created for suppliers on how to fill in the repairability index. A separate guide is made for Action on how to create a repairability index per ErP group. For the buyers a feedback system of the repairability index is created to check their KPI's in regard to repairability. The repairability index is chosen as a solution as the products that are being bought need to be measured in terms of repairability and if needed be improved on certain criteria. The repairability index is inspired on the already implemented FRI and a report by Halte à l'Obsolescence Programmée who discusses its limitations (Ministère de la Transition écologique, 2022 ; HOP, 2022). The criteria are a mix from FRI, JRC (Cordella et al., 2019) and the 45554 standard (NEN, 2020a). By setting a goal for the repairability index the right criteria can be chosen from the proposed criteria. A standard selection is suggested for Action's products which are the disassembly, spare parts and documentation. The use of standards, already implemented indexes and their limitations makes for a well chosen set of criteria. Together with the index guide the repairability index could potentially be used for other retailers as well.

The repairability index was tested by creating a repairability index for one product group and tested by filling it in. The criteria can change if this is needed when problems come up or the goal changes. When the repairability index was filled in no major flaws regarding the criteria were discovered. Penalties had to be given in the disassembly time if a part was not removable to make the repairability index useable. No further flaws were discovered.

Selecting the priority parts proved to be hard as limited information was available on failure rates. By using data from the repair monitor it was possible to select priority parts. However, this information comes from repair cafes all over the world and is not completely trustworthy. The problems indicated by repairers might be due to other causes or unknown. It was the best data available but if Action were to collect data themselves in the future a trustworthy source of data could be generated.

One of the criteria in the repairability index is the disassembly depth. When filling in the repairability index for grills the disassembly depth turned out to be quite low. This makes it hard to improve and easy to do worse on the disassembly depth for this ErP group. The goal of measuring the disassembly depth is quantifying the ease of disassembly. This is also covered by the disassembly time, but the disassembly depth could give insights on why the disassembly takes long. Therefore it might not be needed to use the disassembly depth in the repairability index but rather focus on the disassembly time.

The repairability index focusses on the disassembly of a product and how long this takes. What is left out of scope is how long it takes to put a product back together (reassembly time). As this is the eventual goal this is something that could be taken into account but has to further researched as it is not mentioned by JRC, FRI, HOP or the 45554 standard. The possibility is taken into account with the type of fasteners used but not how much time it would take. Further research into the reassembly time would be needed to conclude if it should be implemented in the repairability index.

In the use case of the grill the heating element and grill were not separable in any of the products. This was seen as one part but eventually it would be preferable if this was not the case. It was mentioned that Action eventually might move to this standard but there is no stimuli if a supplier would already decide on doing this. This could be done by giving out ErP group specific bonus points which is also used in the FRI. This was only the case for this specific ErP group, if it would occur in more product groups it could be implemented in the repairability index. More indexes for more ErP groups have to be made to conclude this.

The filled in repairability index was discussed with three relevant product techs and one supplier. The repairability index feedback system was tested with three buyers. All the buyers stressed that the feedback system is too much info for the buyer to take into account and that buyers should stick to buying. This was not expected as the feedback system is limited to only showing the end results, outliers and knock-out criteria. Buyers were only shown the feedback system and not the future vision from which the repairability index is a part of. This would have cost too much time to explain to the buyers as they had limited time. It was hard to ask them feedback just about the repairability index as the buyers were asking about details on who would repair the products for example. Additionally, the buyers were overloaded with numbers and found the table overwhelming. This could be prevented by giving the buyers a short presentation about how the repairability index would be used to give them a better understanding. It was chosen not to do this as the buyers wanted to focus on buying. Explaining this to the buyers could give different results on the repairability index feedback system. The product techs stated that the repairability index would be doable for suppliers and product techs as expected. However, the product tech and supplier showed concerns about legasl aspects of customer repairs. This should be covered by European law in the future as mentioned in the roadmap. The supplier faced a similar problem as the buyer for wanting to know the framework in which the repairability index would work. But they showed that they could do this by sharing examples on how they filled in the FRI for some of their vacuums. They indicated that delivering spare parts would be hard for them but this is further discussed in the recommendations section.

If the repairability index together with the repairability index feedback system were to be implemented it should first be trialed with one ErP group to further test its function. By doing this it can be tested if the index and supplier guide are clear enough for product techs and suppliers and if filling in the repairability index works. The effects can be measured by tracking the repairability of this ErP group. This helps in testing if the buyer would actually use the feedback system and what might need to be changed. When it works the repairability index could be recreated in an other program than excel to give a more seamless experience.

11.3 Recommendations

During this thesis the product group ErP was chosen as most vulnerable product group of Action. The way legislation aims to solve this is through repairability. While a lot of initiatives point in this direction it could be further verified by talking to experts on European law.

Action is largely owned by 3i who might have different opinions about the future of Action as well as higher management within Action. The chosen direction could be further verified by talking to employees of 3i and higher management within Action.

To be able to repair products affordable it was chosen to collaborate with repair cafes. Although this has happened before, their willingness to collaborate should be further discussed to ensure this.

During the creation of a repairability index it turned out that little information about the products Action sells is available. To be able to determine the priority parts of products the failure rates should be known. Action should generate this information which could be done through the product passport as discussed in the future vision.

While filling in the repairability index it turned out the disassembly depths for one product group were quite low making them less useful for the repairability index. Additionally, the disassembly depth is partly covered by the disassembly time. It does however help suppliers in improving their products. It should be further tested if other ErP groups have more disassembly steps and how this influences the repairability score. Secondly, suppliers should be asked if the disassembly depth helps them in improving their products, other ways it could be left out of the repairability index.

As mentioned in the discussion the reassembly time might be interesting for the repairability as it could hold valuable information about how the product is put together. This can be further tested and potentially be added to the repairability index.

While testing the repairability index some parts were not removable from each other but should be. A bonus system could work in this situation if a manufacturer can already do this. It could be further researched how this could be implemented in the repairability index to aim for better products.

The logistics of spare parts are difficult and as price is key it should be researched what the cheapest option is. Several options could be shipping it to repair cafes, Action stores or customers directly. This should be researched to fully implement the repairability index in the near future.

For the full implementation of the repairability index a trial should be held with one ErP group to see if Action is able to create a repairability index using the index guide. Secondly, should it be tested if the supplier is able to fill in the repairability index using the supplier guide.

During this thesis some findings were out of scope for this project but were worth noticing for further research.

The scope of this project was the repairability of products. This left other strategies out of scope as repairability enables other strategies like remanufacturing and refurbishing. This can be further studied in the future and be added to the repairability index. In one of the grills for example a weight was found which could be removed to reduce weight.

Action sells a lot of products that are similar but look slightly different. A good example is the variety of solar lights they sell. The reason for this is to surprise the customer. If Action could make a basic solar light on which different decorations could be added they would only need a minimal amount of solar lights with a wide variety of decorations. This makes it easier to supply spare parts as there are viewer to supply. These modular designs could help Action keep their surprise factor towards customers while becoming more circular.

11.2 Conclusion

This research aimed to help Action in becoming circular to stay resilient with present and foreseeable legislation. This is due to the European Union, countries and companies taking steps towards a CE (Circular Economy). Additionally, Action is facing ending geographical expansion in Europe in which circularity could play an important role. Using the double diamond method the most vulnerable product group and corresponding circularity strategy was selected.

The first diamond was used to select a product group to focus on and what strategy should be applied. The focus of legislation lies in durability, repairability, upgradeability, maintenance, reuse and recycle. There is also specific legislation for repairability like Right to Repair which still has to be adopted by the European Parliament and Council. How this exactly is going to look like is still a bit uncertain and could be further verified. Repairability itself is a starting point for other CE strategies like the previously mentioned ones. But repairability requires significantly less resources compared to other strategies. Repairability, reliability and upgradeability are tightly related durability aspects for extending a product's service life. This means that designing for repairability can also benefit reliability.

Electrical and Electronic equipment is the most vulnerable product group to legislation and is forcing Action to take responsibility after an electrical and/or electronic product has been sold. Additionally, Electrical and Electronic equipment (commonly referred to as Energy Related Products; ErP) is the fastest growing waste stream and expected to double by 2045. ErP have the biggest potential to reduce CO2 emissions and contains hazardous substances. Therefore, Action should focus on selling repairable ErP as a step towards circularity. While a lot of initiatives point in this direction it could be further verified by talking to experts on European law.

Besides the Sustainability team, repairability is not common knowledge within Action. The buyer has a lot of power in making decisions but is lacking the knowledge of making decisions in terms of circularity. The problem that needs to be solved is that the buyer is making decisions on purchasing ErP products while lacking repairability knowledge. This is solved in the last diamond of the double diamond technique.

To help Action stay resilient with present and foreseeable legislation a repairability index is made which Action can use to quantify the repairability of products. This repairability index is specific for every ErP group and needs to be created by Action.

This is made possible through an index guide that helps to select priority parts and reference values for the repairability index of every specific ErP group. Suppliers can fill in the repairability index using the supplier guide. A repairability index feedback system is used by the buyers to keep track of the repairability of the products they buy and to improve this. In the development of the repairability index the reassembly time is left out of scope but could be implemented as it could provide important information. It could even replace the disassembly depth but this has to be further verified. A system with bonus points could also stimulate suppliers to already start improving their products. Selecting priority parts was hard due to limited available information but could be covered in the future if Action generates this information through manufacturers and product passport.

The repairability index is accompanied by a future vision which aims that Action has build a vibrant ecosystem through innovative partnerships and collaborations in 2035, where Action works together with its manufacturers, repairers and customers to create a circular future where customers are empowered to repair Action's durable products more easily. Getting to the future vision is explained through a roadmap with three horizons. In the first horizon the repairability index will be introduced. In the second horizon will repair cafes start doing repairs and in the third horizon the repairs are being done by customers themselves. This should be further confirmed with Action’s partly owner 3i to see if they want to focus on risk management or value creation. Due to Action’s low prices repairs have to be outsourced first to repair cafes and later to customers. Further legislation is needed to ensure liability of customers repairing products themselves. The cheapest way to supply spare parts to repair cafes or customers should be further researched.

The repairability index was validated by doing a case study to see if it works and can be used while discussing it with product techs, buyers and a supplier. The suppliers and product techs indicated that they could fill in the required

information but were concerned legal aspects of customer repairs. The repairability index feedback system was validated by buyers who found it overwhelming at first. In the validation it was found that a bonus system could potentially further stimulate suppliers to already improve their products. This should be further tested with other ErP groups to verify. The future vision was validated by interviewing managers from Action to see if it resonated with them. The idea of integrating vertically and reduce the price of (spare) parts and increase the availability for customers resonated with them.

For full implementation of the repairability index a trial should be held with one ErP group to test the index guide and supplier guide further in practice. In the future Action could look into expanding the repairability with more criteria to cover other circularity strategies as well. Additionally, they could look into reducing the variety in their assortment by making products more modular. This system of repairability index, future vision, roadmap, suppliers guide, index guide and repairability index feedback system should help Action in becoming circular to stay resilient with present and foreseeable legislation.

11.4 Personal reflection

I originally embarked on this journey because I did not understand why my dryer was so hard to repair myself. This became one of my goals for my thesis: Have a deep understanding of circular design. My other goals were conducting and analyzing qualitative interviews and improving my visual language.

During this process I really dove into circularity learning the basics and some specific techniques. I saw how some companies were trying to focus on circularity but were only cutting materials and saving costs. The importance of closing the loop is often left out of scope as this requires more investments and does not end up in financial gain right away. This financial gain made it hard for me to wrap my head around a circular economy in our capitalistic system. I was really interested in how our monetary system works and how a circular economy would fit in this system. This made it hard for me to make decisions as Action is heavily invested in this monetary system through their exposure to the investment world through 3i. By letting this go and think of an ideal solution I was able to continue my process.

My second goal was to conduct and analyze interviews. The interviews were different from the ones I did at my previous internships. In my previous internship we interviewed random people about what they thought of sustainability and why. These people had less interest in giving “good” answers or give critiques. People from Action were more careful in what they said as they were being interviewed. I noticed for example that recording the interview did not work as people were not completely open as compered to writing down what was being said. This meant I had to change how I was doing the interviews by writing everything down in the moment while having a conversation and asking the right questions. This was challenging at first and resulted in missing some quotes. But I could still write down the essence of the interview. This is a new way of interviewing as I had done before but I know how to tackle this if I were to encounter this again.

My final goal was to improve my visual language as this is not my strength. I did this by making a visual of the buying process at Action which I unfortunately could not use due to confidentially. I tried to make this report visually pleasing as well by keeping it simple and making a draft layout. This helped me to keep the report consistent and readable. My visual language will never be my strongest skill but I think I am able to develop an esthetically pleasing report by now. This certainly was one of my goals as I was never good at this.

On a more personal note, I came to realize that conducting a project for so long by myself is not my thing. I missed the discussion on what to do and how other people look at problems I face. This usually really helps me in getting new insights. I tried to do this with fellow students which helped me sometimes, but it was impossible for them to know everything. Despite this I managed to finish my thesis but working together with other people on a problem gives me energy and has my preference in the future.

In my process I experienced some other things about myself which I encountered in my previous internship as well. I find it to be hard to make decisions which did not help when having such a wide scope. I want to be 100% certain about my decisions but this is not always possible. I also struggle with relevance of importance. Some chapters were way to elaborate aiming at being 100% certain about my decisions. I think I eventually managed to fix this, but the process took a long time resulting in a lot of unused text. I can also be messy or unorganized which I tried to minimize by summarize meetings or interviews right after they were finished. At some times I lost the overview a bit but that could be due to the size of the project.

Finally, I think I can answer why my dryer is so hard to repair. Manufacturers want to repair their products themselves to ensure quality and mitigate responsibility for faulty customer repairs.

12. References

(SOEQ, 2023)

3i. (2023). *Annual Report 2023*. Retrieved June 2, 2023, from https://www.3i.com/investor-relations/annual-report-2023/

Action. (2020). *Update 2020*. Retrieved June 1, 2023, from https:////company.action.com/wp-content/uploads/2021/03/action-update2020.pdf

Action. (2021). *30 jaar Action*. 30 jaar Action.

Action. (2022). *Action risk overview 2022*. Retrieved June 2, 2023, from https://data.maglr.com//3475/issues/41768/519358/downloads/action_annual_report_-_risk_overview2.pdf

Action. (2023). *Future. Update 2022*. https://update2022.action.com/update2022/future

A European Green Deal. (2021, July 14). *European Commission*. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Amfori. (2018). *amfori BSCI System Manual Part II*.

Awasthi, A. K., Li, J., Koh, L., & Ogunseitan, O. A. (2019). *Circular economy and electronic waste*. https://www-nature-com.tudelft.idm.oclc.org/articles/s41928-019-0225-2

Bakker, C. (z.d.). The Circular Economy Show Podcast | Ep 99 (Ellen Macarthur Foundation). *Ellen Macarthur Foundation*. https://the-circular-economy-podcast.simplecast.com/episodes/the-circular-economy-and-repair-Anu7ymla

Bakker, C., De Pauw, I., & M.P. Bocken, N. (2015, April 12). *Product design and business model strategies for a circular economy*. Retrieved March 1, 2023, from https://www.rescoms.eu/assets/downloads/Business-models-and-design-for-a-closed-loop-FINAL.pdf

Bakker, C., Hollander, M. D., Van Hinte, E., & Zijlstra, Y. (2014). *Products that Last: Product Design for Circular Business Models*.

Beekman B.V. (n.d.). *Tefal GC241D24/J5 CONTACT GRILL PANINI GRILL*. Retrieved July 13, 2023, from https://www.beekman.nl/c/onderdelen-koken/tefal/grill/tefal-gc241d24j5-contact-grill-panini-grill-8000036212-2081518

Bracquené, E., Brusselaers, J., Dams, Y., Peeters, J., De Schepper, K., Duflou, J., & Dewulf, W. (2018). Repairability criteria for energy related products. *In benelux.int*. https://www.benelux.int/files/7915/2896/0920/FINAL_Report_Benelux.pdf

Campbell-Johnston, K., Vermeulen, W. J., Reike, D., & Brullot, S. (2020). The Circular Economy and Cascading: Towards a Framework. *Resources Conservation & Recycling X*, *7*, 100038. https://doi.org/10.1016/j.rcrx.2020.100038

Circle Economy. (2020). *Action Circle Scan: Embedding circularity in a surprising and affordable formula*. Unpublished internal company document.

Cordella, M., Alfieri, F., & Sanfelix, J. (2019). Analysis and development of a scoring system for repair and upgrade of products. European Commission, Joint Research Centre, Seville, Spain.

Corporate sustainability reporting. (n.d.). Finance. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

Dao, T., Cooper, T., & Wattkins, M. (2021). Business Innovation for Product Repairability: Implications for Future Policies. *In Plate*. Retrieved June 7, 2023, from https://irep.ntu.ac.uk/id/eprint/44265/1/1472727_Watkins.pdf

De Fazio, F., Bakker, C., Flipsen, B., & Balkenende, R. (2021). The Disassembly Map: A new method to enhance design for product repairability. *Journal of Cleaner Production, 320*, 128552. https://doi.org/10.1016/j.jclepro.2021.128552

Deloitte Sustainability. (2016). *Study on socioeconomic impacts of increased reparability Final report*.

Design Council. (n.d.). *The Double Diamond - Design Council*. Retrieved June 18, 2023, from https://www.designcouncil.org.uk/our-resources/the-double-diamond/

Digital Product Passport. (2023, May 11). *European Health and Digital Executive Agency (HaDEA)*. Retrieved June 2, 2023, from https://hadea.ec.europa.eu/calls-proposals/digital-product-passport_en#description

European Commission. (2018). *A European Strategy for Plastics in a Circular Economy*. Retrieved April 23, 2023, from https://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_1&format=PDF

European Commission. (2019). *The European Green Deal*. Retrieved April 23, 2023, from https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

European Commission. (2020a, March 11). *A new Circular Economy Action Plan For a cleaner and more competitive Europe*. Retrieved April 7, 2023, from https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF

European Commission. (2020b). *A New Industrial Strategy for Europe*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0102

European Commission. (2021). *Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery*. Retrieved June 2, 2023, from https://commission.europa.eu/system/files/2021-05/communication-industrial-strategy-update-2020_en.pdf

European Parliament. (2022). *Right to repair*. Retrieved March 24, 2023, from https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698869/EPRS_BRI%282022%29698869_EN.pdf

European Parliament. (2021). *New circular economy action plan*. Retrieved April 23, 2023, from https://www.europarl.europa.eu/RegData/etudes/ATAG/2021/679066/EPRS_ATA(2021)679066_EN.pdf#:~:text=In%20its%202020%20resolution%20on%20the%20European%20Green,also%20recommending%20combining%20circular%20economy%20and%20digital%20solutions.

European Parliament & Council of the European Union. (2009). *DIRECTIVE 2009/125/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL*. Retrieved April 23, 2023, from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0125
http://data.europa.eu/eli/dir/2009/125/oj

European Parliament and of the Council (2019), *Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment* . Retrieved April 23, 2023, from https://eur-lex.europa.eu/eli/dir/2019/904/oj

European Parliament & Council of the European Union. (2011). *DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL*. Retrieved April 23, 2023, from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0065
http://data.europa.eu/eli/dir/2011/65/oj

European parliament & Council of the European Union. (2018). *DIRECTIVE (EU) 2018/849 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL*. Retrieved April 23, 2023, from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0849

European parliament & Council of the European Union. (2012). *DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL*. Retrieved April 23, 2023, from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0019

European Union. (n.d.). *Types of legislation | European Union*. Retrieved April 23, 2023, from https://european-union.europa.eu/institutions-law-budget/law/types-legislation_en

European Union. (2014). *Frequently Asked Questions on Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE)*. Retrieved April 23, 2023, from https://ec.europa.eu/environment/pdf/waste/weee/faq.pdf

European Union. (2020). *new Circular Economy Action Plan*. Retrieved April 23, 2023, from https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf

European Parliament (2023) *Circular Electronics Initiative March 2023*. Retrieved April 23, 2023, from https://www.europarl.europa.eu/legislative-train/carriage/circular-electronics/report?sid=6801

Eurostat. (2022, September). Living conditions in Europe - poverty and social exclusion. *Eurostat*. Retrieved June 4, 2023 from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_poverty_and_social_exclusion&oldid=584082#Poverty_and_social_exclusion

Ellen MacArthur Foundation. (2013). *Towards the circular economy: Economic and business rationale for an accelerated transition*. Retrieved March 1, 2023, from https://emf.thirdlight.com/file/24/xTyQj3oxiYNMO1xTFs9xT5LF3C/Towards%20the%20circular%20economy%20Vol%201%3A%20an%20economic%20and%20business%20rationale%20for%20an%20accelerated%20transition.pdf

Ellen MacArthur Foundation. (2021). *France's Antiwaste and Circular Economy Law: eliminating waste and promoting social inclusion*. Retrieved May 4, 2023 from https://emf.thirdlight.com/file/24/kLSzgopkL.2CJxQkLb3XkLQlS7_/Case%20Studies%20-%20French%20Anti%20Waste%20Law.pdf

Fifield, B., & Medkova, K. (2016, January 1). Circular Design - Design for Circular Economy. *ResearchGate*. https://www.researchgate.net/publication/313771263_Circular_Design_-_Design_for_Circular_Economy

FixPart. (n.d.). *FixPart - Tefal GC241D12/J5 (PANIN) grill onderdelen*. Retrieved July 13, 2023, from https://fixpart.nl/nl/typenummer/tefal/gc241d12-j5-panin?page=1

Flipsen, B., Bakker, C., & Van Bohemen, G. (2016). *Developing a Reparability Indicator for Electronic Products (Inventing Shades of Green)*. https://ieeexplore-ieee-org.tudelft.idm.oclc.org/stamp/stamp.jsp?tp=&arnumber=7829855&tag=1

Flipsen, B., Bakker, C., & Pauw, I., de. (2020). *Hotspot Mapping for product disassembly; a circular product assessment method*. circonl.nl. Retrieved February 27, 2023, from https://www.circonl.nl/resources/uploads/2022/02/EGG20-Hotspot-Mapping.pdf

Geng, Y., & Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving "leapfrog development." *International Journal of Sustainable Development and World Ecology, 15*(3), 231–239. https://doi.org/10.3843/susdev.15.3:6

Geissdoerfer, M., Morioka, S. N., De Carvalho, M. M., & Evans, S. (2018). Business models and supply chains for the circular economy. *Journal of Cleaner Production, 190,* 712–721. https://doi.org/10.1016/j.jclepro.2018.04.159

Geissdoerfer, M., Savaget, P., Bocken, N., & Hultink, E. J. (2017). The Circular Economy – *A new sustainability paradigm? Journal of Cleaner Production, 143,* 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Handyman. (n.d.). Handyman. Handyman. Retrieved July 13, 2023, from https://www.handyman.nl/merken/tristar/

HOP. (2022). *The French repairability index: A first assessment – one year after its implementation*. Retrieved June 10, 2023, from https://www.halteobsolescence.org/wp-content/uploads/2022/02/Rapport-indice-de-reparabilite.pdf

Hughes, R. a. C. (2017). The EU Circular Economy Package – Life Cycle Thinking to Life Cycle Law? *Procedia CIRP, 61*, 10–16. https://doi.org/10.1016/j.procir.2016.12.006

Jones, P., & Van Ael, K. (2022). *Design Journeys Through Complex Systems: Practice Tools for Systemic Design*.

Jonker, J., Faber, N., & Haaker, T. (2022, January 31). *Classificatie Circulaire Businessmodellen*. Retrieved March 22, 2023, from https://circulairemaakindustrie.nl/app/uploads/2022/02/Whitepaper-Classificatie-Circulaire-Businessmodellen_CTF.pdf

Kirchherr, J., Reike, D., & Hekkert, M. P. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources Conservation and Recycling, 127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Mano, J. F., Miguel, M., Van Langen, S. K., Ncube, A., Zucaro, A., Fiorentino, G., Passaro, R., Santagata, R., Coleman, N., Lowe, B., Ulgiati, S., & Genovese, A. (2021). Circular Economy and the Transition to a Sustainable Society: Integrated Assessment Methods for a New Paradigm. *Circular Economy and Sustainability, 1(1)*, 99–113. https://doi.org/10.1007/s43615-021-00019-y

Meadows, D. H. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing.

Ministère de la Transition écologique. (2022). *Instructions manual for the display and the calculation of the repairability index of electrical and electronic equipments*. Retrieved June 10, 2023, from https://www.ecologie.gouv.fr/sites/default/files/220523_instructions%20manual%20-%20repairability%20index%20-%20final%20V3.0.pdf

Ministerie van Algemene Zaken. (2022, January 19). *Voortgangsrapportage circulair textiel. Kamerstuk* | Rijksoverheid.nl. https://www.rijksoverheid.nl/documenten/kamerstukken/2021/05/20/voortgangsrapportage-circulair-textiel

Ministerie van Infrastructuur en Waterstaat. (2023, February). *Nationaal Programma Circulaire Economie*. Retrieved March 24, 2023, from https://www.rijksoverheid.nl/documenten/beleidsnotas/2023/02/03/nationaal-programma-circulaire-economie-2023-2030

Ministerie van Infrastructuur en Waterstaat. (2023a, February 6). *Nederland circulair in 2050*. Circulaire Economie | Rijksoverheid.nl. Retrieved March 24, 2023, from https://www.rijksoverheid.nl/onderwerpen/circulaire-economie/nederland-circulair-in-2050

Morseletto, P. (2020). Targets for a circular economy. *Resources Conservation and Recycling, 153,* 104553. https://doi.org/10.1016/j.resconrec.2019.104553

Moreno, M., De Los Rios, C., Rowe, Z. O., & Charnley, F. (2016). A Conceptual Framework for Circular Design. *Sustainability, 8(9),* 937. https://doi.org/10.3390/su8090937

NEN. (2020a*). NEN-EN 45554: General methods for the assessment of the ability to repair, reuse and upgrade energy-related products* (EN 45554:2020 E).

NEN. (2020b*). NEN-EN 45552: General method for the assessment of the durability of energy-related products* (EN 45552:2020 E).

Onderdelen.nl. (n.d.). *Tefal GC241D24/J5 CONTACT GRILL PANINI GRILL*. Retrieved July 13, 2023, from https://www.onderdelen.nl/onderdelen-koken/tefal/grill/tefal-gc241d24j5-contact-grill-panini-grill-8000036212-2081518

Onderdelenplanet.nl. (n.d.). *TEFAL - GC241D12J5 PANIN onderdelen*. Retrieved July 13, 2023, from https://onderdelenplanet.nl/grill/tefal/gc241d12j5-panin?searchterm=&categorie=&pagina=2

Parajuly ,K., Kuehr,R. ,Awasthi, A.K., Fitzpatrick, C., Lepawsky, J., Smith, E., Widmer, R., Zeng, X., (2019) . Future E-Waste Scenarios. StEP(Bonn), *UNUViE-SCYCLE (Bonn) & UNEPIETC (Osaka).* https://collections.unu.edu/eserv/UNU:7440/FUTURE_EWASTE_SCENARIOS_UNU_190829_low_screen.pdf.

PartsNL. (n.d.). *Tefal GC241D24/J5 CONTACT GRILL PANINI GRILL*. Retrieved July 13, 2023, from https://www.partsnl.nl/onderdelen-koken/tefal/grill/tefal-gc241d24j5-contact-grill-panini-grill-8000036212-2081518

Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, *135– 246–264*, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Repair monitor (31_03_2023). (unpublished). [Dataset]. RepairMonitor. https://www.repairmonitor.org/nl

Right to repair: Making repair easier for consumers. (2023, March 23). European Commission. Retrieved July 27, 2023, from https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1794

Ruiz-Pastor, L., & Mesa, J. (2023). Proposing an integrated indicator to measure product repairability. *Journal of Cleaner Production, 395, 136434.* https://doi.org/10.1016/j.jclepro.2023.136434

The Ellen MacArthur Foundation. (n.d.). *The butterfly diagram: visualising the circular economy*. Retrieved April 7, 2023, from https://ellenMacArthurfoundation.org/circular-economy-diagram

Van Boeijen, A., Daalhuizen, J., Van Der Schoor, R., & Zijlstra, J. (2014). Delft Design Guide: Design Strategies and Methods. *Bis Pub*.

Van De Hulsbeek, J. (2023, March 22). Brussel: kapotte spullen repareren moet makkelijker worden. *NOS*. https://nos.nl/artikel/2468497-brussel-kapotte-spullen-repareren-moet-makkelijker-worden

Valls-Val, K., Ibáñez-Forés, V., & Bovea, M. D. (2023). Tools for assessing qualitatively the level of circularity of organisations: Applicability to different sectors. *Sustainable Production and Consumption, 36, 513–525*. https://doi.org/10.1016/j.spc.2023.01.023

Vanessa Forti, V., Balde, C. P., Kuehr, R., & Bel, G. (2020). *The Global E-waste Monitor 2020*. Retrieved April 7, 2023, from https://www.researchgate.net/profile/Vanessa-Forti/publication/342783104_The_Global_E-waste_Monitor_2020_Quantities_flows_and_the_circular_economy_potential/links/5f05e6c0458515505094a3ac/The-Global-E-waste-Monitor-2020-Quantities-flows-and-the-circular-economy-potential.pdf

Vergara, M., Braulio-Gonzalo, M., Juan, P., & Bovea, M. D. (2017). Consumer attitude towards the repair and the second-hand purchase of small household electrical and electronic equipment. A Spanish case study. *Journal of Cleaner Production*, 158, 261–275. https://doi.org/10.1016/j.jclepro.2017.04.143

WBCSD. (2022, May). *CIRCULAR TRANSITION INDICATORS V3.0 Metrics for business, by business*. wbcsd.org. Retrieved February 27, 2023, from https://www.wbcsd.org/contentwbc/download/14172/204337/1

WBCSD. (2021, February 1). *Circular Transition Indicators v2.0 – Metrics for business, by business - World Business Council for Sustainable Development (WBCSD)*. World Business Council for Sustainable Development (WBCSD). Retrieved February 27, 2023, from https://www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Resources/Circular-Transition-Indicators-v2.0-Metrics-for-business-by-business

Wigand, C. (2023, March 22). *Recht op reparatie: Commissie introduceert nieuwe consumentenrechten voor gemakkelijke en aantrekkelijke reparaties*. European Commission - European Commission. Retrieved March 24, 2023, from https://ec.europa.eu/commission/presscorner/detail/nl/ip_23_1794

Zaccone, M. C., & Pedrini, M. (2020). ESG Factor Integration into Private Equity. *Sustainability*, 12(14), 5725. https://doi.org/10.3390/su12145725

Image references

Alexandru, C. (2023, June 14). *Light Circles around Trees · Free Stock Photo*. Pexels. https://www.pexels.com/photo/light-circles-around-trees-17127003/

Berlier, E. (2023, May 25). Le magasin Action d'Hornu déménage. . . De l'autre côté de la rue. *DHnet*. https://www.dhnet.be/regions/mons/borinage/2023/05/25/le-magasin-action-dhornu-demenage-de-lautre-cote-de-la-rue-U6PL3S6ISJH25AXDJSM5BWCLXU/

Bolovtsova, E. (2020, December 4). *Brown and Gold gavel on brown wooden Table · Free Stock photo*. Pexels. https://www.pexels.com/photo/brown-and-gold-gavel-on-brown-wooden-table-6077189/

DPG Media Privacy Gate. (n.d.). https://www.deondernemer.nl/innovatie/groei/action-winkels-europa-italie-spanje-frankrijk~4512373?referrer=https%3A%2F%2Flens.google.com%2F

Facebook. (n.d.). https://www.facebook.com/kwinkelier/?locale=it_IT

Grabowska, K. (2020, June 2). *Set of glass tube in laboratory · Free Stock Photo*. Pexels. https://www.pexels.com/photo/set-of-glass-tube-in-laboratory-4021793/

King, C. (2018, July 5). *Black and Silver DSLR lens · Free Stock Photo*. Pexels. https://www.pexels.com/photo/black-and-silver-dslr-lens-1208074/

Lieman, R. (n.d.). *Dossier Action: undercover in het distributiecentrum | Noordhollands Dagblad | door Rens Lieman*. Rens Lieman.nl. https://renslieman.nl/artikelen/noordhollands-dagblad/dossier-action-undercover-in-het-distributiecentrum-zwaagdijk-polen-fnv/120

Longas, M. (2019, October 30). *Close-Up photo of yellow tape measure · Free stock photo*. Pexels. https://www.pexels.com/photo/close-up-photo-of-yellow-tape-measure-3143085/

Lusina, A. (2020, September 28). *Anonymous female showing light bulb · Free Stock Photo*. Pexels. https://www.pexels.com/photo/anonymous-female-showing-light-bulb-4792503/

Shaffer, E. (2020, October 4). *Diamond On White Surface · Free Stock Photo*. Pexels. https://www.pexels.com/photo/diamond-on-white-surface-4997548/

SOEQ. (2023, July 18). *Action Tilburg Centrum – SOEQ*. https://soeq.nl/q/action-tilburg-centrum/

Stories, D. (2021, February 28). *Green and pink post it posted on white surface · Free stock photo*. Pexels. https://www.pexels.com/photo/green-and-pink-post it-posted-on-white-surface-6991872/

13. Appendix

(Lieman, n.d.)

13.1 Project brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Rademakers

initials: M.O. given name: Max

student number: 4663349

street & no.:

zipcode & city:

country:

phone:

email:

Your master programme (only select the options that apply to you):

IDE master(s): ( ) IPD ( ) DfI (★) SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: ( ) Honours Programme Master

specialisation / annotation: ( ) Medisign ( ) Tech. in Sustainable Design ( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: dept. / section: SDE-CPD

** mentor: Sander Mulder dept. / section: DOS-MOD

2nd mentor: Fabeel Butt

organisation: Action

city: Zwaagdijk country: Netherlands

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

Procedural Checks - IDE Master Graduation

TU Delft

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair _____ date ___-___-___ signature _____

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: _____ EC

Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC

List of electives obtained before the third semester without approval of the BoE

★ YES all 1st year master courses passed

NO missing 1st year master courses are:

name _____ date ___-___-___ signature _____

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: APPROVED NOT APPROVED

Procedure: APPROVED NOT APPROVED

comments

name Bas Flipsen date 24 - 2 - 2023 signature 

Initials & Name M.O. Rademakers Student number 4663349

Title of Project Making the shift towards a circular business strategy

Personal Project Brief - IDE Master Graduation

TU Delft

Making the shift towards a circular business strategy — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 13 - 02 - 2023 — 06 - 30 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Sustainability is the practice of meeting current needs without compromising the ability of future generations to meet their own needs. It is crucial for addressing environmental issues such as climate change, resource depletion, and waste accumulation. Implementing sustainable practices in products, systems, and processes can reduce dependence on finite resources, decrease greenhouse gas emissions, and improve overall environmental health. Not only is sustainability important for the future of our planet, but it also can lead to cost savings and increased efficiency in the long run. It is essential to act now to implement sustainable practices and create a more sustainable future for all.

This project will focus on Action, an international discount store that sells a wide range of products. Currently, Action operates over 2000 stores in countries throughout Europe and online, with a revenue of over 5.6 billion euros in 2020.

The demand for more sustainable products and willingness to pay for sustainability is increasing among customers (Simon-Kucher & Partners, 2021). This creates a need for products that have a lower impact on the environment and are comprehensible to customers. Next to the need from the customers perspective there is legislation on the way which requires more transparent reporting regarding sustainability for businesses (Chirez & Stuckens, 2021).

As a discount store, Action does not have a reputation for selling highly sustainable products. If Action can shift towards a more sustainable future throughout their product range, it can improve their reputation and possibly ensure their market position for the coming years. This is one of Action's goals as well: "make sustainability accessible." Action wants to invest in social compliance, materials, packaging, and circularity to make sustainability accessible.

Currently, Action purchases a majority of their products from wholesalers and manufacturers from all over the world. However, it is difficult to determine how circular products are being designed as this is currently not a widely used concept among manufacturers. Currently, the biggest driver while developing new products is price, not circularity.

In order to help Action become more circular, a framework on how to purchase circular products for their inventory would be helpful in order to make the shift towards making sustainability accessible.

Chirez, S., & Stuckens, J. (2021, August 27). How will upcoming EU legislation on sustainability reporting benefit your business? https://www.ey.com/en_be/climate-change-sustainability-services/how-will-upcoming-eu-legislation-on-sustainability-reporting-benefit-your-business
Simon-Kucher & Partners. (2021). Global Sustainability Study 2021. https://www.simon-kucher.com/en. Retrieved January 25, 2023, from https://www.simon-kucher.com/sites/default/files/studies/Simon-Kucher_Global_Sustainability_Study_2021.pdf

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: A discription on how sustainability is a part of Actions strategy

image / figure 2: The 4 pillars Action is currently focussing on in terms of sustainability

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The problem for Action is that the majority of their product inventory is not circular despite increasing needs for affordable sustainable products.

Action already focusses on social compliance and packaging, but to a lesser extent to materials and circularity, therefore this project will focus on these last two categories.

Currently products are resourced from various distributors around the globe. Some products are bought directly from suppliers which gives Actions some leverage to demand more circulair designs. Other products are bought from wholesalers which gives less room to manouver in terms of circularity. Addressing the wide range of suppliers and the possibility for change will be challenging for this project.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Create a framework that guides Action in determining circular compliance of products in order to develop a circular business strategy.

To be able to solve this problem a set of current products from different product categories will be analysed in order to determine in which category the biggest impact can be made. This will be done in collaboration with the course Repair taught by Bas Flipsen in order to gather more information.

Within the selected category a deeper analysis will be conducted in order to map the most significant problems in terms of circulairity and how to tackle these. If these problems are known, a solution can be created on how to avoid or improve products that suffer from these types of problems.

The emphasis of the framework could be towards what sort of products Action buys, how the customers use and discard these product or a combination of both. The solution should contribute to a more circular business strategy for Action.

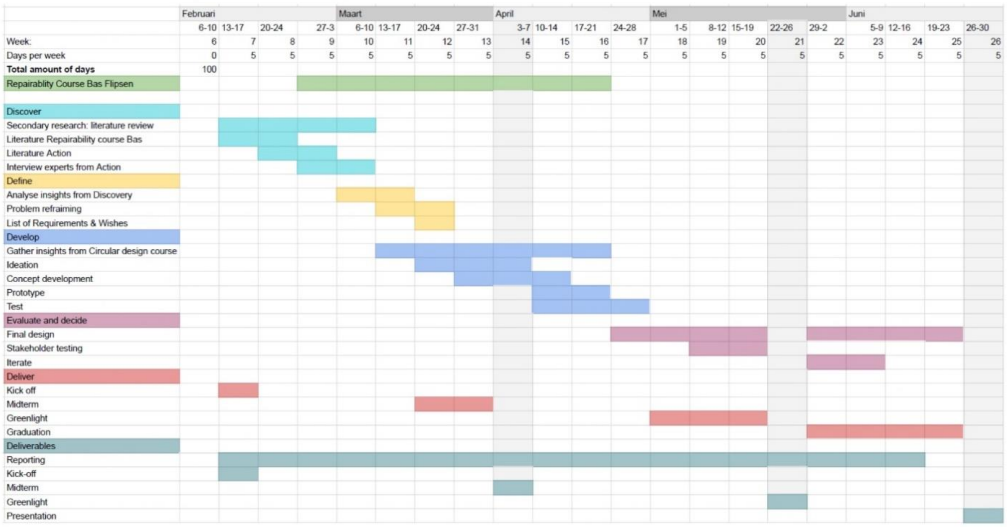
Initials & Name M.O. Rademakers Student number 4663349

Title of Project Making the shift towards a circular business strategy

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 13 - 2 - 2023 6 - 30 - 2023 end date



This project will follow the double diamond approach with an extra iteration at the end in order to implement the gathered insights from the previous stakeholder testing. The project will begin with the discovery phase where a literature review about circularity will be conducted. Simultaneously desk research of the previously mentioned repair course and Action will be conducted as well as expert interviews with employees from Action. The key things I want to know from Action are: What entails purchasing at Action currently? Which product categories would have the biggest impact for Action in terms of circularity? I think these will be answered with the interviews and literature from Action.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

The reason I have chosen this project is because of some of the negative experiences I have had with repairing broken household items. I wanted to repair my dryer but soon found out that there were small intentional design decisions that made it really hard to do so. This is something I want to change using circular design in order to maintain as much value of a product as possible. I almost threw out an entire dryer for one tiny spring that was missing which frustrated me deeply. I think fixing this problem from the perspective of Action is very interesting as Action is not known to be the most sustainable company out there.

For my graduation project I have the following personal learning goals:

Conduct and analyse qualitative interviews

I have practiced a little during some courses throughout the master and at my internship with qualitative interviews and would like to keep practicing with this skill.

Improve my visual language

My visual language is not known to be the most sophisticated but I would like to further develop this in the final poster for example and the report.

Have a deeep understanding of Circular design

I think this is something that will come forward during the project and will help me to implement this in other projects in my future.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

13.2 50 most relevant products calculation

Revenue share: The revenue share describes the product's share out of the total category sales

Formula = € of product revenue / € total revenue

Volume share: The volume share is calculated as follows: The direct weight of the product is multiplied by the number of units sold of this product. This is then divided out of the total product volume.

Formula = (# units sold * kilograms direct weight) / kilograms total volume

The two scores are then weighted evenly and calculated into a normalized score.

13.3 Resource intensive product groups

An overview of legislation on the most resource intensive product groups from figure 8 is shown

Plastics

In order to reduce pollution by plastics and improve plastic recycling, the EU adopted The EU Strategy for Plastics in the Circular Economy (European Commission, 2018). According to the new CEAP further measures are necessary because it is anticipated that pollution by plastics will double in the future (European commission, 2020b).

The following measures are covered in the new CEAP:

- "developing labeling, standardization, certification and regulatory measures on unintentional release of microplastics, including measures to increase the capture of microplastics at all relevant stages of products' lifecycle";
- "restricting intentionally added microplastics and tackling pellets taking into account the opinion of the European Chemicals Agency";
- "sourcing, labeling and use of bio-based plastics, based on assessing where the use of bio-based feedstock results in genuine environmental benefits";
- "use of biodegradable or compostable plastics, based on an assessment of the applications where such use can be beneficial to the environment, and of the criteria for such applications";
- "timely implementation of the new Directive on Single Use Plastic Products" e.g. reduction of single use plastics, adhere to specific plastic product requirements, special markings on plastic products to raise customer awareness. European Parliament and of the Council (2019)".

An overview of these measures on plastics can be seen in Figure 8.

Textiles

According to the new CEAP the production of textiles takes a lot of raw materials and water, and is responsible for the exhaust of a high quantity of GreenHouse Gasses (GHG). Furthermore the recycling of textiles is still at a low level. To support the implementation of new CEAP with regards to textiles the Commission will propose an EU Strategy for Textiles. This strategy aims at making the EU market for textiles more sustainable and circular, and making the market for textile reuse larger. In relation to this strategy the following specific measures are mentioned in the new CEAP (European commission, 2020b):

- "empowering business and private consumers to choose sustainable textiles and have easy access to re-use and repair services";
- "improving the business and regulatory environment for sustainable and circular textiles in the EU, in particular by providing incentives and support to product-as-service models, circular materials and production processes, and increasing transparency through international cooperation";
- "ecodesign measures to ensure that textile products are fit for circularity, ensuring the uptake of secondary raw materials, tackling the presence of hazardous chemicals";
- "boosting the sorting, re-use and recycling of textiles, including through innovation, encouraging industrial applications and regulatory measures such as extended producer responsibility";
- "achieve high levels of separate collection of textile waste".

An overview of these measures on textiles is presented in Figure 8.

Electrical and electronic equipment

There are many documents that give guidance on how to implement a circular approach in the product group electrical and electronic equipment. For instance:

- the new CEAP (European Commission, 2020a).
- the Right To Repair (RTR) initiative of European Commission, supported by the proposal for a directive on common rules promoting the repair of goods as issued by the European commission (European Parliament 2023)
- the Directive for "The Restriction of certain Hazardous Substances (ROHS) (European Parliament & Council of the European Union, 2011)
- the Directives on Waste Electrical and Electronic Equipment directives (WEEE) (European parliament & Council of the European Union, 2012), (European parliament & Council of the European Union, 2018).

A summary of these measures is listed below.

- "give consumers the right to repair their product not only during the guarantee period but also for easy and cheap repair options of their products even if the guarantee period has expired. Repairability of products includes availability of repair manuals and availability of spare parts. Consumers have the right to repair products by themselves" (new CEAP; RTR).
- "mandatory labeling on the estimated lifetime and reparability of products, such as a repair score and usage meter for certain product categories, and ensuring that consumers are provided with the information on availability of spare parts, repair services, repair manuals and software updates at the time of purchase" (new CEAP, RTR).
- "making producers responsible for prevention of waste, e.g. by providing repair services or ensuring spare parts availability" (RTR).
- "mobilizing the potential of digitalisation of product information, including solutions such as digital passports, tagging and watermarks" (new CEAP).
- "devices must be designed for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling and dismantle" (new CEAP, RTR, Directive WEEE).
- "product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle"(new CEAP).
- "introduction of a common charger, improving the durability of charging cables, and incentives to decouple the purchase of chargers from the purchase of new devices" (new CEAP).
- "maximum concentration values on a range of substances that can be used in a large number of types of electrical and electronic equipment" (Directive RoHS).
- "review of EU rules on restrictions of hazardous substances in electrical and electronic equipment" (new CEAP).
- "preventing the creation of Waste Electrical and Electronic Equipment (WEEE) and improving the collection and treatment of WEEE, including by exploring options for an EU-wide take back scheme to return or sell back old mobile phones, Tablets and chargers" (new CEAP, WEEE directive).
- "contributing to the efficient use of resources and the retrieval of secondary raw materials through re-use, recycling and other forms of recovery" (Directive WEEE).
- "a ban on destruction of unsold durable products" (new CEAP).

An overview of these measures on EEE is presented in Figure 8.

General measures

Directives and initiatives in the field of circular economy are not always focussed on a specific product group, but can also define measures that have a more general nature. The new CEAP, the RTR and the National Circular Economy Programme 2023 - 2030 (NCEP) of the Netherlands also defines many measures of this nature. Examples are :

- "the polluter has to pay".(NCEP)
- "making producers responsible for prevention of waste, e.g. by providing repair services or ensuring spare parts availability". (RTR)

- “tax the use of virgin materials to make secondary materials more attractive”. (NCEP)
- “mobilizing the potential of digitalisation of product information, including solutions such as digital passports, tagging and watermarks”.(new CEAP)
- “a ban on the destruction of unsold durable goods”.(new CEAP)
- “enabling remanufacturing and high-quality recycling”.(new CEAP)
- “increasing recycled content in products, while ensuring their performance and safety”.(new CEAP)
- “rewarding products based on their different sustainability performance, including by linking high performance levels to incentives” (new CEAP).
- An overview of these general measures is presented in Figure 8.

13.4 ErP, overview of groups and Sub product groups

Using the sales data of 2021, 575 ErP products have been selected who have sold over 10.000 times (Figure 1). The products are selected based on the commodity group they were in. In Action every product category has commodity groups that cover for example household electronics. By only selecting products that have been sold over 10.000 times only the relevant items have been selected.

An overview of the new formed commodity groups and ErP groups with average price and Mtons over 2021 (without packaging) can be seen Table 1.

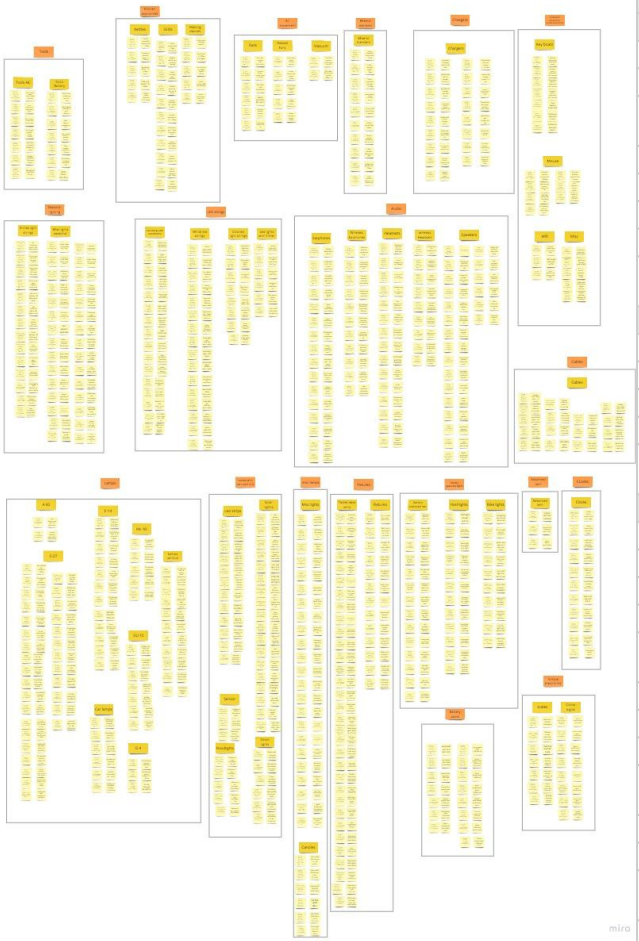


Figure 1: 575 ErP products that have been sold over 10.000 times.

Table 1: formed commodity groups and ErP groups with average price and Mtons over 2021 (without packaging

Average price	Mtons		Indication #
14,65	2708	Kitchen appliances	15
6,17	2208	Fixtures	27
7,02	1854	Seasonal lighting	48
2,86	1774	Lamps with tech add ons	33
3,02	1674	Led strings	51
18,7	1424	Kitchen appliances - Heating devices	18
3,03	1388	Misc Lights	30
7,17	1259	Clocks	63
2	1203	Lamps with tech add ons - Solar lights	35
6,17	1104	Fixtures - Table lamps	28
6,17	1104	Fixtures - Fixtures	29
3,63	1045	Misc Lights - Misc lights	31
14,82	1030	Kitchen appliances - Grills	17
5,21	986	Audio	56
12,75	967	Tools	12
8,02	930	Seasonal lighting - Xmas string lights	49
5,85	924	Seasonal lighting - Misc seasonal lights	50
3,17	829	Led strings with attachments - Colored ld strings	53
1,75	791	Cables	6
12,09	743	Tools - Tools AC	13
6,28	739	Air movement	8
4,58	725	Simple electronics	19
8,45	659	Mixers/blenders	7
2,38	603	Lamps	39
1,9	537	Battery operated lights	23
4,72	520	computer accessories/ simple electronics	0
7,96	461	Audio - Speakers	61
4,84	402	Simple electronics - Scales	20
3,33	398	Led strings with attachments - Led lights with timer	54
4,13	358	Air movement - Fans	9
2,42	343	Misc Lights - Candles	32
4,53	329	Lamps with tech add ons - Led strips	34
4,24	323	Simple electronics - clocks digital	21
2,21	319	Led strings with attachments - White led strings	52
9,72	309	Battery Packs	22
5,09	268	Audio - Headsets	59
20,7	259	Air movement - Vacuum	11
2,24	259	Lamps - E26	41
8,65	254	Kitchen appliances - Kettles	16
4,85	232	computer accessories/ simple electronics - Misc	4
3,35	227	Chargers	5
14,23	224	Tools - Tools Battery	14
1,79	219	Battery operated lights - Bike lights	26
1,98	167	Battery operated lights - Flashlights	25
3,65	153	Lamps - Lamps various	47
1,95	151	Battery operated lights - Battery operated rest	24
4,64	128	Led strings with attachments - Audio	55
8,4	127	Audio - Wireless headsets	60
13,64	122	Air movement - Heated Fans	10
11,22	116	computer accessories/ simple electronics - Wifi	3
4,71	103	Lamps with tech add ons - Floodlights	37
9,04	102	Lamps with tech add ons - Smart lights	38
3,26	95	computer accessories/ simple electronics - Mouse	2
9,8	77	computer accessories/ simple electronics - Keyboard	1
2,4	71	Lamps - Car lamps	43
7,6	69	Audio - Wireless earphones	58
2,73	61	Audio - Earphones	57
2,1	56	Lamps - E13	42
2,79	37	Lamps with tech add ons - Sensor	36
2,43	36	Lamps - GU 9	45
2,23	18	Lamps - RA94	46
3,86	7	Lamps - A59	40
10,15	6	Advanced tech	62
2,88	3	Lamps - G3	44
6,07	**36617**	**Total**	

13.5 Repairability criteria

The criteria of JRC and FRI ordered under the 45554 standard of product and support related criteria.

FRI (Ministère de la Transition écologique, 2022)				Cordella (Cordella et al., 2019)
Pre determined for specific product ErP category				Selecting priority parts
45554 product related criteria (NEN, 2020)				
Criterion 2 : disassembly, accessibility, tools, fasteners list 2: list of a maximum of 3 to 5 spare parts (depending on the category of equipment in question) that most frequently break or break down; list 1: list of a maximum of 10 other spare parts (depending on the category of equipment in question) that must be in good condition for the equipment to function.	**Ease of disassembly** Based on the amount of disassemble steps (DDi) for specific product category ErP	List 1 or 2 parts DDi : number of steps required to disassemble the spare part. - not removable, if the spare part cannot be disassembled or unitarily accessible. - part not included, in case of absence of a part in the equipment	**Disassembly depth/ sequence**	**Pass/ Fail** For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6). Rating classes A score is assigned for each priority part based on their disassembly depths (DDi). A continuous rating can be calculated as: S1,i = 1 – (DDi – 1) / (DDref – 1) where: DDi is the depth for the priority part i; DDref is the reference depth for the priority part i. The score is set to 0 if (DDi – 1) is greater than (DDref – 1). Alternatively, a discrete rating could be considered: I) DDi < X steps = 1 pt. II) X < DDi < Y steps = 0.75 pt. III) Y < DDi < Z steps = 0.5 pt. IV) DD1 > Z steps = 0.25 pt. Where: X, Y and Z have to be defined for each priority part.
	Fasteners characteristics	A: Neither removable nor reusable = 0 point B : Removable and not reusable = 1 point. - C : Removable and reusable: an original fastening system that can be completely removable (without causing damage) and reusable (exemple : screw). = 2 points.	**Fasteners**	**No Pass/ Fail** A score is assigned for each priority part according to the reversibility and reusability of the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be reused are supplied with the new part for a repair, re-use or upgrade process = 1 pt. II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening systems are not removable or reusable, as defined above = 0 pt
	Necessary tools for disassembly	List 1 or 2 parts A : Not removable or unitarily accessible with any existing tools = 0 point. - B : Removable only with proprietary tools.= 1 point. - C : Removable only with specific tools. = 2 points. - D : Removable with no tool, with basic tools or with tools supplied with the product or the spare part = 4 points. if the part is not present in the product design = 4 points	**Tools**	**Pass/Fail** The repair/upgrade process is feasible for each priority part with existing tools. **Rating classes** A score is assigned for each priority part according to the complexity and availability of the tools needed for its repair/upgrade: I) Basic tools: repair/upgrade of the priority part is feasible without any tools, or with tools that are supplied with the product, or with the list of basic tools provided in note 1 = 1 pt. II) Other commercially available tools: repair/upgrade of the priority part is unfeasible only with basic tools and requires the use of other tools that are commercially available = 0.66 pt. III) Proprietary tools: repair/upgrade of the priority parts is feasible only with one or more proprietary tools = 0.33 pt.

Criterion 2 : disassembly, accessibility, tools, fasteners list 2: list of a maximum of 3 to 5 spare parts (depending on the category of equipment in question) that most frequently break or break down; list 1: list of a maximum of 10 other spare parts (depending on the category of equipment in question) that must be in good condition for the equipment to function.			**Disassembly time**	**No Pass/ Fail** A score is assigned for each priority part based on their disassembly time (DTi). A continuous rating can be calculated as: S1,i = 1 – DTi / DTref where: DTi is the disassembly time for the priority part i; DTref is the reference disassembly time for the priority part i. The score is set to 0 if DTi is greater than DTref. Alternatively, a discrete rating could be considered: I) DTi < X = 1 pt. II) X < DTi < Y = 0.75 pt. III) Y < DTi < Z = 0.5 pt IV) DTi > Z = 0.25 pt. Where X, Y and Z (min) have to be defined for each priority part of the product group under assessment.
			Safety, skills, and working environment	**No Pass/Fail** a) A score is assigned for each priority part based on the level of knowledge needed for its repair/upgrade, as well as the level of risk associated: I) The repair/upgrade can be carried out by a person with a general knowledge of basic repair, re-use, upgrade techniques and safety precautions but without any specific qualifications = 1 pt. II) The repair/upgrade has to be carried out by a person with specific training and/or experience related to the product category concerned, who is also aware of the risks involved in the process and is able to handle them correctly = 0.66 pt. III) The repair/upgrade can be carried out only by the manufacturer = 0.33 pt. b) A score is assigned for each priority part based on the working environment required for carrying-out the repair/upgrade operation, also due to safety conditions: I) The repair/upgrade can be carried out without any working environment requirements (e.g. where the product is in use, or in generic environments) = 1 pt. II) The repair/upgrade has to be carried out in a working environment but not in a production site = 0.66 pt. III) The repair/upgrade can be carried out only in a production site that is comparable with the environment in which the product was manufactured = 0.33 pt. Score (#9) = Score (#9a) x Score (#9b)
45554 support related criteria				
			Diagnosis support and interfaces	**No Pass/ Fail** A score is assigned for the product based on the availability of diagnosis support and interfaces to aid the identification of typical failure modes associated to the priority part: I) Intuitive/ coded interface with public reference Table: all main faults can be diagnosed either by i) a signal that can be intuitively understood, or ii) by consulting fault-finding trees and/or reference codes information supplied with the product = 1 pt. II) Publicly available hardware/ software interface: to be diagnosed, some of the main faults need the use of hardware, software and other support which is publicly available = 0.66 pt. III) Proprietary interface: to be diagnosed, some of the main faults need the use of proprietary tools, change of settings or transfer of software which are not included with the product = 0.33 pt.

<table>
<tr>
<td>Criterion 1: documentation

Based on the duration of availability and for whom; Repairers or Consumers.

Availability ranges between; <9, 9<x<11, 11<X<13 and X>13 years where X is availability</td>
<td colspan="2">The unequivocal identification of the product (type of product, trademark, trade name, model, and possibly, serial number)

A disassembly map or exploded view

Wiring and connection diagrams

Electronic boards diagrams

List of necessary repair and test equipment

Technical manual of instructions for repair

Diagnostic fault and error codes

Component and diagnosis information

Instructions for software and firmware (including reset software)

Information on how to access data records of reported failure incidents stored on the product

Technical bulletins

Specific guidance for self-repair (recommended operations, safety and repair instructions, any implications for the guarantee)*

How to get access to professional repairers

Failures detection and required action (consumers approach)

User and maintenance instructions</td>
<td>Type and availability of information</td>
<td>Pass/Fail
Information is made available (for a sufficiently long period to be defined at product level) to different target groups, including:
- Product identification and exploded view;
- Instructions for regular maintenance;
- Troubleshooting charts;
- Repair or upgrade services offered by the manufacturer;
- Safety issues related to the use, maintenance and repair, as well as guarantee issues (e.g. commitment to repair in case of failure, post-repair guarantee if any);
- Disassembly sequences;
- List of available updates, spare parts and recommended retail prices, as well as repair costs of the common failures as offered by the manufacturer.
All this information has to be made available, as repair and maintenance information for professional repairers. Depending on the level of sensitiveness, a part of this information may also to be disclosed to other end users.1) The list above is illustrative and has to be shaped for specific products
2) Any safety issue associated with the use, maintenance and repair of the product has to be identified in accordance with Low Voltage Directive 2014/35/EU and Machinery Directive 2006/42/EC (depending on the type of product) and communicated transparently and publicly in any case.
3) Channels for communicating information may include printed manuals, websites, digital information carriers such as QR codes, DVDs or flash drives.

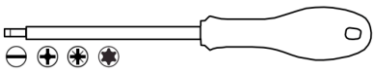
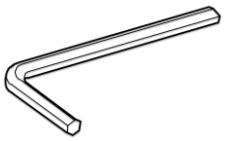
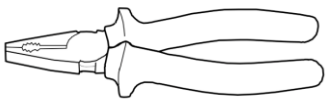
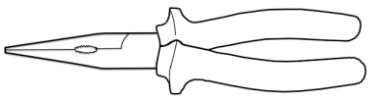
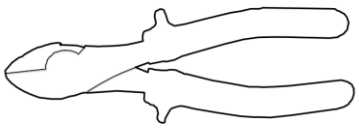
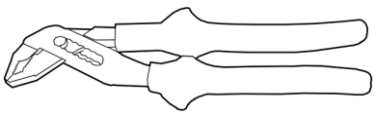
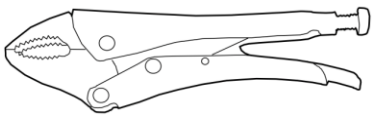
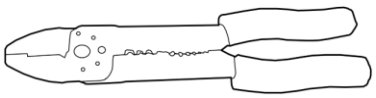
Rating classes
a) A score is assigned for the product based on the cost and availability of all information required as pass/fail criterion:
I) All information is available publicly at no additional cost for consumers = 1 pt;
II) All information is available to independent repairers = 0.66 pt.
III) All information is available to registered professional repairers = 0.33 pt.</td>
</tr>
<tr>
<td rowspan="2">Criterion 3: Availability of spare parts</td>
<td>Sub-criterion 3.1& 2 : Commitment on the availability over time of spare parts (in years) of parts from list 1 & 2</td>
<td>Availability ranges between; <9, 9<x<11, 11<X<13 and X>13 years where X is availability over time</td>
<td rowspan="2">Spare parts</td>
<td rowspan="2">Pass/Fail
For each priority part: i) Spare parts are declared to be available for X years after placing the last unit on the market
ii) Spare parts are deliverable within Y working days iii) Lists of spare parts and recommended retail prices set by manufacturers (and/or contractors, if applicable) are made publicly available (see #6).
Rating classes
a) A score is assigned for each priority part based on the period of time during which spare parts are available:
I) The spare part is declared to be available for a duration of X years = 1 pt.
II) The spare part is declared to be available for a duration of Y years = 0.66 pt.
III) The spare part is declared to be available for a duration of Z years = 0.33 pt.
b) A score is assigned for each priority part based on the target groups:
I) The spare part is available to all interested parties = 1 pt.
II) The spare part is available to any self-employed</td>
</tr>
<tr>
<td>Sub-criterion 3.3& 4 : commitment on the delivery time of spare parts - broken/malfunctioning parts of list 1 & 2</td>
<td>Commitment on the delivery time ranges between; X>10 days, 10 days >X> 5 days, 5 days >X> 3 days, X< 3 days.</td>
</tr>
</table>

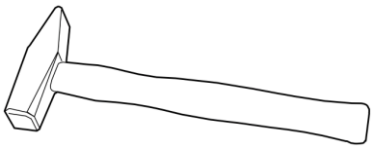
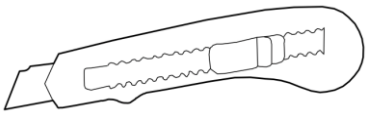
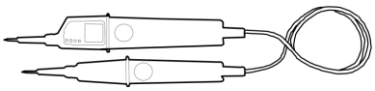
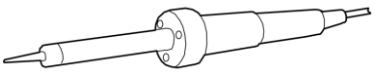
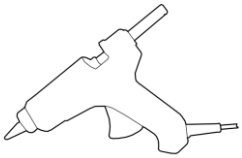
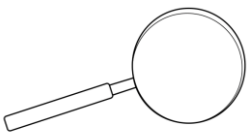
criterion 4 : price of spare parts	Pre-tax price of the most expensive spare part (list 2) Average pre-tax price of other spare parts (list 2) Manufacturer's pre-tax price of concerned model if the result is greater than 0.3 then the number of points is 0; if the result is less than 0.1 then the number of points is 100; if the result is between 0.1 and 0.3 then the number of points is determined according a determined scale		professional as well as any legally established organization providing repair services = 0.66 pt. III) The spare part is available to service providers authorized by the product manufacturer to offer repair services = 0.33 pt. c) When relevant, a score is assigned to specific priority parts based on the spare part interface: I) The part is non-proprietary and has a standard interface = 1 pt. II) The part is either proprietary or does not have a standard interface = 0.5 pt. Score (#7)
		Software and firmware	**Pass/Fail** Software/firmware updates and support are offered for a duration of at least X years after placing the last unit of the model on the market. Full compatibility with open source Operating Systems and/or open source Virtual Machine software is ensured (where applicable). Information about how updates will affect the original system characteristics (e.g. RAM, CPU) is provided, and there is to be always the option to not install, to install or to uninstall the update. **Rating classes** a) A score is assigned for the product based on the period of time during which software/firmware updates and support are offered: I) Software/Firmware updates and support are offered for a duration of time post-manufacture of at least Y years = 1 pt. II) Software/Firmware updates and support are offered for a duration of time post-manufacture of at least X years = 0.5 pt. b) A score is assigned for the product based on the target groups: I) Software/Firmware updates and support is offered to all interested parties = 1 pt. II) Software/Firmware updates and support is offered to any self-employed professional as well as any legally established organization providing repair services = 0.66 pt. III) Software/Firmware updates and support is offered to service providers authorized by the product manufacturer to offer repair services = 0.33 pt. c) A score is assigned for the product based on the cost of the software/firmware update service: I) Software/Firmware updates and support are offered free of charge for the entire period of time (either X or Y) = 1 pt. II) Software/Firmware updates and support are offered free of charge for Z years = Z/X or Z/Y (depending on the period of time) pt. Score (#8) = Score (#8a) x Score (#8b) x Score (#8c)
		Data transfer and deletion	**No Pass/Fail** score is assigned for the product based on the availability of secure data transfer and deletion functionality: I) Built-in secure data transfer and deletion functionality is available to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid state drives) = 1 pt.

			II) Secure data transfer and deletion is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Secure data transfer and deletion is available on request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) = 0.33 pt.
		Password reset and restoration of factory settings	No Pass/Fail A score is assigned for the product based on the availability of an option for resetting the password and restoring the factory setting: I) Integrated reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using functionality integrated within the product = 1 pt. II) External reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Service reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted using services
		Commercial guarantee	No Pass/Fail A score is assigned based on the availability of a "commercial guarantee" for the (entire) product offered by the guarantor, and including a "commitment to free repair as first remedy" in case of failures and, where relevant, a "commitment to upgrade the product

13.6 Standard tools

List of tools retrieved from the 45554 standard (NEN, 2020).

Tool type	Illustration (Informative example)	Reference
Screwdriver for slotted heads, cross recess or for hexalobular recess heads		ISO 2380, ISO 8764, ISO 10664
Hexagon socket key		ISO 2936
Combination wrench		ISO 7738
Combination pliers		ISO 5746
Half round nose pliers		ISO 5745
Diagonal cutters		ISO 5749
Multigrip pliers (multiple slip joint pliers)		ISO 8976
Locking pliers		
Combination pliers for wire stripping and terminal crimping		

Prying lever		
Tweezers		
Hammer, steel head		ISO 15601
Utility knife (cutter) with snap off blades		
Multimeter		
Voltage tester		
Soldering iron		
Hot glue gun		
Magnifying glass		
NOTE 1 Most tools come in different sizes. This list only refers to the tool type. Although some sizes are more common than others, for practical purposes, any size of the listed tools is considered to be a basic tool.		

13.7 Assessment guide

The assessment guide can be used by suppliers to fill in the repairability index

Supplier assessment guide

(*DPG Media Privacy Gate*, n.d.)

Supplier assessment guide

This guides will help with filling in Actions repairability index. The guide will first go through the disassembly of the product to create a disassembly map. This will help in determining the disassembly depth, type of fasteners used, tools needed and the disassembly time. After this the rest of the criteria including spare part's availability, delivery time and price will be discussed. Lastly, the needed documents and how to fill in the repairability index will be discussed. If you have any questions please contact your contact person at Action

Disassembly

For the disassembly a workflow is proposed to help create the disassembly map and determine the tools needed, fasteners needed, disassembly depth and disassembly time. First the product should be filmed from preferably multiple angles and be taken apart completely. This can be done multiple times to practice and reduce the measured time needed for disassembly. It is important for the final measurement of the disassembly a When this is finished all parts should be named and numbered as seen in Figure 1. This overview with the labeled and numbered parts will be helpful for creating the disassembly map later during the assessment. The disassembly map will help in determining the ease of disassembly of the priority parts.

Figure 1: Disassembled product with labeled parts

With the overview from Figure 1 the disassembly map can be made. How to do this is explained using seven tips for mapping the disassembly correctly. The used methodology behind creating the disassembly map is from De Fazio et al. (2021)

The disassembly map starts from one circle or drawing that represents the whole product. From this starting point arrows point the disassembly direction connecting other parts in the assembly. A part is only displayed when it is actually removable.

For the disassembly map three main assemblies have to be taken into account which allow for proper display of the disassembly map. The first assembly is sequential dependency and occurs when a part can't be removed without removing other parts first. A simple example is shown in Figure 2 where first part A and B have to be removed before being able to access part C. This is visualized in a vertical sequential order.

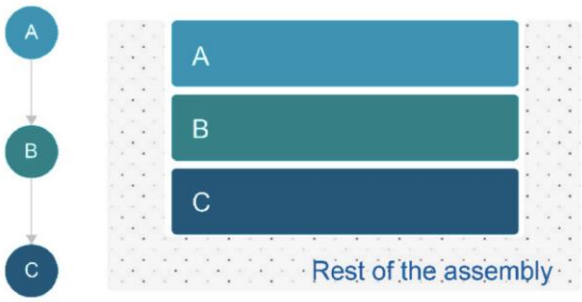


Figure 2: Sequential dependency (De Fazio et al., 2021)

The second assembly is Sequential independency describes a configuration where two or more parts can be disassembled individually. In the example of Figure 3 part A,B and C can be seen. If part A is removed part B and C can be disassembled individually without influencing each other's disassembly time. This assembly is visualized by branching or by drawing a second arrow from the former part.

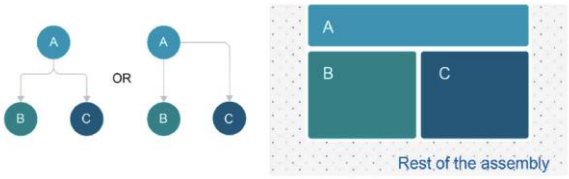


Figure 3: Sequential independency (De Fazio et al., 2021)

The third assembly is called multiple dependency. This occurs when before being able to remove a part two or more other parts need to be disassembled independently from each other. This can be seen in Figure 4 where part A & B have to be removed before being able to access part C. This is visualized by using the ampersand (&), the arrows are important and show the proper sequence if disassembling.

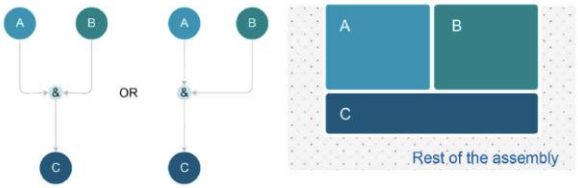


Figure 4: Multiple dependency (De Fazio et al., 2021)

When being faced with cluster blocks problems can occur. Part D could be accessed by sequential disassembling part A,B and C. But part A,B and C could be removed as a whole leaving the way directly to D. This is a cluster of components and can be visualized in one circle as seen in Figure 5 as the fastest disassembly sequence for the removal of D. The use of these clusters depends on the target component. If part C is the target the cluster would have to be taken apart as seen in Figure 5.

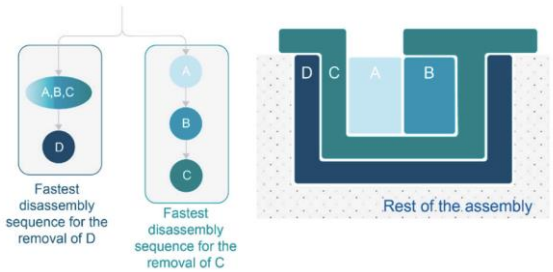


Figure 5: Cluster blocks (De Fazio et al., 2021)

The parts in an assembly are connected with fasteners which are included in the disassembly map. They are represented in disassembly action blocks which are placed before a part describing how it should be removed. If multiple actions with the same tool should be performed this can be visualized by describing how many times next to the box as seen in Figure 6.

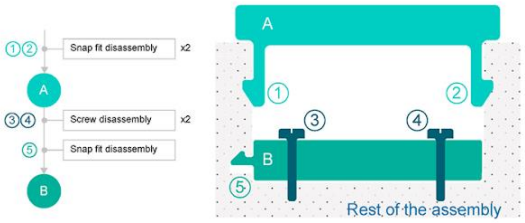


Figure 6: Multiple actions with the same tool (De Fazio et al., 2021)

A disassembly action can be applicable to be able to access a part without removing it. This is shown in Figure 7 where a lid has to be lifted to access parts B and C after which they can be removed. As A can not be removed it is not considered an extra part but a disassembly action.

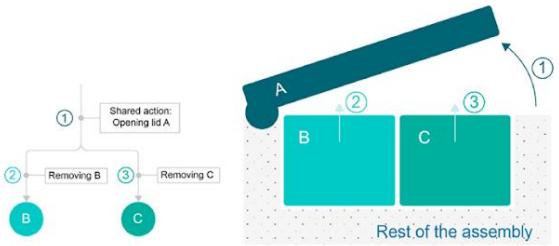


Figure 7: Parts that don't have to be removed (De Fazio et al., 2021)

The final disassembly action is when a cluster of parts is removed from an assembly and is separated into two different parts. As this action does not require extra time it is just represented by the component circle and not by an action block as seen in Figure 8.

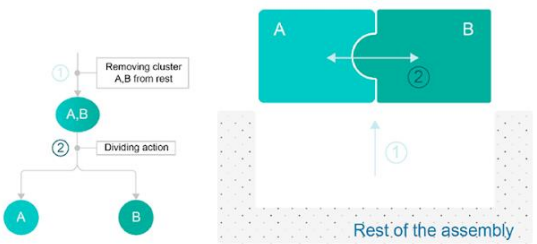


Figure 8: Cluster of parts (De Fazio et al., 2021)

A step is defined as “an operation that finishes with the removal of a part, and/or with a change of tool”. Grabbing a tool, putting a tool down and removing a fastener is not considered to be a step. These steps can be counted which gives the disassembly steps needed to remove a part.

For some disassembly actions tools are needed, this is visualized in the disassembly action blocks. Three different types of tools are defined; Hand motion, Tool single motion and Tool multiple motion. The hand motion “tool” is used in actions that can be performed by hand and do not require any tools, it is displayed as a green rounded rectangle. The second tool are single motion tools and are visualized as an orange rectangle. These tools are used for a single loosening action, example tools are spudgers, pliers and hammers. The third tool is a multiple motion tool and is displayed as a pink hexagon. This type of tool requires multiple loosening actions to remove a fastener. Examples are screwdrivers and wrenches. Inside these disassembly actions the type of fastener should be mentioned together with the type of tool. This can be abbreviated and further explained in a legend to make the map more readable. Further information on the disassembly map can be found in De Fazio, F., Bakker, C., Flipsen, B., & Balkenende, R. (2021). The Disassembly Map: A new method to enhance design for product repairability. Journal of Cleaner Production, 320, 128552. https://doi.org/10.1016/j.jclepro.2021.128552.

It helps by first making a list with all the parts and making a draft version using pos-its or software to move things around easily. When the outline of the map has been made the connections between parts and tools needed should be added to the disassembly map. Keep these questions in mind when drawing up the disassembly map:

1. Which next disassembly step is required to reach the target component?
2. Is this disassembly operation absolutely necessary to reach the target component?
3. Is there any other operation that could be carried out first?
4. Is there any other operation that could be carried out in parallel with the one just completed?

Looking back at the video and its time stamps the time required to perform certain steps can be measured. This can be implemented in the map to determine the disassembly time for priority parts. For the disassembly map a list of predetermined parts are determined to make the disassembly maps as similar as possible between suppliers and products. Additionally, the fasteners and tools used should be displayed the same. The variety of tools and fasteners and their abbreviations are as follows:

Type of fastener:
1. Removable and reusable = R&R
2. Neither removable nor reusable = NRNR
3. Not applicable = NA

Type of tools:
1. No tool or basic tool = NT
2. Other commercially available tools and tools that are supplied with the product or spare part = OT
3. Proprietary tools = PT
4. Not feasible = NF

If a fastener is removed with a tool the needed time should be added in the end. This makes it easy to quickly determine disassembly times later on. An example can be seen in Figure 9 where a removable and reusable connector is used which can be removed using no or basic tools in 89 seconds. If any connector is different than R&R or tool used other than NT the color should be changed. This makes it easy to point out what makes a part less removable.

Figure 9: Removable and reusable fastener, removable with basic or no tools in 89 seconds.

When all fasteners and needed tools are mapped in the disassembly map the time needed between each step can be mapped in the disassembly map. Now the disassembly depth, fasteners, necessary tools needed for disassembly and disassembly time can be filled in

Disassembly depth

The disassembly sequences to priority parts can be read through the disassembly map. With this information the disassembly steps can be determined for each specific priority part. The number of steps to get to the priority part is determined by counting the removed parts and changes of tools. If the number of steps needed to remove the priority part is the same as the reference number of steps the appointed score is 5. If fewer steps are used the score can go up to a maximum of a 10 and if more are needed it goes down to a minimum of 0. If a part scores zero it does not make the product unrepairable, just harder to disassemble. Therefore, it is not a knock-out criteria. The specific reference values can be seen under "Product specific details".

S1,i = DDref-DDi+5
S1,i = Disassembly depth score (between 0 and 10)
DDi = Number of steps to remove priority part
DDref = The reference number of steps for a specific priority part in a specific product group

Extra weight is given to priority parts of list 2 as these have to be repaired more frequently and would benefit more from being better accessible. If parts are not present in a product the reference value can be given. If a disassembly takes two times as many steps or more it is marked as an outlier. This has no further consequences but serves as a heads up. The reference values differ for every ErP (Electronic related Product) group. An example score can be seen in Table 1

Disassembly depth part:	**DDref**	**DDi**	**S1,i**	**Weight**
Motor	5	4	6	2
Battery	4	2	7	1
Total score	(S1,Motor*2+S 1,Battery*1)/3			6,3

Table 1: Example scoring of disassembly depth

Fasteners

Three types of fastener groups are distinguished; A) removable and reusable, B) removable but not reusable and C) neither removable nor reusable. Fasteners will have the following scores: A = 2, B = 1 and C = 0. The score will be weighted according to which list they belong to. Parts from list 2 will weigh double and parts from list 1 will weigh singular.

A removable and reusable fastener is a fastener that can be reused after disassembly. Removable but not reusable fasteners are fasteners that can be removed without causing damage or leaving residue which could hinder reassembly. This includes single use fastenings that are supplied with new parts. Neither removable nor reusable fasteners are fasteners that are not reusable when disassembling a product. This includes glued, welded or soldered parts as removing these parts without damage is considered to be difficult. When different fasteners have to be removed to access a part the least removable fastener is selected, this is the weakest link in the chain. Connectors are also considered to be fasteners. An example of a fastener score can be seen in Table 2. The formula used to determine the score can be seen below:

S1,i = ((Score parts list 2 * 2)+(Score parts list 1))/((# Parts list 2 * 2 * 2) + (# Parts list 1 * 2))* 10

If a part is not in the product "non applicable" should be selected. If a part is non removable it is highlighted as a non removable part in the final score.

Priority part	**Type of fasteners**	**Score**	**Weight**
Motor	Removable and reusable	2	2
Battery	Neither removable nor reusable	0	1
Total score	**(Σ(Priority part score* Weight) / Maximum score) * 10**		6,7

Table 2: Example of scoring of fasteners

Necessary tools for disassembly

The tools needed for disassembly work similarly to fasteners. A score is given for every priority part of list 1 and 2 and according to the type of tools used during the disassembly. Within tools four types of tool groups can be distinguished; A) The use of; no tool, basic tools, B) Other commercially available tools and tools that are supplied with the product or spare part, C) Proprietary tools and D) not feasible. Group A consists of tools as listed in Appendix 1. Group B consists of other commercially available tools. Group C consists of tools which are not commercially available for purchase. The tools will have the following scores: A = 3, B = 2, C = 1 and D = 0. The score will be weighted according to which list they belong to. Parts from list 2 will weigh double and parts from list 1 will weigh singular. An example can be seen in Table 3. The calculation can be seen below:

S1,i = ((Score parts list 2 * 2)+(Score parts list 1))/((# Parts list 2 * 2 * 3) + (# Parts list 1 * 3))* 10

If a part is not in the product "non applicable" should be selected. If a part is non removable with any tool it is highlighted as a non removable part in the final score.

Priority part	Type of tool needed	Score	Weight
Motor	Group A	3	2
Battery	Group C	1	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		7,8

Table 3:Example of scoring of necessary tools for disassembly

Disassembly time

The disassembly time for reaching priority parts holds information of the difficulty of disassembly. The disassembly time is measured per priority part by adding the time needed for all the disassembly steps needed to remove the part. This can be done using the recording of the disassembly and the disassembly map. Every step of removing a fastener should be timed from the beginning to the end. The disassembly time is determined by adding the time required of all the different steps to access and remove the priority part.

S1,i = ((1-(DDi/DDref))*5)+5

S1,i = Disassembly time score (between 0 and 10)
DDi = Time needed to remove a priority part
DDref = The reference time needed for a specific priority part in a specific product group

The maximum time has been set at double the reference disassembly time and will be highlighted from that point onward as an outlier. This gives a head up that something is wrong with that part. If a part is not present the reference value can be filled in. If a part is non removable double the reference value should be filled in. The reference values differ for every ErP group.

Spare parts

For the spare parts the availability, delivery time and price are discussed.

Availability

Spare parts should at least be available during the entire lifetime of the product. This goes in from the moment the last product is placed on the market. Three groups are distinguished; A) Priority parts are available up to 5 years, B) Priority parts are available after 6 to 9 years and C) Priority parts are available for more than 10 years. Group A is the minimum for parts from list 2 making it a knock-out criteria. Parts from list 2 will weigh double and parts from list 1 will weigh singular. An example calculation can be seen in Table 4.

Priority part	Minimal time available	Score	Weight
Motor	10 years	3	2
Battery	10 years	1	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		7,8

Table 4: Example of scoring of availability of spare parts

Delivery time

Spare parts have to be available within 15 working days. How the delivery will take place will be decided on later. The delivery time of 15 days (B) is taken as an average. Delivery time for parts can be over (A) or under this 15 days (C) which will have the following scores: A = 1, B = 2 and C = 3. An example scoring is seen in Table 5. Parts from list 2 will weigh double and parts from list 1 will weigh singular.

Priority part	Delivery time	Score	Weight
Motor	15 days	3	2
Battery	less than 15 days	1	1
Total score	**(Σ(Priority part score * Weight) / Maximum score) * 10**		7,8

Table 5: Example of scoring of delivery time of spare parts

Price relative to the price of the original product

The lower the price, the higher the score. If a spare part costs more than 30% of the retail price the score will be a zero. If it is lower than 30% of the retail price the score increases as seen in the baseline scoring system in Table 7. An example of the calculation is seen in Table 6.

Priority part	Price ratio	Score	Weight
Motor	0,24	30	2
Battery	0,11	95	1
Total score	**(Σ(Priority part score * Weight) / total weight) /10**		5,2

Table 6: Example of scoring of the price of spare parts

Documentation

Action will hold and distribute the information from suppliers to ensure its availability over time. An overview on the needed documentation can be seen in Table 8. The score that can be obtained ranges from 1 to 3, the minimum score that needs to be scored is 1 for every document. This is the minimum documentation needed for products to be repairable. If one of the documents is missing or does not meet the requirements as described in the "1 points" the whole document's criteria scores a zero.

Product specific details

For every ErP group a list of parts is created to make disassembly maps uniform amongst other grills and manufacturers. If additional parts are used in the product these can be added but should be mentioned clearly in the disassembly map. An example can be seen for the ErP group grills bellow:

1. Top grill
2. Bottom grill
3. Cable
4. Top Cover
5. Handle
6. Spring release
7. Spring release cover
8. Left hinge
9. Right hinge
10. Cable cover
11. Indicator light
12. Top Heating element
13. Thermostat
14. Bottom heating element
15. Bottom cover
16. Top insulation
17. Left handle support
18. Right handle support

ratio	0,1	0,11	0,12	0,13	0,14	0,15	0,16	0,17	0,18	0,19	0,20	0,21	0,22	0,23	0,24	0,25	0,26	0,27	0,28	0,29	0,30
Score	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0

Table 7: Price scoring of spare parts

Document	1 points	2 points	3 points
The unequivocal identification of the product (type of product, trademark, trade name, model, and possibly, serial number)	Removable label (Bracquené et al., 2018)	Non Removable label (Bracquené et al., 2018)	
Diagnostic fault and error codes	Available if applicable		
List of necessary repair and test equipment	Available	Avoid scoring double on the same criteria	Further discussed in the "tools" criteria under disassembly
Technical manual of instructions for repair	1. safety measures 2. (check)list of identified root causes for common failures/misuses (Bracquené et al., 2018)	- safety measures- basic fault diagnostic advice: (check)list of identified root causes for common failures*- test method to check working condition of key functional parts*- limited list of error codes and required repair actions, if applicable (Bracquené et al., 2018)	- safety measures- fault diagnostic advice: (check)list of identified root causes for common failures* and troubleshooting tree - test method to check working condition of priority part- complete list of error codes and required repair actions, if applicable - fault detection software , if applicable (Bracquené et al., 2018)
A disassembly map or exploded view	Disassembly map including how to remove list 2 and 1 parts. (Bracquené et al., 2018)	Disassembly video for entire product (HOP, 2022)	
Electronic boards diagrams (internals of the product)	available with component specification (HOP, 2022)		
Total score:	all points combined		

Table 8: Scoring system used for documentation

19. Locking mechanism
20. Protective cover
21. Cable tree
22. Weight
23. AC Cable
24. Heating element place holders
25. Light cover
26. Light holder

Next to the parts there are special reference values for every ErP group, an example for grills can be seen in Table 9.

Table 9: Data from repair monitor (Repair Monitor, unpublished)

Part	Disassembly depth	Disassembly time
1. AC Cable	2	21
2. Thermostat	1	93
3. Bottom grill	4	28
4. Top grill	1	134
5. Left handle support	1	64
6. Right handle support	1	56
7. Left hinge	1	26
8. Right hinge	1	29
9. Handle	3	136

IMPORTANT: The bottom and top grill are selected as priority parts assuming the heating element is irreversibly attached to it. In a later stadium Action wants to move towards fully removable heating elements.

Filling in the repairability score

The scores can be filled in in the provided excel sheet. The first page of the excel sheet explains how this needs to be done. An example of a filled in repairability score can be seen in Figure 10. The orange boxes can be ignored by the supplier. These indicate outliers in certain criteria and if non removable parts are present in the product. These are mere an indicator for the buyer and product tech.

Figure 10: Filled in repairability score

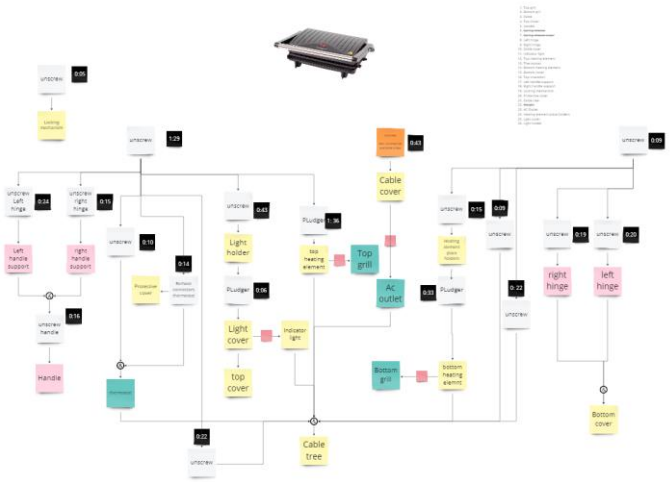


Figure 12: First version of disassembly map

Example

As an example filling in the repairability score of a grill is shared. As mentioned earlier the first step is to disassemble the product and record this. An example can be seen here: https://www.youtube.com/watch?v=SieVpLSEm9E&t=2s. After this disassembly is filmed al the parts are labeled as seen in Figure 11.

Figure 11: Disassembled and labeled product

The parts are checked and labeled to see if there are any parts that are missing or not being mentioned in the pre determined list. When this is complete the first draft version of the disassembly map can be made. This first version can be seen in Figure 12 and includes all the disassembly steps as well as disassembly time. Now this first version is used to calculate the disassembly steps and time for the priority parts. Then this first version is finalized to hand in to Action as one of the required documents for this product (figure 13). The repairability index is further filled in following the guide from the repairability index sheet and the final score is printed (Figure 10). The final score is send to Action alongside other legal documents to complete the transaction.

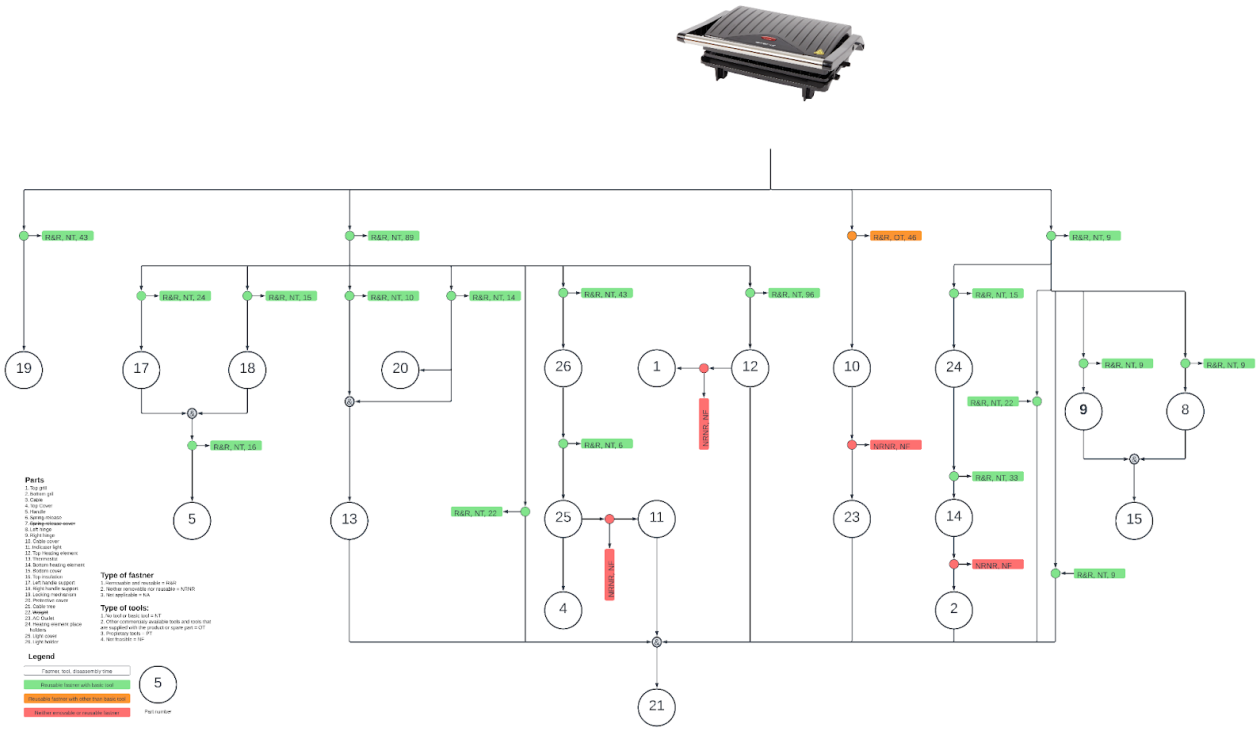


Figure 12: Final disassembly map

Improving repairability

The repairability of products can be improved which would result in a better score. The first step is supplying the required documents that enable repairability of a product. The second step is making spare parts available for a reasonable price within a reasonable amount of time. For ease of disassembly the first steps is to use reusable fasteners which can be removed with basic tools. The second step has to do with the disassembly depth and disassembly time.

The disassembly time is an indicator of a step in the disassembly that takes long. A reason for this could be the amount of steps needed to access the part. Therefore, the disassembly depth is taken into account in the grading of the repairability index. There are three easy ways to reduce the disassembly time; surfacing, clumping and trimming (Flipsen, 2023). For surfacing the idea is to simply move the priority part "higher" in the disassembly, making it easier accessible. If clumping is applied a group of parts that is "above" the priority part is clumped together making it possible to remove in one step. The last way to reduce the disassembly time is called trimming. Trimming focusses on rethinking the used fasteners and replacing them with easier replaceable fasteners.

If you have any questions, please reach out to your contact person at Action.

References

Bracquené, E., Brusselaers, J., Dams, Y., Peeters, J., De Schepper, K., Duflou, J., & Dewulf, W. (2018*). Repairability criteria for energy related products. In benelux*.int. https://www.benelux.int/files/7915/2896/0920/FINAL_Report_Benelux.pdf

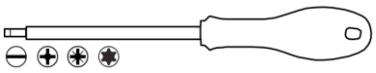
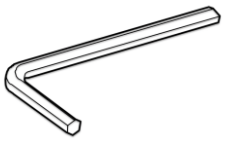
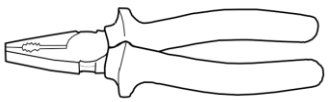
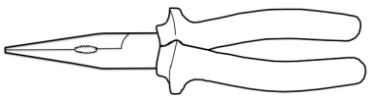
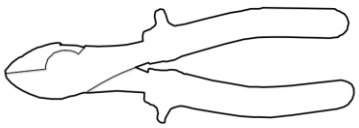
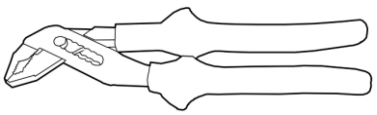
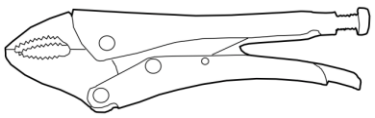
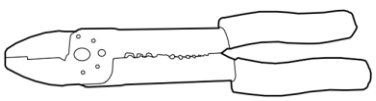
De Fazio, F., Bakker, C., Flipsen, B., & Balkenende, R. (2021). The Disassembly Map: A new method to enhance design for product repairability. *Journal of Cleaner Production*, 320, 128552. https://doi.org/10.1016/j.jclepro.2021.128552

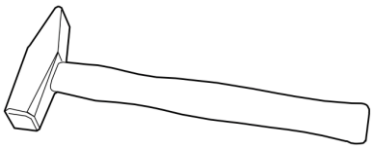
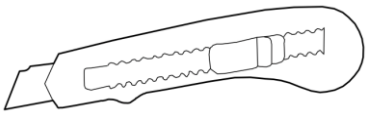
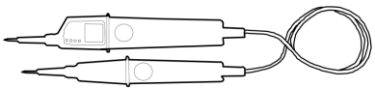
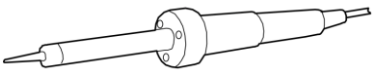
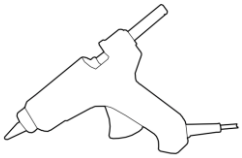
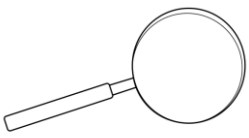
HOP. (2022*). The French repairability index.* Retrieved July 31, 2023, from https://www.halteobsolescence.org/wp-content/uploads/2022/02/Rapport-indice-de-reparabilite.pdf

NEN. (2020a). NEN-EN 45554: *General methods for the assessment of the ability to repair, reuse and upgrade energy-related products* (EN 45554:2020 E).

Appendix

List of tools retrieved from the 45554 standard (NEN, 2020).

Tool type	Illustration (Informative example)	Reference
Screwdriver for slotted heads, cross recess or for hexalobular recess heads		ISO 2380, ISO 8764, ISO 10664
Hexagon socket key		ISO 2936
Combination wrench		ISO 7738
Combination pliers		ISO 5746
Half round nose pliers		ISO 5745
Diagonal cutters		ISO 5749
Multigrip pliers (multiple slip joint pliers)		ISO 8976
Locking pliers		
Combination pliers for wire stripping and terminal crimping		

Prying lever		
Tweezers		
Hammer, steel head		ISO 15601
Utility knife (cutter) with snap off blades		
Multimeter		
Voltage tester		
Soldering iron		
Hot glue gun		
Magnifying glass		
NOTE 1 Most tools come in different sizes. This list only refers to the tool type. Although some sizes are more common than others, for practical purposes, any size of the listed tools is considered to be a basic tool.		

(Lieman, n.d.)

13.8 Index guide

This guide will help Action in creating a repairability index for a specific ErP group

Index guide

(*DPG Media Privacy Gate*, n.d.)

Index guide

This guide will help in creating a repairability index for every ErP group. The guide will go through what the goal of an index is, the criteria that should be selected, the outline of the index and selecting priority parts.

Goal

It is important to have a goal in mind for the repairability index to be able to select the right criteria. This includes the context the repairability score will be used in. Things that have to be considered are: Who is going to do the repair, What products are going to be compared in the index, For whom is the index to be intended, etc.

The goal for the repairability index in horizon 1 of Action's roadmap is to measure the repairability of a product category. This is used as a baseline from which targets can be developed which are translated into tangible KPI's for the buyers. The score is used B2B between Action and suppliers. As Action introduces 150 new products each week efficiency has to be taken into account.

Criteria

The criteria that are used have to contribute to the earlier specified goal. When selecting criteria it is good to keep in mind what the measurement will show. If the outcome of every product will be the same would it then be useful to measure it? Currently the selected criteria that are proposed according to the goal of horizon one can be seen in Table 1. These will give a basic overview of the repairability of a ErP group.

If criteria need to be updated three conditions should be considered which will guarantee the outcome will be equal for every stakeholder, the criteria must:

i. Be measurable and enforceable in an objective way (i.e. not interpretable in different ways depending on who is doing the evaluation);
ii. Stimulate an active market for repair/upgrade (being the aim to favor product options and scenarios that can result in an easier repair operation), without undermining the product safety

Criteria	Sub criteria
Product Criteria (list 1 and 2)	
Disassembly	Disassembly depth
	Fasteners
	Necessary tools for disassembly
	Disassembly time
	Availability
	Delivery time
	Price relative to the price of the original product
Support criteria	
Documentation	

Table 1: Initial criteria according to horizon 1

iii. Be adaptable to reflect specificities of groups/ types of products.
If additional criteria were to be needed Appendix 1 suggests several based on the French Repairability Index and the JRC report.

Index

The index is not really a problem within the context of the earlier specified goal. For B2B full transparency can be demanded for every priority part. This makes the overall score and its weight less interesting as the individual indicators hold more information about the product. KPI's can be adjusted to these specific indicators which makes it possible to control these even better. If the outcome of the criteria and knock-out criteria is not as wished it could be adjusted accordingly.

Priority parts

To make the assessment of repairability more easy only the parts that influence repairability should be selected, these are called the priority parts. The priority parts have to be comparable in the product group they are going to be used in.

For the goal of repairability only reliability is important as this describes the "probability that a product functions as required under given conditions, including maintenance, for a given duration without limiting event."

The priority parts should be selected based on functional importance and if it is, the part is likely to fail. There are three levels in part importance; primary, secondary and tertiary functions. For example the primary function of a washing machine is to clean, rinse and spin clothes. The secondary function are aspects that enable, supplement or enhance this primary function such as a display on a washing machine. Tertiary functions are not important for priority parts. Drawing a product and its parts could help in visualizing the parts that are present in a product. Disassembling a couple of products and checking what their priority parts are could also help.

Products that have been on the market can give the best insights into what parts might fail. There are several ways of obtaining information about parts that are vulnerable to failing such as risk assessments, repair monitor, spare parts supply, etc. Sources for this kind of information can be manufacturers of products and parts, repairers, reuse and remanufacture organizations, consumer testing organizations, insurance companies, researchers and regulators. The actual depth of broken parts is to be considered as well as replacing an electric motor might not be necessary if only the brushes are worn. A distinction between priority parts is used in list 2 and list 1. list 2 is made up of 3 to 5 parts that most frequently break and list 1 is made up of a maximum of 10 parts that must be in good condition for the product to properly operate. If data is available priority parts from list 1 have a minimal failure rate of over 3% which gives them a weight of 1. Priority parts from list 2 have a failure rate of over 10% and have a weight of 2. Input from stakeholders and experts is important as well, parts proposed by them should be taken into account accordingly. The available information on the type of products Action sells can be deducted from:
Repair monitor
Available spare parts
Customer returns
Literature regarding the relevant product
Inspecting physical products
Returns, spare parts and physical structure of competition

A simple way of determining priority parts is described in Table 2. Not all information might be available, if more products are analyzed the outcome might be more accurate.

1. Draw product/ make it visual
2. Determine primary and secondary functions of product
3. Draw/take pictures and visually inspect parts on the product that contribute to these functions
4. Make first selection of priority parts
5. Collect information and check for extra priority parts
6. Divide priority parts between list 1 and list 2

Table 2: Initial criteria according to horizon 1

Reference values

The values for the ability to repair a product are the same for every product. The ease of disassembly is covered by the disassembly depth and time. By setting reference values for the disassembly depth and time Action can influence the desired ease of disassembly of the product they buy. For the reference values it is advised to select a well repairable product and base the reference levels on this product. If this is set as a baseline the manufacturers are still being pushed to go beyond the already most repairable product and actually improve their products.

Next to the reference values for the ease of disassembly of the product a list of parts should be made as well. This makes it easy to compare disassembly maps if all the numbers represent the same parts. By naming and numbering all the parts encountered during the process of selecting priority parts a list can be established. This should be shared with the supplier to make sure the disassembly maps are similar.

Example

An example of determining the priority parts and reference values is shared to give an in practice example.

Goal

The goal for the repairability index in horizon 1 of Action's roadmap is to measure the repairability of a product category. This is used as a baseline from which targets can be developed which are translated into tangible KPI's for the buyers. The score is used B2B between Action and suppliers. As Action introduces 150 new products each week efficiency has to be taken into account. The goal of measuring repairability is to enable the repair of a product and make it accessible through ease of disassembly.

Criteria

The proposed criteria from Table 1 are adapted to get a understanding if the product is repairable and how easy this is. The ability to repair is covered via the types of fasteners used, tools needed, availability of spare parts, delivery time of spare parts, the price of spare parts and the documentation. The ease of disassembly is covered by the disassembly time and number of disassembly steps. These criteria should cover everything, other criteria are not expected to give extra usable or significantly different information between the grills.

Index

As no extra criteria are used the proposed index is used without making any adjustments. This means that if a product complies it will have the score as seen in Table 3. In this example the product is made out of reusable fasteners which are removable with proprietary tools. The product has the same disassembly depth and disassembly time as the set levels.
The spare parts are available between 5 and 10 years similar to the products life time and are delivered in 15 days. The minimal required documents are available for this product. The price depends on the price of the product and its spare parts.

Repairability score:		
Disassembly depth part average:		5
Fastners used:		10
Tools needed:		10
Disassembly time average:		5
Dissasembly score		**7,5**
Availability:		6,7
Delivery time:		6,7
Parts price:		...
Parts		**6,1**
Documentation		**6**

Table 3: Score of a product that complies with the minimal requirements

Priority parts

For determining the priority parts for an ErP group a workflow is proposed. For this case study three grills of Action's assortment have been selected to gather information (Figure 1). These three grills were randomly selected from the current available assortment.

The first step is to make the product visual, three stock photos from Action have been used as seen in Figure 1. The second step is to take apart the products and map all parts as seen in Figure 2. The list with parts of all products is combined in one parts list. Not all parts are present in every product.

Parts list of the Tristar, Alpina and Emerico grills:

1. Top grill
2. Bottom grill
3. Cable
4. Top Cover
5. Handle
6. Spring release
7. Spring release cover
8. Left hinge
9. Right hinge
10. Cable cover
11. Indicator light
12. Top Heating element
13. Thermostat
14. Bottom heating element
15. Bottom cover
16. Top insulation

Figure 1: Tristar, Alpina and Emerio contact grill in sequential order.

17. Left handle support
18. Right handle support
19. Locking mechanism
20. Protective cover
21. Cable tree
22. Weight
23. AC Outlet
24. Heating element place holders
25. Light cover
26. Light holder

The third step is to determine primary and secondary functions of the product. The fourth step is to draw/take pictures and visually inspect parts on the product that contribute to these functions. This can be seen in Table 4.

The fifth step is to make a first selection of priority parts. From the disassembly the hinges look vulnerable. This would hinder the primary function making it an important part. The heating element is essential for heating objects and is an important part as well. The thermostat keeps the temperature of the grill within limits. The grill can not function without it making it an important part. The parts enabling the secondary functions are not really important to the general functionality of the product. For now the parts 12,14,8,9 and 13 are selected as priority parts.

The sixth step is to collect information about potential priority parts from literature and practice. For the data from literature the repair monitor, customer returns from Action.

Figure 2: Products dismantled and labeled. Tristar, Alpina and Emerio from top to bottom

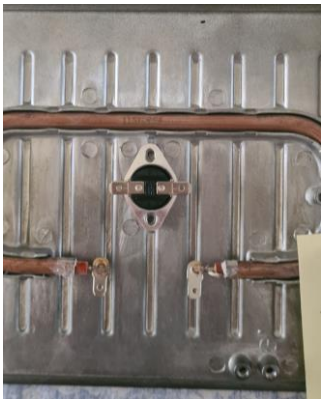
Primary functions	Parts	pictures
Heat objects from two sides	12,14,8,9	  
Control the temperature	13	 
Secondary functions		
Lock the two sides	19	 
Open grill 180°	6,7	 

Table 4: Step 3 and 4 of selecting priority parts.

The data from the repair monitor (Repair Monitor, unpublished), available spare parts from the selected grills and comparable A-brand grills has been used to identify priority parts. The repair monitor collects data from repair cafes all over the world. The data contains what type of product is repaired, the problem and the found defect. In total 133 repairs were monitored for the grill in the repair monitor. These repairs have been mapped according to the nature of the defect The results can be seen in Table 5. There is a clear top three in the Table visible including the thermostat, element and cable which are part 13,12, 14 and 23

Problems:	Amount of repairs:	Percentage
Housing	9	6,77%
Thermostat	26	19,55%
Element	22	16,54%
Cable	37	27,82%
Unknown	16	12,03%
Fuse	6	4,51%
Lamps	2	1,50%
Shortcut	6	4,51%
Loose connections	9	6,77%
Total	133	

Table 5: Data from repair monitor (Repair Monitor, unpublished)

Alpina, Emerio and Tristar do not supply spare parts for their contact grills. Only Tristar offers some spare accessories such as leakage trays for grease. Available spare parts from the suppliers could therefore not be taken into account. Additionally Action has little to no data why customers return products.

To compare the availability of spare parts an A-brand grill has been selected to determine what are considered priority parts by A-brands based on the availability. The selected grill is the Tefal Inicio GC241D panini grill as is it shares the most similarities with the previous selected grills and is from an renowned A-brand. Tefal refers to four websites for spare parts of their products which are parts.nl, onderdelen.nl, handyman.nl and beekman.nl (Tefal, personal communication, June 27, 2023). Handyman does not sell any spare parts (Handyman, n.d.), but the other three websites all sell part 17,18 and 13 respectively (Beekman B.V., n.d. ; Onderdelen.nl, n.d. ; PartsNL, n.d.).

Next to the websites provided by Tefal Fixpart.nl and Onderdelenplanet.nl sell various parts as well. These spare parts are not offered on sites which are promoted by the original brand but are offered on third party sites. But according to these sites the parts are from the original equipment manufacturer (OEM).

The parts included part number 2, 4, 5, 13, 15, 17, 18, 21 and 23 respectively (FixPart, n.d. ; Onderdelenplanet.nl, n.d.). These parts are all claimed to be “original products” and produced by the mother company of Tefal. Some parts were previously mentioned and some were less relevant such as the topcover. The only mentionable part for this grill is the extra available bottom grill and handle. The grills were being sold as one part where the grill and heating element are sold as one. Preferable these are separate available to reduce unnecessary replacement. The handle makes sense to sell as a sparepart if the handle supports are being sold as spare parts as well.

For the Emirio, Alpina and Tristar grill no spare parts were to be found online. Tristar is contacted through Action to share the failure rates of the parts of their products to be able to distinct priority parts in list 1 and 2. However, Tristar could not provide this information.

The parts that came forward in step 5 and 6 are listed in Table 6 and highlighted where they were mentioned. This is used to choose and divide the priority parts between list 2 and 1. For list 2 the AC cable, thermostat, bottom and top grill have been selected. These have been selected as they contribute to the primary function, break often according to the repair monitor and are already available for similar grills. For list 1 the handle supports, hinges and the handle are selected. These parts are probably less prone to breaking as they are not mentioned by the repair cafes. For the A-brand the handle supports are available through their available website but this could be due to being able to offer them easily and not because of demand.

Step 5	Step 6		
First physical exam	Repair monitor	Available spare parts officially	Available spare parts unofficially
Top heating element (12)	16,5%		/ In combination with grill
Bottom heating element (14)			/ In combination with grill
Left hinge (8)			
Right hinge (9)			
Thermostat (13)	19,6%	X	X
	AC cable (23) 27,8%		X
		Handle support (17&18)	X
			Handle (5)
			Bottom Grill (1)
			Top Grill (2)

Table 6: Identified parts throughout step 5 and 6

List 2	List 1
1. AC Cable (23)	5. Handle support left (17)
2. Thermostat (13)	6. Handle support right (18)
3. Bottom grill (2)	7. Left hinge (8)
4. Top grill (1)	8. Right hinge (9)
	9. Handle (5)

Table 7: List 1 & 2 priority parts

The grill and heating element are currently not separable in any of the Action or comparable A-brand grills. Models do exist where this is possible but this is also seen as an extra functionality. Therefore, the Grills are selected as priority parts assuming the heating element is irreversibly attached to it. In a later stadium this could be further discussed with suppliers to move towards fully removable heating elements. The final list with priority parts from list 1 and 2 can be seen in Table 7.

Reference values

The values for the ability to repair a product are the same for every product. The ease of disassembly is covered by the disassembly depth and time. By setting reference values for the disassembly depth and time Action can influence the desired ease of disassembly of the product they buy.

If a product complies with the set ease of disassembly reference level it will score a 5 out of 10 which could be considered as a pass. For the reference value an example is chosen that leaves room for improvements. This encourages manufacturers to go beyond the score of 5 and actually improve their products. For the disassembly steps and time the best product of the current inventory in terms of disassembly depth and time of Action is selected as reference value. The first selection is based on the numbe of removable priority parts. If parts are non removable their disassembly time can not be taken into account. From the remaining products the total disassembly time of the priority parts are added together to get the total disassembly time of the priority parts. From the remaining products the one with the lowest disassembly time is chosen to be the reference value. The Alpina grill is the easiest to disassemble as can be seen in Table 8. This grill is chosen as reference value for the disassembly depth and time.

The disassembly depth and time which are used as reference value for every part can be seen in Table 9. The repairability score of the Alpina, Emerio and Tristar grill have been filled in as seen in Table 3,4 & 5.

Model:	Alpina			Tristar			Emerio		
Part:	Dis?	#	Time	Dis?	#	Time	Dis?	#	Time
1	X	2	21	X	2	13	X	2	43
2		1	93	X	1	48		1	113
3		4	28	X	1	15		3	57
4		1	134	X	1	39		1	185
5		1	64		1	59		1	113
6		1	56		1	57		1	104
7		1	26		1	35		1	29
8		1	29		1	29		1	28
9		2	136		2	131		2	233
Total time:	1	14	587	4	11	426	1	13	908

Table 8: Possibility of disassembly, disassembly steps and disassembly time per part and product

Part	Disassembly depth	Disassembly time
1. AC Cable	2	21
2. Thermostat	1	93
3. Bottom grill	4	28
4. Top grill	1	134
5. Left handle support	1	64
6. Right handle support	1	56
7. Left hinge	1	26
8. Right hinge	1	29
9. Handle	3	136

Table 9: Reference disassembly depth and disassembly time values.

Repairability score:		Alpina Grill
Disassembly depth part average:		5
Fastners used:	Non removable part	8,3
Tools needed:		10
Disassembly time average:		5
Dissasembly score		**7,1**
Availability:		0
Delivery time:		0
Parts price:		0
Parts		**0**
Documentation		**1**

Figure 3: repairability score of the Alpina grill

Repairability score:		Emerio Grill
Disassembly depth part average:		5,2
Fastners used:	Non removable part	8,3
Tools needed:		9,5
Disassembly time average:	Outlier	2,1
Dissasembly score		**6,3**
Availability:		0
Delivery time:		0
Parts price:		0
Parts		**0**
Documentation		**1**

Figure 4: repairability score of the Emerio grill

Repairability score:		Tristar Grill
Disassembly depth part average:		5,5
Fastners used:	Non removable part	3,8
Tools needed:	Non removable part	3,8
Disassembly time average:	Outlier	1,8
Dissasembly score		**3,7**
Availability:		0
Delivery time:		0
Parts price:		0
Parts		**0**
Documentation		**1**

Figure 5: repairability score of the Tristar grill

References

Cordella, M., Alfieri, F., & Sanfelix, J. (2019). *Analysis and development of a scoring system for repair and upgrade of products*. European Commission, Joint Research Centre, Seville, Spain.

Beekman B.V. (n.d.). *Tefal GC241D24/J5 CONTACT GRILL PANINI GRILL*. Retrieved July 13, 2023, from https://www.beekman.nl/c/onderdelen-koken/tefal/grill/tefal-gc241d24j5-contact-grill-panini-grill-8000036212-2081518

Corporate sustainability reporting. (n.d.). Finance. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

FixPart. (n.d.). *FixPart - Tefal GC241D12/J5 (PANIN) grill onderdelen*. Retrieved July 13, 2023, from https://fixpart.nl/nl/typenummer/tefal/gc241d12-j5-panin?page=1

Handyman. (n.d.). *Handyman*. Handyman. Retrieved July 13, 2023, from https://www.handyman.nl/merken/tristar/

Ministère de la Transition écologique. (2022). *Instructions manual for the display and the calculation of the repairability index of electrical and electronic equipments*. Retrieved June 10, 2023, from https://www.ecologie.gouv.fr/sites/default/files/220523_instructions%20manual%20-%20repairability%20index%20-%20final%20V3.0.pdf

NEN. (2020a). *NEN-EN 45554: General methods for the assessment of the ability to repair, reuse and upgrade energy-related products* (EN 45554:2020 E).

Onderdelen.nl. (n.d.). *Tefal GC241D24/J5 CONTACT GRILL PANINI GRILL*. Retrieved July 13, 2023, from https://www.onderdelen.nl/onderdelen-koken/tefal/grill/tefal-gc241d24j5-contact-grill-panini-grill-8000036212-2081518

Onderdelenplanet.nl. (n.d.). *TEFAL - GC241D12J5 PANIN onderdelen*. Retrieved July 13, 2023, from https://onderdelenplanet.nl/grill/tefal/gc241d12j5-panin?searchterm=&categorie=&pagina=2

PartsNL. (n.d.). *Tefal GC241D24/J5 CONTACT GRILL PANINI GRILL*. Retrieved July 13, 2023, from https://www.partsnl.nl/onderdelen-koken/tefal/grill/tefal-gc241d24j5-contact-grill-panini-grill-8000036212-2081518

Repair monitor (31_03_2023). (unpublished). [Dataset]. RepairMonitor. https://www.repairmonitor.org/nl

Appendix 1

The criteria of JRC and FRI ordered under the 45554 standard of product and support related criteria.

FRI (Ministère de la Transition écologique, 2022)				Cordella (Cordella et al., 2019)
Pre determined for specific product ErP category				Selecting priority parts
45554 product related criteria (NEN, 2020)				
Criterion 2 : disassembly, accessibility, tools, fasteners list 2: list of a maximum of 3 to 5 spare parts (depending on the category of equipment in question) that most frequently break or break down; list 1: list of a maximum of 10 other spare parts (depending on the category of equipment in question) that must be in good condition for the equipment to function.	**Ease of disassembly** Based on the amount of disassemble steps (DDi) for specific product category ErP	List 1 or 2 parts DDi : number of steps required to disassemble the spare part. - not removable, if the spare part cannot be disassembled or unitarily accessible. - part not included, in case of absence of a part in the equipment	**Disassembly depth/ sequence**	**Pass/ Fail** For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6). Rating classes A score is assigned for each priority part based on their disassembly depths (DDi). A continuous rating can be calculated as: S1,i = 1 – (DDi – 1) / (DDref – 1) where: DDi is the depth for the priority part i; DDref is the reference depth for the priority part i. The score is set to 0 if (DDi – 1) is greater than (DDref – 1). Alternatively, a discrete rating could be considered: I) DDi < X steps = 1 pt. II) X < DDi < Y steps = 0.75 pt. III) Y < DDi < Z steps = 0.5 pt. IV) DD1 > Z steps = 0.25 pt. Where: X, Y and Z have to be defined for each priority part.
	Fasteners characteristics	A: Neither removable nor reusable = 0 point B : Removable and not reusable = 1 point. - C : Removable and reusable: an original fastening system that can be completely removable (without causing damage) and reusable (exemple : screw). = 2 points.	**Fasteners**	**No Pass/ Fail** A score is assigned for each priority part according to the reversibility and reusability of the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be reused are supplied with the new part for a repair, re-use or upgrade process = 1 pt. II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening systems are not removable or reusable, as defined above = 0 pt
	Necessary tools for disassembly	List 1 or 2 parts A : Not removable or unitarily accessible with any existing tools = 0 point. - B : Removable only with proprietary tools.= 1 point. - C : Removable only with specific tools. = 2 points. - D : Removable with no tool, with basic tools or with tools supplied with the product or the spare part = 4 points. if the part is not present in the product design = 4 points	**Tools**	**Pass/Fail** The repair/upgrade process is feasible for each priority part with existing tools. **Rating classes** A score is assigned for each priority part according to the complexity and availability of the tools needed for its repair/upgrade: I) Basic tools: repair/upgrade of the priority part is feasible without any tools, or with tools that are supplied with the product, or with the list of basic tools provided in note 1 = 1 pt. II) Other commercially available tools: repair/upgrade of the priority part is unfeasible only with basic tools and requires the use of other tools that are commercially available = 0.66 pt. III) Proprietary tools: repair/upgrade of the priority parts is feasible only with one or more proprietary tools = 0.33 pt.

Criterion 2 : disassembly, accessibility, tools, fasteners list 2: list of a maximum of 3 to 5 spare parts (depending on the category of equipment in question) that most frequently break or break down; list 1: list of a maximum of 10 other spare parts (depending on the category of equipment in question) that must be in good condition for the equipment to function.			**Disassembly time**	**No Pass/ Fail** A score is assigned for each priority part based on their disassembly time (DTi). A continuous rating can be calculated as: S1,i = 1 – DTi / DTref where: DTi is the disassembly time for the priority part i; DTref is the reference disassembly time for the priority part i. The score is set to 0 if DTi is greater than DTref. Alternatively, a discrete rating could be considered: I) DTi < X = 1 pt. II) X < DTi < Y = 0.75 pt. III) Y < DTi < Z = 0.5 pt IV) DTi > Z = 0.25 pt. Where X, Y and Z (min) have to be defined for each priority part of the product group under assessment.
			Safety, skills, and working environment	**No Pass/Fail** a) A score is assigned for each priority part based on the level of knowledge needed for its repair/upgrade, as well as the level of risk associated: I) The repair/upgrade can be carried out by a person with a general knowledge of basic repair, re-use, upgrade techniques and safety precautions but without any specific qualifications = 1 pt. II) The repair/upgrade has to be carried out by a person with specific training and/or experience related to the product category concerned, who is also aware of the risks involved in the process and is able to handle them correctly = 0.66 pt. III) The repair/upgrade can be carried out only by the manufacturer = 0.33 pt. b) A score is assigned for each priority part based on the working environment required for carrying-out the repair/upgrade operation, also due to safety conditions: I) The repair/upgrade can be carried out without any working environment requirements (e.g. where the product is in use, or in generic environments) = 1 pt. II) The repair/upgrade has to be carried out in a working environment but not in a production site = 0.66 pt. III) The repair/upgrade can be carried out only in a production site that is comparable with the environment in which the product was manufactured = 0.33 pt. Score (#9) = Score (#9a) x Score (#9b)
45554 support related criteria				
			Diagnosis support and interfaces	**No Pass/ Fail** A score is assigned for the product based on the availability of diagnosis support and interfaces to aid the identification of typical failure modes associated to the priority part: I) Intuitive/ coded interface with public reference Table: all main faults can be diagnosed either by i) a signal that can be intuitively understood, or ii) by consulting fault-finding trees and/or reference codes information supplied with the product = 1 pt. II) Publicly available hardware/ software interface: to be diagnosed, some of the main faults need the use of hardware, software and other support which is publicly available = 0.66 pt. III) Proprietary interface: to be diagnosed, some of the main faults need the use of proprietary tools, change of settings or transfer of software which are not included with the product = 0.33 pt.

<table>
<tr>
<td>Criterion 1: documentation

Based on the duration of availability and for whom; Repairers or Consumers.

Availability ranges between; <9, 9<x<11, 11<X<13 and X>13 years where X is availability</td>
<td colspan="2">The unequivocal identification of the product (type of product, trademark, trade name, model, and possibly, serial number)

A disassembly map or exploded view

Wiring and connection diagrams

Electronic boards diagrams

List of necessary repair and test equipment

Technical manual of instructions for repair

Diagnostic fault and error codes

Component and diagnosis information

Instructions for software and firmware (including reset software)

Information on how to access data records of reported failure incidents stored on the product

Technical bulletins

Specific guidance for self-repair (recommended operations, safety and repair instructions, any implications for the guarantee)*

How to get access to professional repairers

Failures detection and required action (consumers approach)

User and maintenance instructions</td>
<td>Type and availability of information</td>
<td>Pass/Fail
Information is made available (for a sufficiently long period to be defined at product level) to different target groups, including:
- Product identification and exploded view;
- Instructions for regular maintenance;
- Troubleshooting charts;
- Repair or upgrade services offered by the manufacturer;
- Safety issues related to the use, maintenance and repair, as well as guarantee issues (e.g. commitment to repair in case of failure, post-repair guarantee if any);
- Disassembly sequences;
- List of available updates, spare parts and recommended retail prices, as well as repair costs of the common failures as offered by the manufacturer.
All this information has to be made available, as repair and maintenance information for professional repairers. Depending on the level of sensitiveness, a part of this information may also to be disclosed to other end users.1) The list above is illustrative and has to be shaped for specific products
2) Any safety issue associated with the use, maintenance and repair of the product has to be identified in accordance with Low Voltage Directive 2014/35/EU and Machinery Directive 2006/42/EC (depending on the type of product) and communicated transparently and publicly in any case.
3) Channels for communicating information may include printed manuals, websites, digital information carriers such as QR codes, DVDs or flash drives.

Rating classes
a) A score is assigned for the product based on the cost and availability of all information required as pass/fail criterion:
I) All information is available publicly at no additional cost for consumers = 1 pt;
II) All information is available to independent repairers = 0.66 pt.
III) All information is available to registered professional repairers = 0.33 pt.</td>
</tr>
<tr>
<td rowspan="2">Criterion 3: Availability of spare parts</td>
<td>Sub-criterion 3.1& 2 : Commitment on the availability over time of spare parts (in years) of parts from list 1 & 2</td>
<td>Availability ranges between; <9, 9<x<11, 11<X<13 and X>13 years where X is availability over time</td>
<td rowspan="2">Spare parts</td>
<td rowspan="2">Pass/Fail
For each priority part: i) Spare parts are declared to be available for X years after placing the last unit on the market
ii) Spare parts are deliverable within Y working days iii) Lists of spare parts and recommended retail prices set by manufacturers (and/or contractors, if applicable) are made publicly available (see #6).
Rating classes
a) A score is assigned for each priority part based on the period of time during which spare parts are available:
I) The spare part is declared to be available for a duration of X years = 1 pt.
II) The spare part is declared to be available for a duration of Y years = 0.66 pt.
III) The spare part is declared to be available for a duration of Z years = 0.33 pt.
b) A score is assigned for each priority part based on the target groups:
I) The spare part is available to all interested parties = 1 pt.
II) The spare part is available to any self-employed</td>
</tr>
<tr>
<td>Sub-criterion 3.3& 4 : commitment on the delivery time of spare parts - broken/malfunctioning parts of list 1 & 2</td>
<td>Commitment on the delivery time ranges between; X>10 days, 10 days >X> 5 days, 5 days >X> 3 days, X< 3 days.</td>
</tr>
</table>

criterion 4 : price of spare parts	Pre-tax price of the most expensive spare part (list 2) Average pre-tax price of other spare parts (list 2) Manufacturer's pre-tax price of concerned model if the result is greater than 0.3 then the number of points is 0; if the result is less than 0.1 then the number of points is 100; if the result is between 0.1 and 0.3 then the number of points is determined according a determined scale		professional as well as any legally established organization providing repair services = 0.66 pt. III) The spare part is available to service providers authorized by the product manufacturer to offer repair services = 0.33 pt. c) When relevant, a score is assigned to specific priority parts based on the spare part interface: I) The part is non-proprietary and has a standard interface = 1 pt. II) The part is either proprietary or does not have a standard interface = 0.5 pt. Score (#7)
		Software and firmware	**Pass/Fail** Software/firmware updates and support are offered for a duration of at least X years after placing the last unit of the model on the market. Full compatibility with open source Operating Systems and/or open source Virtual Machine software is ensured (where applicable). Information about how updates will affect the original system characteristics (e.g. RAM, CPU) is provided, and there is to be always the option to not install, to install or to uninstall the update. **Rating classes** a) A score is assigned for the product based on the period of time during which software/firmware updates and support are offered: I) Software/Firmware updates and support are offered for a duration of time post-manufacture of at least Y years = 1 pt. II) Software/Firmware updates and support are offered for a duration of time post-manufacture of at least X years = 0.5 pt. b) A score is assigned for the product based on the target groups: I) Software/Firmware updates and support is offered to all interested parties = 1 pt. II) Software/Firmware updates and support is offered to any self-employed professional as well as any legally established organization providing repair services = 0.66 pt. III) Software/Firmware updates and support is offered to service providers authorized by the product manufacturer to offer repair services = 0.33 pt. c) A score is assigned for the product based on the cost of the software/firmware update service: I) Software/Firmware updates and support are offered free of charge for the entire period of time (either X or Y) = 1 pt. II) Software/Firmware updates and support are offered free of charge for Z years = Z/X or Z/Y (depending on the period of time) pt. Score (#8) = Score (#8a) x Score (#8b) x Score (#8c)
		Data transfer and deletion	**No Pass/Fail** score is assigned for the product based on the availability of secure data transfer and deletion functionality: I) Built-in secure data transfer and deletion functionality is available to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid state drives) = 1 pt.

			II) Secure data transfer and deletion is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Secure data transfer and deletion is available on request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) = 0.33 pt.
		Password reset and restoration of factory settings	No Pass/Fail A score is assigned for the product based on the availability of an option for resetting the password and restoring the factory setting: I) Integrated reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using functionality integrated within the product = 1 pt. II) External reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Service reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted using services
		Commercial guarantee	No Pass/Fail A score is assigned based on the availability of a "commercial guarantee" for the (entire) product offered by the guarantor, and including a "commitment to free repair as first remedy" in case of failures and, where relevant, a "commitment to upgrade the product

(Lieman, n.d.)

13.9 Repairs repair cafes

The clustered repairs from repair cafes retrieved from the repair monitor can be seen in figure 1. Table 1 shows the exact numbers of the repairs.

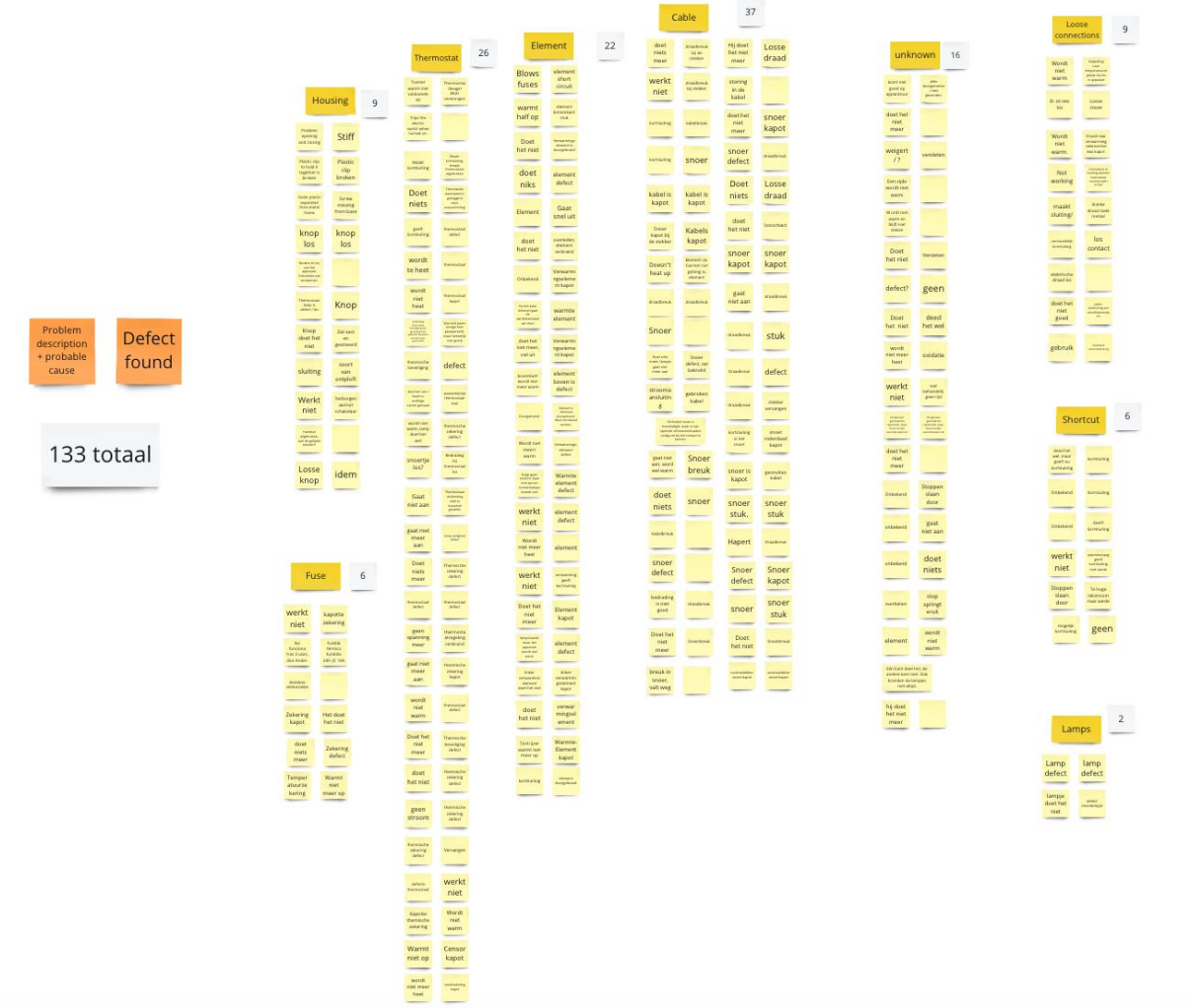


Figure 1: Clustered repairs from repair cafes retrieved from the repair monitor

	Total amount of repairs	133	
Problems:	Housing	9	6,77%
	Thermostat	26	19,55%
	Element	22	16,54%
	Cable	37	27,82%
	Unknown	16	12,03%
	Fuse	6	4,51%
	Lamps	2	1,50%
	Shortcut	6	4,51%
	Loose connections	9	6,77%

Table 1: Exact numbers of the repairs performed in repair cafes from the repair monitor

13.10 Calculation saturation point Europe

The calculations of the saturation point of stores in Europe is discussed here.

Action has 408 stores in the Netherlands for roughly 17815508 inhabitants.

This means one store per 43665 customers.

The Netherlands is seen as saturated. Action opens 15 new stores every week (Action, 2021).

The Eu has roughly 447000000 inhabitants and currently 2332 stores. Taken the same saturation this would cover 101827854 customers. Which leaves 345172145 unserved customers.

To serve these customers an additional 7905 stores are needed. With the current expansion of 15 stores per week this would take 527 weeks or 10 years from now which would 2033.

The growth in population of Europe is left out of scope as well as the growth in the amount of stores opened each weak, assuming they cancel each other out.

(Lieman, n.d.)